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Experimental study on greener fine aggregates (steel slag) in concrete

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ABSTRACT

Steel Slag (SS) is an industrial by product get from the steel manufacturing industries .It is produced in large quantities during the steel making operation which utilize electric arc furnaces .SS can also be produced by smelting iron ore in the basic oxygen furnace. SS can be used in construction industry as an aggregate in concrete by replacing natural aggregate. Natural aggregate are becoming increasingly scare and their production shipment is more difficult. SS is used for aggregate in hot as plat surface application. The majority of the aggregate is quantity of the concrete. Replacing all or a few of the natural aggregate with the SS will leads to some environmental benefits. For this present study M25 concrete is used. The one-sided substitute of the SS will be made for changing percentages, for example 0%,10%, 20%,30%,40%,50%. From this learn the compressive strength, flexural strength and split tensile strength will be made experimentally also to find the optimal level of SS at a particular replacement of SS as natural aggregate.

Key words : *Steel Slag (SS), Fine Aggregate*

Introduction

General

Cement concrete is the widespread man-made construction material. Concrete is most flexible construction materials known has its limitations its has resistance to cracking, limited ductility and low tensile strength. Saud Al-Otaibi, (2008) mentioned is accountable to disintegrate by alkali and sulphate attack. Sustainable construction method is used recently. So moderation has to made time to time to overcome the deficiencies of cement concrete. By Extensive research of concrete technology we are capable of eliminating the basic shortage by development of special types. In some times, concurrent upgrade in a combination of properties is also needed. Such are often called "High Performance Materials" and "Advanced Materials" and they are altered from other conventional materials**.**

Slag

It's a partially clear by product. Slag is the glass like by-product left over after a desired metal has been separated. Slag is usually a mixture of metal oxides and silicon dioxide. However, slags can contain metal sulphides and metal atom in the elemental form. While slag's are typically used to eliminate waste metal smelting, it's serve other uses, for example supporting the temperature control of smelting and reducing any re-oxidation of final liquid metal result previous to the molten metal is separate from furnace and used to build solid metal. The various types of SS are, Ferrous slag, Copper slag,

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Zinc slag, Granulated blast furnance slag, Ground blast furnance slag. Pankaj (2008) The Steel slag, a by- made from metallic making, is produced all through the separation of the molten metallic from impurities in metallic making furnaces. Juan (2006) The slag happens as a molten liquid soften and is a complicated answer of silicates and oxides that solidifies upon cooling.

Literature

Vidhya and Kandasamy (2013) analysed the outcome of natural SS on shear strength of the concrete while used for the fine aggregate. Sudharsan and Saravanaganesh, (2019) to overcome the great demand of natural sand the slag is sound option in the support of ecology while used the fine aggregate in fast concrete area. Sudharsan and Sivalingam, (2019) studied utilization of the SS as a partially or fully replacement of aggregate keeping the other constant parameter. Isayuksel (2007) studied Shear strength is considering on M20 grade on concrete with constant 0.5w/c ratio. SS replacement of 0,20,40,60,100 percentage is used. The best are obtained for replacement of 60%.

Mahendrana (2008) reports the investigational study of using slag as a substitute of aggregate (concrete). From this learn, concrete of M20, M30, M40 grades were consider for a water cement ration 0.55. The investigation revealed development in the compressive strength, flexural strength and split tensile strength over control mixes by 4 to 8%. Establish from the overall observation, the slag should be effective replacement as aggregate in the use of concrete.

Sudharsan and Palanisamy (2018) this study experimental investigation to analyse the result of the replacing the aggregate with the slag on various concrete characteristics. The compressive strength, flexural strength and split tensile strength are determined. From the result of this learn the % of this slag as substitute is increased the aggregate strength is increased.

Sudharsan *et al.* (2018) from this learn an attempt is made using the SS as a coarse aggregate & Eco sand of a fine aggregate. M30 grade of concrete are used. Probable optimum substitute of slag are found to 60% and Eco sand were found to 40%. The result showed the replacement of slag about 60% and Eco sand about 40% not have a few adverse causes on the concrete strength.

Shashidhara (2010) studied on mechanical characteristics of self-compacting concrete is partially substitute of SS. Erhan Guneyisi (2007) to examine the act of the self -compacting concrete with SS mix proportions ranging from M20 to M40 grade of concrete. Vidhya and Kandasamy, (2014) Mechanical characteristics of the self -compacting concrete with the SS were found and the optimum value was attained at the particular replacement of the SS as aggregate. And further replacement affects negatively the concrete strength.

Vidhya and Kandasamy, (2016) report the study on compressive strength (cement mortar mix) with partial substitute of SS as natural aggregate with Ferro cement laminates. Ferro cement elements were investigated by replacement of SS as sand. Cement mortar mix proportion 1:2, 1:2.5 and w/c ratio 0.3,.35 with various % of SS were designed. Praburanganathan, *et al.* (2022) from the terms of unit weight and compressive strength, the act of the mortar was evaluated.

Selvaraj, *et al*. (2022) report the study the concrete mortar with SS aggregate to investigates the early age shrinkage. In this investigation the cement mortar specimen's were cast for various percentages of SS with cement. The result shows that increases in percentage of SS increase the drying shrinkage. Drying shrinkage of cement mortar increases quickly before the age of 14 days while the changes shows after the 28 days.

Hisham Qasarawi *et al*. (2008) studied the characteristics of concrete in which fine aggregate is replaced by the SS. Substitute of fine aggregate with the SS made for M25, M35 and M45 grade concrete. The outcome show that an increases in percentage of the Steel and percentage of the SS. The density increases of concrete are for the reason that of the high specific gravity of the SS.

Pawar and Tribhuvan (2016) study on concrete as using SS as a partially substitute of the fine aggregate. M30 concrete with substitute for fine aggregate with high volume SS is determined. Sudharsan and Grant (2018) the flexural strength, compressive strength and split tensile strength were found experimentally. Substitute of fine aggregate by SS in a various percentage 0%, 25%, 50%. The strength characteristics are increased by increasing the percentage (%) of the SS of about 25% of aggregate.

Experimental investigation

Materials

1. Cement

Ordinary Portland cement of forty three grade confirming to IS12269-2013 becomes procured regionally from market.

S.No	Tests carried out	Experimental results.
1.	Specific gravity	3.15
2.	Consistency	30%
3.	Initial setting time	30 min

2. Fine aggregate

The fine aggregate used become M-sand that is sieved via 4.75 sieves and right care become taken.

S.No	Tests carried out	Experimental results
1.	Specific gravity	2.63
2.	Fineness modulus	2.6

3. Coarse aggregate

The coarse aggregate used become regionally to be had coarse aggregate that is keeping on 4.75 sieves.

S.No	Tests carried out	Experimental results
1.	Specific gravity	2.57
2.	Fineness modulus	7.71

4. SS

SS used on this observe have been procured from close by metal industry.

S.No	Tests carried out	Experimental results
1.	Specific gravity	2.73
2.	Fineness modulus	2.86

5. Water

Fresh and clean water which is free from organic matters and slit and acid materials and oil were used in casting and curing purpose. Water is piped from the public supplies.

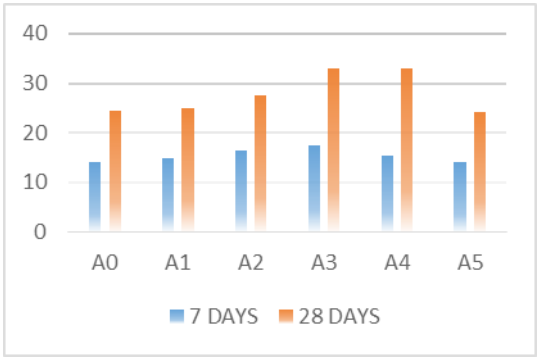
Experimental Programme

Cube specimen of size 150 mm×150mm×150 mm. Cylinder specimen size 150 mm dia and 300 mm height and beam specimen of size 100 mm×100 mm×500 mm was used to determine the mechanical characteristics in the concrete.

Mechanical Properties

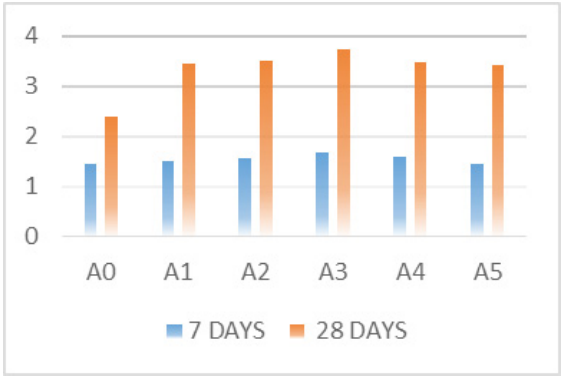
1. Compressive strength test

S. No.	Mix id	Compressive strength (N/mm²)	
1.	A0	7 days	28 days
		14.1	24.5
2.	A10	15	25
3.	A20	16.5	27.5
4.	A30	17.5	33.5
5.	A40	15.5	30.5
6.	A50	14.2	24.3



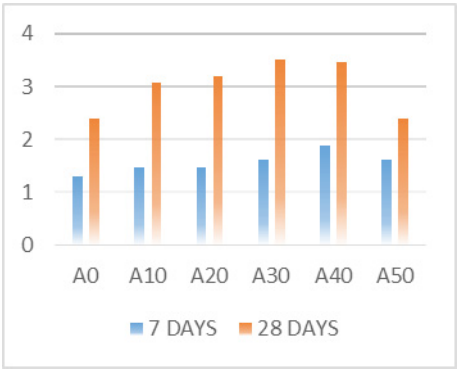
2. Split Tensile Strength Test

S. No.	MIX ID	Split Tensile Strength (N/mm²)	
		7 days	28 days
1.	A0	1.45	3.30
2.	A10	1.52	3.45
3.	A20	1.58	3.59
4.	A30	1.69	3.75
5.	A40	1.60	3.42
6.	A50	1.46	3.42



3. Flexural strength

S. No.	MIX ID	Flexural strength (N/mm²) 7 days	28 days
1.	A0	1.30	2.92
2.	A10	1.47	3.07
3.	A20	1.47	3.20
4.	A30	1.60	3.5
5.	A40	1.87	3.45
6.	A50	1.60	2.40



Applications of SS

Some of the modern-day makes use of of SS consistent with National Slag Association (NSA accessed, 2008) are as follows:

- SS is used as a really aggregate is warm blend asphalt floor aggregate utility because of its excessive frictional resistance and skid resistance characteristics. The cubical nature of SS and its tough texture gives extra resistance than round, clean and elongated aggregates.
- It is likewise utilized in making Stone Matrix Asphalt (SMA) due to the fact the particle-to-particle touch of the aggregate does now no longer spoil down in the course of the manufacturing, laying down, or compaction process.
- It is likewise used for manufacture of Portland cement.
- It is utilized in base application, construction of unpaved parking plenty as a shoulder material and additionally within side the construction of embankment.
- It is likewise utilized in agriculture as it has minerals like iron, manganese, magnesium, zinc and molybdenum that are precious plant nutrients.
- It is surroundings friendly. During the manufacture of cement, the CO is decreased as slag, which has formerly passed through the calcinations process.
- SS aggregates are used for soil stabilisation, soil development material and for remediation of an industrial waste water run-off.

Common Uses of Slag

The following points are to be considered as the common uses of slag in the reinforced cement concrete.

- Its uses in granular base, embankments, engineered field, Highway shoulders, and Hot Mix Asphalt(HMA) pavement .
- Blast furnace slag products have successfully used in all phases of bridge construction.
- SS has been utilized worldwide in water way construction.
- Application includes use of slag for erosion control, mineral filter applications, bank reinforcements and construction of dikes reefs, and sea walls.

Conclusion

- It is obvious that compressive strength increases with increase in percentage of SS up to 30% by means of weight of fine aggregate.
- The enhancement in the compressive strength is about 17.5 N/mm² for 7days curing and 33.5 N/mm² for 28 days curing.
- It is obvious that split tensile strength increases with increase in percentage of SS up to 30% by means of weight of the fine aggregate.
- The enhancement in split tensile strength is about 1.68 N/mm² for 7 days curing and 3.75 N/mm² for 28 days curing.
- It is obvious that flexural strength increases with increase in percentage of SS up to 30% by means of weight of fine aggregate.
- The enhancement in flexural strength is about 1.60 N/mm² for 7days curing and 3.5N/mm² for 28 days curing.
- From the outcome of the flexural strength, compressive strength and split tensile strength of 7 days and the 28 days curing, 30% substitute of the fine aggregate by SS is the optimum percentage (%) of substitute of M25 grade concrete.

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