International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 07 Issue: 12 | Dec 2020 www.irjet.net p-ISSN: 2395-0072

A INVESTIGATIONAL STUDY ON PARTIAL REPLACEMENT OF COARSE AGGREGATE AND FINE AGGREGATE WITH STEEL SLAG AND ECO-SAND

Saurabh S Utage[1], Prof. Gundappa Shete[2]

[1]M.Tech student, Civil Engineering, M.S.Bidve Engineering College, Latur, Affiliated to Dr.Babasaheb Ambedkar Technological University, Lonere, Approved by AICITE, Accredited by NAAC, Maharashtra, India
[2]Professor, Civil Engineering, M.S. Bidve Engineering college, Latur, Affiliated to Dr.Babasaheb Ambedkar Technological University, Lonere, Approved by AICITE, Accredited by NAAC, Maharashtra, India

---

ABSTACT: *Now a days, Concrete is the 2nd highest using material in the world. In concrete we use all-natural materials like coarse aggregate, fine aggregate, water and binder which is called cement. Due to continuous utilization of coarse aggregate and fine aggregates for concrete we are facing different problems like lack of availability of these materials due to this the price of natural materials are increasing rapidly. To overcome this problem many researchers are finding the replacement for coarse aggregate and fine aggregate, through the study it is found that a by product of steel making called as steel slag having properties similarly to the coarse aggregate can be used as partial replacement of coarse aggregate, this steel slag is used because when the steelmaking process is going through Electric Arc Furnace(EAF) due to this process the steel slag have a strong strength properties. And Eco-Sand is a by product of ACC Cement which is manufactured in Coimbatore, Tamil Nadu. The Eco-Sand having micro particles due to this the mixture of concrete becomes strong and workable, due to very micro particles the eco-Sand fill the air voids in concrete and hence it gives better strength. Now using this two materials as partial replacement of carse aggregate and fine aggregate we form a new concrete. The main moto of project is to increase the strength of the normal concrete by replacing coarse aggregate to Steel Slag and fine aggregate to Eco-Sand. Here coarse aggregate is partially replaced to Steel Slag in 10%, 20% and 30%, and fine aggregate is replaced to Eco-Sand in 25% permanently. After conducting various tests on replaced concrete we can conclude that replaced concrete gives high slump value, compression value, flexural value and tensile value. For making concrete we used a M30 GRADE of concrete and all the results are noted and compared with the conventional concrete and thus the replaced concrete gives better compressive strength more than (30mpa) than conventional concrete, and flexural strength, tensile strength are noted, and studied. From the tests results a Particular mix of 30% of Steel Slag to coarse aggregate and 25% Eco-Sand to fine aggregate gives the maximum strength.*

Key words: **Steel Slag, Eco-Sand, replacement of aggregates, strength comparison.**

1. INTODUCTION

Conventionally concrete is proper mixture of cement, sand and aggregate, water. The aggregates occupy the almost 60-75 percent of the total volume of concrete. To meet the global demand of concrete in the future life, it is necessary to use a for alternative material in construction which can fully or partially replace to natural aggregates without affecting their main constitutional properties. In concrete main role for making concrete durable is played by river sand i.e fine aggregate hence due to high demand of river sand the cost is also increasing. In this situation there is high demand for alternative or by-product materials in construction world. Hence an alternative material like utilization of Eco sand which is a by-product of ACC cement factory Coimbatore, Tamil Nadu, as this is a by-product of cement hence it have ability to bind the material properly because it have properties similarly to that of cement. This by product is very useful to fill the micro voids in concrete and make a concrete more workable which is not done by fine aggregate, and hence this amazing material Eco-Sand has been accepted as a building material in the industrial construction.

For replacement of coarse aggregate we use steel slag which is a by-product of steel making process. This steel is produces from a method called as Electric Arc Furnace (EAF) could be used as a partial replacement for coarse aggregate. If this materials having properties for making a good concrete then its utilization is must hence otherwise it will harm the nature. As this materials are been used for road pavements due to their mechanical strength, stiffness, porosity, wear resistance and water absorption capacity.

Due to such unique properties we can replace coarse aggregate and fine aggregate to steel slag and Eco-sand.

1.1 Scope of the Project:

Steel slag as partial replacement to coarse aggregate and Eco-sand to river sand shows economical, technical and energy saving benefits. To check its properties for concrete which is to be used for construction a study of all strength such as compressive strength, Flexural strength & Tensile strength is needed.

1.1.1 Scope:

The project aim is to compare the strength of conventional concrete and replaced concrete. By conducting compressive strength test, flexural strength test, Tensile strength, water absorption test and thus comparing the results obtained with normal conventional concrete using M30 grade of concrete.

- A much more extensive study on the properties and behaviour of concrete with eco-sand and steel slag can be made.
- Study may be done for higher grades of concrete because of their properties.

2. METHODOLOGY

2.1. MATERIALS COLLECTION AND PROPERTIES

2.1 Cement

The making process of PPC Cement is done by burning calcareous and argillaceous materials by partial fusion at a high temperature of about 1450ºC. The Portland Pozzolana Cement has been used. Brand used is Ultratech PPC Cement and it was conforming to IS:1489-1991.

Here PPC is used because it makes concrete more impermeable, denser, as compared to OPC. The strength for long term is more in PPC compared to OPC.

2.1.1 Physical Properties

Sr.no	Test Conducted	Results Obtained	Requirement as per IS
1	Specific Gravity	3.15	-
2	Normal Consistency	31%	-
3	Setting Time	initial 150 final 210	Min 30 Max 600
4	Fineness(kg/m3)	342	300
5	Soundness(mm) Le-chatelier test	1.00	10.0mm max

Table 2.1.1 physical properties of PPC cement

2.1.2. Chemical Composition Properties of PPC

S. NO	Characteristic	Required value
1	Total loss on ignition (%by mass)	Not more than 5.0
2	Magnesia (% by mass)	Not more than 6.0
3	Insoluble residue (% by mass)	Not more than x+4(1000 – x)/100
4	Sulphuric anhydride %	Not more than 3.5%
5	Total chloride content %	Not more than 0.10%

Table 2.1.2 chemical properties of PPC cement

2.2 Coarse Aggregate

Coarse aggregate is crushed stone which is locally available. The requirements follow IS 383-1970. And the test is carried conforming to IS2386 (part 1) 1963. The maximum size of C.A is 12.5 mm which is used and the physical properties are as follows.

2.2.1. Physical properties of Coarse Aggregate

Sr.no	Tests	Coarse aggregate (12.5mm down size)
1	Specific Gravity	2.68
2	Bulk Density Loose compacted	1350 kg/m3 1600 kg/m3
3	Fineness modulus	7.13
4	Moisture content	Nil

Table 2.2.1 Physical properties of Coarse Aggregate

2.3 Fine Aggregate

Fine aggregate plays the major role in making of concrete as it fills the space between coarse aggregate and cement. River sand is known as fine aggregate and it is locally available. The sand was washed and screened at site to remove deleterious materials and tested as per the procedure given in IS: 2386-1963 and the test results fill the requirement of IS 383-1970. The results are as follows.

2.3.1. Physical Properties of Fine Aggregate

IS sieve size	Percentage passing	Requirements for Zone 2 as per IS 383-1970	Remark
10mm	100	100	Samples of sand satisfy grading requirements for zone Fineness modulus 3.75 Specific Gravity = 2.63 Bulk density Loose = 1450kg/m3 Compacted = 1710kg/m3 Moisture content = nil
4.75mm	99.1	90-100	
2.36mm	94.3	75-100	
1.18mm	81.0	55-90	
600	46.4	35-39	
300	4.2	8-30	
150	0.2	0-10	

Table 2.3.1 physical properties of fine aggregate

2.4 Water

For preparation and curing of concrete potable water is used having pH value 7 as per IS 456-2000.

2.5. Steel slag

As the manufacturing of steel is wide in nature and hence while manufacturing steel their by-product is also obtained called as Steel slag. While manufacturing the steel there are different methods for making a steel one of the methods is Electric Arc Furnaces (EAF). As we know Steel slag is been used for road pavements due to their properties to resist higher load, we can use this material in construction industry as partial replacement of aggregates in concrete.

2.5.1. Physical properties

The slag have high bulk specific gravity and average water absorption (less than 3 percent).

Below Table 3.5.1 shows typical physical properties of steel slag.

Property	Value
Specific Gravity	3.2 – 3.6
Unit Weight, Kg/m3 (lb/ft3)	1600 – 1920 (100 – 120)
Absorption	Up to 3%

Table 2.5.1. Typical Physical Properties of Steel slag

2.5.2. Chemical properties

Steel slag chemical properties are studied and its chemical compositions are determined in terms of simple oxides which is calculated from elemental analysis by x-ray fluorescence. Following table shows the lists of compounds present in steel slag.

Constituent	Composition (%)
CaO	40 – 52
SiO_2	10 – 19
FeO	10 – 40 (70 – 80% FeO, 20 -30% Fe_2O_3)
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 2.5.2. Typical Steel Slag Chemical Properties

2.5.3. Mechanical properties

The slag has all mechanical properties which are required for construction including soundness, abrasion, and high bearing strength. Following table shows mechanical properties of slag.

Property	Value
Los Angeles Abrasion (ASTM C131)%	20 – 25
Sodium Sulfate Soundness Loss (ASTM C88)%	<12
Angle of Internal Friction	40 – 50
Hardness (measured by mohs scale of mineral hardness)	6 – 7
California Bearing Ratio (CBR), % top size 19mm (3/4 inch)	Up to 300

Table 2.5.3. Steel Slag Mechanical Properties

2.5.4. Steel slag Aggregate

Steel Slag is a by-product of steelmaking process. The thought of replacing to coarse aggregate is unique concept. Because of their mechanical strength, stiffness, porosity, wear resistance and water absorption capacity using of slag in construction industry is good. Following table shows the properties of slag aggregate.

S.no	Property	Value
1	Specific Gravity	2.61
2	Water Absorption	1.05%
3	Flakiness Index	8.5%
4	Elongation Index	4.5%
5	Impact Strength	19.5%
6	Crushing Strength	19%

Table 2.5.4. Steel slag aggregate

2.6 Eco-Sand

A by-product from cement manufacturing industry by semi-wet process Eco-Sand is formed which have very fine particles, it is a product by ACC cements Coimbatore Tamil Nadu. The micro-filling from eco-sand fill the pores in concrete and gives good moisture resistivity and durability. It has more consistent grading than many extracted aggregates. Due to this property we can replace river sand to eco-sand by 50%. Thus, use of eco-sand in construction industry saves the extraction of river sand and saves the nature, using eco-sand gives more sustainable structure.

Eco-sand has unique properties such as energy efficient, fire resistant, reduction of dead load, environmentally friendly, durable, light weight, low maintenance and low construction cost.

The cost of Eco-Sand compared to River sand is very cheap, yet its behaviour and characteristics is studied. Its specific gravity is 2.63 and the particle size is less than 15 µm sieve.

3. MIX PROPORTION

1. Cement = 500kg/m3
2. Water = 200kg/m3
3. Coarse aggregate = 1065kg/m3
4. Fine aggregate = 640kg/m3
5. W/C ratio = 0.40

4. EXPERIMENTATION AND TESTS RESULTS

The main moto of this experimental project is to study the strength related properties of concrete using steel slag and eco-sand. In this project study is done by replacing natural materials by by-product. It is found from the past researches that optimum replacement level of steel slag for cement is 0 to 30% by means of weight. So, in all the mixes fine aggregate was replaced with 25% of Eco-sand. The strength related properties such as compressive strength, flexural strength, tensile strength was studied. Minimum three specimens were tested for each mix for each test. The entire tests for concrete were conducted as per specifications required.

4.1. Test Result

4.1.1. Compressive Strength

The wooden cubes having size (150mm x 150mm) have been tested and the compressive test results are listed in the Table 4.1.1

Formula = $\frac{P}{A^2}$

4.1.2 Flexural Strength

The flexural strength test for beam having size (150 X 150 X 750 mm) has been carried out and the results are noted below in the Table 4.1.2.

Formula = $\frac{P\ x\ L}{b\ x\ d^2}$

4.1.3. Tensile Strength

The Split Tensile strength tests are done on cubes, and these cubes are placed on diagonal planes by applying compressive forces along two opposite edges & using formula = 0.5187 X $\frac{P}{S^2}$ results are noted in Table 4.1.3

Mix Combination	7days strength (Mpa)	28days strength (Mpa)
Control mix	20.71	31.92
Steel slag 10% and Eco-sand 25%	21.86	32.96
Steel slag 20% and Eco-sand 25%	22.59	33.88
Steel slag 30% and Eco-sand 25%	23.89	34.90

Table 4.1.1 Compressive Strength

Chart 1. Bar chart of Compressive strength

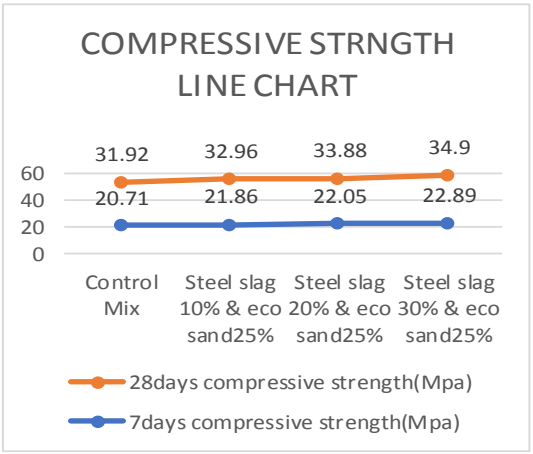

Chart 2. Line chart of Compressive strength

Mix Combination	Ultimate Load (KN)	Flexural strength at 28days strength (Mpa)
Control mix	31.06	4.15
Steel slag 10% and Eco-sand 25%	29.16	3.88
Steel slag 20% and Eco-sand 25%	31.67	4.22
Steel slag 30% and Eco-sand 25%	90.5	4.02

Table 4.1.2. Flexural strength

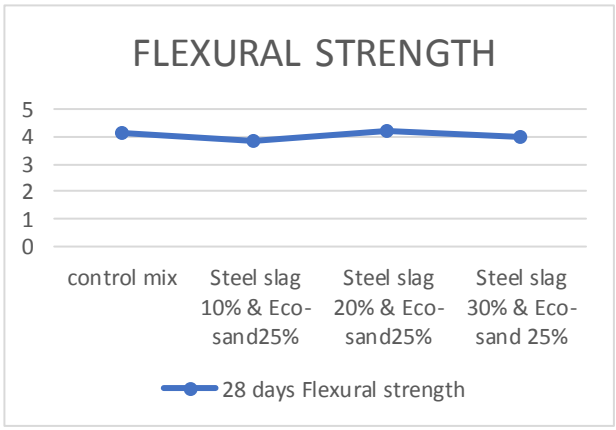

Chart 3. Line chart of Flexural strength

Mix Combination	Load on Cubes which is placed Diagonal (KN)	Tensile strength at 28days strength= 0.5187 X $\frac{P}{S^2}$ (Mpa)
Control mix	718.44	16.56
Steel slag 10% and Eco-sand 25%	741.72	17.09
Steel slag 20% and Eco-sand 25%	766.52	17.67
Steel slag 30% and Eco-sand 25%	785.62	18.11

Table 4.1.3 Tensile Strength

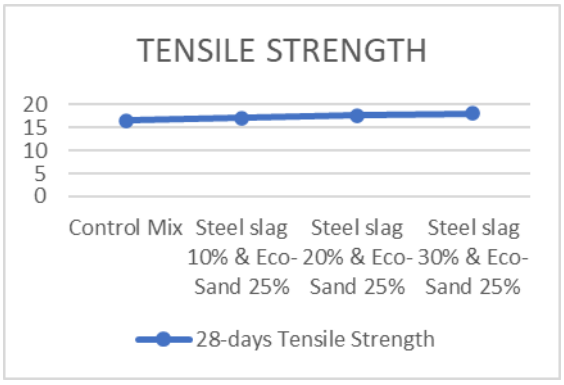

Chart 4. Line chart of Tensile strength

5. CONCLUSIONS

Following broad conclusions can be drawn from the experimental results obtained in this study.

1. By the addition of Steel Slag and Eco-Sand the slump value of the concrete is increased.
2. The presence of Eco-sand in concrete fill the voids which makes the concrete workable.
3. Optimum level of replacement of Eco-sand is found as 25%. Initially the strength of eco-sand is increased which is due to its particle size, which is very micro in nature.
4. Optimum level of replacement for steel slag is found as 30%. Strength is increased due to its shape.
5. The combination, 25% replacement of Eco-sand and 30% replacement of steel slag is fixed for study and it gave compressive strength of above 30Mpa for concrete mixes M30, flexural strength and tensile strength were also found to be comparatively good.
6. In comparison to Conventional concrete, the strength at 28days is increased by 8% by partial replacement of steel slag 30% & eco-sand 25%, in concrete mix having w/c ratio 0.4 and aggregate to cement a/c ratio 3.41.
7. The increase in strength for the replacement of coarse aggregate by steel slag up to 30% is due to shape, size and surface texture of steel slag aggregates, which provide better adhesion between the mixture of concrete.
8. From the test results obtained it may be concluded that Eco-Sand 25 & Steel slag 30 combination is the optimum and most suitable for areas not exposed to marine conditions.

6. REFRENCES

1. Abdulaziz I. Al-Negheismish, Faisal H. Al-Sugair and Rajeh Z. Al-Zaid (1996), 'Utilization of Local Steelmaking Slag in concrete for M20, M30, M40 grade of concrete', Journal of Environmental science of sustainable society, Vol. 1, pp. 39-55.
2. Anon. Steel Slag Has a Future on the Road. World Construction. 4, No. 3 (Mar. 1987), 36,38
3. An overview utilisation of steel slag, Sinosteel Wuhan safety & environmental protection research institute, China
4. Influence of steel slag on mechanical properties and durability of concrete, wang, Qiang Dept. of civil engineering, Tsinghua university Beijing china
5. Anastasiou E. and Papayianni I. (2006) Use of Steel Slag Aggregates in Concrete, Measuring, Monitoring and Modeling Concrete Properties.
6. Dubravka Bjegovic´, Goran Vrhovac, Ivanka Netinger, (2011) Utilization of steel slag as an aggregate in concrete.
7. EmeryJ.J(1980),Pelletized lightweight steel slag aggregate 'Journal of Environmental engineering, Vol. 24, pp 111-116.
8. Juan M Manso, Juan A Polanco, and Javier J Gonzalez (2004), 'Electric Arc Furnace Slag in Concrete', Journal of Materials in Civil Engineering, Vol. 16.pp 639-645.
9. IS: 2386:1963, Testing of aggregates for concrete, Bureau of Indian standards, New Delhi, India.
10. IS 10262: 1982 – Mix Proportion

11. IS 456-2000

BIOGRAPHIES

Saurabh Subhash Utage
Student of M.TECH (M.S.Bidve Engineering College Latur)

Prof. Gundappa Shete completed his M.E from M.S. Bidve Engineering college, Latur (Working as professor at M.S.Bidve engineering college, Latur)