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MANUFACTURING LOW-COST CONCRETE BY USING FOUNDRY SAND AND SLAG

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Abstract - *It has now been found that industrial solid waste management is a major worldwide concern. Because of its heavy price effects, which cause economical and other environmental risks, most industries are not interested in the therapy and secure disposal of these waste. The disposal of waste foundry sand and slag is of main significance due to the trivial amount produced from the foundries throughout the world. Steel slag is a waste product produced during steel production. Ferrous and non-ferrous metal casting industries produce several millions tons of byproduct in the world. In India, approximately 2 million tons of waste foundry sand is produced yearly. WFS is major byproduct of metal casting industry and successfully used as a land filling material for many years. But use of waste foundry sand (WFS) for land filling is becoming a problem due to rapid increase in disposal cost. In an effort to use the WFS in large volume, research has being carried out for its possible large scale utilization in making concrete as partial replacement of fine aggregate.*

***Key Wods*: Foundry sand, slag, concrete.**

1. INTRODUCTION

Concrete is an artificial material which is widely used in all the construction sectors. All the constructions around the world are constructed with the help of concrete such as Buildings, Roadways, Bridges, and Dams etc. The concrete is a costly material and due to which the cost of the construction increases with the increase in the quantity of the concrete. To overcome this problem we have used industrial waste materials as a fine aggregate and coarse aggregate. Waste foundry sand is used as a fine aggregate and slag is used as a course aggregate.

1.1 FOUNDRY SAND

Waste foundry sand are by-products which appears possess the potential to partially replace regular sand as a fine aggregate in concretes, providing a recycling opportunity for them. If such types of materials can be substituted partially or fully for natural sand (Fine Aggregates) in concrete mixtures without sacrificing or even improving strength and durability, there are clear economic and environmental gains. Currently, very limited literature is available on the use of these by-products in concrete. Waste foundry sand (WFS) is one of the major issues in the management of foundry waste. WFS are black in color and contain large amount of fines. The typical physical and chemical property of WFS is dependent upon the type of metal being poured, casting process, technology employed, type of furnaces (induction, electric arc and cupola) and type of finishing process (grinding, blast cleaning and coating).

Fig 1; foundry sand

1.2 SLAG

Slag is also a by-product obtained during steel manufacturing and is commonly used in concrete because it improves durability and reduces porosity by improving the interface with the aggregate. Economic and ecologic benefits in the form of energy-savings and resource conserving properties can also be achieved using slag-blended cement. Compressive strength is the most important engineering property of concrete. To ensure progress in construction and safety in engineering practices, we aim to develop understanding on the strength development of concrete. Many experimental investigations have been conducted on the strength development of slag-blended concrete.

Fig 2 ; slag

1.3 ABOUT RESEARCH

The innovations of this research are as follows. First, the proposed numerical procedure is valid for concrete with various mixing proportions, such as different waste foundry sand ratios and different slag replacement ratios. The dependences of waste foundry sand and slag reactivity on concrete mixing proportions and curing conditions are clarified; second, the proposed numerical procedure is valid for both early-age concrete and late-age concrete. Evolutions of concrete properties are expressed as functions of reaction degrees of waste foundry sand and slag; third, the proposed numerical procedure evaluates the physical properties, such as the compressive strength of concrete, splitting tensile strength of concrete.

2. LITERATURE REVIEW

2.1 LITERATURE RELATED TO WASTE FOUNDRY SAND (WFS) IN CONCRETE

2.1.1 Workability (Slump)

Guney et al. (2010) studied the effect of waste foundry sand (WFS) on the slump of concrete. Fine aggregates were partially replaced with 0, 5, 10 and 15% WFS. It was observed that waste foundry sand decreased the fluidity and the slump value of the fresh concrete. This may be probably due to the presence of clayey type fine materials in the waste foundry sand, which are effective in decreasing the fluidity of the fresh concrete.

Etxeberria et al. (2010) determined the slump of concrete containing chemical foundry sand and green foundry sand. The mixture proportion on concrete made with chemical foundry sand was 300 kg cement, 447.5 kg foundry sand, 399.6 kg natural sand and 1150 kg coarse aggregates per cubic meter of concrete, with water/cement ratio of 0.61, whereas, proportion of concrete with green foundry sand was 300 Kg cement, 326 kg foundry sand, 458 kg natural sand and 1150 kg coarse aggregates with water/cement ratio of 0.69. Values of slump were 150 mm and 75 mm for concrete made with chemical foundry sand and green foundry sand respectively.

2.1.2 Compressive Strength and Modulus of Elasticity

Khatib and Ellis (2001) studied the influence of three types of foundry sand as a partial replacement of fine aggregate on the compressive strength of concrete, up to the age of 90 days. Three types of sand used in foundries were; the white fine sand without the addition of clay and coal, the foundry sand before casting (blended) and the foundry sand after casting (waste). The standard sand (Class M) was partially replaced by (0, 25, 50, 75 and 100%) these sands. They concluded that (i) with the increase in the replacement level of standard sand with foundry sand, the strength of concrete decreased; (ii) the concrete containing white sand showed somewhat similar strength to those containing waste sand at all replacement levels; (iii) presence of high percentage of blended sand in the concrete mixture caused a reduction in strength as compared with concrete incorporating white sand or waste sand; (iv) increase in strength was not observed at low replacement levels (less than 50%).

2.2 LITERATURE RELATED TO SLAG

2.2.1 Workability

Al-Jabri et al (2009) has investigated the performance of high strength concrete (HSC) made with copper slag as a fine aggregate at constant workability and studied the effect of super plasticizer addition on the properties of HSC made with copper slag. Two series of concrete mixtures were prepared with different proportions of copper slag. The first series consisted of six concrete mixtures prepared with different proportions of 15 copper slags at constant workability. The water content was adjusted in each mixture in order to achieve the same workability as that of the control mixture. Twelve concrete mixtures were prepared in the second series. Only the first mixture was prepared using super plasticizer whereas the other eleven mixtures were prepared without using super plasticizer and with different proportions of copper slag used as sand replacement. The results indicated that the water demand reduced by almost 22% at 100% copper slag replacement compared to the control mixture. The strength and durability of HSC were generally improved with the increase of copper slag content in the concrete mixture. However, the strength and durability characteristics of HSC were adversely affected by the absence of the super plasticizer from the concrete paste despite the improvement in the concrete strength with the increase of copper content.

2.2.2 Compressive Strength test

Arino and Mobasher (1999) presented the effect of ground copper slag on the strength and fracture of cement-based materials. Upto 15% by mass of ground copper slag was used as a Portland cement replacement. The strength and fracture toughness of concrete samples were studied using closed-loop controlled compression and three-point bending fracture tests. The compression test utilized a combination of the axial and transverse strains as a control parameter to develop a stable post-peak response. A cyclic loading-unloading test was conducted on three-point bending notched specimens under closed-loop crack mouth opening control. Test results were used to construct the Resistance Curve (R-Curve) response of the specimens 24 describing the dependence of fracture toughness on the stable crack length. Mechanical response of GCS concrete was also reported. The compression test results indicated that GCS concrete was stronger but more brittle than ordinary Portland cement concrete. Fracture test results confirmed the increased brittleness of concrete due to the use of GCS. Long-term results showed equal or higher strengths for the GCS specimens without concern for degradation of other properties.

3. OBJECTIVES

- To check the strength of concrete by adding foundry sand and slag.
- To estimate the difference in cost with conventional concrete.
- To utilize the waste product generated at industry which may harm to environment and human life.
- For preserving the natural minerals by utilizing the excess of waste natural product.

4. METHODOLOGY

- Collection of information regarding the convectional concrete as well as foundry sand and slag concrete.
- Collecting the information of required material (i.e. quantity, type, cost).
- Collecting the material from available sources.
- Testing the various parameters of materials.
- Mixing of concrete as per mix design.
- Testing the foundry sand and slag concrete.

4.1 Design of concrete mix

Concrete mix design is the process of finding right proportions of cement, foundry sand and aggregates for concrete to achieve target strength in structures. So, concrete mix design can be stated as Concrete Mix = cement: foundry Sand: Aggregates. The proportions for the mix were calculated adopting the requirements of water as specified in BIS: 10262-1982.

The concrete mix design involves various steps, calculations and laboratory testing to find right mix proportions. This process is usually adopted for structures which require higher grades of concrete such as M25 and above and large construction projects where quantity of concrete consumption is huge.

T 1: Mix proportion for conventional concrete (M25) for a volume of 1 cube (15×15×15cm).

S. no.	Cement (gm)	Natural Fine Agg. (gm)	Natural Coarse Agg. (gm)	Water (lit.)
1.	1898	2126	3950	950

T 2: Mix proportion for a conventional concrete (M25) with the replacement of foundry sand and slag for a volume of 1 cube (15×15×15cm).

Replacement material (%)	Cement (gm)	WFS (Fine Agg.) (gm)	Natural Fine Agg. (gm)	Natural Coarse Agg. (gm)	Water (lit.)
WFS (20)	1898	455	1700	3950	950
WFS (40)	1898	911	1276	3950	950

T 3: Mix proportion for a foundry sand and slag, concrete (M25) for a volume of 1 cube (15×15×15cm).

Replacement material (%)	Cement (gm)	WFS (Fine Agg.) (gm)	Natural Fine Agg. (gm)	Steel Slag (gm)	Water (lit.)
WFS (20)	1898	455	1700	2025	950
WFS (40)	1898	911	1276	2025	950

5. RESULT

T 4: Compressive strength of conventional Concrete (M25)

Sr No.	Curing (days)	S1 (N/mm²)	S2 (N/mm²)	S3 (N/mm²)	Avg.compressive Strength (N/mm²)
1.	7 days	17.77	16.44	18.44	17.55
2.	14 days	20.44	21.56	18.22	20.07
3.	28 days	26.89	27.55	27.55	26.74

T 5: Compressive strength of concrete (M25) with 40% replacement of foundry sand and 20% replacement of slag.

Sr No.	Curing (days)	S1 (N/mm²)	S2 (N/mm²)	S3 (N/mm²)	Avg.compressive Strength(N/mm²)
1.	7 days	22.67	22.22	21.11	22.00
2.	14 days	22.00	24.00	25.11	23.70
3.	28 days	27.22	26.77	25.78	26.59

T 6: Compressive strength of concrete (M 25) with 50% replacement of foundry sand and 25% Replacement of slag.

Sr No.	Curing (days)	S1 (N/mm²)	S2 (N/mm²)	S3 (N/mm²)	Avg.compressive Strength (N/mm²)
1.	7 days	18.25	19.24	18.22	18.63
2.	14 days	23.78	24.89	23.11	23.93
3.	28 days	29.78	27.15	29.44	28.79

T 7: Compressive strength of concrete(M 25) with 60% placement of foundry sand and 30% Replacement of slag.

Sr No.	Curing (days)	S1 (N/mm²)	S2 (N/mm²)	S3 (N/mm²)	Avg.compressive Strength (N/mm²)
1.	7 days	18.58	19.24	18.22	18.63
2.	14 days	23.78	24.89	23.11	23.93
3.	28 days	30.78	29.15	29.44	29.79

6. CONCLUSIONS

- From the above tables, we can say that the waste foundry sand and steel slag is increased the strength of concrete.
- After the 7, 14 and 28 days of curing of concrete cubes, tested cubes has given satisfactory results regarding their compressive strength and workability.
- According to these results, the foundry sand and slag concrete can easily be used for all types of concreting works.
- The use of waste foundry sand and slag concrete will help to achieve the required strength at a low cost.

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