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Effect on Mechanical Properties of Concrete Using Mill Scale as a Partial Replacement of Fine Aggregate

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***Abstract*—Concrete is very popular construction material in the world. Globally, over 10 billion tons of concrete produces each year which require enormous amount of natural aggregate which leaves substantial mark on the environment. In this study, the characterization of mill scale was performed to study the physical and chemical properties. The X-ray analysis showed that mill scale consists of a large fraction of Fe_2O_3. Later, the fine aggregates in concrete were partially replaced with the mill scale by mass in different proportions to optimize the strength characteristics. At 40% replacement of fine aggregate with the mill scale the strength value attained is maximum. Workability was found to decrease as the percentage replacement increases in concrete.**

***Keywords*—Concrete, Mill Scale, Optimize, Strength, Workability.**

I. INTRODUCTION

Mill scale is a black bluish flaky material mainly constitute of iron oxides and is formed on the steel outer surface during hot rolling operations. The thickness of these scales is usually less than a millimeter [1-3]. It acts as a protective coating to steel from atmospheric corrosion as it is cathodic to steel unless it is cracked. But the presence of mill scale proves detrimental to steel, because it can easily peel off. Nearly 35-40Kg of mill scale is produced for every ton of hot rolled steel (1). Mill scale is reported to be used as raw material in sintering plants (2) and as briquette in steelmaking. (3, 4, 5). Apart from these scarce uses, most of the mill scale is dumped in landfills, which pose dangerous environmental hazard due to leaching action of heavy metals in soil. Concrete is a vastly used construction material and it generally a mixture of coarse aggregate, water, fine aggregate, and cement but due to rapid growth in construction industry the resources of natural coarse aggregates are scarce and depleting very fast [4-7]. The mechanical properties and durability of concrete increases by utilizing mill scale as a partial replacement of fine aggregate in concrete mix.

Physical Characterization

The physical properties of mill scale are presented in Table I. It is seen that the specific gravity is 4.96 of mill scale, which generally is nearly two times that of sand (typical values being ≈ 2.65). This means that if mill scale is used as partial replacement of fine aggregates in concrete it would result in denser concrete and hence it can be used in high density concreting. Further, the material has negligible water absorption. This also makes it a suitable material for concreting [8].

TABLE I
PHYSICAL PROPERTIES OF MILL SCALE.

S.No.	Physical Property	Value
1	Color	Bluish black
2	Specific gravity	4.96
3	Water absorption	< 0.5%
4	Magnetic properties	Present
5	Texture	-
6	Plasticity	Nil
7	Permeability	Moderate

II. EXPERIMENTAL PLANNING AND TESTING

The experimental planning and testing was planned to study the properties of Mill Scale and Properties of concrete when aggregates is partially replaced by Mill Scale by using standard test methods. The mix design of M30 grade, casting of the specimen, curing according to boundary condition, testing of the specimen for the mechanical properties of concrete and furthermore the test specimen for fourth stage were casted in this stage only [9]. Fourth stage of experimentation concludes the test for durability i.e. sorptivity and

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chloride-ion penetration.

III. MATERIALS USED

A. Cement

A commercially available Ordinary Portland cement of 43 grade (Jaypee cement) conforming to the requirements of IS:1489 (part-1)-1991 and IS 8112:1989, is used throughout the study [10].

B. Coarse Aggregate

The aggregate use will be the standard coarse aggregate compliant with IS: 383-1970 specifications which is widely used for cement concrete testing. The sand will uniformly grade with grain size should be under 20mm.

C. Fine aggregate (F.A.)

The aggregate use will be the standard sand compliant with IS: 2116-1980 specifications which is widely used for mortar testing. The sand will uniformly grade with grain size lying between 1-2mm was used as fine aggregate (F.A) throughout the work. The various properties and particle size distribution of fine aggregate/sand are experimented and discussed.

D. Mill scale

Mill scale will be obtained from a firm located in Rathi steels Pvt. Ltd., Pithampur Industrial Area, Indore (M.P.). As the size of particles are less than 4.75mm, **then it can be used in construction for replacing natural aggregate**. The bulk density as determine by the IS: 2386 (Part III)-1963. Particle size distribution will be done for mill scale and standard sand as per IS: 2386 (Part I)-1963 specifications.

IV. MECHANICAL PROPERTIES OF THE CONCRETE

Experimental Slump Values

Here we have discussed the experimental slump values with approximate theoretical values which are used in the Concrete Mix Design. From the result we conclude as the percentage of replacement is increases the experimental slump values decreases from that the percentage replacement of mill scale increases so workability of concrete decreases.

- Sample of 00% Replacement of Sand 74 mm
- Sample of 20% Replacement of Sand 72 mm
- Sample of 40% Replacement of Sand 66 mm
- Sample of 60% Replacement of Sand 58 mm
- Sample of 80% Replacement of Sand 52 mm.

Compressive Strength

From this compressive strength result we found maximum compressive strength of M30 Grade of concrete at 40% replacement of sand with mill scale. From the experimental result we also found that as the percentage replacement of sand with mill scale, increases compressive strength increase up to 60%.

- Sample of 00% Replacement of Sand 31.20 MPa
- Sample of 20% Replacement of Sand 34.685 MPa
- Sample of 40% Replacement of Sand 34.55 MPa
- Sample of 60% Replacement of Sand 31.78 MPa
- Sample of 80% Replacement of Sand 29.37 MPa.

V. CONCLUSION

1) Further, iron, alumina and silica are essential ingredients in cement and aid in the formation of C_2S, C_3S, C_4AF and C_3A, which in turn provide strength characteristics to concrete.
2) On implementing mill scale as fine aggregate in concrete we lead to denser concrete.
3) As the percentage of replacement in concrete are increases, Workability of concrete decreases.
4) We found maximum compressive strength of concrete at 40% replacement, and strength increases upto 60%. Replacement of sand with mill scale is feasible upto 80% replacement.

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REFERENCES

[1] International Iron and Steel Institute, "The management of steel industry by-products and waste," *Brussels Committee on Environmental Affairs*, 1987.

[2] V. W. Y. Tam, G. X. Pao and C. M. Tam, "Microstructural analysis of recycled aggregate concrete produced from two-stage mixing approach," *Cement and Concrete Research*, vol. 35, pp. 1195-1203, 2004.

[3] D. Paswan, M. Malathi, R. K. Mini and D. Bandhopadhayay, "A Potential Raw Material for Iron and Steel Making," *In Steel World Jamshedpur: CSIR-National Metallurgical Laboratory*, pp. 54-56, 2014.

[4] N. M. Gaballah, A. F. Zikry, M. G. Khalifa, A. B. Farag, N. A. El-Hussiny, M. E. H. Shalabi, "Production of Iron from Mill Scale Industrial Waste via Hydrogen," *OJIN*, Vol 3, pp. 23-28, 2013.

[5] C. L. Peng, D. L. Scorpio and C. J. Kiber, "Strategies for Successful Construction and Demolition Waste Recycling Operations," *Construction Management and Economics*, Vol. 15, pp. 49-58, 1997.

[6] C. Seungyoun and J. Lee, "Metal Recovery form Stainless Steel Mill Scale by Microwave Heating," *Metals and Materials International*, vol. 14, no. 2, pp. 193-196, 2008.

[7] N. A. El-Hussiny, F. M. Mohamed, and M. E. H. Shalabi, "Recycling of Mill Scale in Sintering Process," *Science of Sintering*, vol 43, pp. 21-31, 2011.

[8] M. A. Legodi and D. de Waal, "The preparation of magnetite, goethite, hematite and maghemite of pigment quality from mill scale iron waste," *Dyes and Pigments*, 74, pp. 161-168, 2007.

[9] R. C. Nascimento, G. Lenz, D. Martins, C. Takano and M. B. Mourão, V Japan-Brazil, "Symposium on Dust Processing-Energy-Environment in Metallurgical Industries – ABM, Sao Paulo," vol 5, pp. 507, 2004.

[10] K. H. Kim, H. K.Shin, Y.C.Chunq and T.D.Kin, "POSCO Technical Report 8", 387, *POSCO* 1987.