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Development of high strength concrete using waste foundry sand

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ABSTRACT

This paper consists of the experimental results carried out for utilization of waste foundry sand (WFS) in High strength concrete. The waste foundry sand was replaced in the place of normal sand with four different percentages (10%, 20%, 30%, and 40%). The several tests such as compressive strength, split tensile strength, modulus of elasticity, flexural strength, ultrasonic pulse velocity (UPV), rebound hammer test, are performed for 7 days and 28 days to obtain the behaviour the concrete due to foundry sand. The temperature effects of concrete were observed for the different temperatures such as (200, 400, 600, 800, and 1000°C) for 28 days. In this test results there is sudden decrease in compressive strength due to the increase in percentage of foundry sand from 30%. But moreover 10% to 20 % replacement of foundry sand almost have similar strength as to that of the control mixture.

KEY WORDS: Compressive strength, waste foundry sand, concrete.

1. INTRODUCTION

Foundry sand is a waste sand which is obtained from the metal casting industries. It has high silica content with uniform physical properties. It is obtained as the by-product of ferrous and non-ferrous metal casting industries. Due to its thermal conductivity it is used for centuries in the casting industries as a casting material. Raw Foundry sand used in the casting industries are having higher quality than that of natural sand used in construction industries. The characteristics of foundry sand depend on the industry in which it is used and the casting process involved. In general foundry sand consists of high-quality of silica's and in the range of 85-95%, betonies or kaolinite clay up to 10-15%, water content of 2-5% and about 5% sea coal. Foundry sand can be recycled and reused several times as possible, it is termed as waste foundry sand when it is completely degraded and it becomes useless for moulding process. Foundry sand finds it wide range of application in the automobile and its parts generating sectors. Huge amount of waste foundry sand is accumulated from the all these industries annually. Thousand tons and tons of foundry sands are used in engineering application. Waste foundry sand can be used in landfill cover, embankments, barrier-layer construction, roadway construction, soil reinforcement, and hot mix asphalt, traction material on snow and ice, smelting, rock-wool manufacturing and hydraulic barriers. Apart from these usages it can be used in the manufacturing of Portland cement mortar and concrete mix. In this paper foundry sand is used as partial replacement of fine aggregate in order to obtain the high strength concrete of 60 MPa waste foundry sand were proportioned to replace fine aggregate by 10% 20% 30% 40%. The behaviour of the concrete is investigated by the mechanical properties such as compressive strength, split tensile strength, flexural strength and modulus of elasticity. Apart from the physical properties temperature of the concrete is also investigated the results states that 10% and 20% replacement shows similar result of control mix.

Effect of Fire on Building Materials: In order to determine the fire exposure condition of the concrete new method is used first we have to calculate the fire load density in the concrete. It is also necessary to take care of the ventilation condition and to note down source of combustion at various temperature. Active fire protection systems is the other factor to be considered in the analysis of the fire effect for example sprinklers or fire brigades on the growth of the fire. By changing ventilation conditions during the fire the size and timing of the fire growth can be determined in the fire analysis which is sensitive to changes in the fuel load over time. The special software and extensive training were required to determine the fire analysis by this methods and it is used for high rise building or unusual buildings. The effect of rise in temperature of the concrete can be determined by obtaining the temperature time relationship using a standard curve or by this methods. The free water in concrete changes from a liquid state to a gaseous state by the high temperature. The rate of heat transmitted from the surface into the interior of the concrete is affected by the change in state. Due to the rise in temperature there will be a decrease in the strength and modulus of elasticity for both concrete and steel reinforcement. However, the insulating properties of the concrete along with the rate of increase in the temperature is responsible for the decrease in the strength and modulus of elasticity of the concrete. Maintain the temperature in such a range concrete does not burn due to excessive heat.

2. EXPERIMENTAL STUDIES

Materials:

Cement: Ordinary Portland cement of grade 53 was used. The tests were carried out as per (IS: 8112-1989) the Indian Standard Specifications. The requirements of ASTM C150 for Type I cement matches with the above grade of cement. The properties were shown in the table.1.

Table.1. Physical properties of Portland cement

Physical test	Results obtained	IS:12269-2013	ASTM C150
Fineness (retained on 90μm sieve) (%)	3.5	10 max	
Fineness: specific surface (air permeability test) (m^2/kg)	346	225	280min
Normal consistency (%) Vicat time of setting (min)	34	-	-
Initial	70	30 min	-
Final	290	600 max	375max
Compressive strength (MPa)			
7 days	38.1	27	12.4
28 days	59.6	53	27.6
Specific gravity	3.15	-	-

Foundry sand: Foundry sand had been obtained from the nearby area. It was used for the manufacturing of alloy wheels. The Scanning Electron Microscope (SEM) photography of foundry sand was shown in fig. The chemical analyses, atomic absorption spectrometry (AAS) and X-ray fluorescence (XRF) of the waste foundry sand were shown in table. Since it was used as the partial replacement of the fine aggregate properties of foundry sand was calculated and compared with the fine aggregate results were shown in the table. In comparison with the regular river sand foundry exhibited less unit weight and fine modulus are given below in table.2.

Table.2. Physical properties waste foundry sand and regular sand

Property	Waste Foundry Sand	Regular Sand	ASTM Standards
Specific gravity	2.47	2.68	-
Fineness modulus	2.46	2.54	2.3-3.1
Absorption %	1.3	0.86	
Materials finer than 75μm (%)	8	0.8	3 max

Table.3. Chemical Composition of waste foundry sand

Constituents	Weight %	Constituents	Weight %
$CaCO_3$	9.79	Feldspar	0.35
SiO_2	70.85	Wollastonite	0.39
Albite	4.72	Iron oxide	6.34
MgO	0.39	Zirconium	4.98
Al_2O_3	2.18	**Total**	**100**

Aggregate: Coarse aggregate of maximum size 12.5mm which is available in the local market were used in the project. River sand with a maximum size 4.75 mm was used as a fine aggregate. Aggregate tests have been carried out as per IS383-1970.The results are tabulated in the table. These results matches with the requirements of ASTM C33. The physical properties of coarse aggregates are given below in table.4.

Table.4. Physical properties of coarse aggregates

Properties	Coarse aggregates (12.5mm)
Specific gravity	2.74
Fineness modulus	6.48
SSD absorption	0.81

Super plasticizer: CERA HYPERPLAST XR-W40 High range water reducing admixture which is polycarboxylate ether based was used for the reduction of water content and to get good workability.

Mix proportion: Concrete mix design were designed as per Indian standard specifications (IS: 10262-1982) to give a compressive strength of 60MPa after 28 days. Including the control mix five proportioning of concrete mixes were made. The proportions of fine aggregate replaced by foundry sand were 10%, 20%, 30% and 40%. Mix design contains of 493.33 Kg/m3 of Cement and water cement ratio of 0.3. Mix design of five different proportioning were given in the table.5.

Experimental works: As per the mix proportion the required material were weighed. Coarse aggregate, fine aggregate, foundry sand and cement were mixed in the dry state. After the dry mix preparation, water and super plasticizer were added and mixed thoroughly till we obtain homogenous mix. For the determination of the compressive strength the cube specimen of 100mm x 100mm x 100mm, for split tensile strength cylindrical specimen of 100mm diameter and 200mm height. Flexural strength was determined from the prism specimen of 500mm x100mm x 100mm .Modulus of elasticity was determined from the specimen of size 150mm diameter and 300mm height were casted. To obtain the temperature effect of the concrete cube specimen of size 100mm x100mm x 100mm were casted. The test specimens were casted at the room temperature of 27^0c. The concrete were allowed to set at the room temperature for 24 hours. After completion of 24 hours the specimens were remoulded and kept in the curing tank for 7 and 28 days. Every specimen should be completely immersed in the water completely till the test date commences.

Table.5. Mix proportion for concrete mixtures containing waste foundry sand

Mix No.	CM	M1	M2	M3	M4
Cement (kg/m^{3})	493.33	493.33	493.33	493.33	493.33
Fine Aggregate (kg/m^{3})	852.91	773.12	693.32	613.52	533.71
Foundry sand (%)	0	10	20	30	40
Foundry sand (kg/m^{3})	0	79.79	159.59	239.39	319.19
Coarse Aggregate (12.5mm) (kg/m^{3})	956.33	965.33	965.33	965.33	965.33
W/C ratio	0.3	0.3	0.3	0.3	0.3
Water (kg/m^{3})	156	156	156	156	156

3. RESULTS AND DISCUSSION

Slump test: Slump test is conducted in order to determine the workability of the concrete. After the addition of foundry sand fluidity property of the concrete got reduced. Most probably due the presence of bentonite clay material in the foundry sand workability of concrete was affected. In order to get good workable concrete super plasticizer were added to concrete in the optimum range.

Compressive strength: The compressive strength of concrete specimen without and with replacement of foundry sand were tested at 7 and 28 days of curing. There was increase in the compressive strength of concrete by the partial replacement of the foundry sand. Due to ageing of the concrete compressive strength of the concrete gets increased. Since the foundry sand finer than the regular river sand it is capable of producing denser mix than regular sand. This might be the reason of increase of compressive strength in concrete mix by partially replacing the foundry sand to certain percentage. The results of compressive strength and the comparison were shown in the fig.1.

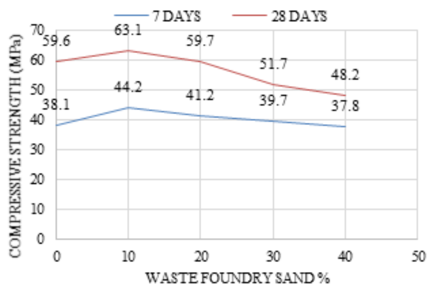

Fig.1. Compressive strength graph for 7 and 28 days

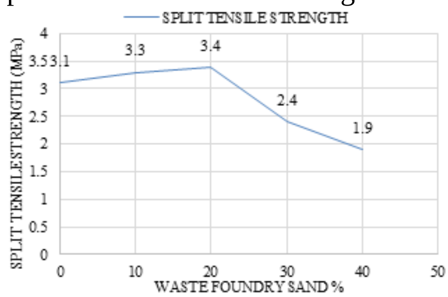

Fig.2. Split tensile strength graph for 28 days

Split tensile strength: The split tensile strength of the concrete specimen without and with replacement were tested after 28 days of curing. The increase in split tensile strength is similar to increase in the compressive of the concrete. By increasing the percentage of the foundry sand split tensile strength got increased. The results of split tensile strength and the comparison were shown in the fig.2.

Flexural strength: The flexural strength of the concrete specimen with and without replacement were tested after 28 days of curing. Like the compressive and tensile strength there was a gradual increase in the flexural strength by increasing the percentage of the foundry sand. The results of flexural strength and the comparison were shown in the fig.3 the flexural strength is determined the formula.

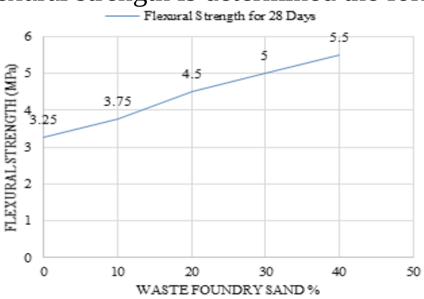

Fig.3. Flexural strength graph for 28 days

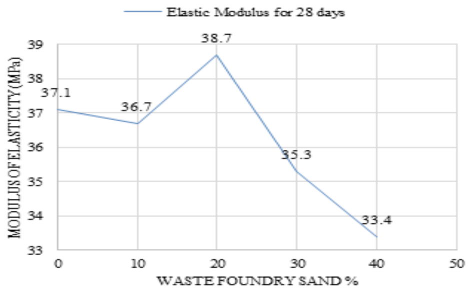

Fig.4. Modulus of elasticity graph for 28 days

Modulus of elasticity: The modulus of elasticity of the concrete specimen with and without replacement were tested after 28 days of curing. It was found that the modulus of elasticity for concrete mixes with replacement of foundry sand were higher than the control mix. The modulus of elasticity of concrete increases with the increase in the age of concrete. The results of modulus of elasticity and the comparison were shown in the fig.4.

Temperature effect of the concrete: The specimens casted for the temperature effect is placed in the furnace at a temperature of about 200, 400, 600, 800, 1000^0C for one and half hour and it is taken out to cool for half an hour at the room temperature. Then the specimens were tested in the universal compressive testing machine to determine the load factor due to temperature of effect. By observing the surface of the concrete the damage caused due to the high temperatures can be roughly detected. Visual observation such as colour change, cracking and spalling of concrete surface were due to assesses the elevated temperature affect on the specimen. Up to 400^0C there were no visible effect on the surface of the concrete specimens. When the temperature was raised to 600^0C there started the occurrence of crack in the surface of concrete specimen but the effect was not significant. At the 1000^0C the specimen lost its binding properties and the strength of the concrete got reduced extensively. Increasing the temperature beyond this will lead to the spalling and excessive cracking in the surface of concrete.

4. CONCLUSION

According to the above results of this study the following are the conclusion drawn.

a) Partial replacement of sand with WFS (up to 10% and up to 20% in some cases) increases the strength properties (compressive strength, splitting tensile strength flexural strength and modulus of elasticity) of concrete for M60 grade.

b) Beyond the substitution rate of 20% the concrete mixtures showed inferior behavior when compared to the Control mix.

c) Maximum increase in compressive strength, splitting tensile strength, flexural strength and modulus of elasticity of concrete was observed with 10% WFS at the age of 28 days.

d) From the results obtained it can be suggested that waste foundry sand with a substitution rate up to 10%-20% can be used effectively as a fine aggregate in good concrete production without affecting the concrete standards.

REFERENCES

Albert Noumowe, Geert De Schutter, Rafat Siddique, Effect of used-foundry sand on the mechanical properties of concrete, Construction and Building Materials, 23, 2009, 976–980.

Anita Rajor, Gurdeep Kaur, Rafat Siddique, Waste foundry sand and its leachate characteristics, Resources, Conservation and Recycling, 54, 2010, 1027–1036.

El Hadj Kadri, Rafat Siddique, Effect of meta kaolin and foundry sand on the near surface characteristics of concrete, Construction and building materials, 25, 2011, 3257–3266.

Gert Konig, Jianzhuang Xiao, Study on concrete at high temperature in China — an overview, Fire Safety Journal, 39, 2004, 89–103.

Gurpreet Singh, Rafat Siddique, Utilization of waste foundry sand (WFS) in concrete manufacturing, Resources, Conservation and Recycling, 55, 2011, 885–892.

IS 12269: 53 grade ordinary Portland cement, CED 2: Cement and Concrete, 1987.

IS: 383-1970, Specifications for coarse and fine aggregates from natural sources for concrete, New Delhi, India, Bureau of Indian standards, 1970.

IS: 516-1959, Indian standard code of practice- methods of test for strength of concrete, New Delhi, India, Bureau of Indian Standards, 1959.

Omer Arioz, Effects of elevated temperatures on properties of concrete, Fire Safety Journal, 42, 2007, 516 – 522.