Experimental Investigation on Partial Replacement of Steel Slag as Fine and Coarse Aggregate in Concrete Blocks

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Abstract - The amount of Steel slag consumed annually has been growing progressively in utilization. Consequently, slag waste usage has become one among the main challenges in recent times. The management and usage of slag waste is speedily growing because it may be a valuable resource of industries and its terribly unsafe substances and with low usage rate. The employment of slag waste materials may be a partial answer to environmental and ecological issues, because the use of plastic waste can reduce the mixture value and provides a good strength for the structures. It'll reduces the lowland value and it is energy saving. This study has chosen steel slag waste, to analyse its potential use as slag mixture in concrete application. The waste plastic was utilized in concrete with partial replacement of 21%, 23% and 25% by volume of standard coarse aggregate. The tests were conducted on block prepared with course aggregate, fine aggregate, steel slag, M-sand, and cement to their property i.e. compressive strength. 3 varieties of concrete specimens each type 3 blocks, for comparison purpose, were ready. All the concrete specimens were tested for its completely different mechanical properties after a curing period of 7 days. Moreover, it's complete that the utilization of steel slag in concrete provides some benefits like reduction within the use of standard mixture, disposal of wastes, prevention of environmental pollution, and energy saving.

***Key Words*: Steel slag, fine and coarse aggregate, partial replacement.**

1. INTRODUCTION

The wastes from the industries are the major problem in present condition. The recycling of all waste using recycling unit is economically facing many problems. The main objectives of this study is the partial replacement of Steel slag from the industrials to find the strength of concrete. The main objectives of this study is the partial replacement of Steel slag from the industrials to find the strength of concrete. Highquality slag concrete, which possess standard shape, sharp edges, smooth surfaces, high durability, and great strength, can be used for temporary structural construction such as roads prepared during construction work, parking tiles, etc.

Steel slag are used in concrete mix with different ratios. In this process to reducing constructional cost, reducing the environmental pollution and some of the general disposal methods are reduced.

2. OBJECTIVES

- To develop an alternative building material.
- To determine the compressive strength of concrete containing slag aggregate.
- To analyses the cost of concrete block using steel aggregate.

3. SCOPE

- Mix Design and casting methodology may be further improved and studied for future.
- Suitable admixture increasing the compressive strength may be studied.
- High-quality steel slag concrete, which possess standard shape, sharp edges, smooth surfaces, high durability, and great strength, can be used for temporary structural construction such as roads prepared during construction work, parking tiles, etc.
- Low-quality blocks or poorly mixed blocks are used as aggregate for foundation concrete and road metal works. This is because they can break easily and not suitable for construction purpose.

4. ADVANTAGES

The advantages of using slag in a concrete mix are as follows: enhancing the compressive strength of concrete due to the tendency of slow increase in compressive strength; increasing the ratio between flexibility and compressive strength of concrete; reducing the variation of compressive strength of concrete.

5. DISADVANTAGES

A disadvantage of slag is its greater weight compared to natural rock, and this has an impact on logistics and transport costs.

6. APPLICATIONS

- High-quality slag blocks, which possess standard shape, sharp edges, smooth surfaces, high durability, are often used for permanent structural construction.
- The Concrete Blocks are employed in many small Landscape Projects. as an example, in Outdoor Seating, Decorative Screen, Outdoor Bar, Flower Bed, many Outdoor Furniture.

7. MATERIALS USED

A) Steel Slag

Fig. 1. Steel slag

Steel slag can normally be obtained from slag processors who collect the slag from steel-making facilities. Slag processors may handle a variety of materials such as steel slag, ladle slag, pit slag, and used refractory material to recover steel metallic. These materials must be source separated, and well-defined handling practices must be in place to avoid contamination of the steel slag aggregate. The slag processor must also be aware of the general aggregate requirements of the end user.

B) M-Sand

Fig. 2. M-Sand

Manufactured Sand (M-Sand) is sand made from exhausting granite stone by crushing. The crushed sand is of cube like form with grounded edges. It is then washed and ranked with consistency to be used as a substitute of river sand as a construction material. Factory-made sand is an alternate for river sand, because of quick growing industry, the demand for sand has raise hugely, causing deficiency of appropriate river sand in most part of the globe.

C) Coarse aggregates

Fig. 3. Course aggregate

Coarse aggregates are irregular broken stone or naturally occurring rounded gravel used for preparing concrete. Materials that are large to be retained on 4.7 mm sieve size are referred to as coarse aggregates, and its maximum size will be up to 63 mm. They must be washed well before using in concrete. Aggregate is one amongst the foremost vital part components of the concrete. Coarse Aggregates offers volume to the Concrete. Coarse aggregates are used in every Construction projects which includes the development of roads, Buildings, Railway Tracks etc.

D) Cement

Fig. 4. Cement

Cement is a binder, a substance used for construction that sets, hardens, and adheres to alternative materials to bind them together. Cement is rarely used on its own, however rather to bind sand and gravel (aggregate) along, Cement mixed with fine mixture produces mortar for masonry, or with sand and gravel, produces concrete. Concrete is the most widely used material existing and is behind only water because the planet's most consumed resource.

E) Water

The water used for experiments was potable water Fresh portable water free from organic matter and oil is employed in mixing the preparation of plastic bricks. Water in required quantities were measured by graduated jar and added to the quarry dust and M-sand mix. The rest of the material for preparation of concrete was taken by weigh batching. The pH value shouldn't be less than 7.

8. METHODOLOGY

A. Steps followed for cube preparation for test

1) Preparing of material for Cube test

The material of M20 grade ratio 1:1.5:3 was brought and stored to an approximate temperature of 27 ±3 degree Celsius. Also our waste product i.e. waste plastic was brought. Water cement ratio for M20 grade of concrete we used is 0.42 for maintaining workability of concrete.

i. Mix ratio for 21% replacement of steel slag

Table 1: Ratio for 21% replacement

S. No.	Material	Weight (g)
1.	Cement	1500
2.	M - Sand	2250
3.	Course Aggregate	3555
4.	Steel Slag	945

ii. Mix Ratio for 23% replacement of steel slag

Table 2: Ratio for 23% replacement

S. No.	Material	Weight (g)
1.	Cement	1500
2.	M - Sand	2250
3.	Course Aggregate	3465
4.	Steel Slag	1035

iii. Mix Ratio for 25% replacement of steel slag

Table 3: Ratio for 25% replacement

S. No.	Material	Weight (g)
1.	Cement	1500
2.	M - Sand	2250
3.	Course Aggregate	3375
4.	Steel Slag	1125

2) Mixing of concrete

Hand mixing: The process is completed on the rectangular pan until a uniform mix is obtained. Cement must be uniformly mixed with a trowel so as there exist no lumps.

Dry mixing of fine aggregates and cement, addition of coarse aggregate and steel slag with the correct proportion, addition of m-sand and quarry, addition of calculated water in batch till consistency is achieved.

Fig. 5. Mixing of concrete

3) Casting of specimen

The casting mould was chosen made of cast iron and was rubbed with oil on inner side for easy removal of cubes. The specimen was casted in 3 layers (5cm each) and properly compacted in order to prevent honeycombing formation.

Fig. 6. Casting of Specimen

4) Compaction

Compacting was done through tamping bar, minimum 35 strokes was exhausted in all parts of a cube for correct compacting. This tamping bar has the dimension of diameter 16mm and length of 0.6m.

5) Age of test

The cube test for Compressive strength can be done on 7 days. In some cases, the strength of greater ages is required which is performed from 13 to 52 weeks. But we took cube test on 7th day after curing.

6) Number of specimens

It is necessary to have a minimum of 3 specimens for testing from different batches. The mean of compressive strength achieved by this specimen is employed to determine actual strength of the batch.

B. Procedure for Compressive strength of concrete or Cube test

1) Place the prepared concrete mix in the steel cube mould for casting.

2) Once it sets, after 24 hours remove the concrete cube from the mould.

3) Then specimen was kept in water for 7 days.

4) Ensured that concrete specimen was well dried before placing it on the CTM.

5) Testing specimens was placed in the space between bearing surfaces.

Fig. 7. Specimen placed on CTM

6) Care must have been taken to prevent the existence of any loose material or gritted on the metal plates of machine or specimen blocked.

7) The concrete cubes were placed on bearing plate and aligned properly with the center of thrust in the testing machine plates.

Fig. 8. Aligned specimen on CTM

Fig. 9. Failure/breakdown of specimen

8) The loading must be applied axially on specimen without any shock.

9) Due to the constant application of load, the specimen started cracking at a point and final breakdown of the specimen been noted.

9. CALCULATIONS AND RESULTS

A. Calculation Table after 7days

1) For 21% replacement of Steel Slag

Table 4: Calculation for 21% replacement

Details	For block 1	For block 2	For block 3
Test result (load)	48000 Kg	56000 Kg	54000 Kg
Compressive strength	20.92 N/mm^2	24.41 N/mm^2	23.54 N/mm^2

Calculation:

i. Compressive Strength of Concrete for block 1

= Load carried by block / Top surface area

= (48000 x 9.81) /150 x 150

= 20.92 N/mm^2

ii. Compressive Strength of Concrete for block 2

= Load carried by block / Top surface area

= (56000 x 9.81) /150 x 150

= 11.37 N/mm^2

iii. Compressive Strength of Concrete for block 3

= Load carried by block / Top surface area

= (54000 x 9.81) / 150 x 150

= 23.54 N/mm^2

Average Compressive Strength of Concrete for blocks

= 20.92 + 24.41 + 23.54 /3

= 22.95 N/mm^2

2) For 23% replacement of Steel slag

Table 5: Calculation for 23% replacement

Details	For block 1	For block 2	For block 3
Test result (load)	42000 Kg	41000 Kg	43000 Kg
Compressive strength	18.31N/mm^2	17.87N/mm^2	18.74N/mm^2

Calculation:

i. Compressive Strength of Concrete for block 1

= Load carried by block / Top surface area

= 42000 x 9.81 /150 x 150

= 18.31 N/mm^2

ii. Compressive Strength of Concrete for block 2

. = Load carried by block / Top surface area

= 41000 x 9 .81 /150 x 150

= 17.87 N/mm^2

iii. Compressive Strength of Concrete for block 3

= Load carried by block / Top surface area

= (43000 x 9.81) /150 x 150

= 18.74 N/mm^2

Average Compressive Strength of Concrete for blocks

= 18.31 + 17.87 + 18.74/ 3

= 18.30 N/mm^2

3) For 25% replacement of Steel slag

Table 6: Calculation for 25% replacement

Details	For block 1	For block 2	For block 3
Test result (load)	39000 Kg	38000 Kg	41000 Kg
Compressive strength	17.04N/mm^2	16.56N/mm^2	17.87N/mm^2

Calculation:

i. Compressive Strength of Concrete for block 1

= Load carried by block / Top surface area

= 39000 x 9.81 /150 x 150

= 17.04 N/mm^2

ii. Compressive Strength of Concrete for block 2

= Load carried by block / Top surface area

= 38000 x 9.81 /150 x 150

= 16.56 N/mm^2

iii. Compressive strength of concrete for block 3

= Load carried by block / Top surface area

= (41000 x 9.81) / 150 x 150

= 17.87 N/mm^2

Average Compressive Strength of Concrete for blocks

= 17.04 + 16.56 + 17.87 /3

= 17. 15 N/mm^2

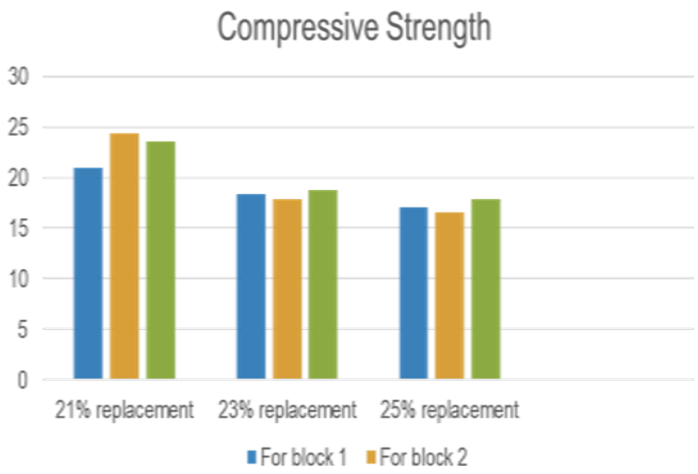

Fig. 10. Strength of blocks

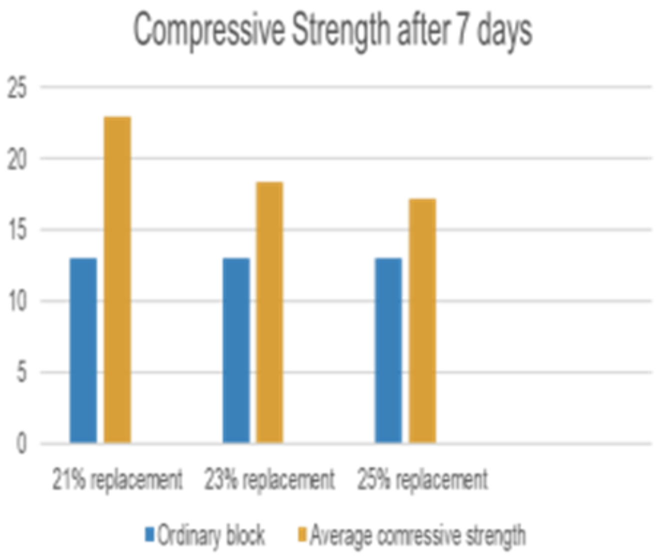

Fig. 11. Comparison between ordinary concrete block Strength and slag containing concrete blocks.

B. Results

1. Average compressive strength for 21% replacement of steel slag after 7 days = 22.95 N/mm^2

2. Average compressive strength for 23% replacement of steel slag after 7 days = 18.30 N/mm^2

3. Average compressive strength for 25% replacement of steel slag after 7 days = 17.15 N/mm^2

10. COST COMPARISON

Cost comparison for ordinary concrete and steel slag concrete (1m^3 volume):

Table No. 7 Cost comparison

Sr. No.	Details	Cost (Rs)
1	Ordinary concrete	4695
2	21% replacement of steel slag aggregate	4630
3	23% replacement of steel slag aggregate	4625
4	25% replacement of steel slag aggregate	4619

11. CONCLUSION

In this research, compressive strength has been investigated for various types of concrete containing 21%, 23% and 25% of steel slag aggregate by volume of course aggregate.

The following conclusions can be drawn based on the above report:

• The compressive strength of concrete containing different proportion of steel slag was different however the compressive strength at 21% volume of course aggregate provided higher strength that allowed it to be utilized in structural application.

• Steel slag are often used to replace a number of the aggregates in a concrete mixture.

• Cost of concrete containing steel slag is less as compare to ordinary concrete, so economy can be achieved as well as strength. So concrete containing steel slag is beneficial in strength and cost.

• Mainly, all the above are concluded that the steel slag are utilized in concrete mix with completely different ratios. During this method to reducing constructional cost, reducing the environmental pollution and some of the final disposal ways are reduced.

12. REFERENCES

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