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STUDY AND ANALYSIS OF CONCRETE BY REPLACING FINE AGGREGATES WITH WASTE FROM STEEL INDUSTRY.

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Abstract- **At the present time there has been a tremendous growth in demand for construction material due to rapid urbanization. Because of this the price of sand, specifically river sand is getting very high which increases the construction cost. Projects are getting stalled due to shortage of sand. The river banks are getting swallowed over the period of time due to excessive sand extraction from rivers. Moreover, the steel industry has a serious problem of proper management of waste produced in steel production process which could also result in causing serious health problems and environmental degradation. In this study, the effects of replacing fine aggregates by unprocessed steel slag and steel dust on the strength and workability of M25 grade of concrete having mix proportion of 1:1:2 with water cement ratio 0.48 by replacing sand with steel waste (slag and dust) in ratio of 10%, 20% and 30% by weight of sand is been investigated. The steel waste used as replacement for sand consist of 80% steel slag and 20% steel dust. The results obtained are analyzed and compared with a control specimen of 0% steel industry waste or standard M-25 concrete for effective study of variation of strength and workability. Eventually the study shows that there is a considerable increase in strength and decrease in workability. Concludingly steel waste can be used as a partial replacement option for sand in concrete but only up to a limited percentage of replacement.**

Keywords- steel slag, steel dust, concrete, compressive strength, flexural strength, workability, river sand, environment, waste management.

1. INTRODUCTION

In a fast-emerging economy like India which is developing at a tremendous rate, the need for new construction projects is increasing hastily for which there has been a growth in demand for construction material. Nowadays, everyone seems to be getting something constructed whether it be for public use or private use and for that the most widely used material is concrete. In fact, concrete is the second most consumed material in the world after water.With increasing demand of concrete in India the pressure on aggregate demand is also increasing, which put a great burden on natural resources like rivers to meet the sky touching demands of sand, which further results in the exploitation of natural resources that creates environmental problems. Construction industries of the country are in stress to identify alternative materials to replace the demand for natural sand which is not only costly and face shortage in most of the areas but also have concerning environmental impact. On the other hand, Steel which is also one of the important constituent in all of the civil engineering structures is produced in steel industries across the world. During the production of steel there is high quantity of steel waste generated. This waste generated during the production of steel is in different forms like steel slag and steel dust.Steel slag is a waste whose proper waste management is not practiced by the steel industries which is a thing of great concern of today’s world as the quantity at which it is been produced is very high. Even though steel dust is produced in lesser quantity as compared to steel slag but still this too don’t have any proper channel of waste management. Steel slag is generally used in landfilling in low level land in name of waste management but it further causes land pollution. So proper waste management of steel slag and steel dust is very important. In this research work the scope of using steel industry waste like steel slag and steel dust by partially replacing it with fine aggregates specifically river sand in concrete is been investigated. From eternity steel slag and dust generated by steel plants has been called “waste", but now this term can be replaced with “useful by-product” by re-utilization of these wastes.

2. LITERATURE REVIEW

2.1. The Authors, YerukondaSathiBabu, M. Lakshmi Kumar, M.K.M.V Ratnam Department of Civil Engineering DNR College of Engineering & Technology, Bhimavaram, Andhra Pradesh, India Studied the Mechanical Properties of Concrete by Replacing fine aggregate in different proportions with mild Steel Scrap with considerable water cement ratio in production of concrete. The experimental results show that the steel dross can be used as an aggregate for the production of high density concrete by replacing the fine aggregate in different proportions. The ductility in concrete also increases by almost 12%.

2.2. The authors, Prof. Pankaj BhausahebAutade, Hardeep Singh Jaswinder Singh Saluja of Department of Civil Engineering, P.D.V.V.P. College of Engineering, Ahmednagar, Maharashtra, India have attempted to use steel slag as a replacement of fine aggregate in M40 grade of concrete. Their research concluded that there is a considerable increase in compressive strength for 20% & 40% replacement; flexural strength and tensile strength had an increment of about 20% more than the required strengths.

2.3. The authors, S.T. Borole, R.V. Shinde, R.B.Mhaske, S.S.Pagare, K.S.Tribhuvan, N.M.Pawar, V.D.Tiwari, A.K.Sanehi, Department of civil engineering, MCERC, Nashik(India) in their research paper published in IJIRSE have worked on replacing steel slag with fine aggregates and have experimentally found the effect on compressive strength, flexural strength and tensile strength. They concluded that this replacement of fine aggregates with steel slag in pre-set percentages will not do any harm to concrete and also it will not have any adverse effects on the strength and durability, so it can be used in concrete as a replacement option of aggregates.

3. MATERIAL USED

3.1. Cement: The cement used in this study is Ordinary Portland Cement (OPC) of 43 grade manufactured by Ambuja cements ltd. conforming to IS:8112-1989. The cement is in dry powdery form with the good quality chemical compositions and physical characteristics. The cement used was free from any lumps and feels cool when touched with dry hands.

3.2. Fine aggregates: Fine aggregates used in this research is locally available natural river sand collected from Nud area of Samba District of Jammu and Kashmir, India, passing from 4.75mm sieve and being retained of 150-micron sieve. The fineness modulus of this sand sample was found to be 2.82.

3.3. Coarse aggregates: Coarse aggregates used in this study were angular crushed aggregates passing from 20mm sieve and being retained on 10 mm sieve of IS standards.

3.4. Water**:** Portable tap water from government water supply free from oil, silt or any harmful matter is used.

3.5. Steel slag**:** Steel slag used in this research work is obtained from Basic Oxygen Furnace (BOF) process of steel production and was blackish brown in colour, having rough surface and angular shape in appearance. Fineness modulus of steel slag used was found out to be 3.18. Chemical composition of steel slag falls under the range as shown in Table 1

Table 1. Chemical composition of steel slag

Constituents	**Composition (%)**
CaO	40-52
SiO_2	10-19
FeO	10-40
MnO	5-8
Al_2O_3	1-3
P_2O_5	0.5-1
S	<0.1
Metallic Fe	0.5-10

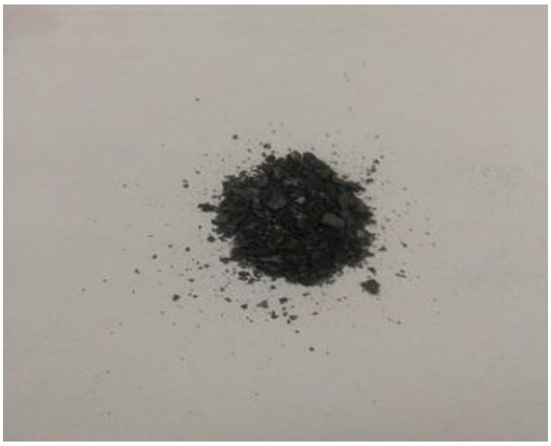


Fig. 1. Picture showing steel slag sample

***3.6. Steel dust*:** Steel dust used in this research work is the steel dust that is produced during cutting, grinding and finishing operations performed on steel in steel processing industry. Steel dust have fine particles and should be used carefully so that it is not inhaled while it is in dry powdered form which can creates respiratory problem to workers.

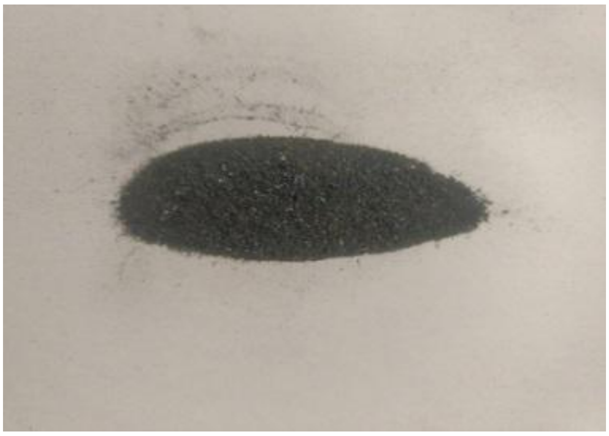


Fig. 2. Picture showing steel dust sample

4. METHODOLOGY

Standard concrete mix of M25 grade of proportion 1:1:2 i.e. one part of cement, one part of fine aggregates and two parts of coarse aggregates is prepared using fine aggregates passing from 4.75mm sieve and coarse aggregates passing from 20mm sieve and retained on 10mm sieve. Fine aggregates (river sand) is partially replaced with steel industry waste in proportion of 10%, 20% and 30% by its weight. To prepare this concrete mix water cement ratio of 0.48 was adopted in this study. Slump test on Freshly prepared concrete of different steel waste percentages was performed to check the slump values to determine the workability of concrete. Then concrete cubes of size 150x150x150mm are casted with concrete having various steel waste replacement percentages and of standard concrete mix of M25 grade so that their strength values can be compared with standard M25 grade concrete cubes.

Table 2. Proportion of steel slag and steel dust in the total steel waste added

Total steel waste replacement with sand in %	Percentage of steel slag (of total sand)	Percentage of steel dust (of total sand)
0%	0%	0%
10%	8%	2%
20%	16%	4%
30%	24%	6%

As the quantity of steel slag produced by steel industry in much higher than that of the steel dust produced. Steel dust produced is very less as compared to the steel slag produced as steel industry waste so I have taken 80% of the total waste added in concrete as steel slag and 20% of the total steel waste added in concrete as steel dust.

5. EXPERIMENTAL TESTING AND RESULTS

5.1. Slump Test: Slump test was performed to determine the workability of freshly prepaid concrete mix. Standard slump cone of 30cm base diameter, 10cm top diameter and 20cm height was used to perform slump test. The slump values of all concrete mixes i.e. with 10% replacement of sand with steel waste, 20% replacement, 30% replacement and standard M25 concrete mix with 0.48 water cement ratio was found out so that it could be compared with each other especially with the standard specimen. The results of slump test values are shown in the table 2 bellow

Table 3. Slump Value

S.NO	Percentage of Replacement	Slump Value in mm
1	0% (Standard)	110
2	10%	106
3	20%	102
4	30%	95

5.2. Compression Test: The Compression test was carried out to find out the compressive strength of the concrete cubes having different proportion of partial replacement of steel waste with sand in concrete. M25 concrete mix of ratio 1:1:2 is prepared by partially replacing fine aggregates with steel industry waste by 0% (standard M25 concrete) replacement, 10% replacement, 20% replacement and 30% replacement. Then this freshly prepared concrete is casted into cubes of size 150x150x150mm and after 24 hours of casting these cubes are stripped off from their moulds and left in curing tank submerged in water for curing purpose. These cubes are taken out after 7days, 14days and 28 days for compression testing of specimens in Compression Testing Machine, the specimen were subjected under pure axial compression. Tables below shows the results obtained performing this test on different concrete cube specimen on different time span of 7days,14days and 28days.

Table 4 Compressive strength 7 days

S.NO	Percentage of Replacement (in %)	Compressive Strength (N/mm2)
1	0%	20.38
2	10%	22.66
3	20%	24.10
4	30%	19.71

Table 5 compressive strength 14days

S.NO	Percentage of Replacement (in %)	Compressive Strength (N/mm2)
1	0%	26.28
2	10%	27.68
3	20%	30.30
4	30%	25.59

Table 6. Compressive strength 28days

S.NO	Percentage of Replacement (in %)	Compressive Strength (N/mm2)
1	0%	29.01
2	10%	30.54
3	20%	33.32
4	30%	27.78

5.3. Flexural Test: Flexural test is performed on concrete to find out its flexural strength which is an indirect method to find the tensile strength of concrete. As we know concrete is not good in taking tensile load as compared to its ability to with stand the compression load acting over itand concretes tensile strength is almost ignored while designing a concrete structure. To perform this test, beams of size 100x100x500 were casted and flexural strength was found at interval of 7 days, 14 days and 28 days by performing two-point flexural test on different flexural beam specimens using flexural testing machine. Table below shows the values of flexural strength obtained after conducting this test.

Table 7 Flexural Strength of different specimen in N/mm2

Percentage of replacement	7Days	14Days	28Days
0%	2.49	3.62	4.90
10%	2.67	3.83	4.96
20%	2.88	4.07	5.12
30%	3.02	4.21	5.38

6. RESULTS AND GRAPHICAL REPRESENTATION

6.1. **Slump Values**:Slump values which indicates the workability of fresh concrete were determined by performing slump test on different concrete mixes having different proportion of replacement of fine aggregates with steel waste and on standard M25 concrete mix so that these values of slump can be compared with the slump values of standard mix without any replacement.

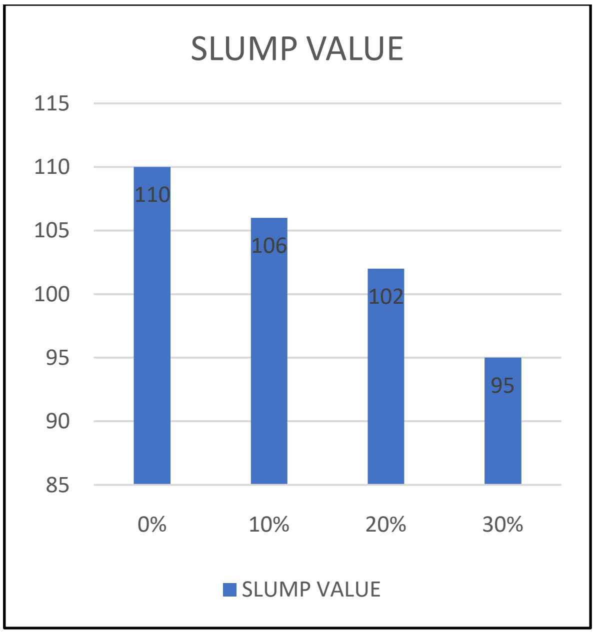


Fig. 3. Slump Values

6.2. Compressive Strength Values:Concrete is a composite material which shows brittle behaviour. Concrete has ability to withstand heavy compressive loads but fails miserably when subjected to tensile forces for which steel is provided with concrete in structure so that it can bear both compressive and tensile force acting over it. Therefore, the main purpose of concrete in structures is to take the compressive loads so it should have adequate compressive strength which is the foremost criteria to check the Strength of concrete. The compressive strength of concrete was determined by performing the compression test of concrete sample of different replacement proportions. The values of result found from compression test is represented below

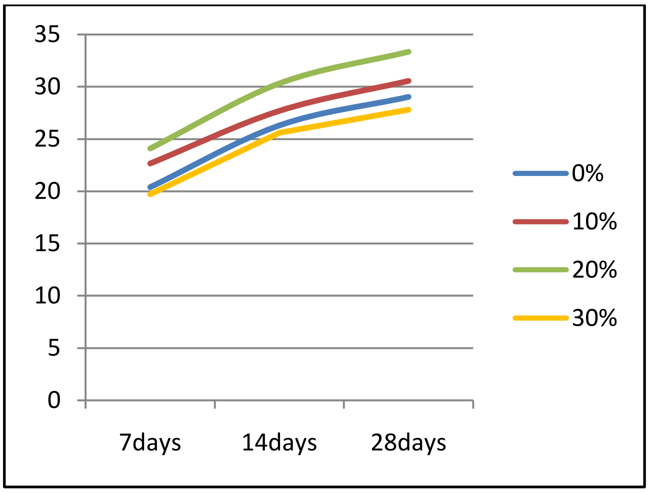


Fig. 4. Graph comparing compressive strength in N/mm2

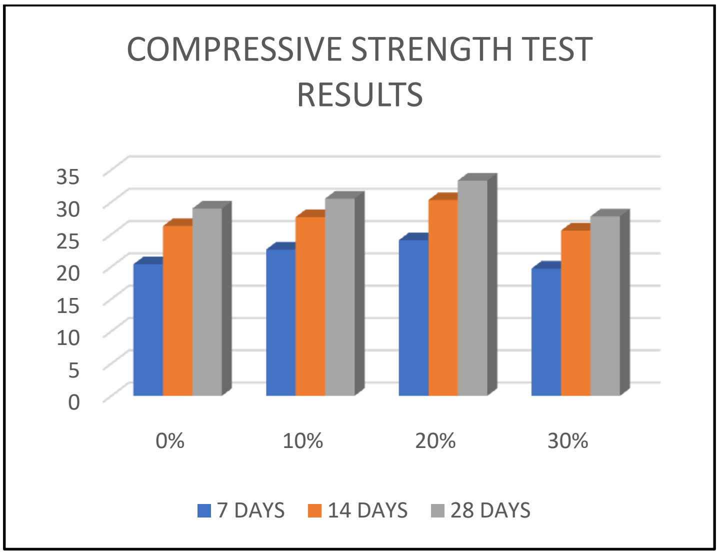
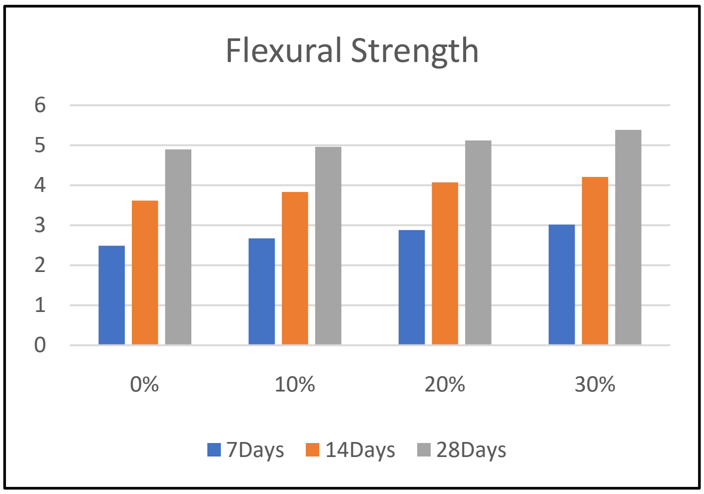


Fig. 5. Bar Chart showing compressive strength in N/mm2

6.3. Flexural strength values: We already know that concrete does not have that much ability to withstand high tensile force. It can take tensile forces up to a very small amount that is why steel reinforcement is provided in RCC structures. The Flexural strength of concrete was found by performing flexural strength test on concrete beam specimen of different replacement proportions, which is an indirect method of finding tensile strength of concrete. The values of result found from flexural test is represented below by a bar chart.

Fig. 6. Bar chart comparing flexural strength



7. CONCLUSIONS:

i. Steel slag can be used a replacement material in place of natural sand in concrete but in a controlled amount in well-defined replacement percentages to achieve better values of compressive strength.

ii. Workability of concrete decreases with the increase of percentage of replacement of fine aggregates with steel waste as indicated by slump test. This could be due to higher roughness and highly angular particles of steel slag.

iii. The optimum value of compressive strength was achieved on 20% replacement of fine aggregates with steel waste.

iv. The compressive strength of concrete specimen having 20% of replacement of river sand with steel slag and steel dust at age of 28days increases by about 15% as compared to 28days strength of standard specimen having no replacement with steel slag.

v. The compressive strength of concrete specimen having 20% replacement of river sand with steel slag and steel dust shows increase in compressive strength by about 33% as compared to the characteristic strength of M25 concrete according to IS 456:2000.

vi. The Flexural strength of concrete increases by adding steel waste but the rate of increase of flexural strength decreases as the quantity of steel waste is increased.

vii. The Flexural strength at 28 days of sample having 30% replacement of sand with steel waste shows a increase by about 9.79% as compared to sample have no steel waste or standard M25 concrete sample.

viii. The study concludes that steel slag and steel dust which are waste from steel industry and don’t have any environmental friendly way of disposal can be used in construction industry in concrete and can also increase the strength of concrete.

ix. This study displays a twofold convenient method of using steel industry waste which can help in both eco-friendly waste management and increasing strength of concrete by also conserving natural river sand to some extent.

8. REFERENCES

[1] YerukondaSathiBabu; M. Lakshmi Kumar; M.K.M.V Ratnam (2015) “A Study on Mechanical Properties of Concrete Replacing Fine Aggregate with Steel Scrap”,International Journal for Innovative Research in Science & Technology| Volume 2, Issue 07, pp-26-28, December 2015.

[2] Caijun Shi. (2004), “Steel Slag-Its Production, Processing, Characteristics, and Cementitious Properties”,Journal of Materials in Civil Engineering,Vol. 16, Issue 3 pp-230-236(June 2004).

[3] Prof. Pankaj BhausahebAutade; Hardeep Singh; Jaswinder Singh Saluja (2016) “Effect of Steel Slag as a Replacement of Fine Aggregate in M40 Grade of Concrete”, International Journal of New Innovations in Engineering and Technology Volume 5 Issue 4– pp-17-26, August 2016.

[4] S.T. Borole; R.V.Shinde; R.B.Mhaske; S.S.Pagare; K.S.Tribhuvan; N.M.Pawar; V.D.Tiwari; A.K.Sanehi.(2016) “Replacement of fine aggregate by steel slag”, International Journal of Inovative Research in Science and Engineering Vol 2 Issue 03,pp 628-635,March 2016.

[5] D. K. Ambasta, Bikas Pandey; NabarunSaha .“Utilization of Solid Waste from Steel Melting Shop”, MECON Limited, Ranchi -834002, India.

[6] M L Gambhir “Concrete Technology Theory and Practise”, Tata McGraw-Hill Education, 2009.

[7] IS383-1970 “Indian Standard specification for coarse and fine aggregates from natural sources for concrete”, Bureau of Indian Standards.

[8] IS 456: 2000, “Plain & Reinforced Concrete code of Practice” Bureau of Indian Standards.

[9] IS: 516 – 1959 (Reaffirmed 2004) “Methods of Tests for strength of concrete” Bureau of Indian Standard