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RESEARCH ARTICLE

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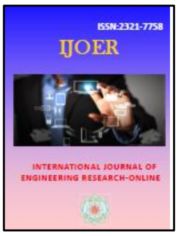
A STUDY ON UTILIZATION OF STEEL SLAG AS A PARTIAL REPLACEMENT MATERIAL FOR COARSE AGGREGATE IN MEDIUM STRENGTH CONCRETES

CH.THEJA[1], Dr. T. SURESH BABU[2]
[1]M.Tech Student, Visvodaya Engineering College, Kavali
[2]Professor and Head, Department of Civil Engineering, Visvodaya Engineering College, Kavali



ABSTRACT

As a construction material, concrete is the largest production of all other materials. Aggregates are the important constituents in concrete. They give body to the concrete, reduce shrinkage and effect economy. The increase in demand for the ingredients of concrete is met by partial replacement of materials by the waste materials which is obtained by means of various industries. Slag is a byproduct of metal smelting and hundreds of tons of it are produced every year all over the world in the process of refining metals and making alloys. Like other industrial byproducts, slag actually has many uses, and rarely goes to waste. In appearance, slag looks like a loose collection of aggregate, with lumps of varying sizes. It is also sometimes referred as cinder. This substance is produced during the smelting process In several ways. Slag represents undesired impurities in the metals, which float to the top during the smelting process. Secondly, metals start to oxidize as they are smelted , and slag forms a protective crust of oxides on the top of the metal being smelted, protecting the liquid metal underneath. When the metal is smelted to satisfaction, the slag is skimmed from the top and disposed of in a slag heap to age. Again material is an important part of the process, as it needs to be exposed to the weather and allowed to break down slightly before it can be used. In this experimental investigation an attempt is made to study the effect of partial replacement of coarse aggregate by steel slag in the mechanical properties of M20,M25,M30 grade concrete

1. INTRODUCTION

Concrete contains the materials which are sand, cement ,water ,coarse aggregate. In this the addetives are also present for good strength .for getting the required shape the reinforcement is needed. all these materials are mixed then it is easy to moulded into shape. after some time these mix was getting good strength these mix was used in several ways in construction purposes. world wide famous structures are constructed by using concrete. Concrete technology was getting very advanced features. concrete technology is man made wonder. Maximum constructions are done by using concrete. Man made wonders are maximum constructed by concrete.

The use of concrete in now a days very large requirement it effects environment in good and same time bad ways .in concrete cement playing major role ,in industries also it was playing a wide role. Depending on these industries lot of peoples are living their lifes in better way same time they are getting health problems because of these industries .mainly these industries are producing co2,and green house gases. Due to the production of Portland cement 7 to 10 percent of global anthropogenic co2. Sintering of clay and lime stone at 1500 centigrade. It was using for the hard surfaces it causes the decreasing of runoff, it causes soil erode. water bodies are going to be polluted ,these are causing floods ,but these concrete

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structures are mainly used to divert rivers ,storing water.

But it is some better when compared to the ashalt workers who cut and grind or polishing concrete are under danjourus situation. those are inhaling the airborn silica .At the time of destroying the old structures and environmental damages ,natural disasters ,the air going to be polluted in high level. The fresh or wet concrete is going is very high alkaline and it has to handle very careful manner with refered protective tools.

Generally concrete having the high compression and the low tensile strength. For that purpose we are using steel as the reinforcement which is strong in tension, Elasticity of concrete is constant at low stress levels and it start to decreasing in high stress levels. Different mixes of concrete producing different strengths units are MPa. Due to shrinkage effects buildings or structures getting cracks. coming to the strengths when we want less or light weight have to use 2000psi. it was achieved by adding the air ,foams ,light weight aggregates ,it also causes the strength decrement. For largely using 3000-psi to4000psi is used.5000psi is also available as more durable and more costly ,it is mainly used for civil projects. And above this strength are used for special building elements example the lower floor columns of high rise concrete buildings to keep column size small. For bridges long beams 10,000psi was using to lower the spans number. High strength concrete required for other structural needs. For a rigid structures high strength concrete specified, for need of very high strength structures 19000 using commercially.

2. MATERIALS USED

1. Ordinary Portland Cement.
2. Steel Slag.
3. Coarse aggregate.
4. Fine Aggregate
5. Water.

2.1 Properties of Portland cement*:* These properties are taken from the various standard books, journals and some standard codes as reference.

Table 1: CHEMICAL COMPOSITION OF CEMENT

S.NO	Constituent	Percentage
1	Cao	64.00
2	SiO_2	22.00
3	Al_2o_3	4.10
4	Fe_2o_3	3.60
5	Mgo	1.53
6	So_3	1.90

2.2 STEEL SLAG : Steel plant are being set up across the world causes a huge production of solid waste material like slag. Presently, total steel production in India is about 72.20 million metric tons and the waste generated annually is around 19 million metric tones and 50 million metric tons worldwide. Steel slag contains a certain amount of important minerals of cement clinker, such as C2S and C3S.So it can be used as cement and concrete admixtures Steel slag is industrial waste resulting from st refining plants in conversion process. There are two methods for steel slag production: Basic Oxygen Steel (BOS) and Electric Arc Furnace(EAF). BOS slag is obtained by blowing high pressure oxygen into a vessel containing molten iron, steel scrap and lime and EAF.

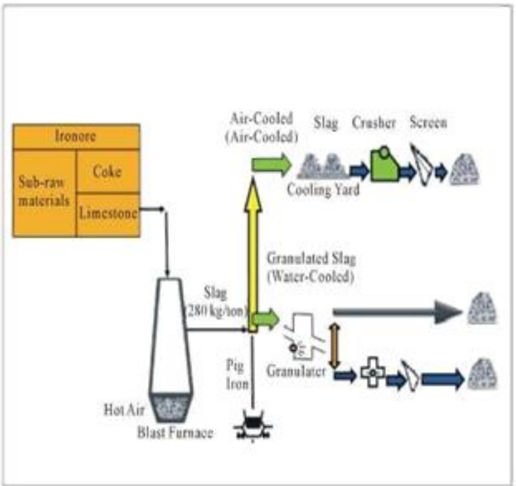

Figure 1:schematic diagram of steel slag production

Table No 2: STEEL SLAG CHEMICAL COMPOSITION

Constituents	Composition
CaO	40-52
SiO2	10-19
FeO	10-40
MnO	5-8
MgO	5-10
Al_2O_3	1-3
P_2O_5	0.5-1
S	<0.1
Metallic Fe	0.5-10

TABLE 3: PHYSICAL PROPERTIES OF STEEL SLAG

Appearance	Black crystalline
Colour	Black
Specific gravity	2.67
Compacted unit weight (kN/M3)	10.98-13.34

2.3 FINE AGGREGATES: River sand locally available in the market was used in the investigation. The aggregate was tested for its physical requirements such as gradation, fineness modulus, and specific gravity and bulk density in accordance with IS: 2386-1963.The sand was surface dried before use.

2.4 COARSE AGGREGATES: Crushed aggregates of more than 12mm size produced from local crushing plants were used. The aggregate exclusively passing through 10mm sieve size and retained on 6.5mm sieve is selected. The aggregates were tested for their physical requirements such as gradation, fineness modulus, specific gravity and bulk density in accordance with IS: 2386-1963.

2.5 WATER: Water plays a vital role in achieving the strength of concrete. For complete hydration it requires about 3/10th of its weight of water. It is practically proved that minimum water-cement ratio 0.35 is required for conventional concrete. Water participates in chemical reaction with cement and cement paste is formed and binds with coarse aggregate and fine aggregates. If more water is used, segregation and bleeding takes place, so that the concrete becomes weak.

3. MIX PROPORTION AND CASTING

Table 4. Showing Mix Proportion

Water	Cement	Fine aggregate	Coarse aggregate
191.6 lit	383.2kg	543.9675kg	1169.30kg
0.5	1	1.41	3.05

Hence the mix is **1:1.41:3.05**(Designed for M20)
Similarly 1:1.274:2.99 (Designed for M25
1:1.05:2.87 (Designed for M30)

3.1 MIXING: In this we are mixing steel slag mixes of 45%, 55%, 65% while mixing concrete with the above mix proportion

3.2 CASTING

3.2.1 COMPRESSIVE STRENGTH TEST: For each set, two standard cubes were cast to determine 7 and 28 days compressive strength after curing. Also two no. of cubes were casted to know the compressive strength of concrete. The size of a cube is as per the IS 10086 – 1982.

3.2.2DURABILITY: for each set 6 cubes were casted and tested for 7 days and 28 days.for determining the durability.

3.2.3WORKABILITY: Workability is the ability of a fresh (plastic) concrete mix to fill the form/mould properly with the desired work (vibration) and without reducing the concrete's quality. Workability depends on water content, aggregate (shape and size distribution), cementitious content and age (level of hydration) and can be modified by adding coir fibres. Raising the water content or adding coir fibres admixtures increases concrete workability. Excessive water leads to increased bleeding (surface water) and/or segregation of aggregates (when the cement and aggregates start to separate), with the resulting concrete having reduced quality.

Table No 5:Workability for mix of normal concrete

Water-cement ratio	Height of the cone (in cm)
0.5	0
0.55	2
0.6	4
0.7	7
0.8	Total collapse

3.2.4 CURING: In all but the least critical applications, care needs to be taken to properly cure concrete, to achieve best strength and hardness. This happens after the concrete has been placed. Cement requires a moist, controlled environment to gain strength and harden fully. The cement paste hardens over time, initially setting and becoming rigid though very weak and gaining in strength in the weeks following. In around 2 weeks, typically over 90% of the final strength is reached, though strengthening may continue for decades. The conversion of calcium hydroxide in the concrete into calcium carbonate from absorption of CO2 over several decades further strengthen the concrete and making it more resilient to damage. However, this reaction, called carbonation, lowers the pH of the cement pore solution and can cause the reinforcement bars to corrode

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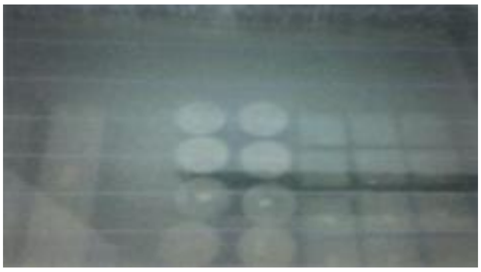


Figure 2: showing the curing of concrete

4. LABORATORY TESTS AND RESULTS

4.1 COMPRESSIVE STRENGTH TEST: For each set, two standard cubes were cast to determine 7 and 28 days compressive strength after curing. Also two no. of cubes were casted to know the compressive strength of concrete. The size of a cube is as per the IS 10086 – 1982.

Figure 3 showing the compression test

Table No 6: Compressive strength of concrete

Types of concrete	Mix designation	percent replacement of slag	Compressive strength(mpa)at	
			7days	28 days
Conventional concrete	M0	0	23.71	33.629
Steel slag Replaced concrete	M1	45%	24.59	34.81
	M2	55%	26	41.77
	M3	65%	22.6	38.22

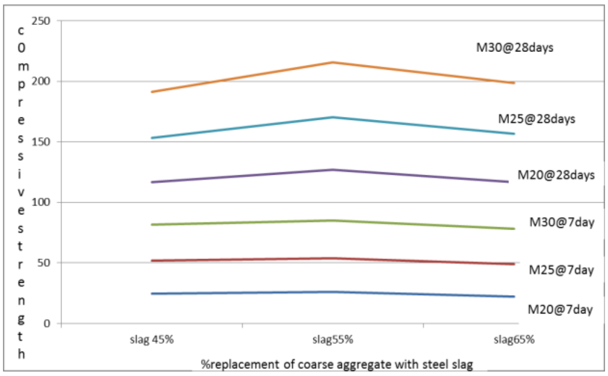
4.2 DURABILITY: To determine the resistance of various concrete mixtures to alkaline attack,the residual compressive strength of concrete mixtures of cubes immersed in alkaline water having 5% of sodium hydroxide (NAOH) by weight of water was found.The concrete cubes which were cured in water up to 90days were removed from water and allowed to dry for one day.Then the cubes were immersed in alkaline water continuously for 90 days.The alkalinity of water was maintained through the test period.after 90 days of immersion ,the concrete cubes were taken out of alkaline water.Then the specimen were tested for compressive strength.The resistance of concrete to alkaline attack was found by the % loss of compressive strength on immersion of concrete cubes in alkaline water.

Table No 7: Compressive strength values of durability

Types of concrete	Mix designation	percent replacement of slag	Compressive strength 90 days(mpa)	
			Alkaline solution	Base solution
Conventional concrete	M0	0	32	32
Steel slag Replaced concrete	M1	45%	35.5	31.1
	M2	55%	41.77	33.3
	M3	65%	36.62	32

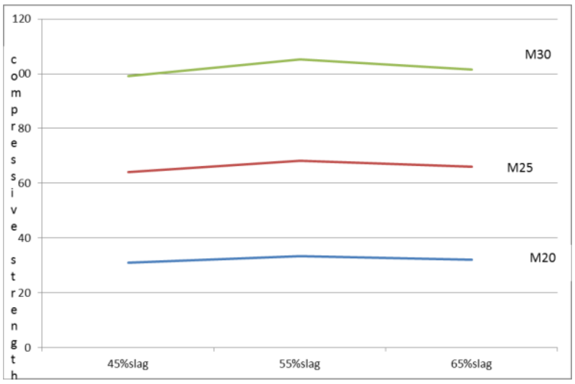
5. GRAPHS

Graph No 1: Compressive strength (mpa)@7 and 28days



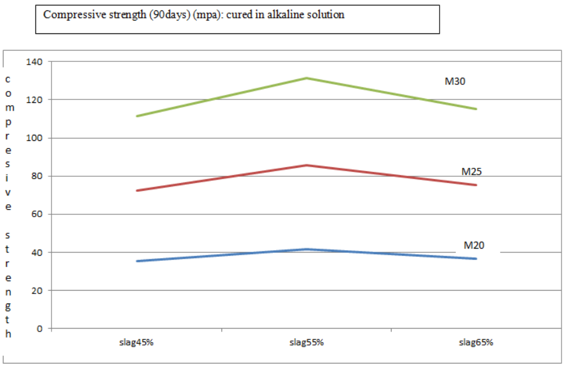
Graph No 2:compressive strength (90days) mpa;cured in base solution

Compressive strength (90days)mpa;cured in base solution



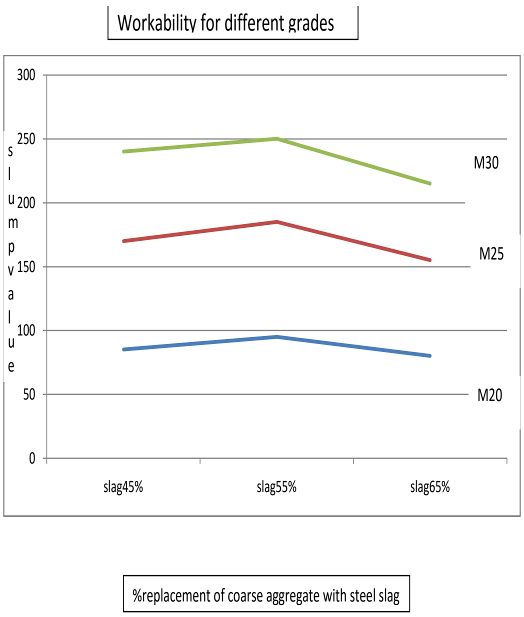
%replacement of coarse aggregate with steel slag

Graph No 3:Compressive strength (90days) (mpa) : cured in alkaline solution



%Replacement of coarse aggregate with steel slag

Graph No 4:Workability for different grades



6. CONCLUSION

- Workability was increased 20% at replacement of 55%slag with course aggregate when compared to conventional concrete . workability was decreasing with 45% and65% replacement of slag when compared to 55%.
- At55% replacement of coarse aggregate with slag the compressive strength was increasing 26%at 7daysand 41% at28days.compressive strength was decreasing with 45% and 65%relacement of slag when compared to 55%.
- At 55% replacement of slag with course aggregate the durability also increased 10%at 90days.when increasing of slag % the strength was decreasing.

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