Utilization of Used Foundry Sand in Construction Industries

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Abstract: *Concrete is a widely comprehensive material that is used construction industry, it is the most predominantly used material after water around the globe. It creates a considerable utilization of natural sources like fine and coarse aggregate, this utilization creates extensively problems for the environment. To reduce these problems alternative material like foundry sand is used as a partial replacement. Foundry sand is known us waste material coming from ferrous and non-ferrous metal casting industries. There are about 35000 foundries industries in the world with an annual production of 69 million metric tons of castings per annum and the largest part of this production is goes for landfilling. It becomes a kind of anxiety for the environment like acquire enough space of land for landfilling and transportation which increases cost and also generates disposal issues. Published literature has conducted the usage of the foundry sand in concrete to replace the fine aggregate in different percentages. The amount of papers has been reviewed in this perusal, as a conclusion of various studies, results show foundry sand is an appropriate and suitable material to replace fine aggregate in concrete.*

Keywords*: Concrete, Foundry Sand, Mechanical Properties, Waste Material.*

1. Introduction:

Concrete is widely comprehensively used material, which is most widely used in construction in the wide, it is the most predominantly used material which comes second after water The word "concrete" has its origin from the Latin word "concretus", which means to grow together. It is a very strong and versatile construction material as it can be molded to take up the shapes required for the various structural forms. Concrete produced from the substitute of cement/lime, coarse aggregate, fine aggregate, water, and some admixture is needed. These material are mixed and placed needs curing for 28 days to reach its 98% strength, becomes a rock, which knows as concrete. That provides extensively good strength, durability, high temperature. Concrete obtained from the utilization of neutral available material materials like fine aggregate, coarse aggregate, water. It brings out an extensively huge problem to the environment. Researchers have been done a study on the utilization of waste materials in concrete. Because concrete is widely utilized material in the globe. It can bring out an eco-friendly environment. In this review utilization of foundry sand in concrete to replace fine aggregate. Foundry sand is produced by ferrous and nonferrous metal casting industries. It is known as silica sand in globe. there are about 35000 foundries industries in globe, it annually production is about 69 million tons of casting per annum and huge part of foundry sand goes to like waste material for landfilling, which become a kind anxiety for environment like acquire large space of land for filling process need enough money for transportation need management team for process manpower. Which increases cost and also generates the disposal issues in the environment. In this review, experimental evaluation has been done on the utilization of foundry sand in concrete to replace the fine aggregate. After replacement compares the conventional concrete and foundry sand concrete and checks the mechanical properties of concrete.

1.1 MATERIALS OF CONCRETE:

Cement: there are two types of cement in the globe that mostly utilized in construction industries OPC (ordinary Portland cement) available grade in OPC is 43 Mpa and 53 Mpa and PPC (pozzolanic Portland cement) the grade of PPC is around 33 Mpa it has a combination of pozzolanic materials in itself. Portland cement, the most extensively used cementing ingredient is nowadays, Portland cement consist of silicon, aluminum, iron, and oxygen. It also provides good strength and also workability.

Aggregates: Aggregates comprise about 60–75% by volume of concrete mix Normal-density aggregates are classified mainly into the following two sizes.

Coarse Aggregate: Coarse Aggregate is defined as whose size is bigger than 4.75 mm. It should be angular shaped for possessing well-defined edges formed at the intersection of roughly planar faces. Locally available coarse aggregate having maximum size 20mm is used. It is tested as per IS: 383-1970.

Fine Aggregate: Particles in between 0.075 mm and 4.76 mm (3/16 in.). Coarse aggregates are generally gravels and crushed stone. Naturally occurring aggregates are called gravels. Natural gravel and sand are mostly dug or dredged from pit, lake, river, or seabed. Crushed aggregate is produced by crushing quarry rock, boulders, cobbles, or large-size gravels. Fine aggregate is basically sand. There are two types of sand like river sand and manufactured sand.

1.2 FOUNDRY SAND:

Foundries purchase high-quality size-specific silica sands for use in their molding and casting operations. The raw sand is normally of a higher quality than the typical bank run or artificial sands used infill construction sites Fig.1 (Associate & Budhgaon, 2017).

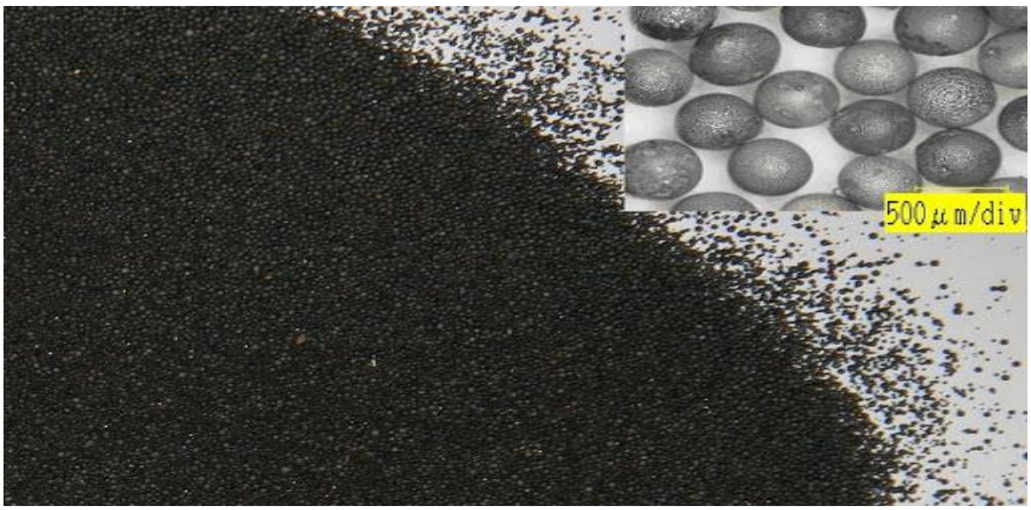


Fig 1: Foundry sand

1.3 USES:

Foundry sand is mainly fine aggregate. It can be utilized indifference ways mostly is used for molding and casting operations or in the same ways as artificial manufactured sands. It utilized in many civil engineering applications such as embankments, flow able fill, hot mix asphalt (HMA) and Portland cement concrete (PCC). Foundry sands have also been used extensively agriculturally as topsoil. Currently, approximately 500,000 to 700,000 tons of foundry sand is used annually in engineering applications. The largest volume of foundry sand is used in geotechnical applications, such as embankments, site development fills and road bases Fig.2 (Associate & Budhgaon, 2017).

Fig 2: Utilization of foundry sand in different applications.

1.5 TYPES OF FOUNDRY SAND:

There are two basic types of foundry sand available:

a) Green Sand

b) Chemically Bonded Sand

1.6 GREEN SAND:

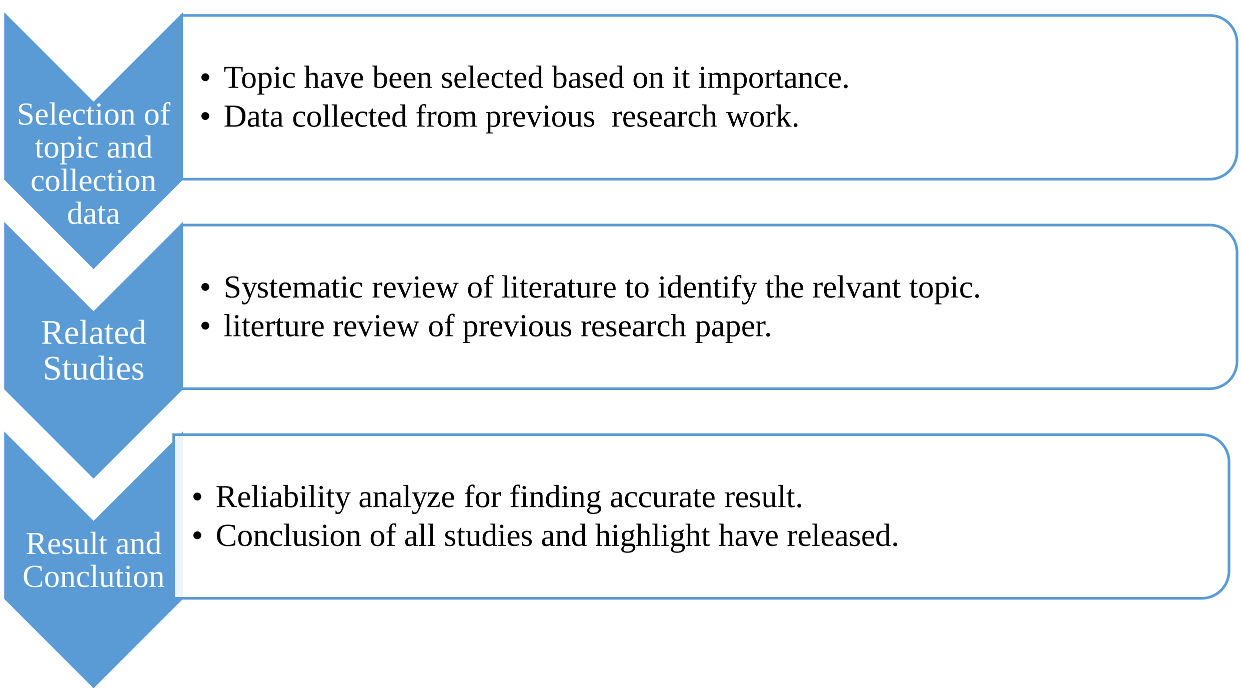
Greensand consists of 85-95% silica, 0-12% clay, 2-10% carbonaceous additives, such as seacoal, and 2-5% water. Greensand is the most commonly used molding media by foundries. The silica sand is the bulk medium that resists high temperatures while the coating of clay binds the sand together. The water adds plasticity. The carbonaceous additives prevent the "burn-on" or fusing of sand onto the casting surface. Greensands also contain trace chemicals such as MgO, K_2O, and TiO_2(Associate & Budhgaon, 2017).

1.7 CHEMICALLY BONDED SAND:

Chemically bonded sand consists of 93-99% silica and 1-3% chemical binder. Silica sand is thoroughly mixed with the chemicals; a catalyst initiates the reaction that cures and hardens the mass. There are various chemical binder systems used in the foundry industry. The most common chemical binder systems used are phenolic-urethanes, epoxy-resins, furfyl alcohol, and sodium silicates(Associate & Budhgaon, 2017).

2. RESEARCH METHODOLGY:

This studies have conducted on utilization of used foundry sand in concrete. Foundry sand in largely applied in civil engineering or construction industries. Used foundry sand is foundries which is remove from casting industries. Which is known as waste material. For conducting this review following research methods have been used to collected relevant data. This section justifies and discusses the methodological approach to the study. Fig.3 depicts the methodological flow chart for the study.



3. LITERATURE REVIEW:

Bhandari and Tajne 2016 Examination was done to produce a low cost concrete, and reduction environmental problems by using of waste foundry sand in concrete, in this investigation concrete containing waste foundry sand in the range of 0%, 10%, 20%, 30%, 40%, 60%, 80% and 100% by weight for M-25 grade concrete. And then compared to conventional concrete by workability, compressive strength, and acid attack. After the experiment has been done for all above percentage of waste foundry sand result shows, after 20% partial replacement compressive strength decrease. And the use of waste foundry also eco-friendly building material, and problems of disposal and maintenance cost of landfilling is reduced.

(Torase *et al.,* 2019) have experimental scrutiny on soil stabilization addition of foundry sand and rice husk ash in various proportion 10% Foundry Sand (5, 10, 15, 20)% Rice Husk Ash. The outcome of this scrutiny reveals that with the addition of Foundry sand and Rice Husk Ash show an overall improvement in soil. it also one of the superb material for stabilization of soil.

(Kuldeep and Tripti 2019) Have done an experimental probe on soil stabilization with some waste material foundry sand and marble dust in different percentages. The utilization of foundry sand (13 to 22)% and marble dust (13 to 22)%. The maximum CBR value achieved in 16% of marble dust and 22% of foundry sand. These materials improve soil bearing capacity.

(Naeethu and Johnson 2019) Have done an experimental probe on soil, in this probe tried to evaluate the effect foundry sand on CBR characterization of soil. The outcome reveals that 20% utilization of soil is the best combination. It creates maximum MMD value.

(Ajeet *et al.,* 2018) Have done an appraisal on soil stabilization with the utilization of foundry sand and fly ash in different proportions. The outcome of the evaluation shows that the best point of MMD is 1% fly ash and 0.25% foundry sand and also ¼ is the best addition for stabilization of soil.

(Gowtham *et al.,* 2018) have utilized glass waste and plastic waste in (2, 4, 6) percentage for stabilization of soil. The consequence of the evaluation shows that up to 4% and 6% of Glass and Plastic powder is beneficial to utilize for the improvement of geotechnical properties of soil.

(Premlatha *et al.,* 2018) Examined on the utilization of plastic waste and foundry sand for soil stabilization. The consequence of examination conveys that 17.5 % plastic waste and 40% foundry sand produce superb stability and also reduce construction costs up to 10% compared to conventional material.

(Matthew and Olusegun 2018) have done experimental scrutiny on the utilization of glass fiber for soil stabilization various percentages Glass Fiber at proportions of 0.4%. 0.8%, 1.2%, 1.6%, 2.0%, 2.5% and 3.0% by weight. The outcome of the inspection reveals that the addition of glass fiber increase CBR and maximum dry density with the peak influence show at (1.2 to 1.6) %.

Chandrakanth and Hamane 2016 studied the low-cost concrete production by replacement of fine sand and foundry sand is a trend and makes effective use of waste foundry as engineering material by reducing disposal and pollution problem. This paper identifies a potential use of wastes form foundry sand industry and construction industry for utilization in construction industry and represents the experimental partial replacement of natural sand by(0%, 20%, 40%, 60%) and recycle aggregate as partial replacement of natural coarse aggregate by (0%, 20%, 40%, 60%) and evaluate the strength of 7 and 28 days. It is found that compressive strength increase by with increase in the percentage of foundry sand, it was 40% maximum replacement after that the strength is reduced. And tensile strength increases up to 40% and after reduce, Increase of average compressive strength 4.47%, 10.615% & 4.237% as compared to conventional concrete. Increase in average split tensile strength 15.38%, 34.10% & 17.554% as compared to conventional concrete. Increase in average split tensile strength 21.99%, 35.67% & 19.50% as compared to conventional concrete. By using this waste in concrete in concrete, problems regarding safely disposal is reduced.

Barros Regina ''et al" 2014 carry out an investigation on concrete by utilization of foundry sand to replace fine aggregate in concrete. In this investigation which has evaluated by Barros 10 and 20 percent foundry sand has been utilizing to replace the natural sand or fine aggregate in concrete. The result shows that both utilization increases the compressive strength of concrete.

Prabhu G. *et al.,* 2014 this investigation carried out to evaluate the utilization of the foundry sand (FS) as a replacement material for fine aggregate in concrete. Foundry sand obtained from aluminum casting industry, and five replacement (10%, 20%, 30%, 40%, and 50%) of fine aggregate by foundry sand and the following density, slump cone, split tensile strength, flexural strength; ultrasonic pulse velocity (UPV) test has done. In all ages concrete, the strength properties of the concrete mixtures containing Foundry Sand up to 20% was relatively close to the strength control mixtures, and concrete has a combination of 20% and 30% foundry sand shows reduction in compressive strength 1.6% and 5.7% at age of 28 days compared to control mixtures. The flexural strength of control mixtures at the age 28 days is 4.087M/mm2 and with a mixture of foundry sand by 10%, 20%, and 30% the flexural strength is 3.986, 3.988 and 3.879 N/mm2, respectively which just show the reduction is only 2.47%, 2.42%, and 5.08% lower than control mixtures. And beyond 20% show inferior behavior compare to control mixture, because of the existence of clay, sawdust and wood floor in foundry sand. As the final result shows that we can use up to 20% efficiently as a fine aggregate in concrete production with an affecting the concrete standards.

Prasath *et al.,* 2014 have done experimentally on good performance concrete by using Glass Fiber and Foundry sand. For checking mechanical properties of concrete Foundry Sand replace as fine aggregate by (10%, 20% 30%) and Glass Fiber (0.5%) for checking mechanical properties of concrete. In the age of (7, 14, 28) days compression, split tensile strength and flexural strength tests have been done on this experiment. The result shows a slight increase in concrete with Foundry Sand and Glass Fiber as compare to control concrete. After 28 days, compressive strength, split- tensile strength, flexural strength has been evaluated shows increased up to (27.15, 24.82 and 33.17) percent by 30% replacement of fine aggregate by Foundry Sand and by adding 0.5% Glass Fiber. Foundry Sand is waste sand while using it then made eco- friendly environmental structures, and also can reduce disposal problems from waste material which happens to the environment.

Siddique and Sandhu 2013 concluded that similar traditional concrete, and utilize the foundry as replacement of fine aggregate by (0, 5, 15, and 20) %. The results show improvement of SCC compressive strength also increased with the FFS sand replacement level of up to 15%. The results also showed an increase in early age intensity, i.e., 7 days and 28 days, compared to the control mixture of 15% replacement level of WFS as a fine aggregate.

Singh and Siddique 2012. Observed an increase in concrete strength and an increase in WFS content, replacing natural sand in different proportions (5%, 10%, 15% and 20% by mass). The 28-day concrete compressive strength increased by 8.25-7%. Above 15% WFS, there is no significant increase in strength, which can be attributed to an increase in the surface area of the fine particles, which may result in a decrease in the hydrogel gel in the matrix, resulting in insufficient bonding. The factors that lead to a decrease in strength are poor process ability of the matrix and the presence of binders (i.e., very fine carbon and clay powders) in the WFS that adhere to the sand particles and prevent adhesion between the cement slurry and the aggregate. Siddique and Kadri reported increasing the strength by adding a mineral admixture, a Metakaolin (MK) of WFS-containing concrete.

Kaur *et al.,* 2012 Adding fungal Aspergillus spp. Fungal culture about 5% (w / v) treated 20% WFS as a sand substitute and reported a 15.6% increase in concrete 28-day compressive strength. The incorporation of fungal treated WFS showed an increase in strength due to the plugging of pores in the concrete by depositing fungal spores or biominerals in the pores of the cement sand matrix. The fungal culture (Aspergillus spp.) increases the ability of the cement to react properly with the foundry sand, thus increasing the formation of the C-S-H gel. Kaur et al. XRD analysis showed some extra peaks of calcium aluminosilicate (gismondine) in concrete containing fungal treated WFS (20%) and the results showed similar results. This confirms the formation of a new silicate phase within the matrix of the mortar material, which results in an increase in the strength of the material.

Salokhe and Desai 2011 the conclusion is that the WFS concrete from ferrous foundries is performed superior to the concrete with the non-ferrous WFS in the case of increased strength. The sand containing two areas gets dense concrete and is replaced by 20%. Basar and Aksoy studied the potential reuse of WFS in ready-mixed concrete production by studying the five different alternative percentages (0%, 10%, 20%, 30%, and 40%) of WFS. Concrete with 20% WFS exhibited nearly similar results similar to the control and similar microstructure properties and morphological characterization. Due to the low density of WFS, WFS produces concrete that is lighter than conventional concrete, but its density is still in the range of 2000-2600 kg / m3, which is effective for ordinary concrete grades.

Sahmaran *et al.*, 2011 The possibility of producing SCC with fly ash and WFS were explored by replacing Portland cement with different alternative levels of fly ash. Instead of fine aggregates, WFS was used up to 100% volume, where they concluded that the SCC mixture met EFNARC. Limits were observed in the SCC mixture and there was no visible separation or exudation but over 50% of the WFS replacement level, the superplasticizer demand increased to achieve the desired slump flow and the like. Similar results are shown elsewhere. Joy and Mathew studied the effect of WFS on the workability of geo polymer concrete made with GGBS and silica ash and found similar trends in reducing concrete slump values.

Khatib *et al.*, 2010 WFS replaces the fine aggregate in ordinary concrete in variable proportions (0%, 20%, 40%, 60%, 80%, and 100%) and observes a systematic loss of slump values from 200 mm to zero. The 20%, 40%, 60% slump value is 80%, 50% and 20% of the control slump value. Aggarwal and Siddique report that when WFS and bottom ash (BA) is added to concrete, the water requirement of the concrete increases because they partially replace ordinary sand in the same proportion. Up to 60% of alternatives were studied and the water content was increased by 4%, 6%, 10%, 16%, 22%, and 36% initial values to keep the slump level of all mixtures constant at 30 mm. A significant loss of slump was observed compared to the control concrete due to the higher fineness of the WFA resulting in a higher surface of the hydrated product. A delay in the initial and final set times was observed because of the very fine carbon particles in the WFS and/or the loss of joints between the aggregate and the cement slurry, resulting in delayed cement hydration. A similar trend is exhibited in the case of air-entrained concrete, and the demand for superplasticizers and bleed air mixtures increases as the WFS content increases.

Guney *et al.*, 2010 Reuse of waste foundry sand in high-performance concrete was studied. Natural sand replaced by (0%, 5%, 10%, and 15%) test shows the reduction in compressive, tensile strengths, and elasticity modulus, and with 10% waste of foundry, sand exhibits are a similar result to control one. The slump test and workability decrease with the increase of foundry sand. Useless 5% is inadequate and more 10% will concern about the strength. However, these reduction areas allowable limits of the ACI code. The result showed that foundry sand can be successfully used in high strength concrete if the particle-size distribution is arranged carefully. The use of waste foundry sand is so beneficial to the environment and also can help to reduce the cost of concrete.

Tarun *et al.*, 1996 The effect of replacing the fine aggregate in concrete with clean/new foundry sand and using foundry sand (WFS) in two ratios, 25%, and 35%, was studied. At 28 days of solidification, the compressive strength values of the concrete and WFS mixture were about 23% and 35% lower than the control concrete, while the mixing strength of the concrete with the new/clean foundry sand was almost the same as that of the control concrete. Similar results were reported when a wide range of mixtures was studied with three different types of sand, namely foundry sand, fine white sand, mixed sand, and WFS. As the level of WFS replacement increases, the compressive strength decreases linearly. In addition, the mixed sand mixture also reduces strength as its content increases. Etxeberria et al. Concrete containing green foundry sand (GFS) and chemical foundry sand (CFS) were studied and it was reported that both concretes had stronger strength than the control concrete at high water to cement ratios. Even after exposure to high temperatures, higher residual strength was obtained in the case of concrete mixtures with CFS and GFS compared to control concrete.

5. CONCLUSIONS:

1) Used foundry sand can be sustainable used material to replace fine aggregate in making high quality concrete
2) Utilization of used foundry sand increases compressive strength up to some in both ferrous & nonferrous mixtures increases as compared to conventional mixed.
3) Split Tensile Strength and Flexural Strength is increase as compare to conventional up to some percentage.
4) Utilization used foundry sand in fresh concrete produce a low slump flow or workability, in foundry sand the presence of very fine particulars size, and there for utilization of foundry sand acquire high superplasticizer dosage in order to provide a good slump flow or workability.
5) Huge part Foundry Sand goes for landfilling which acquire enough space of land and transportation man power and also create worst environment issue, by utilization of them in concrete or in construction brings out ecofriendly environment.
6) Inclusion of used foundry sand increases the USPV values and decreased the chloride ion penetration in concrete, which indicates that concrete
7) With utilization of used foundry sand to replace fine aggregate in concrete, it brings out to safe the natural resource.

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