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STUDY OF SCC WITH PARTIAL REPLACEMENT OF FINE AGGREGATE WITH STEEL MILL SCALE

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ABSTRACT

This paper provides an overview of Self-Compacting Concrete (SCC) and Steel Mill Scale (SMS). In the current scenario of the construction industry, the demands in constructing large and complex structures often lead to difficult concrete conditions. When placing large amounts of heavy reinforcement in reinforced concrete (RC) elements, it is difficult to fully compact without voids and honeycombs. Compression by hand or a mechanical vibrator is very difficult in this situation. This led to the invention of a new type of concrete called self-compacting concrete (SCC). This type of concrete flows easily around rebar and into the corners of formwork. In the present study of steel mill scale, waste from steel industries was tested as a partial substitute for sand. Steel mill scale is a waste product obtained from steel manufacturing industries and it has an adverse impact on the environment. Mill scale has become a good substitute for fine aggregates in the construction industry. Test parameter is the rate of replacement of steel mill scale (0%, 20%, 40%, 60%, 80% and 100%) by weight into fine aggregate content in concrete grade M30 and result The results obtained from these mixtures were compared with the original concrete of quality M30. The compressive strength, split tensile strength, flexural strength and microstructural properties of this concrete were evaluated. The interaction of scale in concrete has been methodically investigated using microstructural studies. It has been found that the very small grain size of the steel mill scale fills the gap between fine and coarse aggregates, causing the concrete to become dense. The paper-based test results reviewed show that steel mill scale recycling using it as a minor substitute for fine aggregate offers a viable, cost-effective and friendly solution. Environmentally friendly with a optimum replacement rate of 30%.

Keywords: Concrete With Self-Compaction, Mix Design, Fibers, Durability, And Workability, Steel Mill Scale, River Sand, Compressive Strength, Tensile Strength, Flexural Strength, SEM.

I. INTRODUCTION

The population development that results in a rise in agricultural activities as well as industrialization is what is behind the day by day rapid increase in trash output. An significant amount of garbage is produced as these activities increase. For instance, after harvesting crops, it's common to find numerous agricultural trash like wheat straw, rice husk, maize cob, etc. Similar to how wasteful industrial processes produce different wastes like rubber, fly ash, and waste glass. Such solid waste is regularly created in large quantities throughout the world, and if it is not properly disposed of, it could have detrimental effects on both human health and the environment. Researchers from all across the world are working to find practical ways to use trash, much like those in civil and environmental engineering who have made concrete with agricultural waste and industrial byproducts. Due to its mechanical and chemical characteristics, affordability, and simplicity of production, concrete is a widely utilized construction material. However, the massive amount of concrete used in the construction sector is depleting natural resources, harming the environment, and contaminating air and water. Therefore, it is essential to prevent environmental deterioration and substitute different by-products for the materials in concrete (cement, fine aggregates, and coarse aggregates), which will help to at least partially alleviate environmental issues. When steel billets are hot rolled in the steel manufacturing business, one sort of industrial waste known as steel mill scale (SMS) is created. For every tonne of steel produced, 10 to 20 kg of mill scale are produced. Mill scale used to be regarded as wasted material and was typically dumped in landfills. Nevertheless, mill scale has the ability to replace some of the aggregates in concrete. There hasn't been much research on the mechanical and durability characteristics of concrete that incorporates steel mill scale, despite some studies using it as a partial replacement for aggregates in mortar There have been several studies done on the use of steel and iron industrial waste as a substitute for natural aggregates. Less research has, however, been done on the mechanical and durability characteristics of concrete that incorporates waste steel mill scale

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as a partial replacement for natural fine particles (sand). Therefore, the goal of this study was to assess the workability, compressive strength, and flexural strength, a of concrete containing steel mill scale.

1.1 SELF COMPACT CONCRETE-.

Self-compacting concrete is highly fluid, helping the concrete to flow into the formwork, lightening the reinforcement between them and maintaining the homogenous properties of the concrete. SCC also does not require vibration for compaction, which improves machinability. It is estimated that the effective use of self-compacting concrete can increase productivity in the construction industry by up to 5% to 10%.

1.2 STEEL MILL SCALE WASTE GENERATION

Globally, about 13.5 million tons of mill scale are produced. In several iron and steel-making processes, about 500 kg/ton of solid wastes of different natures are generated; one of these wastes is the mill scale which represents about 2% of steel produced. Mill scale is a very attractive industrial waste due to its richness in iron (~72 % Fe).

1.3 ENVIRONMENTAL IMPACT

The amount of mill scale generated annually—on average, by one steel processing unit—ranges between 6500 and 8500 tonnes, or roughly 18–20 million metric tonnes. The majority of the waste is disposed of in landfills.

1.4 CONCRETE DEMAND

Due to its adaptability and several performance advantages, such as its abundance, strength, robustness, durability, resistance to fire, and resistance to water, concrete is utilized widely and in substantial quantities. It has been and will continue to be the basis of society for these reasons.

The predicted demand until 2050 shows significant regional diversity. The demand for concrete is expected to decline since China, where the majority of the world's consumption of concrete occurs, has made considerable recent investments in infrastructure. Even after accounting for the savings in design and construction efficiency stated in this roadmap, demand for infrastructure in the rest of the world, particularly in Africa, India, and Latin America, is expected to rise due to population expansion, urbanization, and infrastructure needs.

II. LITERATURE REVIEW

- **Muhammad Azam Khan et. Al.,** This paper studies to utilize the unusable industrial waste i.e., steel scale mill in concrete this study is going to be done. Tests were performed on concrete specimens including steel mill scales varying in proportion to the weight of sand and a controlled specimen to assess the workability, compressive strength, flexural strength, and durability, and this study says that the replacement of industrial waste partially or completely is possible.
- **Dana Adriana Iluţiu Varvara et. Al.,** Steel-making plants generate various kinds of waste, including oily mill sludges and scales. They are generated at the rolling mill plant during the cooling and rolling process of hot steel. Mill scale is a steel-making by-product from the rolling mill in the steel hot rolling process. Worldwide about 13.5 million tons of mill scales are generated annually, and some wastes from steel-making operations and metallurgy have established widespread use in the construction sector. Many investigations have shown that slag aggregate concretes achieve higher values of compressive strength, tensile strength, flexural strength, and modulus of elasticity, compared to natural aggregate concretes. The purpose of the paper is to assess the recycling potential of the mill scale in the composition of mortars, to improve the management of industrial wastes from steel making, and also have shown results as using metallurgical wastes in the composition of mortar is possible.
- **Dr. Amit Kumar et.Al.,** In any integrated steel plant, a lot of waste is generated. By the application of appropriate technology the wastes produced can be recycled and reused. This will help in creating waste in a wealthy and eco-friendly environment. The recovery and use of steel industry by-products have contributed to a material efficiency rate of 97 % in some of the advanced countries, whereas India is far behind this target. The goal should be 100 % efficiency or zero waste. A critical analysis has been presented in this paper with special reference to the Indian steel industry.
- **Suman Kumar Adhikar et. Al.,** The review aimed to provide a detailed study of lightweight self-compacting concrete containing several types of natural and sustainable lightweight aggregates. The review provides a detailed study of the physical, mechanical, and mineral composition of different lightweight aggregates. The

impact of different types of lightweight aggregate and other influential factors on workability, strength, and durability have been carefully discussed in this study which shows it is possible to develop lightweight self-compacting concrete even below the 1000 kg/m3 density. In addition, lightweight self-compacting concrete shows excellent frost Resistance.

- **Velumani et. Al.,** Fine aggregate is one of the large-scale consuming materials in the construction industry. In general, river sand has been used as a fine aggregate for making concrete, mortar, etc. This paper presents a detailed experimental study on compressive strength and bulk density of M20 grade concrete containing steel mill scale as a replacement for fine aggregate and granite powder.
- **P.M Rameswaram et. Al.,** A Sieve analysis test was done in the lab, to identify the particle size distribution of the steel mill scale. The appearance of this material has bluish black in color. Mill scale is mainly composed of iron. aluminum and Silicon are the minority composition. traces of Chromium, Nickel and Manganese are found in steel mills. scale. This waste is already used by many cement industries for making various types of Portland cement because of its iron content. Even though it is used by the cement manufacturing industry, the waste is not fully utilized because the output of steel mill scale is at a drastic level.
- **Gidion Turuall oa et. Al.** Three mixes were provided namely normal weight self-compacting concrete with Portland cement as a control, lightweight self-compacting concrete with GGBS, and lightweight self-compacting concrete with limestone powder concrete. There were three cubes of each mix for each testing age, which were cured at 20, 30, 40, and 50°C to investigate the effect of curing temperature on strength development. They were tested at ages 1, 3, 7, 14, and 28 days. The results showed that the strength development of self-compacting concrete is strongly affected by curing temperature as it does with normal concrete. At early ages, the strengths of concrete cured at higher curing temperature were faster than that of concrete cured at a lower temperature. The strength development of concretes cured at a lower temperature, however, has higher strength at later ages.
- **Erika furlani et. Al.,** Steel scale waste, a by-product of steel production, is formed on the steel monoliths during their high-temperature thermal treatments after casting. SSW mainly contains iron oxides and minor fractions of other oxides. This type of waste is mainly disposed of in a landfill or used to prepare counterweight concrete. The study is to evaluate if the addition of SSW enables the improvement of some properties of the hydrated mortars without paying an exaggerated cost.
- **Kotaro Doi et. Al.,** The role of mill scale on the corrosion behavior of steel rebars in the mortar was studied using Hyperbaric-Oxygen Accelerated Corrosion Tests (HOACT) and polarization measurements. The rust formation process was examined through cross-section observations and laser Raman spectroscopy. SEM observations and Raman spectroscopy measurements revealed that a Fe3O4 layer initially formed under the mill scale and further corrosion resulted in the migration of Fe ions through the defects and formation of a rust layer mainly composed of α- and γ-FeOOH on the mill scale.
- **P Ganesh Prabhu et. Al.,** To study the possibility of replacement of Steel scale mills in concrete. The experimental parameter was the percentage of steel mill scale substitution (0%, 20%, 40%, 60%, 80%, and 100%) by weight to fine aggregate content in M30 grade concrete. Compressive strength, split tensile strength, flexural strength, and micro-structural characteristics of such concrete were evaluated. The interaction of steel mill scale within the concrete has been methodically investigated using micro-structural studies. And the results were favorable accordingly.
- **Premkumar R et. Al.,** As a building material in concrete, some of the industrial waste can reduce landfill costs and protect the environment from negative effects. The recycling and use in the construction sector of industrial by-products complement sustainable technology and development considerably. Geopolymer is an environmentally sustainable replacement for the standard Portland cement binders, a new generation of binding material. As an alkaline activator, a sodium hydroxide solution with 12 mol and sodium silicate was used. The alkaline liquid to fly ash ratio in all the mixes is 0.4. Consider the oven temperature of 70C for 48 h and the curing conditions in the environment. The compressive strength, water absorption, and density of the concrete were all measured on each specimen. According to the tests, the compressive strength increases as the amount of steel mill slag increases. Steel mill slag is the alternative fine particle in geo-polymer concrete.
- **Ozturk Met. Al.,** Electromagnetic (EM) wave shielder mortar can be produced by mixing cement, natural limestone, and tap water with mill scale (mill scale-I and mill Scale-II) which is one of the biggest disposal area

problems of the iron-steel sector in Iskenderun, Hatay. In this paper, detailed analysis and information were presented on the influence of electromagnetic properties of mortars including iron steel industry waste mill scales to contribute the solving waste problems. All experimental results point out that the waste mill scales are viable candidates for EM wave shielders for the buildings and will gain added value as well as solve the scale storage problem of the iron and steel industry.

- **Quenne ville et. Al.,** Tests were carried out on slip-friction connectors in which the sliding surfaces were either in the clean mill scale condition or had the mill scale completely removed through a process of either grit blasting or grinding. However, where only one of the opposing sliding surfaces is of clean mill scale, and the other grit blasted or polished, stable sliding will eventuate only after a substantial amount of cumulative travel at low loads. To minimize the possibility of design loads being significantly exceeded during a seismic event, it is strongly recommended that the sliding surfaces of slip-friction connectors are in the clean mill scale condition before their installation.
- **Ming J et. Al.,** This study investigated the corrosion performance of reinforcing steels in concrete exposed to flowing 3.5 wt% NaCl solution for 4 years. Two kinds of steel were selected: low-carbon (LC) steel and low-alloy (LA) steel with alloying element Cr. Both steels were prepared with two surface conditions: as-received one (with mill scale) and pickled one (removal of the mill scale). The microstructure of the steel-concrete interface was observed to investigate the effect of steel type and surface condition on the corrosion pattern. The results reveal that the corrosion resistance and the corrosion pattern of steel were largely influenced by the feature of the mill scale.

III. CONCLUSION

SCC can build concrete with almost zero flaws because it can guide itself into every nook and hole in the form. Reducing the number of pouring locations makes it unnecessary to lay pipe over each pour, which is a laborious process. By substituting components like fibers for about 40 to 50 percent of the cement, the cost of the concrete is significantly decreased. It is possible to significantly minimize the need for qualified supervisors, engineers, vibrator operators, and pipe fitters. Formwork has a greater number of uses. As the number of flaws is greatly reduced, the cost of fixing the structure is decreased. A conclusion was reached based on the findings of the paper review investigations that steel mill scale from industrial wastes could be substituted for sand as a fine aggregate. The wastes demonstrated impressive compressive strength up to 100% replacement and were optimized at 30% to reach the maximum strength. Concrete's density and water absorption rose as the replacement of steel mill scale grew in percentage. The results demonstrate that more research into the behavior of hardened concrete in flexural behavior, as well as enhanced durability testing, can be done in the future. Future studies may also take into account the waste generated from the optimization of steel mill scale and self-compact concrete.

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