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Examining the use of recycled steel mill scale as fine aggregate

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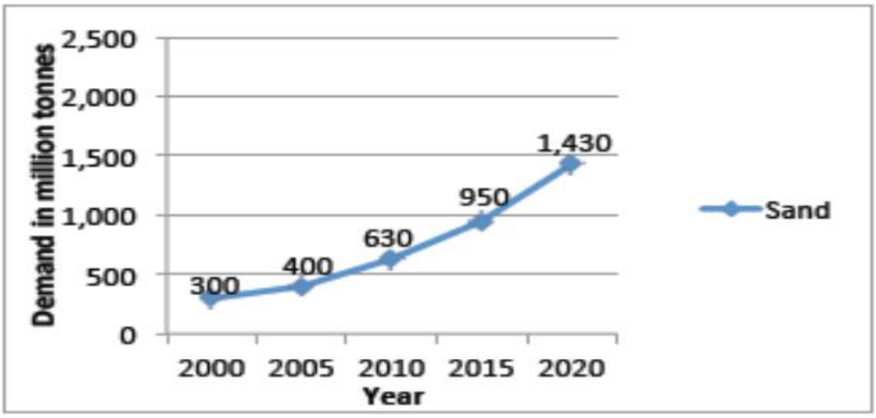
ABSTRACT: Cement concrete is one of the world's most important construction materials. The aggregates are one component, the cement paste is another, and the binder is the third. Concrete can only be as strong as its aggregates. A majority (75%) of the volume of concrete is made up of aggregates (Fine and Coarse). It is generally considered that aggregate is the most important part of concrete, since it has a significant impact on the material's properties both before and after it sets. Standard fine aggregate in concrete is often river sand. A shortage of manufactured sand has resulted from the growing demand for natural river sand over the last several decades, as urbanization and modernization have expanded around the world. Therefore, in order to save natural resource and generate sustainable environment, a suitable material for fine aggregates in concrete should be replaced. Industrial waste management, however, is one of the most rapidly expanding fields in environmental protection.

I. INTRODUCTION

Concrete, the most used building material, is made up mostly of filler components that are held together by a binder. In order to improve the characteristics of concrete, occasionally admixtures are added to the mix. Nearly 70% of the volume of cement concrete is taken up by aggregates. Between 1900 and 2010, the quantity of natural resources used in global infrastructure development rose by a factor of 23. The most extensively mined materials are sand and gravel (79 percent, or 28.6 gigatons annually in 2010). A. Torres et al (2017) The construction industry in India now accounts for 6.3% of GDP, but that number is expected to rise to as high as 13% by 2028. The expansion of the construction sector has a multiplier effect on overall demand. There is a severe shortage of building aggregates in India at the moment. Demand for river sand has expanded as the usage of concrete has grown in all facets of building. Since river sand has a high silica concentration, it is the material of choice for making concrete, and its popularity consequently rises. As a result of this need, there has been a dramatic increase in the quarrying of river sand, which has had a devastating effect on river ecosystems. Because to sand mining, major environmental concerns have arisen, along with the destruction and relocation of people's means of subsistence. The mining of sand in India is mostly uncontrolled. So mining is a simple procedure that requires little effort. The unregulated sand mining by a number of individual investors has significantly impacted sand prices in several regions of the nation. The government has passed legislation to stop the excessive use of river sand. The Ministry of Environment, Forest, and Climate Change (MoEF& CC) developed the Sustainable Sand management guidelines for 2016 to regulate sand mining in the country and protect the nation's river sand resources. Changes in India's sand demand over the last two decades are seen in Figure 1.1.



(Source: Aggregate Business International, 2013)

Figure 1.1 Estimated fine aggregate demand in India

On the other hand, several industrial processes around the nation have resulted in an enormous amount of solid waste. This kind of garbage has major environmental consequences if dumped directly into the environment. Partial replacement of solid waste materials for fine aggregates in concrete is one inventive method of preserving natural river sand. Plastic, rubber, glass fiber, Ground Granulated Blast Furnace Slag, copper slag, sintered sludge pellets, steel slag, foundry sand, demolition debris, kiln dust, and other types of solid waste have all been studied as potential partial replacements for fine aggregate in concrete. The use of waste materials in concrete has been claimed to have a number of beneficial effects, including solid waste management, Sustainable development, conservation of natural resources, cheap cost, and environmentally friendly building.

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II. REVIEW OF LITERATURE

[1] It was found that fibers added to dry mix were more effective. Boosting the fiber count improves the material's durability. PFRC has been shown to increase strength by 8%-16%. The inclusion of polypropylene fibers increases the splitting tensile strength by anywhere from 5 percent to 23 percent. The tensile strength after being split for 28 days is almost 50% higher than the initial 7-day reading.

[2] The use of fibers to reinforce composites has apparently gained popularity in recent years. Fibers are advantageous because of their combination of rigidity, strength, and temperature resistance. Polypropylene fiber reinforced concrete has compressive strength and resistance to splitting in the range of 0% to 1.5% fiber content, with the remaining range covering 1% to 2.0% fiber content in concrete samples.

[3] The behavior of concrete under forces off this surface is represented by a nonlinear orthotropic model whose axes correspond with the primary strain direction. Similar uniaxial correlations in the orthotropy axis are used to derive the concrete strain relationship. The relevance of the many elements that impact the global and local response of reinforced concrete buildings is determined by correlation studies of the results of experiments and analytical studies, as well as through investigations of various parameters.

[4] evaluated publications dealing with recycling of steel scale debris, drawing on the results of certain experimental production of mortars. For this experiment, the researchers mixed commercial natural aggregate with steel scale waste, commercial CEMII/B-LL cement, water, and super-plasticizer. Natural aggregate was substituted with a wide range of steel slags (5, 10, 20, 30 and 40 weight in percentage). After 28 days of curing, all of the hydrated materials had excellent compressive strength, making them high-performance mortars because to their low water absorption.

[5] Cantilever testing equipment and theory that elucidates the beam's inherent vibrational modes. An experimental technique and the mathematical (FEA) approach using the ANSYS software are used to find the free vibration of a fixed beam. Error ratios between the two methods have been shown to be rather low. It is acceptable to have a discrepancy of up to 7% between the results of a numerical (FEA) method and those of an experimental approach. Numerical (FEA) findings created using ANSYS software are compared to the experimental form shape frequency values for the mode.

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Numerical (FEA) findings are found to agree with experimental values in a number of cases.

[6] investigated. In this procedure, testing was done on the mechanical parameters of steel sludge and steel slag concrete. Due to its increased loss of conductivity, steel sludge has higher reactivity which is roughly 72.9%as against 43.3% for steel slag based on the data obtained from pozzolanic activity testing. Nonetheless, both substances exhibit remarkable activity in a Ca (OH)2 solution. The compressive strength of cement concrete was increased by the inclusion of both steel sludge and steel slag.

[7] Argue that steel slag could be used as a viable replacement for coarse aggregate in construction projects. Reusing waste water was made possible by replacing the natural coarse particles in the concrete with steel slag at varied ratios (15-25%, 50-75%, 75-100%). The typical values for the ash content, relative density, and dry materials in super plasticizer are 11.76, 1.24, and 51.03 pH units.

[8] examined the impact of employing either partial or total substitution of natural aggregates with Electric Arc Furnace (EAF) steel slag on the mechanical and fracture properties of Roller Compacted Concrete (RCC). Multiple tests were performed on the specimens to determine their durability; they included three-point bending, compression, semi-circular bending, and a split tensile test.

III. RESEARCH GAP

Blast furnace dust, slag, LD sludge, mill sludge, coke breeze, and coke dust were all studied further as potential replacements for fine aggregate and binding components in concrete. The usefulness of using scrap steel mill scale in concrete is not studied in such depth. This study fills a gap in the literature.

The civil engineering projects of today are well-known for being difficult and complex. The use of self-compacting concrete, or SCC, has several practical and financial advantages. The use of steel fiber significantly boosts the effectiveness of these benefits. If cracks are anchored by steel fiber, they cannot propagate and the concrete's strength and longevity are improved. This research investigates the flexural behavior of steel fiber reinforced concrete using silica gas in the structural components. When making self-compacting concrete, silica fume is used in place of coarse aggregate at a weight percentage of 25-35%. In all, eight different types of mixers were put through their paces. All other variables, such as the cement-to-water ratio, the water-to-cement ratio, and the quantity of superplasticizers, were held

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constant. The performance of the fresh mix was assessed by means of the following metrics: slump flow, diameter, J-Ring, and V-funnel.

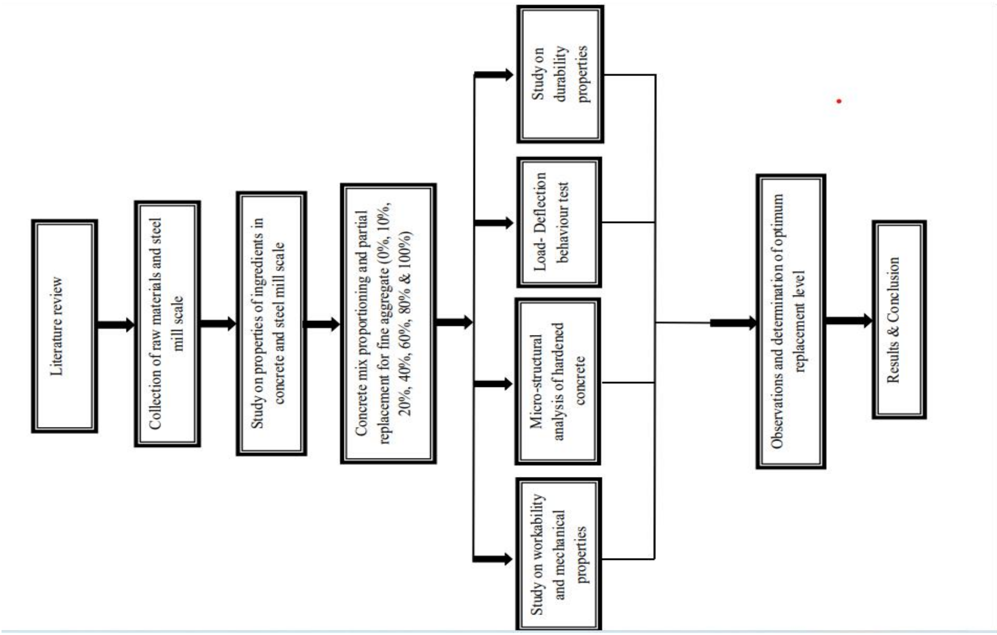
IV. NEED FOR THE PRESENT STUDY

Steel by-products (Steel slag, blast furnace slag, ferro nickel slag, etc.) have been used in concrete as a partial substitute for aggregates in a number of studies, demonstrating the growing importance of research in this field. Since the micro-structural features and extensive analysis other than mechanical qualities were not shown in the prior studies, a large gap was detected in the efficient utilization of steel mill scale in concrete. Concrete constructed using steel mill grade aggregates was not properly examined for its fresh, hardened, durability, structural, or micro-structural qualities. Therefore, the current research has a great deal of room for exploring the potential of using steel mill scale in concrete.

Incorporating steel mill scale as an active ingredient in concrete increases options for management of industrial wastes, which indirectly leads to the conservation of natural resources, as the current study will reflect the micro-structural behavior and durability aspects in addition to the physical and structural properties of the material.

V. RESEARCH METHODOLOGY

the research's methodology and provides a comprehensive analysis of the qualities of the materials employed in the investigation, such as fine aggregate, steel mill scale, coarse aggregate, cement, and reinforcing bars. In this part, we will go over the specifics of the elements used to make concrete, including their physical, chemical, and micro-structure qualities. Since strength of concrete relies directly on material qualities, a detailed examination on the material properties was done. As an added bonus, this method may be used to determine the ideal ratios for a concrete mix that will provide the desired results. This chapter also details the many types of concrete testing that may be performed, including tests on both fresh and cured concrete, as well as the requirements for the specimens used in those tests, how they are cast, and how long they are allowed to cure.



In order to guarantee that the cement fine aggregate, coarse aggregate, and fibers were all up to code for usage in concrete per IS standards, they were put through a battery of tests. In accordance with the testing methods specified by the EFNARC Standards, this part discussed a variety of tests, including as the compaction factors test and the slump flow tests, that may be used to assess the FRC mix's new properties. The IS Code of practice standards are used to determine whether a given substance is acceptable for use. Mechanic and physical characteristics of SFC, PFC, and HYFC mixtures have been studied. Therefore, methods for measuring compressive strength, split tensile strength, and flexural strength were explored. Extensive studies were also performed to learn about the toughness, energy absorption, deflection ductility, and other structural features of a hybrid of SFC, PFC, and HYFCs.

Highly flowable self-consolidating concrete can fill the molds without mechanical vibration. A non-segregating concrete is one that can be compacted to its final shape by the weight of the mixture alone. When it comes to performance and longevity, self-compacting concrete is on par with any other kind of concrete. To lessen the likelihood of bleeding and separation, some manufacturers use super plasticizers or viscosity modifiers. Segregated concrete is less durable and may cause honeycombed surfaces directly adjacent to the formwork. High-quality SCC mixtures are highly deformable and exhibit good stability; they also show no signs of segregation due to their design.

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Characteristics of self-compacting concrete

To prevent segregation, self-compacting concrete is fortified with chemical additives and mineral fillers. Self-consolidating concrete is necessary for it to flow into and fill precise molds. To get past the fortifications, it has to be flowable. When it comes to placement and flow, this concrete must adhere to certain specifications. Self-compacting concrete made with the same water cement or cement binder as regular vibrated concrete has a little bit more strength. Without the tremors, the aggregate and the set concrete have a greater chance of bonding. In comparison to conventional concrete, SCC concrete mix requires a quicker application speed. The use of self-compacting concrete allows for the safe and efficient placement of concrete at heights more than 5 m. It also operates in places with regular or crowded reinforcement and aggregates up to 2 inches.

Tips for Working with Self-Compacting Concrete

Self-compacting concrete might speed up the building process and save costs. You should pay close attention to the following details:

• It would be unsafe to use a full mixer of self-compacting concrete because of the possibility of leakage along the road. It is crucial to design formwork that can sustain pressures in fluid concrete that are up to ten times higher than those in normal concrete, or else there is a possibility of environmental and contamination issues. Self-consolidating concrete may need greater lifts than conventional concrete while being placed.

Self-consolidating concrete (SCC) is more difficult to work with than conventional vibrated concrete and may add up to $50 per yard to your building expenditures. Ready-mix concrete prices will vary based on the manufacturer.

FIBER REINFORCED SELF COMPACTING CONCRETE

The aggregate and cement used to create FRSCC (or fibre reinforced self-compacted concrete) may be of varying sizes. Fibres may be included in these aggregates. Fibre reinforced concrete, or FRC, is concrete in which the fibres are randomly spread throughout the material. When subjected to tensile stress, concrete may crack. However, mechanical qualities of concrete may be enhanced by randomly placed discrete fibres. This inhibits and regulates the spread of any fractures that may have originated from a fusion of separate ones. Improvements in toughness and fatigue resistance, impact resistance, fatigue resistance, strength, shear strength, flexibility, and spalling resistance may be achieved by adding fibbers with the right mechanical

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characteristics to the concrete mix. The design of the fibre, the aspect ratio of the volume fraction, and the mix parameters determine the contribution of the fibbers to each of these characteristics. The use of glass fibres increases the concrete's strength while decreasing its unit mass.

TYPES OF FIBRE

Steel Fiber

This is how the concrete's ductility is determined, which in turn informs the design of the stress-strain relationship. Steel-fiber concrete was still highly ductile after being exposed to high temperatures, as was previously shown. In areas prone to earthquakes, fiber concrete may be used in structural components. Fiber concrete was shown to have a number of desirable properties. Fresh concrete mixes with a little number of steel-fibers added to them had better bonding between the mortar matrix and the particles, better energy absorption, and tougher behavior. Steel fibers have been shown to significantly affect how concrete cracks and deforms in several studies.

Polypropylene Fiber

You may think of it as a hybrid of polyolefin and polymer. The material is very resistant to alkalis and acids. Polypropylene fibrillated films fibber's fibres have strong matrix adhesion. The result is excellent resistance to impact. As a result of their very long length (15-25%), they may be used in situations where a lot of energy absorption is required. The fibber's weak reinforcing ability is due to its low modulus of elasticity. Numerous construction components, including pile shells, cladding boards, flotation units, geniting, and crack inhibitor, make use of this material.

Another idea that has been shown to have greater characteristics and more appeal is the hybridization of various kinds of fibres in concrete. The notion of hybrid fibres consists of at least two different varieties, each of which makes better use of the fibres' qualities. Researchers have conducted several investigations to investigate the properties of regular concrete reinforced with hybrid fibres.

The control concrete was reinforced with steel and polypropylene hybrid fibres. In light of this, studies were conducted to compare the performance of steel and polypropylene Fibre Reinforced Concrete (FRC) and Hybrid Fibres (steel & polypropylene), reinforced concrete with varying amounts of these fibres.

BEAM

Beams made of fibre reinforced concrete are highly regarded. The need for such a thing arises from the fact that contemporary buildings take up a lot of room. Beams

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are often employed as structural supports for a wide variety of building components, including water tanks, underground bunkers or silos, nuclear reactors, pile tops, and many more. Fibre-reinforced concrete beams may be used to produce vertical beams with the help of dividing walls.

Beams are divided into three categories based on their span-to-depth ratio. There are four different kinds of laser beams: shallow (or standard), medium, deep, and deep. According to clause 29.1 on page 51 of the Indian Standard Code IS456: 2000, a beam is defined as having an effective span (L/D) less than its overall depth (D). Limits on L/D are I 2.0 for a supported beam, and (ii) 2.5 for a continuous beam.

The only part of the plane that is relevant to traditional flexural beam theory is that which is left behind after the normal beams have been bent. No inferences about structural behaviour can be made from this paragraph. If only supported members are used, the effective span to overall depth ratio must be less than 2, and if nonstop members are used, it must be less than 2.5, in accordance with CIRIA Guide 2 and IS456-2000. Because of their ability to withstand shear and bending stresses when subjected to transverse loading, normal beams are best seen as linear, one-dimensional components. The low stress pattern is the result of normal pressure. The flexure strength of a typical beam is much lower than its shear strength. Failure occurs due to pure flexure as well.

CONCLUSION

In order to guarantee that the cement fine aggregate, coarse aggregate, and fibers were all up to code for usage in concrete per IS standards, they were put through a battery of tests. In accordance with the testing methods specified by the EFNARC Standards, this part discussed a variety of tests, including as the compaction factors test and the slump flow tests, that may be used to assess the FRC mix's new properties. The IS Code of practice standards are used to determine whether a given substance is acceptable for use. Mechanic and physical characteristics of SFC, PFC, and HYFC mixtures have been studied. Therefore, methods for measuring compressive strength, split tensile strength, and flexural strength were explored. Extensive studies were also performed to learn about the toughness, energy absorption, deflection ductility, and other structural features of a hybrid of SFC, PFC, and HYFCs.

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