Available online at http://www.journalcra.com

International Journal of Current Research
Vol. 4, Issue, 11, pp.106-109, November, 2012

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

ISSN: 0975-833X

RESEARCH ARTICLE

MILD STEEL SLAG AS A POTENTIAL REPLACEMENT FOR CONCRETE AGGREGATE

J. Gokul, S. Suganthan, R. Venkatram and K. Karthikeyan

113, Pioneer Mill Road, India *Corresponding author: gokuljayaprakashkrishnan@gmail.com

ARTICLE INFO

Article History:
Received 11th August, 2012
Received in revised form
22th September, 2012
Accepted 19rd October, 2012
Published online 21th November 2012

Key words:
Slag, Aggregate,
Compressive strength,
Water absorption testing,

ABSTRACT

Waste management is one of the most common and challenging problems in the world. The steel making industry has generated substantial solid waste. Mild steel slag is a residue obtained in steel making operation. This paper deals with the implementation of mild steel slag an effective replacement for stone or aggregate. Mild steel slag which is considered as the solid waste pollutant can be used for road construction, clinker raw materials, filling materials, etc. In this work, mild steel slag is used as replacement for aggregate or stone, which has highest content in concrete mixture. This method can be implemented for producing hollow blocks, solid blocks, paver blocks, concrete structures, etc. Accordingly, advantages can be achieved by using mild steel slag instead of natural aggregates. This will also encourage other researchers to find another field of using mild steel slag.

INTRODUCTION

Steel slag exist as by-product during melting of steel scrap from the impurities and fluxing agents, which form the liquid slag floating over the liquid steel in arc or induction furnaces, or other melting units. The ferroalloys industry has generated historically substantial solid waste. Great amount of wasted materials is generated by industries and has caused tremendous harm to both the environment and ecology. The waste removed from the furnace separately in a rate of about (10-15%) of the produced steel [1]. Reuse of waste material has become very important during the past decade because of the reinforcement of environmental regulations that require minimizing waste disposal. The main aim of the environment protection agencies and the government are to seek ways and minimize the problems of disposal and health hazards of by-products. Steel making operations are specifically concerned by this problem because of generation of a huge quantity of by-products. However, the development of science and technology has made it possible to transform the waste into new resource to benefit human beings.

In fact, zero discharge of waste materials in many industries becomes true. Consequently, the construction of plants that is “environment-friendly” and that accommodate “recycling” has become the target of most ferroalloy producers in the world to ensure sustainable development. In India, there is a great demand of aggregates mainly from civil engineering industry for road and concrete constructions. The construction of highways and development of several expressways for high-speed corridors exert tremendous pressure on natural resources. Mainly highway agencies, private organizations and individuals are in the process of completing a wide variety of studies and research projects concerning the feasibility, environmental suitability, and performance of using waste industrial products in highway construction[3]. These studies try to match society’s need for safe and economic disposal of waste materials with the highway industries need for better and more cost-effective construction materials. In the past 20th century, slag was found to be excellent aggregate for road paving. Chemical composition of typical steel slag consist mainly SiO_2, Al_2O_3, CaO, MnO, MgO, TiO_2, $P_2O_5$and Fe_2O_3[1]. The steel slag is considered as the waste material which would have a promising future in the construction field. Concrete is a widely used construction material for various types of structures due to its durability. For a long time it was considered as the durable material requiring a little or no maintenance. In recent times it was found that, when reinforced concrete structures are exposed to harsh environments, deterioration of concrete will occur due to many reasons like chloride and sulphate attack, acid attack, corrosion failure etc. On the contrary the aggregates used for the concrete are facing the greater demand. Utilization of industrial soil waste or secondary materials has been encouraged in the construction field for the production of cement and concretes. There are very less investigators on the use of mild steel slag in cement concrete. Not much research has been carried out in India and other countries concerning the incorporation of durability effect of mild steel slag in concrete. Therefore, to generate specific experimental data on strength and durability characteristics of mild steel slag as an aggregate, this work is performed.

EXPERIMENTS

RAW MATERIALS

The materials used in this work to make the samples used in the test consist of, Portland cement, fly ash, construction aggregate and mild steel slag.

Cement

Cement is a binder, a substance that sets and hardens independently and can bind other materials together.

Fly Ash

Fly ash is one of the residues generated in combustion, and comprises the fine particles that rise with the flue gases. Composition of fly ash is given below.

Table 1. Chemical composition of fly ash [4]

	Ignition loss	SiO_2	Fe_2O_3	CaO	MgO	TiO_2	KO_2	Na_2O
%	24.48	38.03	6.48	26.62	0.79	1.18	0.67	0.45

Construction Aggregates

Construction aggregates, is a broad category of coarse particulate material used in construction, including sand, gravel, crushed stone, recycled concrete and geosynthetic aggregates.

Mild Steel Slag

Mild steel slag exist as by-product during melting of mild steel scrap from the impurities and fluxing agents, which form the liquid slag floating over the liquid steel in arc or induction furnaces, or other melting units. Composition of mild-steel slag is given below.

Table 2. Chemical composition of steel slag [1]

Cao	Fe_2O_3	SiO_2	MnO	MgO	Al_2O_3	TiO_2	P_2O_5
41.3	31.2	12.5	6.1	4.3	2.4	0.8	1.1

Experimental design and Test Methods

In order to form the samples required in this work, the first group, without slag, as a standard mixture was used to compare its properties with those of (20, 40, 60, 80 and 100%) of mild steel slag by volume. Concrete of each composition mentioned in Table-3 were made respectively and cast in the prepared moulds.

Table 3. Mixture Proportions

Mixtures	0 (Standard mixture)	20% Slag	40% Slag	60% Slag	80% Slag	100% Slag
Cement	1	1	1	1	1	1
Fly Ash	3	3	3	3	3	3
Aggregate	7	5.5	4	3	1.5	0
Slag	0	1.5	3	4	5.5	7

The above said values in Table 3 are with respect to volume of the material in a standard mason pan. One full mixture taken in this proportion will provide five to six solid models. Dimension of the model are in cm – 40x20x15. The formed samples were left for curing for 28 days. After curing samples for water permeability were made dry. After drying, weights of the samples were determined, samples were immersed in water bath for 48 hours, then the weight of samples were rechecked. The difference in water is the water absorbed. The remaining samples are used for compression testing and density calculation. The Compression testing is carried out in a Universal Compression Testing machine and density calculations are carried out manually by measuring the dimensional valve of the prepared samples.

RESULTS AND DISCUSSIONS

Compression Testing

The test is achieved by using the universal testing machine. The tests are carried out after 28 days of curing the solid models. The results are tabulated in Table 4 for first set samples.

Table 4. Compression testing for first set samples

Percent Relative to Natural Aggregate volume	Compressive strength (Tons)
0 (Standard Concrete mixture)	25
20 % Slag	33
40% Slag	52
60% Slag	59
80% Slag	54
100% Slag	83

Coarse grain slags were used in 60 and 80% slag models, hence not much variation in their compressive strength.

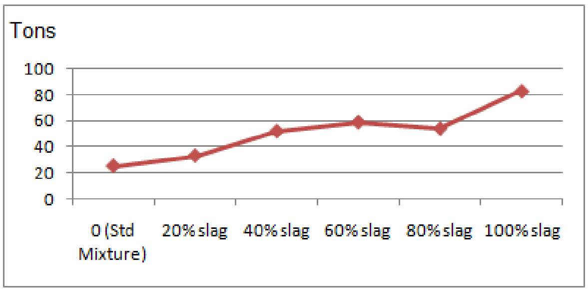

Figure 1. Slag % vs Compressive Strength

The compression test for the second set of samples is tabulated in the Table 5.

Table 5. Compression testing for second set samples

Percent Relative to Natural Aggregate volume	Compressive strength (Tons)
0 (Standard Concrete mixture)	28
20 % Slag	32
40% Slag	49
60% Slag	62
80% Slag	57
100% Slag	79

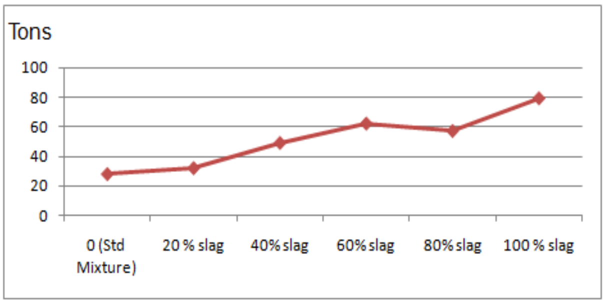

Figure 2. Slag % vs Compressive Strength

The compressive strength of the cubic samples increased from 25 tons without slag to 83 tons with 100% slag in the first set of samples after 28 days is shown in Fig 1. Similarly the compressive strength increased from 28 tons without slag to 79 tons with 100% slag in the second set of samples after 28 days is shown in Fig 2.

Water Absorption Testing

Test is achieved by using the weight of the dry sample as a base, then given samples were soaked completely in water for 48 hours, the samples then weighed again. The difference between the first and second weight is the weight of absorbed water. The results are tabulated in Table 6.

Table 6. Water absorption testing for first set of samples

Percent Relative to Natural Aggregate Volume	Mass of Dry Samples (Kg)	Mass of Wet Samples (Kg)	Absorbed Water Percent Relative to Dry Mass (%)
0(Standard Concrete Mixture)	21.50	22.30	3.66
20% slag	21.50	22.26	3.55
40% slag	23.53	24.30	3.30
60% slag	22.04	22.75	3.24
80% slag	19.53	20.14	3.16
100% slag	23.56	24.17	2.62

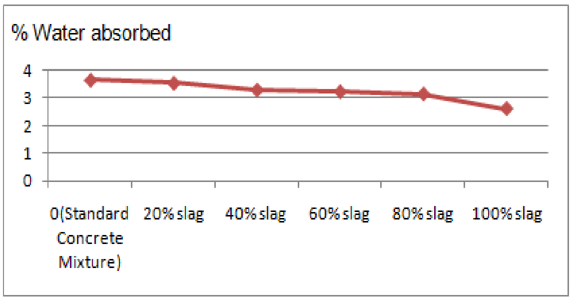

Figure 3. Slag % vs % Water absorbed

Water absorption test for the second set of samples are tabulated in the Table 7. The table shows that, the water absorbed by the model with maximum amount of slag is less.

Table 7. Water absorption testing for second set of samples

Percent Relative to Natural Aggregate Volume	Mass of Dry Samples (Kg)	Mass of Wet Samples (Kg)	Absorbed Water Percent Relative to Dry Mass (%)
0(Standard Concrete Mixture)	21.65	22.44	3.65
20% slag	21.48	22.23	3.52
40% slag	22.98	23.71	3.22
60% slag	22.36	23.07	3.2
80% slag	20.01	20.62	3.08
100% slag	23.65	24.25	2.54

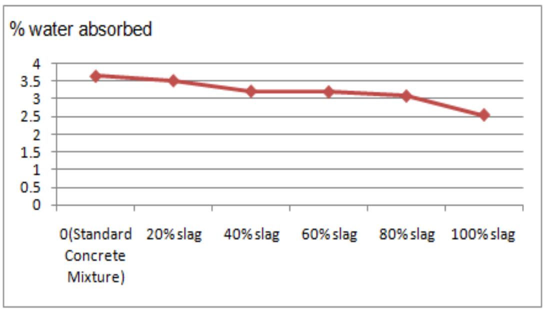

Figure 4. Slag % vs % Water absorbed

Water absorption decreased by increasing the slag content from 3.66% without slag to 2.62% with 100% slag for the first set of samples shown in Figure 3. Water absorption decreased by increasing the slag content from 3.65% without slag to 2.54% with 100% slag for the second set of samples shown in Figure 4. The ability of the samples to absorb is less by increasing the slag content within it.

Density Calculation

This is achieved by curing the solid model for 28 days to ensure the dryness of the samples. Density is calculated by dividing the dry weight of the each sample by volume of the samples. The results are tabulated in the Table 8.

Table 8. Density calculation for first set of samples

Percent Relative to Natural Aggregate Volume	Mass of Dry Sample (Kg)	Volume of the Sample(cm^3)	Calculated Density (gm/ cm^3)
0 (Standard Concrete Mixture)	21.50	40.2x19x15.3	1.839
20% slag	21.50	40.5x19.6x14.4	1.880
40% slag	22.98	39.6x18.6x14.5	2.151
60% slag	22.36	40x19.2x15.1	1.980
80% slag	20.01	40.1x18.2x14.7	1.865
100% slag	23.65	40.2x20.2x14.7	1.981

The density calculations are irrespective to the dimensions of the solid model. The density is high for fine aggregates used in the model.

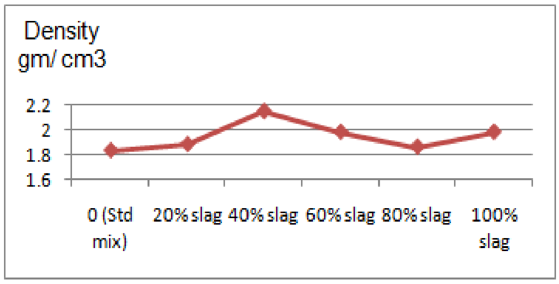

Fig 5. Slag % vs Density

The density calculation for the second set of samples are tabulated in the Table 9.

Table 9. Density calculation for Second set of samples

Percent Relative to Natural Aggregate Volume	Mass of Dry Sample (Kg)	Volume of the Sample(cm^3)	Calculated Density (gm/ cm^3)
0 (Standard Concrete Mixture)	21.65	40.2x20.2x14.7	1.813
20% slag	21.48	40.5x19.6x14.4	1.879
40% slag	22.98	40.1x18.2x14.7	2.14
60% slag	22.36	40x19.6x14.4	1.980
80% slag	20.01	39.8x18.6x15.2	1.79
100% slag	23.65	39.8x18.6x14.8	2.158

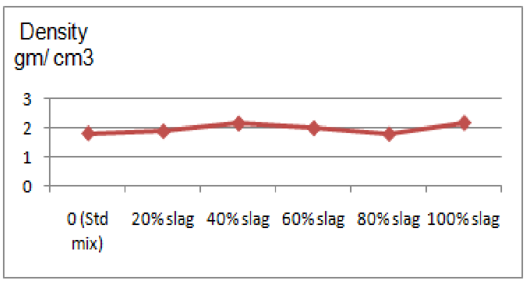

Figure 6. Slag % vs Density

The density of the samples increased from 1.83 gm/ cm^3 for samples without slag to 1.98 gm/ cm^3 for samples with 100% slag for the first set is shown in Fig 5 and 1.81 gm/ cm^3 for the samples without slag to 2.15 gm/ cm^3 for 100 % slag, is shown in Fig 6.

Conclusions

Results achieved could be considered in different aspects,

- Compressive strength and the other tests show that mild steel slag is superior to the natural aggregates.
- Modification of concrete by using mild steel slag.
- Addition of mild steel slag as a fine aggregate improves good interlocking and eventually improved the mechanical properties of the mixes. The use of fine crushed mild steel slag also improves the stiffness of the concrete model.
- Protection of environment from the pollution effects of huge quantities of slag rejected from steel melting in India or in all over the world.
- High strength and durable concrete blocks at low cost.

From the above results we can insure the improvements of the concrete mixture properties due to addition of mild steel slag. Accordingly we could state that many advantages were achieved by using mild steel slag instead of natural aggregates, however the last was available, and also this will encourage other investigations to find another filed of using slag

REFERENCES

Bagampadde. U, Wahhab. HI, and Aiban. SA, “Optimization of steel slag aggregates for bituminous mixes in Saudi Arabia”, Journals of materials in Civil Engineering, 1999, pp. 30 – 35.

Brindha. D, Baskaran. T, Nagan. S, “Assessment of corrosion and durability characteristics of copper slag admixed concrete”, International Journal of Civil and Structural Engineering, Vol.1, 2010, pp. 192 – 211.

Maslehuddin. M, Alfarabi. M, Shameen. M, “Comparison of properties of Steel Slag and crushed Limestone aggregate Concretes” Construction and building materials, 2003, pp. 105 – 112.

Mohammed. J and Abbas. O, “Using of Steel Slag in Modification of Concrete Properties”, Eng.& Tech. Journal, Vol 37,No 9, 2009.

Paul Bosela, Norbert Delatte, “Fresh and hardened Properties of Paving Concrete with steel slag aggregate”, 9th international conference on Concrete Pavements, 2008, pp. 836 – 853.

Pundhir. NKS, Kamaraj. C, and Nanda. NK, “Use of Copper Slag as a construction material in bituminous pavements”, Journal of Scientific & industrial Research, 2005, pp.997 – 1002.

Song.J and Kang.G, “A practice of Ferroalloy production in an Environment friendly and Recycling way”, Document transformation technologies, 2004, pp.705 – 711.

Takahashi, and Yubuta, “New application for Iron and Steel making Slag”, NKK Technical Review, 2002, pp. 38 – 44.

Turan Ozturan and Cengizhan Cecen, “Effect of coarse aggregate type on Mechanical properties of concrete with different strengths”, Cement and Concrete Research, Vol. 27,1997, pp. 165 – 170.

****