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A New Approach of using Foundry Sand for Enhancing Concrete Mechanical Properties

Abhishek B K

Student, M.Tech, Department of Construction Technology, Karavali Institute of Technology Mangalore, Karnataka, India

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Abstract – *To produce low cost concrete by using various ratios of fine aggregate with used foundry sand to reduce disposal and pollution problems due to foundry sand. The innovative use of used foundry sand in concrete formulations as a fine aggregate ,replacement material was tested ,as alternate to traditional concrete. This paper identifies a potential use of waste from foundry industries and construction industry for utilization in construction industry and represents the 0%,20%,40%,60%,as a partial replacement of natural sand .Concrete mixture were produced tested and compared in terms of strength with congenital concrete. These tests were carried out to evaluate the strength for 7&28 days.*

Key Words: Fondry sand, concrete, Fine aggregate…

1. INTRODUCTION

About 60% to 80% of concrete is composed of aggregate by volume. Both fine and coarse aggregate is used in concrete production. The utilization of sand as fine aggregate in the construction industry has increased by an alarming rate. To cater to this increasing demand the industry is facing difficulty in the supply of natural river sand. To overcome this situation, construction industries have identified alternatives like manufactured sand, robo sand, rock dust etc. Another alternative to this can be use of waste material in concrete. Waste foundry sand is a waste material obtained from ferrous and non-ferrous metal casting industries. In foundry industries sand is recycled and reused many times for the purpose of casting. When the sand finds no advantage in this industry, it is disposed as a waste material, and termed as waste foundry sand (WFS). The incorporation of such material in concrete can help to reduce the disposal concerns of waste foundry sand, and also makes concrete production economical. A foundry is a manufacturing facility that produces metal castings by pouring molten metal into a preformed mold to yield the resulting hardened cast. The primary metals cast include iron and steel from the ferrous family and aluminium, copper, brass and bronze from the nonferrous family. Foundry sand is high quality silica sand that is a by-product 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. Metal foundries use large amounts of sand as part of the metal casting process. Foundries successfully recycle and reuse the sand many times in a foundry. When sand can no longer be reused in the foundry, it is removed from the foundry and is termed "foundry sand." Foundry sand production is nearly 6 to 10 million tons annually. Like many waste products, foundry sand has beneficial applications to other industries. 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 natural sands used in fill construction sites. The sands form the outer shape of the mold cavity. These sands normally rely upon a small amount of betonies clay to act as the binder material. Chemical binders are also used to create sand "cores".. Two general types of binder systems are used in metal casting depending upon which the foundry sands are classified as: i) clay bonded systems (Green sand) and ii) chemically- bonded systems. Both types of sands are suitable for beneficial use but they have different physical and environmental characteristics. Green sand is the most commonly used recycled foundry sand for beneficial reuse. It 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%). It is black in colour, 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. Depending upon the geometry of the casting, sands cores are inserted into the mold cavity to form internal passages for the molten metal. Once the metal has solidified, the casting is separated from the molding and core sands in the shakeout process. 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 by-product, new sand is introduced, and the cycle begins again. Although there are other casting methods used, including die casting and permanent mold casting, sand casting is by far most prevalent mold casting technique. Sand is used in two different ways in metal castings as a molding material which focuses the external shape of the cast part and as cores that form internal void spaces in products such as engine blocks. Since sand grains do not naturally adhere to each other so binders must be introduced to cause the sand to stick together and holds its shape during the introduction of molten metal into mold and cooling of casting. Kolhapur is recognized by World Industrial Sector for highly casting productions. In Kolhapur district near around 300 foundry industries are there thus ranking first in Maharashtra state. Foundries in Kolhapur use much of silica sand for casting processes & waste generated from these foundries are about 700-1000 tonne/day. This solid waste is used for dumping near river banks. Foundry industry is declared as a „Red Category Industry" for discharging hazardous substance in the environment, But due to high treatment cost, foundry industries are not much interested to invest on safely disposal of waste sand. If we see the present scenario of foundry industries & waste disposal methods adopted by them, it is clear that in future, problems related to disposal of spent foundry sand are going to become severe. As per present disposal practices sand which is dumped on baron land can not be recovered. If it can be used for other purposes such as in construction materials, flow filling, ceramic industry, bricks (Hollow blocks), embankment construction & repair, mineral wool products etc., it will get profit & production cost of the industry where sand is to be reused will get reduced & by this way we can achieve a sustainable disposal of spent foundry sand.

2. LITERATURE REVIEW

Several researchers investigated the use of WFS in various civil applications. Billie J. Lindsay and Terry J. Logan [1] reported agricultural Reuse of Foundry Sand, normally used in blended top soil for residential, landscaping, industrial, or reclamation purposes and as a rooting zone for sports turf. T.R.Naik et.al.[2] reported that excavatable flowable slurry with desirable physical properties can be manufactured using foundry sand as a replacement for fly ash up to 85%. Tara Sen and Umesh Mishra [3] reported the use of FWS in village road construction. Evaggelia Petavratzi and Scott Wilson [4] reported the use of foundry sand into facing bricks as filler was successful at small substitution rates (primary sand substitution at 2.5 and 5%). Alberta C. Carpenter and Kevin H. Gardner[5] studied the use of Industrial By-Products in Urban Roadway Infrastructure. J. P. de Koff, B. D. Lee and R. S. Dungan [6] studied amelioration of Physical Strength in Waste Foundry Green Sands for Reuse as a Soil Amendment. Kae-Long Lin, Ching-Jung Cheng, Ang Cheng and Sao-Jeng Chao [7] reported use of recycled waste foundry sand as raw materials of cement additives. Robert S. Dungan, Jong-Shik Kim, Hang-Yeon Weon, April B. Leytem.[8] studied the characterization and composition of bacterial communities in soils blended with spent foundry sand. Sayeed Javed,[10] investigated the use of Waste Foundry Sand in Highway Construction. M B Mgangira,[11] carried out assessment of the influence of the proportion of waste foundry sand on the geotechnical engineering properties of clayey soils. Kwanho Lee, Jaeyoon Cho, R. Salgado and Inmo Lee,[12] carried the Retaining Wall Model Test with Waste Foundry Sand Mixture Backfill. Not much work has been reported on the use of WFS in concrete and concrete related products. Some researchers have reported on the work concerning to the various application and methods used for testing of the concrete made by foundry sand which are,

1Naik et al. (1987) He carried out a research on Utilization of Used Foundry Sand in Concrete. This research was conducted to investigate the performance of fresh and hardened concrete containing discarded foundry sands in place of fine aggregate. A control concrete mix was proportioned to achieve a 28-day compressive strength of 38 MPa. Other concrete mixes were proportioned to replace 25% and 35% by weight of regular concrete sand with clean/new foundry sand and used foundry sand. Concrete performance was evaluated with respect to compressive strength, tensile strength, and modulus of elasticity. At 28-day age, concrete containing used foundry sand showed about 20-30% lower values than concrete without used foundry sand. But concrete containing25% and 35% clean/new foundry sand gave almost the same compressive strength as that of the control mix.

2.2 Reddi et al. (1995): He reported that compressive strength of stabilized foundry sands decreases as the replacement proportion of foundry sand increases in the mixes and the strength is achieved relatively faster with fly ash than with cement. Cement and fly ash mixtures were prepared using 0%, 25%, 50%, 75%, & 100% levels of replacement of silica sand by foundry sand. Initial experiments with class F fly ash were unsuccessful because it lacked cementitious properties to form a stable mix therefore subsequent experiments were restricted to class C fly ash only. The ratio of water to the cementitious binder was chosen to be 1.0 in the case of Portland cement and 0.35 in the case of fly ash. The samples were founded in PVC pipes, 2.85 cm in dia. and 5.72 cm long. The mixtures of sands and the binders were poured into these pipes and then vibrated on a vibrating table to minimize air pockets. For each of the replacement levels, compressive strengths were obtained after 3, 7, 14, 28, & 56 days in order to evaluate the difference due to curing time. The clay bonded foundry sand reduced the strength of the stabilized mixes more than the resin- bonded foundry sands. A similar observation is made in context of fly ash stabilization. The drastic reduction in strength with an increase in clay bonded foundry sand replacement is apparent in the cases of both fly ash & cement. Cement – stabilized mixes acquired their strength considerably slower than fly ash stabilized mixes. After 7 days of curing the cement-stabilized RBS reached only 30% of peak strength whereas its fly ash counterpart achieved 80% of its peak strength.

2.3Naik et al. (1997): He carried out the research on the effect of the clean as well as used foundry sand on the compressive strength of the concrete by using cube as well as cylinder block. He reported that compressive strength increased with age. To determine the compressive strength, 150mm × 300mm diameter cylinders were made for each flow able slurry mixtures. The compressive strength for all slurry mixtures with and without foundry sand varied from 0.17 to 0.4 Mpa at the age of 7 days. The compressive strength values ranged from 0.27 to 0.55MPa for the fly ash F1 mixtures and 0.3 to 0.6Mpa for the fly ash F2 mixtures at 28 days. Compressive strength increased with an increasing amount of foundry sand up to certain limit, and then decreased. The strength data revealed that excavatable flow able slurry with up to 85% fly ash replacement with clear and used foundry sand can be manufactured without significantly affecting the strength of the reference mixtures. To obtain a relatively high strength at the age of 28 days and beyond for mixtures tested, fly ash replacement with foundry sand should be maintained between 30 & 50%. The amounts of foundry sand corresponding to the maximum compressive strength values were 50% for clean and clear sand for fly ash F1 mixture,30% for used sand for fly ash F1 mixture, 70% for clean sand for fly ash F2 mixture and30% for used sand for fly ash F2 mixture at the age of 91 days. The maximum Compressive strength for both fly ash mixtures were obtained at 30% fly ash replacement with the used foundry in spite of variation in the mixture design and source of fly ash.

Khatib et al.[14] investigated some mechanical and fresh properties of concrete containing waste foundry sand (WFS). With reference to the properties investigated, they reported that (a) There is systematic loss in workability as the foundry sand content increases which was found by observing the percentage decrease in slump with increase in WFS. (b) All the mixes (with and without WFS) show an increase in strength with curing time. (c) The compressive strength of concrete also decreases with increasing amounts of WFS. This decrease is systematic. (d) The control mix shows the least water absorbed and generally the water absorption increases as the WFS in the concrete increases. (f) The shrinkage increases as the WFS in the concrete increases and this increase is systematic.

3. MATERIAL USED

3.1 Cement Ordinary Portland cement of 53 grade conforming to standards of IS 12269-1987 [9] was used for all the concrete mixtures. The physical properties of cement was tested as per IS 4031-1999 [10]. Specific gravity was 3.15, with initial setting time of 40 minutes.:

3.2 Foundry sand: Foundry sand consists primarily of silica sand, coated with a thin film of burnt carbon, residual binder (bentonite, sea coal, resins) and dust. 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.Green sands are typically black, or gray. Thespecific gravity and water absorption of the foundry used has values 1.15 and 31.57% respectively. The foundry sand was conformed to zone III

3.3 Fine aggregate Those fractions from 4.75 mm to 150 micron are termed as fine aggregate. The river sand and crushed sand is be used in combination as fine aggregate conforming to the requirements of IS: 383. The river sand is wash and screen, to eliminate deleterious materials and over size particles.

3.4 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.

3.5 Water The water used for mixing and curing should be clean and free from injurious quantities of alkalis, acid, oils, salt, sugar, organic materials, vegetable growth and other substances that may be deleterious to concrete or steel. Potable water is generally considered satisfactory for mixing. The pH value of water should be not less than 6. Generally, water that is suitable for drinking is satisfactory for use. Water from lakes and streams that contain marine life also usually is suitable. When water is obtained from sources mentioned above, no sampling is necessary. When it contains sewage, mine water, or wastes from industrial plants or canneries, it should not be used in the mix, unless tests indicate that it is satisfactory, Water from such sources should be avoided since the quality of the water could change due to low water or by intermittent discharge of harmful wastes into the stream. In the present experimental programme, potable tap water is used for casting.

4. METHODOLOGY

4.1 Experimental Methodology According to the objective of the project the minimum requirement of the strength of the structure is decided i.e. M25and from that mix design for M25 concrete is carried out and sampling has been decided and from that the overall quantity of the material has been calculated and material is purchased. Before casting to find out the property of materials different tests on cement has been done such as normal consistency, initial & final setting time, soundness & fineness tests, etc. The sieving of CA through 20 mm sieve and the fine aggregate through 4.75 mm sieve is done and the sieving of Used Foundry Sand before grinding & after grinding is done for getting appropriate results. The trial mix is done with water cement ratio 0.43. The concrete blocks are casted with UFS as a Fine Aggregate in Concrete. There are three blocks for each trial mix for 28 days testing. Then the mix for water cement ratio 0.43 is final according to compliance requirement is adopted. Then the final casting has been done as per the above mix design by using 0, 10%, 30%, 50%, 100% Foundry Sand for 28 days testing and for each % there are five samples for each testing day and each sample there are three blocks.

5. CONCLUSION

Excessive addition of waste foundry sand in concrete affects its workability due to the presence of very fine binders in waste foundry sand. Therefore, high amount of super plasticizer is necessary to preserve excellent workability. The success of using foundry sand depends upon economics. The bottom line issues are cost. Availability of the foundry sand and availability of similar natural aggregates in the region. If these issues can be successfully resolved, the competitiveness of using foundry sand will increase for foundries and for end users of the sand. This is true of any recycled material. From physical analysis the physical properties are somewhat similar to the natural sand & chemical analysis there is no harmful chemical in it which gives no hazardous to use in concrete.

1. Water absorption for foundry waste sand is higher than local sand
2. Foundry waste sand fineness is nearly same as that of the local sand
3. Foundry waste sand has lower specific gravity compared to local sand
4. From this test, replacement of fine aggregate with this used foundry sand material provides maximum compressive strength at 40% replacement.

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REFRENCES:

1. JOJU JOSE AND NABIL HOSSINEY Department Of Civil Engineering, Christ University, Bangalore, Karnataka, INDIA Email: jojujose92@gmail.com, nabil.jalall@christuniversity.in
2. Mr. I .M. Attar1 Prof. A.K. Gupta2 (Student M.E. (C&M) Part-I, Dr .J.J. Magdum College of Engineering, Jaysingpur-416101 (Professor & Vice-Principal, Dr. J.J. Magdum College Of Engineering, Jaysingpur-416101)
3. Eknath P.Salokhe1, D.B.Desai2 1(PG Student, Department of Civil Engineering, Dr. J.J. Magdum College of Engineering, Jaysingpur, Shivaji University, Kolhapur, India) 2(Asso. Prof. Department of Civil Engineering, Dr. J.J. Magdum College of Engineering, Jaysingpur, Shivaji University, Kolhapur, India)
4. Xerses N. Irani1, Suresh G. Patil5 Ramesh Patil2, Yuvaraj3, Vivekanand S.C4 1,2,3,4(UG Student, Department of Civil Engineering ,Poojya Doddappa Appa College of Engineering, Kalaburagi ,affiliated to VTU Belagavi ,India 5(Professor, Department of Civil Engineering ,Poojya Doddappa Appa College of Engineering, Kalaburagi ,affiliated to VTU Belagavi ,India
5. Dushyant Rameshbhai Bhimani 1, Prof. Jayeshkumar Pitroda 2, Prof. Jaydevbhai J. Bhavsar 3 Address for Correspondence 1Student of final year M.E. C E & M, B.V.M. engineering college, Vallabh Vidyanagar 2 Assistant Professor& Research Scholar, Civil Engg Department, B.V.M. Engineering College, Vallabh Vidyanagar 3Associate professor, Civil Engg Department, B.V.M. Engineering College, Vallabh Vidyanagar – Gujarat – India.
6. Vema Reddy Chevuri*1, S.Sridhar*2 M.Tech Student, Dept of Civil Engineering, Nalanda Institute of Technology, Dist: Guntur, AP, India. Assistant Professor, Dept of Civil Engineering, Nalanda Institute of Technology, Dist: Guntur, AP, India.

BIOGRAPHIES

Abhishek B K Presently Pursuing his M.Tech Degree in department of Construction Technology at Karavali Institute of Technology, Mangalore 575029. He completed B.E in Civil Engineering branch at BIT Bangalore, Karnataka in the year 2016. His M.Tech project Replacement of fine aggregate sand with foundry sand for enhancing concrete mechanical properties. His area of interest in New Construction technologies, Pursuing Management skills