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PERFORMANCE OF STEEL SLAG : USE IN NORMAL & SELF-COMPACTING CONCRETE

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ABSTRACT

Self-compacting concrete (SCC) has the property of compacting under its own weight when placed in the formwork . As the total time of construction and the cost reduces by the use of SCC and it also eliminates vibration and can be very useful when there is congested reinforcement . Because of their superior engineering and performance properties, fly ash (FA), ground granulated blast furnace slag (GGBFS), and silica fume (SF) are the most commonly used materials in the production of high strength and high-performance concrete . Steel slag is a by-product of the steel industry produced during the manufacturing process, with iron accounting for 15–20% of the crude material used . Slag, which is a by-product of the procedures that are used to produce steel and iron, was utilized in the field of civil engineering tenths of years ago. Because of its pozzolanic activity, Portland granulated ground blast furnace slag cement, which is formed from blast furnace slag that is rapidly cooled by water, has been effectively utilized in the production of concrete mixtures. In terms of the utilization of steel slag as a fine material in SCC, the findings of the research shown that it is feasible to manufacture SCC components that possess superior qualities.

Keywords: *Performance , Steel Slag , Self-Compacting , Concrete*

INTRODUCTION

With 11 billion tons consumed annually, concrete is the most popular building material worldwide. The main ingredient in concrete is cement, which emits 0.9 tons of CO2 into the sky for every ton produced. Additionally, the usage of fine and coarse aggregate, which together make up about 70% of the volume of the concrete, depletes natural resources. Even though industrialization benefits people much, it also makes waste management and environmental degradation more urgent issues. In light of this, industrial by-products like slag, silica fume, glass powder, fly ash, etc. are utilized to substitute all or a portion of the components in concrete, significantly improving both its strength and environmental performance. Over the past few decades, there has been a surge in the creation of concrete structures due to enhanced working conditions and higher productivity. When poured in formwork, self-compacting concrete (SCC) has the ability to compact under its own weight. When SCC is used, construction time and expense are reduced overall, vibration is eliminated, and it may be especially helpful in cases when reinforcement is crowded. Fly ash (FA), ground granulated blast furnace slag (GGBFS), and silica fume (SF) are the most often utilized ingredients in the manufacturing of high strength and high-performance concrete because of their outstanding technical and performance features. A byproduct of the steel industry, steel slag is created throughout the manufacturing process, and 15–20% of the raw materials utilized are made of iron. .

Fly Ash:

It is referred to as fly ash, and it is a waste by-product of power stations that burn coal. Class C fly ash and Class F fly ash are the two forms of fly ash that are frequently utilized in the context of the construction industry. The amount of calcium, silica, alumina, and iron that are present in the ash is a key contributor to the distinction that exists between these two categories. The use of fly ash is done in order to improve the flow characteristics. Additionally, fly ash reduces the hydration heat of the cement, which in turn significantly lessens the likelihood of cracking in concrete. It is possible to use fly ash into self-compacting concrete in order to enhance both its fresh and hardened properties. Specifically, Karmegam et al. There is a considerable improvement in the rheological parameters of SCC when fly ash is substituted by up to 35 percent. This improvement features good flow ability and more. As a result of the spherical shape of the particles, fly ash is the additive that is utilized most frequently for SCC. As an additional component, fly ash is used in the powder composition in order to enhance the workability of SCC to its maximum potential. Due to the fact that it possesses the appropriate physical, chemical, and mineralogical qualities, fly ash shows excellent performance in concrete.

Alternaate Aggregates in Concrete

Schroeder (2016) There are a number of waste items that are non-degradable elements, and it has been stated that these materials would linger in the environment for hundreds of years, and maybe even thousands of years. A waste disposal issue has arisen as a consequence of this circumstance, which, when paired with the ever-increasing consumer population and demand, has led to the situation. Several studies conducted over the course of the last several decades have shown evidence that reusing materials can result in a reduction in the costs associated with the extraction and processing of fresh raw materials as well as the consumption of virgin resources. Mindess et al (2017) materials that may be utilized as an alternative to natural aggregate have been identified in a broad variety of forms. Whenever any new material is employed as an aggregate in concrete, there are three key concerns that need to be taken into account: concrete qualities, affordability, and compatibility with other materials are the three most important factors. The cost-effective utilization of non-traditional materials in concrete is contingent upon a number of elements, including the transportation that is necessary to convey the materials from the manufacturing facilities to the building site, the amount that is available, and the requirements that are imposed by the mix design. An additional expense would be incurred in order to separate any usable elements from ones that are not desired. One further significant concern is the crushing of the aggregates into certain sizes. When combined with the other components of the concrete mixture, the aggregates should not have any unfavorable reactions. They must not alter the qualities of the concrete in a manner that is negatively affecting. In addition to providing concrete with strength and durability, they play an essential function in the production of concrete. Over the past several years, there has been a growing interest in discussing the utilization of industrial by-products in concrete.

Brito and Saikia (2015) Additionally, it has been discovered that there is a growing interest in the utilization of waste materials as alternative aggregate materials. A substantial amount of research is being conducted on the utilization of a wide variety of materials, including coal ash, blast furnace slag, fiber glass waste materials, waste plastics, rubber waste, sintered sludge pellets, and other materials, as aggregate substitutes. When waste materials are employed as aggregate in cement mortar and concrete, the amount of waste materials that are used can grow by a factor of multiplicative power. This particular application of a waste material has the potential to alleviate environmental issues that are associated with aggregate mining and waste disposal, as well as to solve difficulties that arise from a scarcity of aggregate at various building sites. Utilizing leftover aggregates is another way to cut down on the expenses associated with the manufacture of concrete. Due to the fact that aggregates have the ability to exert a large amount of influence over the qualities of concrete, the properties of the aggregates are of utmost significance. For this reason, it is essential to conduct a comprehensive evaluation prior to use any waste material as aggregate in concrete.

OBJECTIVES OF THE STUDY

1. To study on Use of Steel Slag in Normal and Self-Compacting Concrete
2. To study on Mechanical and Durability Performance of Steel Slag

Natural aggregates with granulated slag

Zeghichi (2016) a partial substitution of natural aggregates with granulated slag has been seen to result in an increase in the strength of concrete, as stated by the author. It is concluded that the partial replacement of coarse and fine aggregates with slag products leads to an improvement in compressive strength while simultaneously leading to a reduction in stocks of granulated slag. This is the conclusion reached by the researchers. It has also been noted that the complete substitution of natural course aggregates with slag products need to be avoided since it has a detrimental impact on the strength of concrete. Indian Minnerals Yearbook (2017) During the process of making steel, it has been stated that the steel slags are created at stainless steel melting shops. During the process of producing steel, excess silicon and carbon are extracted from iron through the process of oxidation, which is accomplished by adding limestone and coke. There is a greater quantity of iron present in the steel slag, and its physical features are comparable to those of iron slag that has been air-cooled. After being crushed and filtered, the slag is then cooled. Fines are put to use in the production of sinter, whereas lumps are loaded into the blast furnace after being processed. The primary fundamental distinction between blast furnace (BF) slag and steel slag is the amount of iron that is present in the former. The total iron concentration of steel slag can range anywhere from 16 percent to 23 percent, whereas the FeO percentage of BF slag is only 0.5 percent. Kalyoncu (2015) It has been claimed that steel slag is a by-product that may be created either via the conversion of iron to steel in a Basic Oxygen Furnace (BOF) or through the melting of scrap to make steel in an Electric Arc Furnace (EAF). Silica, alumina, calcium, and magnesia are the primary components of iron and steel slags, and they account for approximately 95% of the overall composition of the slag and its constituents. Minerals such as manganese, iron, and sulphur compounds, together with trace amounts of a number of other elements, are included in this category. The pace at which the slag cools and the chemical composition of the slag both have an impact on the physical features of the slag, among which are porosity, density, and particle gradation.

Use of Steel Slag in Normal and Self-Compacting Concrete

Slag, which is a by-product of the procedures that are used to produce steel and iron, was utilized in the field of civil engineering tenths of years ago. Because of its pozzolanic activity, Portland granulated ground blast furnace slag cement, which is formed from blast furnace slag that is rapidly cooled by water, has been effectively utilized in the production of concrete mixtures.

Despite the fact that a great number of studies have been carried out on the assessment of the use of steel slag as coarse aggregate in road construction and the utilization of blast furnace slag in concrete mixes, a smaller number of research have been carried out on the utilization of steel slag as coarse aggregate in regular concrete.

There have been reports of improved mechanical characteristics. There is a documented effect on the durability.

In spite of the fact that there is some study on the utilization of steel slag aggregate as a supplemental cementitious material in SCC, there is only a very limited amount of research on the utilization of coarse SSA in SCC. In terms of the utilization of steel slag as a fine material in SCC, the findings of the research shown that it is feasible to manufacture SCC components that possess superior qualities. Examples may be found here. The results shown that it is feasible to incorporate Algerian steel slag into SCC as a supplementary cementitious material, and that it is possible to achieve the desired level of mix stability. In the construction of SCC, carbon steel slag (CSS) was utilized as a fine additional cementitious material. steel reducing slags (SRS) were utilized as fillers and cement substitutes in the formulation. SCC characteristics were enhanced with the usage of GGBFS in SCC.

There is a relatively limited amount of research that can be discovered on the World Wide Web about the utilization of SSA as coarse aggregate in SCC operations. It was demonstrated that it is feasible to apply SSA in SCC by substituting thirty percent of the natural aggregate with SSA. Conducted research on the application of atomized steel slag aggregate in SCC. The results of his investigation led him to the conclusion that the fresh and hardened characteristics of SCC with and without atomized steel slag aggregate are virtually identical. An overview of the Indian experience is provided. Instead than focusing on the crucial fresh qualities, the three most recent publications put more of an emphasis on the influence that SSA has on the properties that have been toughened. demonstrated that the production of SCC by the use of SSA is feasible. The criteria and procedures that they presented were aimed at ensuring the effective creation of these mixes. In order to evaluate the viscosity qualities of the mixes as well as their workability, they suggested a technique that takes into account the dose as well as the characteristics of the components that make up the mixture.

Suiwei Pan (2020) Exploring the possibility of using steel slag to manufacture self-compacting concrete (SCC) and to make the most of the resources that are available from solid waste has significant application value as well as economic significance. Steel slag self-compacting concrete (SSCC) with nearly optimal workability is made in this study by utilizing steel slag instead of natural fine aggregate. This preparation is based on mix proportion optimization and research on the performance of SSCC. In order to determine whether or not SSCC is suitable for use, tests were conducted to determine its filling capacity, passing ability, and resistant segregation. According to the findings, the workability performance of SSCC is comparable to that of SCC with natural aggregates when the percentage of steel slag sand to the total composition of the material is twenty percent. After making adjustments to the quantity of raw materials, the performance of SSCC may also fulfill the workability criteria when the percentage of steel slag sand included in the composition is less than sixty percent.

Deepak Shrivastav (2023) This century has seen concrete emerge as a versatile material for use in construction. In spite of the fact that it is a material that is often utilized, concrete is plagued by a number of issues that are caused by improper building practices and the presence of substandard components in the concrete mix. Inadequate compaction during the building process is the key factor that leads to the degradation of concrete. Honeycomb formations are the product of concrete that has not been compacted to the appropriate level. Self-Compacting Concrete (SCC) structures are able to overcome this challenge since they do not require any external compaction or vibration before they can be used. The development of SCC also helps to reduce the amount of labor that is necessary for the process of compaction.

Among the special concretes, SCC is one of them. Whether it is under the influence of gravity or by its own weight, it is capable of compacting on its own without experiencing vibration, bleeding, or segregation. The process of industrialization has resulted in the production of a significant quantity of trash from industrial processes. There are many different types of industrial activity that result in the production of waste. These substances exhibit a diverse array of characteristics and chemical compositions, and they have an influence on both the health of humans and the environment. As a consequence of this, waste management and disposal must be carried out in a secure manner in order to maintain an ecosystem that is sustainable. In addition to polluting the climate through the emission of carbon dioxide, the cement industry is responsible for the consumption of a significant quantity of natural resources in order to manufacture cement. As a result, waste materials from businesses that have a pozzolonic character can be used in conjunction with cement. The construction industry in India is under a great deal of pressure to discover replacements for fundamental building materials in order to meet the ever-increasing demand for infrastructure. This is due to the fact that river sand and natural aggregates are becoming increasingly scarce across the country. Due to the detrimental effects that sand mining in rivers has on the ecology, these activities have been made illegal in a number of regions across our nation.

Mechanical and Durability Performance of Steel Slag

Qiasrawo et al (2019) have carried out an experimental investigation on the possibility of using steel slag as a fine aggregate. The compressive strength and tensile strength of the material were reevaluated after 28 days, with each replacement ratio of slag being evaluated separately. An increase in compressive strength was observed for the slag replacement ratio at 15%-30%, and an increase in tensile strength was observed for the slag replacement ratio at 30%-50%, as demonstrated by the results. Pengand Wang (2017) discovered that the primary chemical components of Carbon Steel Slag (CSS) are calcium oxide (CaO), aluminum oxide (Al2O3), and silicon dioxide (SiO2), which has a composition identical to that of Portland cement and BFS. Therefore, it is reasonable to anticipate that CSS will have favorable cementitious characteristics and consequences. Enhancing the CSS content would result in an increase in the amount of time required for the cement to set in compared to Ordinary Portland Cement (OPC). Concreting with CSS results in a compressive strength that is greater than that of concrete made with OPC. At the end of the 90-day period, the percentage of compressive strength improves by more than 211% when w/cm ratios of 0.32 or 0.400 are utilized. The compressive strength of concrete reduces in proportion to the quantity of CSS that is present in the concrete. Nevertheless, when a CSS of 5.0–7.5% is employed, the strength is comparable to that of the other concrete, with the exception of the seven-day period.

Bernal et al (2019) There has been a paper that details the mechanical and durability performance of concretes that were formed by employing alkali activated ground granulated blast furnace slag as the binder. Additionally, a comparison has been made between the performance of the concrete and that of the reference concrete that was produced using Portland cement. In comparison to the concrete that is used as a reference, it has been discovered that alkali activated slag concrete develops a compressive strength that is significantly higher. A greater binder content leads to increases in water absorption, permeability, and carbonation resistance. These advantages are brought about by the presence of the binder. In the process of producing concrete, it has been shown that modifying the parameters of the mix design can result in the manufacture of concrete that boasts outstanding mechanical strength and durability.

Fineness of fly ash on concrete properties

That grinding Turkish fly ash had resulted in an increase in the 7-day pozzolanic activity index from 7.9 to 14.2 accordingly, which was caused by the fineness of the fly ash being raised from 222m2 /kg to 604m2 /kg. This rise was associated with the fact that the fly ash had been ground. When fly ash or ggbfs were replaced for fifty percent of the cement, the performance of concrete that contained slag was superior to that of concrete that contained fly ash. Considering that the slag possesses both cementitious and pozzolanic reactivity, it can be concluded that it is preferable than fly ash in terms of its properties. On the other hand, the fly ash had a fineness of around 600 square meters per kilogram on average. It was found that the strength of the concrete that was created from slag was higher than the strength of the concrete that served as the control in a number of situations. It is likely that the pozzolanic reaction and the better particle packing were responsible for the increase in strength. This is one of the most plausible explanations for the phenomenon. They hypothesized that the densification of the transition zone between the aggregate and the cement paste would make the concrete more homogeneous and would make it possible to obtain bigger strengths. This would be the outcome of the concrete being more homogenous. Because of this development, it is possible that it will be more effective at lower water-to-binder ratios, which will contribute to the increased performance of the pozzolan.

CONCLUSION

Due to the fact that river sand is a natural resource that is depleting at an alarming rate, it is of the utmost importance to reduce the amount of river sand that is employed by making efficient use of industrial by-products such as fly ash, M-Sand, and steel slag. In the event that fine aggregate is not accessible, M-sand and steel slag are used as an alternative in order to reduce the amount of natural resources that are needed and the amount of environmental damage that is created. According to the results that were published in the past, M-sand and steel slag have the potential to be employed as fine aggregates in the building of S CC as a partial replacement. When M-Sand and steel slag are used as fine aggregate in SCC, there is a reduction in the amount of resources that are depleted, the amount of money spent on construction, and the impact on the environment. The findings of this research will make it possible for the building and construction industries to focus on the use of M-Sand and steel slag as a partial replacement for fine aggregate. This will result in SCC that is comparable to or even better to that of fine aggregate.

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