

Study of SCC with Partial Replacement of Fine Aggregate with Steel Mill Scale

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Abstract— The current study investigates whether steel mill scales, which are byproducts of the steel industry, could be used in building in place of sand. Although it is well recognized that steel mill scale harms the environment, it can be utilized to replace fine aggregates in the construction industry. The study focuses on adjusting the weight-based proportion of steel mill scale substitution in M30 grade concrete (0%, 10%, 15%, 20%, and 25%) and contrasts the outcomes with Self Compact Concrete M30 grade. The concrete's micro structural features as well as its compressive strength were evaluated. Through micro structural analysis, the study also explores how steel mill scale and concrete interact.

Index Terms— Steel Mill Scale, Fine Aggregate, Sand Replacement, Green Concrete, Self compact concrete.

I. INTRODUCTION

Steel mill scale - Iron makes up the majority of this waste product, which has an iron content that ranges from 60 to 70%. Due to the high quantity of iron present in it, this material is primarily employed by the cement manufacturing sector as one of the cement compositions. Despite the fact that it is used in the cement manufacturing sector, the waste is not fully utilized since the output of steel mill scale is at an extremely high level while the consumption of steel mill scale in the cement industry is quite minimal. Due to its high metal content, putting this waste product on land will result in environmental risks and soil degradation. Therefore, alternate uses of steel mill scale must be investigated. Steel mill scale is partially employed as fine aggregate in this operation.

1.1 STEEL MILL SCALE

Each year, around 13.5 million tones of mill scales are produced worldwide. This is one of the waste products generated during the steel-making process. This substance appears to be a blue black color. Iron is the primary component of mill scale. Steel mill scale

mostly consists of aluminum and silicon, with traces of manganese, nickel, and chromium also present.



Fig. 1 Steel Mill Scale

1.2 SELF COMPACT CONCRETE

Self-compacting concrete (SCC) is concrete that can flow under its own weight, completely fill a hole or formwork, and produce a dense, sufficiently homogenous material without the need for vibration compaction. Construction projects including repairs, restoration, and renewal require SCC. With the use of SCC, retaining walls are built that are extremely sturdy and long-lasting. Construction of raft and piling foundations makes use of SCC.

II. OBJECTIVES

The project's objective is to carry out experiments and evaluate the outcomes in order to determine the physical properties of steel mill scale. The project's main goal is to make Self Compacting Concrete stronger by adding admixtures like Glenium 233-B. In this study, the properties of self-compact concrete with steel mill scale are examined both while it is fresh and when it has hardened. This study's primary goal is to find the best partial replacement for steel mill scale in self-compacting concrete. Also studying the microstructure properties of concrete.

III.RESULTS AND DISCUSSION

1. Physical Character of mill scale
2. A lab test using a sieve to analyze the particle size distribution of steel mill scale was conducted. The IS 2386 (Part-1) - 1963 (Method of Testing for Aggregates for Concrete) was taken into consideration for the test to assure accuracy and standards. Additionally, the result values are checked to make sure they fall within the acceptable range according to standards using Indian Standard 2116 - 1980, Specification for Sand. The findings of the sieve analysis were displayed in table 1 together with the acceptable values in line with Indian Standard.

Table – 1: Steel Mill Scale - Sieve Analysis.

IS Sieve Size (mm & Micron)	Weight Retained (g)	Percentage of weight Retained (%)	Cumulative Percentage of Retained (%)	Cumulative Percentage of Passing (%)	Allowable Cumulative Percentage of Passing (%)
4.75	0	0	0	100	100
2.36	50	10	10	90	90-100
1.18	80	16	26	74	70-100
600	120	24	50	50	40-100
300	185	37	87	13	5-70
150	60	12	99	1	0-15
75	5	1	100	0	-

According to the results of the sieve analysis test, this material can be used as a placement material for fine aggregate since the allowable limit in line with IS 2116 - 1980 matches with steel mill scale. Not only does the significant feature depend on the material's particle size distribution, but also on its specific gravity.

A. Specific gravity

The density of the substance has an indirect link with specific gravity. The compressive strength of the concrete will be lessened if the material has a very low density, which will also affect the sand density. And as a result of the material's extremely high density, concrete will become even denser and heavier, increasing the building's dead load in the process. However, the high-density material can be utilized to create high-density concrete, which has a number of uses, including pavement concrete and gravity dams. The test method for testing the aggregates used in concrete is outlined in Indian Standard 2386 (Part-III) - 1963, Methods of test for aggregate for concrete.

Additionally, this test is carried out in compliance with the aforementioned code.

According to the test results, the steel mill scale has a specific gravity of 6.1 and a water absorption rate of 0.806 percent. Sand has a specific gravity of 2.74 whereas steel mill scale has a specific gravity of 6.1, meaning that the density of the concrete will be higher than that of controlled concrete. Table 2 presents the test findings.

Table – 2: Specific gravity test - Pycnometer.

Key	Weight (g)
Surface Dry Sample	500 g
Water + Sample + Pycnometer	1963
Water + Pycnometer	1549
Oven Dry Sample	494

B. Compression Test

For experimentation purpose, Totally 24 cubes are cast in the M25 grade of concrete is used with partial replacement of steel mill scale in increment of 5 percent from 0% up to 35%. The specimens are cast for 150 X 150 X 150 mm³. All 24 casted cubes are cured for 28 days and after curing of cubes, it is subjected to testing. The testing observations are tabulated in table -3.

Table – 3: Observation for Compression Test

S.No	Percentage of Mill Scale %	Strength on 28 days of Curing (N/mm ²)	Mean Strength (N/mm ²)
Cube No 1	0	39.3	38.54
Cube No 2		37.6	
Cube No 3		38.5	
Cube No 4	10	38.2	38.90
Cube No 5		39.5	
Cube No 6		38.8	
Cube No 7	15	50.3	45.45
Cube No 8		40.5	
Cube No 9		45.4	
Cube No 10	20	35.1	36.70
Cube No 11		38.2	
Cube No 12		36.6	
Cube No 13	25	41.3	40.08
Cube No 14		38.7	
Cube No 15		40.7	

IV.CONCLUSION

Specimens were cast for the control mix and mixes that were substituted with steel mill scale percentages varying from 0%, 10%, 15%, 20% and 25% in order to study the influence of steel mill scale as a replacement for fine aggregate. The investigation's findings led to the following conclusions:- The inclusion of steel mill scale reduces the workability of concrete. It's because the size of fine aggregate particles has been reduced, increasing the specific surface and raising the water consumption as a result. It has been determined that the use of steel mill scale in place of fine aggregates in concrete is practical for real-time implementation.

The compressive strength of the M30 grade concrete is increased by partially replacing sand with steel mill scale. Optimized strength is gained when 15% of sand is replaced with steel mill scale. And when steel mill scale is replaced with sand the strength of the concrete is increased to 1.15 times of controlled concrete. (The Strength of Controlled Concrete Cube is 38.54N/mm^2 , 15% partially replaced steel mill scale concrete attains 45.45N/mm^2) Self-compacted concrete's compressive strength could be increased by substituting steel mill scale for fine aggregate.

When compared to replacement levels of 0%, 10%, 15%, 20%, and 25%, the micro-structural performance of concrete built with 60% replacement of fine aggregate with steel mill scales is better. Because it was tightly packed and free of pores, the concrete prepared with 15% steel mill scale performs better in tests of strength.– Since the steel mill scale particles are totally enclosed in the concrete matrix, there won't be any problems about durability, making it possible to use it practically to achieve economic and environmental sustainability. Conducting comprehensive durability testing will reveal more information about durability.– Based on the findings, it is suggested that steel mill scale be utilised in concrete to enhance its mechanical and microstructural qualities because it is environmentally safe and widely available.

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