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Review on Durability Study of Concrete Using Foundry Waste Sand

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Abstract- Concrete is the most extensively used construction material in the world, second to water. Increasing rate of urbanization and industrialization has lead to over exploitation of natural resources such as river sand and gravels, which is giving rise to sustainability issues. It has now become imperative to look for alternatives of constituent materials of concrete. Waste foundry sand, a by-product of ferrous and non ferrous metal casting industries is one such promising material which can be used as an alternative to natural sand in concrete. In last few decades, several studies have been conducted to investigate the effect of addition of waste foundry sand as partial and complete replacement of regular sand in concrete. It has been found suitable to be used as partial replacement of sand in structural grade concrete. A number of properties have been reviewed in the current paper, the results observed from the various studies depict that replacement of foundry sand to a certain extent enhance the durability as well as strength properties of the concrete but simultaneously decreases the slump value with the increase of replacement level of waste foundry sand.

Keywords- Foundry waste sand (Weathered sand, Burnt black sand), Porosity and Water absorption, Permeability, Compressive strength, Acid attack.

I. INTRODUCTION

During the 1970's and 1980's, federal and state environmental agencies began to pay increasing attention to industrial pollution, safety and waste management control. As a result, the foundry industry had to reevaluate standard practices with regard to the disposal of their used sands. One of the main concerns for the foundry industry has been the need to reduce the disposal cost and minimize the maintenance costs of landfill sites. A typical current disposal cost is about Rs.10 to Rs. 20 per ton. During the next decade, the cost is expected to increase by 5 to 10 fold due to new laws. Also, old landfills are reaching capacity while new landfills will not be coming to market in sufficient numbers as desired by industries.

Nationwide, this was mainly because of the passage of Public Law 94-580, the Federal Resource Conservation and Recovery Act of 1976, which is the nationwide program that regulates and manages by-product disposal. Shrinking landfill space throughout the world has caused landfill operators to refuse used foundry sand on the basis of high volume and "special waste" status. The typical amounts of total by-product materials from foundries range between 227 to 2270 kg per ton of produced metal casting.

The eastern and Midwestern states are leaders in the number of foundries per state. After extensive testing, American Foundry men's Society recommended that fine aggregate be replaced by 33% of the used foundry sand in a batch of normal weight concrete. Based on this report it was decided to replace 25 and 35% fine aggregates by used foundry sand to determine the effect of different levels of replacements. This research was performed to achieve technical, ecological and economical benefits by utilizing the huge amounts of foundry by-products, produced every year, in construction field.

The industrial through merchandise which have been disposed in the past are now being regarded for really useful use. Beneficial use can limit our nation's carbon manufacturing and consumption of virgin material and result in financial gains. It is essential issue of nation's solid waste administration hierarchy that first promotes supply reduction and waste prevention followed via reuse, recycling, electricity restoration and disposal. Researches all over the world nowadays are focusing on ways of utilizing either industrial or agricultural wastes as a supply of raw materials for the industry.

These wastes utilization would not solely be economical, however may additionally also result to foreign change earnings and environmental pollution control. The utilization of industrial and agricultural waste produced by means of industrial procedure has been the focus of waste discount research for economical, environmental and technical reasons. This is due to the fact over 300 million tons of industrial wastes are being produced per annual via agricultural and industrial process in India.

The hassle arising from non-stop technological and industrial development is the disposal of waste material. If some of the waste substances are determined appropriate in concrete making not only value of development can be cut down, but also protected disposal of waste cloth can be achieved.

Concrete is a crucial component of structural engineering construction practice, which is critical and influences the stability and efficiency of various structures. The compressive strength of the concrete is a test conducted with the aid of a universal test machine or some other compressive strength machines to find the concrete cylinder's strength. The concrete mix specification is the basic quantity/quantity of the various materials used to blend and produce the appropriate concrete properties. The fine and coarse aggregate is the major and prominent ingredients of the concrete, and the properties of concrete change by changing its size, texture, and properties.

The quality and strength of the concrete solemnly depending upon the adjustment of the watercement ratio. The appropriate water-cement ratio is assumed around 0.5~0.70. Optimal amounts and sizes of the concrete mix product elements are achieved to produce improved post-concrete performance and to enhance the technique. The aggregate size (uniform graded, distance graded, incorrectly graded) must be tested to build the sample for proper examination. This research procedure includes calculating the size of the fine and coarse aggregate sample, specific gravity, and other tests. Foundry waste sand is collected as a byproduct from industries like iron, metal, etc. This foundry waste may be reused in concrete to reduce the fine aggregate by different acceptable amounts. The study includes the replacement of sand by different percentages, and then further, it can be used in large-scale construction works in more beneficial ways.

II. MANAGEMENT OPTION

In foundry processes, sand from collapsed moulds or cores can be reclaimed and then reused. Some new sand and binder is then added to maintain the quality of the casting and to make up for sand lost during normal operations (Javed and Lovell, 1994). Foundry sand is produced by different foundry classes. The ferrous foundries (gray iron, ductile iron and steel) produce the most sand and aluminum, copper, brass and bronze produce the rest.

The sands from the brass, bronze and copper foundries are generally not reused. Little information is available regarding the amount of foundry sand that is used for purposes other than in-plant reclamation but waste foundry sand has been used as a fine aggregate substitute in construction applications and as kiln feed in the manufacture of Portland cement.

III. RISK EVALUATION

Greenhouse experiment to determine the suitability of waste foundry sand from ferrous and non ferrous foundry in soil by measuring the plant growth, plant uptake and leaching of nutrient, trace metals, metalloids and organic. They observed that use of waste foundry sand in soil will not increase the risk of trace element or organic contamination transport to surrounding soil and water.

Dungan and Dees (2006) conducted a 28-day experiment with the earthworm Eisenia Fetida and 6 different waste foundry sands to assess the bioavailability of metals in soil blends up to 50% foundry sands. Based upon the earthworm mortality and metal accumulation data, the study suggests that waste sands from the iron, aluminum and steel foundries do not pose an ecotoxicological or metal transfer risk. However earthworms in soil blends using sands from a brass foundry suffered excessive mortality and metal uptake.

IV. SCOPE OF RESEARCH WORK

The concentration on the work of the initial phase was on the feasibility of beneficial utilization of used foundry sand in concrete as a partial replacement of regular sand by studying properties of both fresh and hardened concrete. An extensive literature search was undertaken and tests were conducted on by-product samples to determine their physical properties to evaluate the possible uses (Naik et al. 1991, 1992).

A total of five concrete mixes, two containing 25% and 35% partial replacement of regular sand with used foundry sand, the other two containing 25% and 35% partial replacement of regular sand with cleaned foundry sand, and one control mix were investigated in the laboratory. These mixes were tested to determine axial compressive strength, splitting tensile strength, modulus of elasticity and bulk density.

1. Problem Identification:

Any countries have a variety of issues with the decomposition of by-products from different fields. Foundry sand waste created as a by-product of the steel and metal industry is analyzed by various researchers. It can be used productively in concrete for many construction works. To protect the environment from any harm, these by-products should be used safely for welfare and quality work, where possible. Yeah, it is normal for each industry to decompose by-products safely, and it is more beneficial for each country to reuse waste by-products for this valuable use.

The other significant prospect for research on this topic is the lack of sand sources. As construction work progresses, the supply of sand is diminishing, and broad

and detailed studies on the development of foundry sand may replace traditional sand.

2. Significance of research work:

The development of concrete structures starts in ancient times, and many researchers are working on getting less costly, more beneficial results, including this more appropriate environmentally safe construction. Based on the significance and research prospective, introducing the waste products element in the concrete can have a good and reliable effect on the concrete mix and further in terms of positive environmental effect in some ways.
But the research for this is always required to use the waste substance as the construction industry is progressing with high proportions, which may help to utilize the waste substance in beneficial ways. The suggested scale of the gross aggregates would be 38 mm.

The size of the gross aggregate depends on the type of concrete, strength, and site-specific characteristics. Literature suggests that concrete compressive power increases as the volume of sand smelting waste increase to a rate of 60%. It is more attractive than unpredictable from the point of view of the minimum space round aggregate. From the point of view of the capacity to bind to the mortar, the round aggregate may be inferior, but in general, the form of the grains may be much less important than their size and hardness.

V. LITERATURE REVIEW

Deepankar Kumar Ashish et al.[1] In light of massive industrialization, Industrial symbiosis has gained traction by most countries to employ wastes of one industry as a resource to another. Waste foundry sand obtained from the metal casting industry is a threat to the environment and the health of living beings due to the presence of organic and inorganic materials. However, this waste can be a resource for the construction industry.

Despite its broad application scope, usage of waste foundry sand is highly limited due to inadequate understating of its performance in concrete. It becomes essential to understand the behaviour of waste foundry sand in concrete, more importantly, for accessing a strength-efficient and durable structure. In addition, a leaching analysis was performed that revealed an increase in heavy metal concentration with the increasing WFS content.

Vikas Mehta et al.[2] The scarcity of landfilling and the growing expense of disposal, recycling, and reusing industrial byproducts have become attractive alternatives to removal. There are several sorts of industrial waste and byproducts; one is waste foundry sand (WFS). Using such materials in concrete not only saves costs but also helps reduce disposal concerns, including a lower impact on natural resources, a lower CO_2 impact, and enhanced mechanical and durability attributes. Concrete compressive, tensile, and flexural strengths are essential in constructing concrete structures. To identify the issue above, this research aims to develop systematic multiscale models to forecast the substantial compressive, tensile, and flexural strengths of concrete replacement with WFS for usage in the building sector with no theoretical constraints.

Experimental data (137 tested) from various academic research investigations were statically examined and modeled for that objective. Artificial neural networks (ANN), gaussian processes (GP), support vector machines (SVM), and the M5P model techniques were applied for the measures.

The most important aspects influencing the strength of concrete in the process model are water/cement ratio (w/c) ratio, fine aggregates, cement, coarse aggregates, WFS (%), sand, WFS (mix with others), curing days, and water. Using various modeling techniques, the compressive, tensile, and flexural strengths of concrete containing WFS can be predicted in terms of (w/c), fine aggregates, coarse aggregates, cement, sand, WFS (%), and curing time using the coefficient of determination (R^2) and the root mean square error.

M.A.B. Martins et al.[3] Although the use of waste foundry sand (WFS) in concretes is already widespread, there is a gap regarding to waste foundry exhaust sand (WFES) and durability. In this research, the marble/granite processing waste (MGPW) was used as mineral addition, to improve the concrete viscosity, and WFES was used as a partial substitute (10%, 20%, 30%, 40%) for natural sand in self-compacting concrete (SCC). Compressive strength was evaluated at 7, 28 and 90 days. Also, as durability indicators, capillarity, sulfate and acid resistance tests were performed.

Mujahid Ali et al.[4] The abundance of waste foundry sand (WFS) produced by the foundry industry has become a global issue. As a result, foundry waste management and disposal are getting more complex, necessitating more extensive and inventive efforts. The purpose of this study was to use WFS as a partial replacement to reduce the use of fine aggregate in various concrete mixtures and to evaluate fresh concrete performance such as slump and mechanical properties such as compressive strength (CS), split tensile strength (STS), and flexural strength (FS). WFS was adjusted using the Design-Expert software's Central Composite Design (CCD) tool in Response Surface Methodology (RSM). The optimization process investigated the interaction between WFS ratio and curing days on the mechanical properties of concrete.

The responses of the optimization process were the CS, STS, and FS, which were generated by the quadratic regression model created by ANOVA. The WFS was replaced in 10% increments from 0% to 40%. The highest

mechanical properties were achieved at 20% replacement and 56 days of curing with a CS of 29.37 MPa, STS of 3.828 MPa, and FS of 8.0 MPa. The quadratic model was suggested for the three responses by RSM, in which the coefficient of determination (R^2) ranges from 0.987 to 0.995, showing the model's high significance. Up to a 30% replacement level, the fresh qualities of all substitutes were nearly identical to the control mix.

Maria Auxiliadora et al.[5] Martins Several studies have already been conducted using residues to substitute or be added to Self- Compacting Concrete (SCC), including Waste Foundry Sand (WFS), yet there are still failures when using Waste Foundry Exhaust Sand (WFES), with respect to the potential for concrete corrosion. This study assesses using WFES as a partial substitute (10%, 20%, 30% and 40%) for natural sand. The mixtures showed negligible corrosion levels and very low permeability to chloride ions due to high electrical resistivity.

The potential for corrosion was low and uncertain. The results indicated that fine marble and granite powder and WFES particles act as good filler materials, hindering harmful agent penetration, consequently increasing the durability of the concrete compared with the control concrete. The properties were improved using 30% WFES.

N.T. Sithole et al.[6] The objective of this study was to synthesize a sustainable concrete material from readily available waste and by-products; Ground Granulated blast furnace slag (GGBFS) and waste foundry sand (WFS). GGBFS was alkali-activated using NaOH solution and used as a binder to completely replace Ordinary Portland cement (OPC). Concurrently, WFS was used as fine aggregate to replace natural sand in concrete production. An optimization experimental program of various conditions was used to get the best concrete specimens in terms of high strength and low metal leachability.

O.R. Kavitha et al.[7] Environmental issues were ascended in construction field owing to the rapid growth in population, over utilization and utilization of non-renewable resources. It is necessary to look for alternatives of waste disposal and relevant constituent materials for concrete to impart sustainable development in construction industry. To effectively reduce the utilization of natural occurring fine aggregate in concrete, the biologically treated discarded foundry sand (WFS) was used as a replacement material in this investigation.

Sheikh Mayesser Mushtaq et al.[8] Concrete being most extensively used construction material all over the globe has resulted in the over-exploitation of natural resources such as river-sand and gravels. Meanwhile, advancing industries and increasing population have also lead to an increased generation of waste materials. Many of these waste materials have the potential to be used in concrete. This study has investigated the effect of one such waste material referred to as Waste Foundry Sand (WFS) on the properties of concrete. Many researchers have studied the effect of WFS on the mechanical properties of concrete. However, no consensus has been reached yet and very contradictory results have been reported. Moreover, shrinkage of concrete containing WFS has not received much of the researchers' attention and very limited literature is available related to this property.

T.V. Reshma et al.[9] This study reports the experimental investigation about the performance of fly ash and untreated waste foundry sand on fresh and hardened state of concrete mix. In this research, 30% fly ash is kept constant as a partial replacement of cement and Natural river sand is replaced with waste foundry sand (WFS) in varying percentages (0%, 10%, 20%, 30% and 40%) for M40 grade concrete. Compaction factor test and slump cone test is conducted to assess the fresh properties of concrete. Similarly, Compressive, split tensile and flexural strength tests are conducted to evaluate the mechanical properties of concrete as per Indian standard.

Anuj Parashar et al.[10] Large amounts of waste foundry sand (WFS) is being generated worldwide every year and it is necessary to re-use it for valuable cause. WFS is reported suitable up to a certain extent for replacement of fine aggregate in concrete. Answering the doubt on the issue of workability and durability properties can enhance its potential use. This study investigates the usability of waste foundry sand in self-compacting concrete (SCC). Fine aggregate was replaced with WFS with ratios ranging from 0 to 40%. The properties of WFS were characterised using X-ray diffraction (XRD), scanning electron microscopy (SEM), thermogravimetric analysis (TGA) and X-ray fluorescence (XRF) methods.

Manoharan Thiruvenkitam [a], Sivakumar Pandian [b], M ahula Santra [c], et al.[11] For ages the safe disposal of industrial wastes has been a threat to most of the industries. In recent times, metal casting industries are facing challenges in safer disposal of Waste Foundry Sand (WFS). Furthermore, all over the world natural sand deposits are drying up. So, there is the immense need to find a material that has the properties of sand for construction.

Gustavo J.L. Coppio et al.[12] The steel industry generates large amounts of waste foundry sand (WFS) in landfills. Studies on the viability of using this residue as a fine aggregate have been carried out for asphalt mixtures. However, studies are still scarce in relation to their use in concrete. In this sense, the present work analysed the effects of the use of WFS as fine aggregate in Portland cement concrete, in the electrical resistivity and compressive strength.

Muhammad Farjad Iqbal et al.[13] Waste Foundry sand (WFS), a major solid waste from metal casting industry, is

posing a significant environmental threat owing to its disposal to landfills. In this research, an innovative artificial intelligence technique i.e. Multi-Expression Programming (MEP) is applied to model the split tensile strength (*ST*) and modulus of elasticity (*E*) of concrete containing waste foundry sand (CWFS).

The presented formulations correlate mechanical properties with four input variables i.e. w/c, foundry sand content, superplasticizer content and compressive strength. The results of statistical analysis validate the model accuracy as evident by the low values of objective function (0.033 for *E* and 0.052 for *ST*).

Ashwini R. Patil et al.[14] This study examines the feasibility of using various waste materials in concrete paver blocks to reduce consumption of natural resources, increased global warming and hazardous waste material generation. Exessive waste is generated from the construction, thermal power plant and industrial sector causing landfill issues too.

Sand is the most demanding resource in the construction industry, there is a scarcity of natural aggregates due to rapid urbanization, an estimated 1.4 billion tons of sand will be required by 2020, compared to 630 million tons in 2010. Approximately 1 ton of cement produces 1 ton of CO_2. Nowadays cement production is reached to 337.32 million tons in 2018–19 contributing 7–8% CO_2 emission globally.

Emadaldin Mohammadi Golafshani et al.[15] The amount of waste materials obtained from industries is increasing every day, which has been identified as one of the crucial issues in many countries. Waste foundry sand (WFS) is a by-product of the foundry industry, which can be used as a partial replacement for fine aggregate in concrete. The aim of this study is to predict the mechanical properties of concrete containing WFS using an artificial neural network (ANN) assisted by multi-objective multi-verse optimizer (MOMVO) algorithm. In the proposed model, both network error and complexity were considered as multi-objective optimization problems which were solved using MOMVO.

VI. CONCLUSION

So we conclude that, the foundry waste sand can be used as a construction material as a replacement of the fine aggregate. That will help making Eco-friendly concrete from recycled materials saves energy and conserves resources which lead to a safe sustainable and economic environment.

As per the research papers we will further cast the paving blocks with 20% and 40% replacement of fine aggregate by foundry waste sand and testing the same after curing period of 3days, 7days and 28days.

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