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Experimental Study on Strength of Concrete Using Industrial Steel Slag

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Abstract: ***Concrete is the most widely used construction material all over the world. It is difficult to find out alternate material for construction which is as suitable as that of such a material from durability and economic point of view. In this project work, sand is partially replaced by industrial steel slag to compare the compressive strength of concrete with conventional concrete for the different curing period i.e. 3, 7 and 28 days. This project was done in three phases. In first phase fine aggregate was replaced by 10% of industrial steel slag. In second phase fine aggregate was replaced by 15% of industrial steel slag and in third phase 20% fine aggregate was replaced by industrial steel slag for M_{30} grade of concrete. This paper presents an experimental investigation carried out to study the effects of industrial steel slag as a replacement of sand on strength development of concrete and optimum use of slag as a substitute material in concrete. In this study, concrete of M_{30} grade were considered for a W/C ratio of 0.45 with the targeted slump of 100±25 for the replacement of fine aggregate with that of industrial steel slag. These concrete mixes were studied for the properties like compressive strength.***

Keywords: Compressive strength, steel slag, Concrete, Sand, Slump

I. INTRODUCTION

As a construction material, concrete is the largest production of all other materials. Aggregates are the important constituents in concrete which give the body to the concrete. In a concrete, aggregate is the main ingredient which occupies 70% to 80% of volume of concrete. In whole world we have used natural river sand and gravels in concrete manufacturing. Fine aggregate is essential component of concrete. The consumption of the natural river sand is very high due to excess use of concrete. The demand of natural river sand is quite high due to infrastructure growth. In this situation there is a shortage in the supply of natural river sand and due to demand it becoming costly. Now a day's waste material management has become one of the challenging problems in India affecting the environment. The problems of disposing & managing solid waste materials in all countries have become one of the major environmental, economical and social issues. The aim of project work is developing materials that can partial replace the conventional aggregate in concrete work like an industrial steel slag. Steel slag is selected due to its characteristics and easily obtainable as a by-product of steel manufacturing industry. Utilization of steel slag will save natural resources and clean environment. The purpose of this project is to evaluate possibility of using industrial steel slag waste materials to partial substitute for the fine aggregate (sand) in concrete composites. Use of steel waste materials in a concrete as a fine aggregate to improve the properties of concrete. Use of steel slag has a dual advantage cost of material is low also it solve the problem of disposal. Base on overall project, it could be recommended that steel slag could be effectively utilized as a fine aggregate in concrete application

A. Objective of Work

1) Find out partial substitute for the fine aggregate (sand) in concrete composite.
2) To determine the percentage of industrial steel slag which gives more strength when compared to conventional concrete.
3) Comparison of cost analysis between sand and industrial steel slag.
4) To reduce the impact of waste material (industrial steel slag) on environment.

II. MATERIAL AND PROPERTIES

A. Industrial steel slag

The steel slag used in this project collected from Uttam Galva Steel Plant, Bhugaon Wardha. The steel slag is crushed to get the desired size of aggregates. The slag had greyish white colour. Chemical analysis of steel slag usually show that four major oxides (lime, magnesia, silica and alumina). Minor elements include sulphur, iron, manganese, alkalis and trace amounts of several others. The chemical composition of steel slag is dependent upon the composition of the available iron ores, flux stones, fuels and on the proportions required for efficient furnace operations.

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TABLE I- Chemical composition of steel slag

Constituent	Weight Percent
Lime (CaO)	32-34%
Silica (SiO_2)	32-35%
Magnesia (MgO)	9-11%
Alumina (Al_2O_3)	18-21%
Iron Oxide (FeO)	< 1%
Manganese oxide (MnO)	< 0.5%
Sulfur (S)	< 1%
Basicity	0.9-1.1%
Glass Content	90% min
Moisture	12%

Figure 1- Industrial Steel Slag

B. Cement

Ordinary Portland cement (OPC) of 43 grades having specific gravity 3.15 and fineness 10.80 was used.

C. Fine Aggregate (River Sand)

Natural river sand passing through the 4.75mm sieve are used. The sieve analysis of sand is carried out to know the zone of sand. From the sieve analysis result, the fineness modulus of sand is found to be 3.49. This shows that the sand falls under the zone-II. Specific gravity of sand was found to be 2.61.

D. Coarse Aggregate

Crushed granite coarse aggregates of maximum 20 mm size are used. Aggregates are the important constituent in concrete reduce shrinkage and effect economy. The fineness modulus of coarse aggregate is 4.46.

E. Water

The water having P_H value of 7±1 and confirming to the requirement of IS 456:2000 was used for mixing concrete and also for curing.

III.MIX DESIGN

The food The mix proportion is made by using IS-10262:2009. Mix design for M_{30} grade of concrete is prepared for W/C ratio 0.45.

Specific gravity of cement = 3.15
Specific gravity of coarse aggregate = 2.65

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Specific gravity of fine aggregate = 2.61

TABLE III-Mix Proportion

Cement	FA	CA	Water
1	673.29	1073.35	197
1	1.573	2.45	0.45

Total three mixes were made by replacing the fine aggregate with industrial steel slag keeping water cement ratio is constant for replacement of 10%, 15% and 20%.

IV. METHOLOGY

A. To collect the industrial steel slag material from a local steel manufacturing industry.
B. To perform the preliminary tests on all the constituent materials.
C. To design a concrete mix for M_{30} grade using IS 10262:2009
D. Casting of standard cubes for checking the compressive strength for a curing period of 3 days, 7 days and 28 days.
E. Experimental validation for comparing the strength efficiency with different proportions.
F. Cost analysis to compare the unit rates for an optimized mix.
G. Analysis of results and conclusion

V. EXPERIMENTAL SET UP

The experimental program consists of following steps:

A. Collection of material.
B. Casting
C. Curing
D. Testing

The test were carried out according to IS standard. The aggregates were tested for physical properties such as specific gravity and particle distribution test (sieve analysis). The concrete was subjected to the slump test followed by casting of concrete. All the mixes were prepared by mixing the concrete in laboratory transit mixer. 12 no's. cubes Specimens of 150mm X 150mm X 150 mm size for compressive strength were prepared. All the cubes de-mauled after 24 hours and put into the water tank for curing maintaining temperature as per IS requirement. The set of cubes were tested for compressive strength at 3 days, 7 days and 28 days using compressive testing machine.

Figure 2- Casting of cubes and curing tank

VI. RESULT AND DISCUSSION

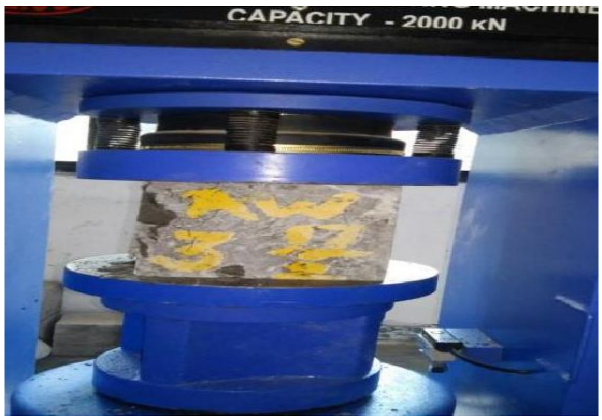

Figure 3- Compressive Testing Machine

Slump value for conventional concrete is 90. Addition of industrial steel slag as a replacement of fine aggregate gives effect on workability. The Following graph shows the comparison of compressive strength of concrete between 0%, 10%, 15% and 20% replacement of steel slag for 3 days, 7days and 28 days

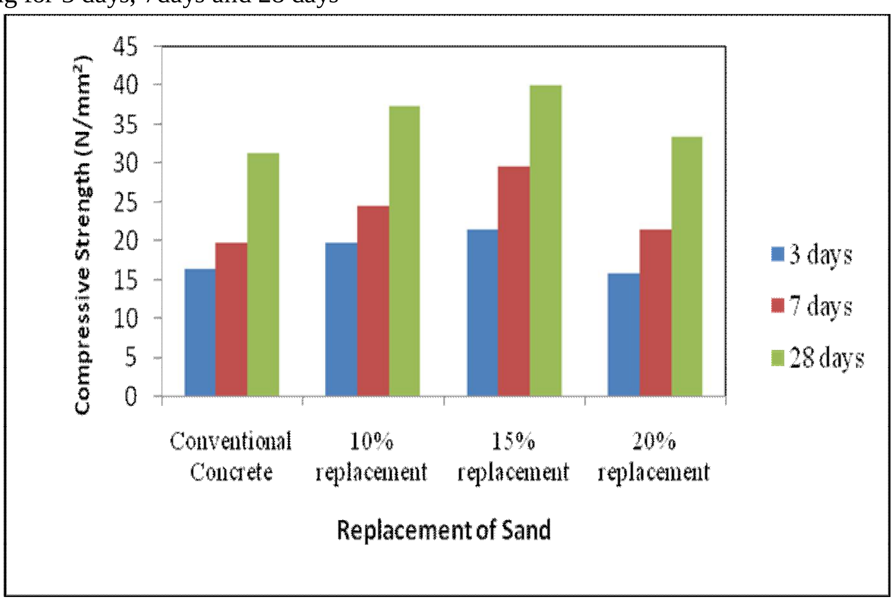

Figure 4- Comparison of compressive strength (N/mm^2)

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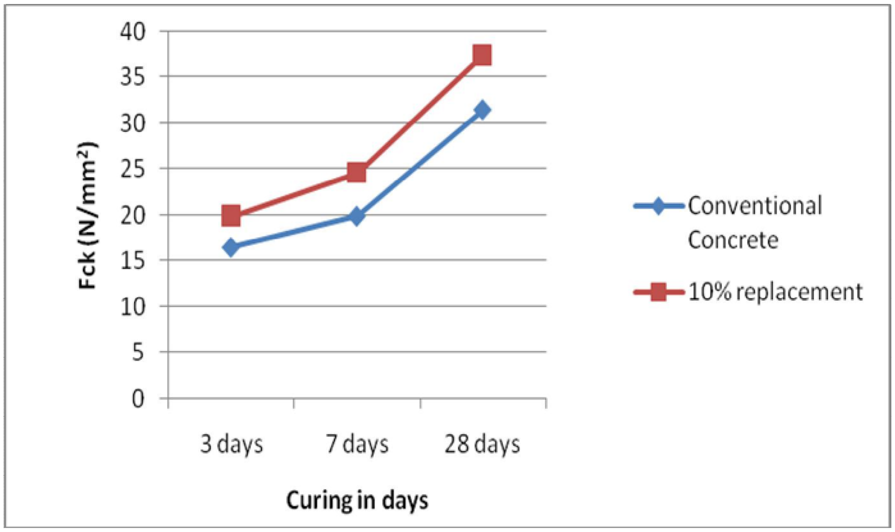

Figure 5- Comparison of compressive strength between conventional concrete and 10% replacement

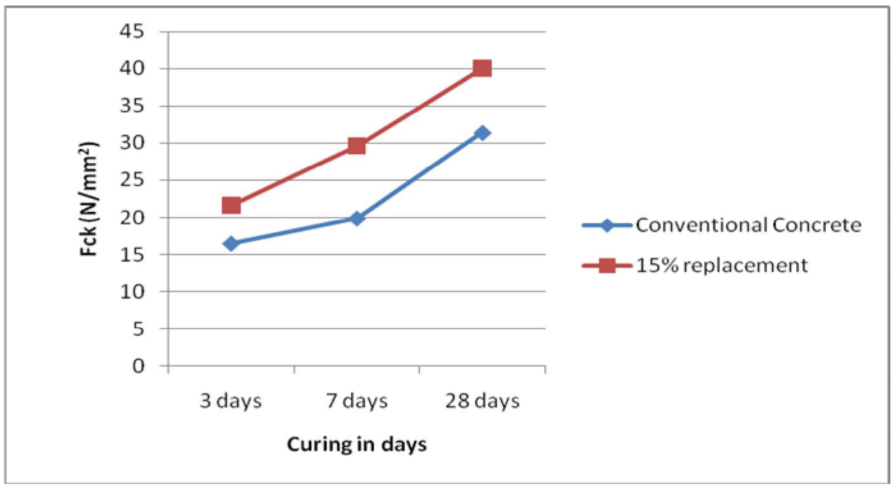

Figure 6- Comparison of compressive strength between conventional concrete and 15% replacement

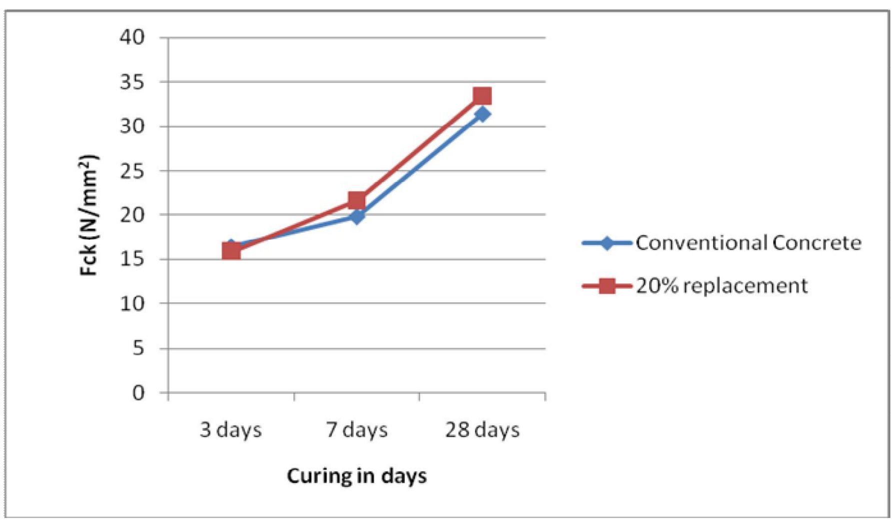

Figure 7- Comparison of compressive strength between conventional concrete and 20% replacement

VII. CONCLUSION

A. From this project work, we are concluded that

1) Compressive strength of 10% and 15% steel slag included concrete is higher than conventional concrete. The compressive strength for 28 days is more than 3 and 7 days respectively.
2) Compressive strength of 20% steel slag included concrete for 3 days is slightly less as compare to conventional concrete hence it is failed
3) The compressive strength of concrete achieved in 20% replacement of sand by industrial steel slag for 7 & 28 days are higher as compare to conventional concrete hence there are chances to replace more quantity of sand by industrial steel slag.
4) The Maximum average compressive strength of concrete achieved in 15% replacement of sand by industrial steel slag as compared to 10% & 20% replacement of sand.
5) The cost of industrial steel slag is low as compare to the fine aggregates hence it is economical to use the industrial steel slag.
6) In plane concrete application, it could be recommended that industrial steel slag could be utilized as fine aggregate

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