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Experimental Investigation of Waste Foundry Sand on Strength Properties of Plain Concrete and Comparison with Partial Replacement of Cement with Metakaolin Binary Blended Concrete

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ABSTRACT: *An acute shortage of river sand which is generally used as a fine aggregate in concrete has been affecting the construction sector. The scarcity has led to the skyrocketing price of sand, escalating construction costs. The situation has dashed the dreams of many in the lower- and middleincome groups to own a house. There were studies about the depletion of river sand and the need for scientific management and exploitation of the available resource. Following the shortage of river sand, some research institutions are searching alternatives that can be used for construction.Ferrous and non ferrous metal casting industries produce several million tons of byproduct in the world. In India, approximately 2 million tons of waste foundry sand is produced yearly. WFS is a major byproduct of metal casting industry and successfully used as a land filling material for many years. In an effort to use the WFS in large volume, research is being carried out for its possible large scale utilization in making concrete as partial replacement of fine aggregate. 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 can be used in concrete to improve its strength and other durability factors. Foundry Sand can be used as a partial replacement of fine aggregates or total replacement of fine aggregate and as supplementary addition to achieve different properties of concrete.This experimental investigation was performed to evaluate the strength properties of concrete mixtures, in which river sand was partially replaced with Waste Foundry Sand by weight. Compression test was carried out at the age of 28 days of curing. Split tensile test was performed at the age of 28 days. Flexural strength was tested at 28 days of curing. Test results indicate an increase in compressive strength of plain concrete by inclusion of WFS as a partial replacement of fine aggregate. The maximum strength was achieved at 40% replacement, after which there was loss in compressive strength, split tensile strength and Flexural strength decreased.*

The results indicate in concrete. However, the partial replacement should not exceed 40% in plain concrete.

INTRODUCTION

The word concrete comes from the Latin word "concretus" meaning compact or condensed. Concrete was used for construction in many ancient structures. Concrete is a composite material

composed of gravels or crushed stones (coarse aggregate), sand (fine aggregate) and hydrated cement (binder).

Concrete, in the broadest sense, is any product or mass made by the use of a cementing medium. Generally, this medium is the product of reaction between hydraulic cement and water. For concrete to be good concrete it has to be satisfactory in its hardened state and also in its fresh state while being transported from the mixer and placed in the formwork. The requirements in the fresh state are that the consistence of the mix is such that the concrete can be compacted and also that the mix is cohesive enough to be transported and placed without segregation.

As far as the hardened state is considered, the usual requirement is a satisfactory compressive strength. Many properties of concrete are related to its compressive strength such as density, impermeability, durability, resistance to abrasion, resistance to impact, tensile strength, and resistance to sulphates.

Waste Foundry Sand (WFS)

Solid waste management has become one of the global environmental issues, as there is continuous increase in industrial by-products and waste materials. Due to lack of land filling space and its ever increasing cost, utilization of waste material and by-products has become an attractive alternative to disposal. Waste foundry sand (WFS) is one of such industrial by-product

General overview on admixtures

An admixture is defined as a material other than water, aggregate and cement that is added as an ingredient of concrete or mortar either immediately before or during the process of mixing to modify certain desired properties of the normal fresh or hardened concrete or mortar or the grout.

The most common reason for adding admixtures are to alter the workability, improve the rate of gain of strength, increase the strength itself, improve the impermeability and durability and also to improve the appearance. Sometimes many admixtures affect more than one property of concrete. Sometimes they affect the desirable properties adversely. An admixture should be employed only after an appropriate evaluation of its effects on the particular concrete under the conditions in which the concrete is intended to be used. Therefore one must be cautious in the selection of admixture and in predicting the effect of the admixture in concrete

Pozzolanic Admixtures in Concrete

Pozzolona is either naturally occurring or available as a by-product. They mainly contain silica, which becomes reactive in the presence of free lime available in Cement when pozzolanic admixtures are mixed with cement. The reactivity varies depending upon the type of Pozzolona, its chemical composition and its fineness.

Metakaolin

General the raw material in the manufacture of Metakaolin is kaolin clay. Kaolin is a fine, white, clay mineral that has been traditionally used in the manufacture of porcelain. Kaolins are classifications of clay minerals, which like all clays, are phyllosilicates, i.e. a layer silicate mineral. The Meta prefix in the term is used to denote change. In case of

Metakaolin, the change that is taking place is de hydroxylation, brought on by the application of heat over a defined period of time. De hydroxylation is a reaction of decomposition of kaolinite crystals to a partially disordered structure. The results of isothermal firing show that the de hydroxylation begins at 420^0C. At about 100-200^0 C clay minerals lose most of their adsorbed water. The temperature at which kaolite loses water by de hydroxilization is in the range 500-800^0 C. This thermal activation of a mineral is also referred to as calcining.

Super Plasticizer

Super plasticizers, also known as high range water reducers, are chemicals used as admixtures where well-dispersed particle suspensions are required. These polymers are used as dispersants to avoid particle aggregation, and to improve the flow characteristics. Their addition to concrete or mortar allows the reduction of the water to cement ratio, not affecting the workability of the mixture, and enables the production of self-consolidating concrete and high performance concrete. This effect drastically improves the performance of the hardening fresh paste. Indeed the strength of concrete increase whenever the amount of water used for the mix decreases.

Testing of Hardened Concrete

Testing of hardened concrete plays an important role in controlling and confirming the quality of cement concrete works, one of the purposes of testing hardened concrete is to confirm that the concrete used at site has developed the required strength. The tests also have a deterring effect on those responsible for construction work. It is to be remembered that standard compression test specimens give a measure of the potential strength of concrete, and not of the concrete in structure. Knowledge of the strength of concrete in structure cannot be directly obtained from tests on separately made specimens.

Need for the Present Work

Referring to the article "Alternatives to river sand" reported in the daily newspaper "THE HINDU" dated April 21, 2007 "Property plus" edition, states that:An acute shortage of river sand has been affecting the construction sector. The scarcity has led to the skyrocketing price of sand, escalating construction costs. The situation has dashed the dreams of many in the lower- and middle-income groups to own a house.There were studies about the depletion of river sand and the need for scientific management and exploitation of the available resource. Following the shortage of river sand, some research institutions are developing alternatives that can be used for construction.

LITERATURE REVIEW

Sanjay N. Patil, Anil K. Gupta, Subhash S. Deshpandepresented the result of an experimental investigation the use of Metakaolin which is having good pozolanic activity and is a good material for the production high strength concrete. which is getting popularity because of its positive effect on various properties of concrete

RafatSiddique, Geert de Schutter and Albert Noumowec[3] (2008) presented the results of an experimental investigation carried out to evaluate the mechanical properties of concrete mixtures in which fine aggregate (regular sand) was partially replaced with waste foundry sand. Fine aggregate was replaced with three percentages (10%, 20%, and 30%) of WFS by weight. Tests were performed for the properties of fresh concrete. Compressive strength, splitting- tensile strength, flexural strength, and modulus of elasticity were determined at 28, 56, 91, and 365 days. Test results indicated a marginal increase in the strength properties of plain concrete by the inclusion of WFS as partial replacement of fine aggregate (sand) and that can be effectively used in making good quality concrete and construction materials.

YogeshAggarwal, ParatibhaAggarwal, RafatSiddique, El-HadjKadri and RachidBennacer[4] (2010) presented the design of concrete mixes made with waste foundry sand as partial replacement of fine aggregates up to 40%. Various mechanical properties are evaluated (compressive strength, and split tensile strength). Durability of the concrete regarding resistance to chloride penetration, and carbonation is also evaluated. Test results indicate that industrial by-products can produce concrete with sufficient strength and durability to replace normal concrete. Compressive strength, and split-tensile strength, was determined at 28, 90 and 365 days. Comparative strength development of foundry sand mixes in relation to the control mix i.e. mix without foundry sand was observed. Thereby, indicating effective use of foundry sand as an alternate material, as partial replacement of fine aggregates in concrete

EXPERIMENTAL PROGRAM

In the present experimental program standard cubes of size (150x150x150mm) conforming to IS: 10086-1982 were casted and tested for compressive strength, standard cylinders of size 150mm diameter and 300mm height conforming to IS: 10086-1982 were casted and tested for split tensile strength and standard beams (100x100x500mm) were casted and tested for finding the flexural strength property of plain cement concrete and binary blended concrete.

MATERIALS

Thematerials used in this experimental study were cement, fine aggregate, coarse aggregate, water, waste foundry sand, Metakaolin and super plasticizer.

Preparation of Test Specimens

Weighing

Concrete Mixing

Workability

Casting of Specimens

Compaction

Curing

Testing of Specimens

Water Importance

This is the least expensive but most important ingredient in concrete. The water, which was used for making concrete, was clean and free from harmful impurities such as oil, alkali, and acid.

Mixing of Concrete

In the process of mixing, the material was weighed with their proportions exactly and then the materials were stacked on a water tight platform. The materials were thoroughly mixed in their dry condition before water was added. The prepared mix was immediately used for testing the workability of fresh mix.

Casting of Test Specimens

By using the above mix proportion the Cubes of size 150x150x150 mm, Cylinders of size 150 mm diameter and 300 mm height and beams of size 100x100x500 mm respectively were casted. Total 87 no's Cubes, 54 no's Cylinders, 22 no's beams and also 24 no's of 70.7x70.7x70.7 mm mortar cubes were casted.

Curing of Test Specimens

After casting, the molded specimens were stored in the laboratory at room temperature for 24 hours. After this period the specimens were removed from the mould and the specimens were cured for required days.

OBSERVATIONS AND DISCUSSION OF TEST RESULTS

Results obtained from experimental investigation to study the strength properties of plain concrete mixes in which fine aggregate is replaced by waste foundry sand at various percentages are presented here for discussion they are compared with the binary blended concrete.

The study was conducted to find out the influence of Metakaolin and waste foundry sand on strength properties of plain concrete.

The effects of following parameters were studied.

- The various percentage replacement of fine aggregate with waste foundry sand on some of the strength properties of plain concrete.
- The optimum percentage replacement of Metakaolinwith cement and various percentage replacement of fine aggregate with waste foundry sand on some of the strength properties of binary blended concrete.

TEST RESULTS OF PLAIN CONCRETE

Various tests were done to investigate the effect of replacement of fine aggregate with waste foundry sand in different proportions on workability, compressive strength, split tensile strength and flexural strength on plain concrete. The replacement percentage of waste foundry sand was taken at 0%, 10%, 20%, 30%, 40%, 50% and 60%.

TEST RESULTS OF BINARY BLENDED CONCRETE

Trial Mixes to find Optimum Percentage of Metakaolin

Cement was replaced with5%, 10% and 15% Metakaolinand the compressive strength of concrete was found at 7 and 28 days. The maximum strength was achieved with 10% of Metakaolin.

Comparison of Results of Tests on Plain Concrete and Binary Blended Concrete

The effects of replacement of fine aggregate with waste foundry sand in different proportions on workability, compressive strength, split tensile strength and flexural strength on Plain Cement Concrete (PCC) and Binary Blended Concrete incorporating 10% Metakaolin(MTK) have been

studied in detail. A study of the results of various tests done on PCC and MTK are as follows.

Summary

In this chapter, the results obtained from the experimental program are tabulated and are represented in the form of graphs. The results were studied and based on the study, the conclusions were drawn. The conclusions for the present study are given in the next chapter.

CONCLUSIONS

- When percentage of waste foundry sand was increased beyond 40% the mix started losing its workability.
- When cement replaced with Metakaolin for mortar cubes strength increased upto 10 % replacement and then decreased. So, 10 % replacement is optimum here.
- Replacement of fine aggregate with waste foundry sand showed increase in the compressive strength of plain concrete of grade M40 up to 40% and then there was a considerable decrease in the strength. Maximum strength was achieved at 40%.
- For Plain Concrete mix at 60% replacement of fine aggregate strength of 46.43 MPa was achieved at 28 days which is less than the target strength.
- Flexural strength of concrete decreased with the inclusion and increase in the percentage of waste foundry sand for plain concrete.
- 10% replacement of cement with Metakaolinwas found to be optimum for M40 grade of concrete.
- Binary Blended Concrete mix with Metakaolinas binder replacement containing 60% waste foundry sand was still workable.
- For Binary Blended Concrete mix at 60% replacement of fine aggregate, strength of 52.0 MPa was achieved at 28 days which is more than the target strength.
- Binary Blended Concrete incorporating Metakaolinshowed better performance when compared to plain concrete.
- 12 % increment in the compressive strength was found at 28 days using Metakaolin5% increase in the flexural strength was observed in Binary Blended Concrete mixes when compared to Plain Concrete mixes.
- Metakaolinwhich is taken from amarphus chemicals pvt ltd can be opted for replacement of cement for a considerable percentage (10 %) only.

SCOPE FOR FURTHER INVESTIGATIONS

- Further research can be carried out to study the different physical properties of Metakaolinwhich was used for this investigation
- The study of behavior of Metakaolinfor different chemical compositionscan be carried out to know the effect on strength properties.
- The fineness of Metakaolinalso differentiates the properties, so detailed study to be carried out for variation in grinding hours on durability and strength properties.
- Further research can be carried out to study the durability properties of concrete incorporating waste foundry sand as a partial replacement of fine aggregate.

- The investigation of concrete incorporating waste foundry sand can be carried out with addition of different types of fibers like steel fibers, recron fibers, synthetic fibers, natural fibers and glass fibers and with different aspect ratio.
- Further research can be carried out to study the properties of concrete with partial replacement of fine aggregate with waste foundry sand and partial replacement of cement with different mineral admixtures like GGBS, fly ash, Rice husk ash, etc, with addition of different percentages of fibers.
- Further investigation is also possible by using Metakaolinand other waste materials in self compacting concrete.
- We can further study the materials which can be replaced in concrete instead of cement and aggregates and compare the different properties.

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