Webology, Volume 18, Number 5, 2021
ISSN: 1735-188X
DOI: 10.29121/WEB/V18I5/91

Investigation on Structural Steel Self-Compacting Concrete with Fly Ash as a Partial substitute for cement and Slag Cement with Granite Powder

Nikhil Garg[1], Anoop Bahuguna[2]

[1]Department of Civil Engineering, Graphic Era Deemed to be University, Dehradun, Uttarakhand India, 248002
[2]Department of Civil Engineering, Graphic Era Hill University, Uttarakhand India

ABSTRACT

Due to the increased complexity of building designs in recent years, compacting concrete in areas with dense reinforcement has become more challenging. Self-Compacting Concrete (SCC) is a novel high-performance concrete that does not need vibration or compaction to flow through gaps, corners, and joints in reinforcement, resulting in superior deformability and segregation resistance. In 1986, in Japan, it was initially developed. However, the use of SCC is far lower in the United States than in places like Japan and Europe. The availability of natural resources is a major issue for the construction industry. To get around this problem, we need to use something other regular aggregate as our main building material. Research on reusing industrial waste items like fly ash and copper slag is being driven by a concern for the environment. M60 grade concrete will be used in this experiment. Fly ash and Copper slag are used to partly replace the cement and the fine aggregate. Fly Ash will be substituted for cement and copper slag in the amounts of 5%, 10%, 15%, 20%, and 25% (by weight) of cement and copper slag (by weight) of fine aggregates. It has to be determined how different substitutions affect the hardened concrete's compressive strength, flexural strength, and split tensile strength. There will also be tests like the slump cone, V-funnel, L-box, J-box, and T-50.

Keywords: Self-Compacting Concrete, Fly ash, copper slag.

INTRODUCTION

Self-consolidating concrete, unlike traditional concrete, does not need mechanical vibration to expand inside the form. Self-Compacting Concrete, also known as self-leveling or self-compacting concrete, does not segregate and is compacted only by its own weight upon placement [1]. Self-compacting concrete is valuable because it satisfies performance expectations while retaining all of the beneficial properties and longevity associated with conventional concrete. Super plasticizers and viscosity modifiers are sometimes added to a mixture to prevent bleeding and segregation.

Segregation weakens concrete and creates honeycombed regions around the formwork. In addition

Webology, Volume 18, Number 5, 2021
ISSN: 1735-188X
DOI: 10.29121/WEB/V18I5/91

to not segregating, being highly deformable, and exhibiting great stability, a well-designed SCC mix also shows no degradation over time. Fillin Ability, Passing Ability, and Segregation resistance are the three primary features of self-consolidating concrete (SCC). The development of very efficient water reduction agents (super plasticizers), often based on poly-carboxylate ethers, allowed for the creation of materials with these properties. SCC differs from standard concrete in that its mixing composition is unique [2]. In comparison to regular concrete, SCC often has higher powder concentration.

The civil engineering sector accounts for the vast majority of aggregate consumption in India; this sector is also responsible for the majority of coarse aggregate consumption (around 70% of aggregate). However, there is now an issue since fine aggregate is in short supply. Therefore, experts in the field created waste management solutions that may be used in lieu of fine aggregates depending on the application [3]. There has been a global decline in natural resources, while at the same time, industrial waste has been on the rise. In order to make up for a shortage of natural resources and to discover alternative means of saving the environment, sustainable development for building necessitates the use of nonconventional and novel materials, as well as the recycling of waste materials.

As a byproduct of the copper refining process, copper slag is a potentially useful waste product that might one day be used in lieu of cement or aggregates in building projects. It's a byproduct of copper refining and smelting in a matte form. About 2.2 to 3.0 tonnes of copper slag are produced for every tonne of copper produced. Satellite Industries Ltd (SIL), located in the Indian city of Tuticorin, Tamil Nadu, is a major producer of copper slag [4].

While making copper metal, copper slag is created. The current rate of Copper slag production is roughly 2600 tonnes per day, with a total stockpile of about 1.5 million tonnes. By substituting copper slag for traditional sand, we can save money and resources while also helping the environment. Consequently, there is an increasing need to provide a viable option for slag management. The purpose of this research is to examine how using copper slag in conjunction with regular sand changes the properties of the resulting concrete.

LITERATURE SURVEY

The impact of copper slag on high performance concrete qualities when substituted for sand. Khalifa S. Al-Jabri, et al., 2009. (HPC).

From 0% to 100% copper slag was used into concrete mixes. HPC density increases by roughly 5% as copper slag concentration rises, and workability rises quickly. To get high performance concrete with good strength and durability properties, copper slag is recommended to be used as a re-placement of fine aggregate at a rate of 40–50%.determined that cement substitution with fly ash and copper slag research M50 grade of concrete. Fly ash and copper slag are used in lieu of some of the cement and fine aggregate. For example, replacing 10%, 20%, 30%, 40%, or even 100% of copper slag with fine aggregates has no negative impact on strength. Copper slag uses far less water than river sand does throughout its production [5]. Use of copper slag and fly ash in building is relatively affordable and produces excellent result. Compressive strength in concrete is greatly

Webology, Volume 18, Number 5, 2021
ISSN: 1735-188X
DOI: 10.29121/WEB/V18I5/91

improved by using copper slag to replace 30% of the sand and 40% of the cement weight.

A research in which they compared using copper slag coarse aggregate in place of limestone coarse aggregate. High-strength concretes are tested and analysed for their compressive strength, splitting tensile strength, and rebound hammer values [6]. Different ratios of water to cementitious ingredients were used to create concrete mixes with varying concentrations of silica fume. Cement substitution by silica fume ranged from 0% to 6% to 10%. Ten to fifteen percent more compressive strength was achieved at 28 days when copper slag aggregate was used instead of limestone aggregate, and ten to eighteen percent more splitting tensile strength was achieved. Since copper slag aggregates are harder, the rebound hammer readings were raised from 2.6% to 9.3%.

GOALS OF THE STUDY

This study examined the effects of varying the proportions of a self-compacting concrete mix designed to have a typical strength of 60 MPa. The SCC features in their uncured form were obtained by using a super plasticizer and a viscosity modifying agent. The SCC blend's optimal percentage of HSSCC was determined by testing its compressive, tensile, and flexural strength in addition to its modulus of elasticity. The primary aim of this research was to examine the feasibility of using copper slag as a fine aggregate substitute in both regular and high strength self-compacting concrete. Particular responsibilities included the following:

First, test several standard and high strength self-compacting concretes to see how adding copper slag affects their workability and density.
(2) Test the concrete for compressive, tensile, and flexural strengths.
Concreting using Self-Compacting Materials

SCC, or self-compacting concrete, is a specialised form of concrete with excellent workability and self-compacting property, meaning that it compacts itself naturally due to its high flowing property without the need of additional vibrators. There will be no bleeding or segregation in this concrete. Preparing high-rise self-compacting concrete

In order to achieve maximum strength, the water-to-cement ratio should be as low as possible. Chemical admixtures are used to improve the workability of concrete without altering the water-to-cement ratio or weakening the concrete's strength [7].

Filling and passing requirements can only be met if SCC maintains consistent compaction throughout the placement and transport processes. So far, SCC has been successfully used in many different contexts, and many different tests have been employed. In all of these cases, however, the SCC was manufactured and installed by a seasoned contractor whose team has been educated in and has expertise with a plethora of testing. The fresh concrete qualities of SSC were measured using the slump flow test, L – Box test, U – Box test, and V funnel test.

The a) sluggish flow test is widely used because it accurately predicts how well a material will fill a space. Slump cone is pressed down forcefully. Concrete is subsequently poured into the cone. There is no tamping. A perimeter of excess concrete is chipped away from the foundation. A diameter is

Webology, Volume 18, Number 5, 2021
ISSN: 1735-188X
DOI: 10.29121/WEB/V18I5/91

measured twice, and the mean of the two values is determined. Slump height in millimetres; the steeper the slump, the more it collapses under its own weight. Distances might be anything between 600 and 800 millimetres [8].

B) The L-BOX TEST evaluates the SCC's capacity for filling and passing containers. When the gate is raised, concrete may flow freely from the vertical part into the horizontal one. After the current has ceased, two heights, H1 and H2, are recorded. The permeability and resistance to segregation in concrete are evaluated using the V-Fuel test, which is method C. The assembly under test is placed firmly on the ground, and the interior surfaces are dampened. A bucket is put beneath the trap door, and the door is closed. After that, concrete is added to the device and allowed to settle on its own. When the concrete is full, the discharge is timed by opening the trap door. How well concrete fills is measured by this inverted-V funnel. When light can be seen entering the funnel from above, this is assumed to indicate that the funnel is open. The V-funnel is quickly refilled when the trap door is closed at T 5 minutes to measure the flow time. After 5 minutes, the trap door is opened and the timing of the discharge is noted. At T 5 minutes, this is the current flow rate. A lower time-to-flow suggests a more efficient flow rate. The resistance to segregation is shown by a V-Funnel at a temperature of 5 mm. However, if the concrete segregates, as illustrated in Fig. III, the time required to complete the task rises to more than three seconds.

D) U-BOX TEST: The U-type test, devised by the Taisei group, is used to assess self-compatibility.

suitable since it requires less concrete than alternatives depicted in Fig- IV. By measuring how far the concrete rises after it has been channelled around the barriers, we may get an idea of how well the two substances get along. The self-compacting quality of concrete is defined by a filling height more than 300 mm. When the filling height is more than 85% of the maximum height feasible, some businesses consider the concrete Self-Compacting.

MATERIALS

For this study, we utilise the following components to make our Self-Compacting Concrete.

CEMENT Ultra-tech 53-grade regular Portland cement is employed in this investigation. In India, this kind of cement has become the standard. Table - III displays the various cement properties. In accordance with IS recommendations, it passes a battery of standard tests.

When bituminous or sub-bituminous coal is burned, it produces a finely split powder known as fly ash (lignite). Also called "Flue Ash," after its other common name. Because it is a byproduct of the nation's thermal power facilities, it is abundant across the country. Cement concrete may have up to 50 percent of its cement replaced by fly ash.

Fly-Ash has a specific gravity of 2.625% and a fineness of 4%.
FINE AGGREGATE: Sand particles devoid of clay or inorganic elements and determined to be robust and durable. Fine aggregate often refers to particles that are between 0.075mm and 4.75mm in size. Fine aggregate is chosen in accordance with IS-383 standards.

Webology, Volume 18, Number 5, 2021
ISSN: 1735-188X
DOI: 10.29121/WEB/V18I5/91

The following characteristics are those of the Fine aggregate that will be utilised in the SCC.

Pure sand from a riverbed
ine aggregate zone –II D) Specific gravity 2.66 Fineness modulus 2.81
Copper slag is a by-product of the copper refining process. Copper smelting produces a significant quantity of trash in the form of slag. About 2.2 to 3.0 tonnes of copper slag are produced for every tonne of copper produced. Table-IV displays Copper Slag's characteristics.
The following characteristics are those of the Coarse aggregate that will be utilised in the SCC.
Blue granite, crushed to a 12 and 10 mm size
• An obtuse angle of 90 degrees • Specific Gravities of 2.925 and 2.915 • A fineness modulus of 7.29 °F

H2O: Cement and concrete can't function without water. Water suitable for human consumption is utilised in the production of concrete blocks.

Chemical admixture Glenium B233 is a new generation admixture based on modified poly carboxylic ether, and it goes by the trade name "G" for "super plasticizer." Forced action for 60 seconds in mixers is advised instead of adding super plasticizer to dry aggregate or cement, This is predicated on a novel long-chain lateral carboxylic ether polymer. This is a significant step forward in cement distribution. Electrostatic dispersion occurs at the beginning of the mixing phase, but the existence of lateral chains connected to the polymer backbone provide a steric barrier that stabilises the cement particle to split and disperse [9].

Aggregates larger than 4.75 millimetres in diameter are often categorised as coarse aggregate. Coarse aggregate with a maximum size of 12 mm and 10 mm were employed in this experimental study; chips with a size of 12 mm passing and 10 mm retaining were also used at a 20% volumetric percentage. Coarse aggregate of high quality is received from the closest crusher facility. Coarse aggregate is chosen in accordance with IS-383 standards.

PROPORTIONS IN THE MIX

To produce concrete of a specified minimum strength and durability as cost-effectively as feasible, mix design involves the selection and determination of appropriate constituents of concrete. To get the right balance of characteristics in newly mixed SCC, the following steps are taken: • The fluidity and viscosity of the concrete paste are adjusted and balanced by selecting and proportioning the cement and additions, by preventingive the water to powder ratio, and then by adding a super plasticizer (SP). The key to producing high-quality filling ability, passage ability, and segregation resistance is precisely managing these characteristics of SCC, along with their compatibility and interaction.

To ensure that each coarse aggregate particle is completely coated in mortar, the ratio of coarse to fine aggregate in the concrete mix is decreased. As a result, the self-compacting concrete's capacity to flow through narrow apertures or gaps between reinforcing bars improves, which may minimise and weak aggregate connection and bridging.

Webology, Volume 18, Number 5, 2021
ISSN: 1735-188X
DOI: 10.29121/WEB/V18I5/91

Result AND DISCUSSION

Compressive Strength Test Results on Cured Concrete

Crushing a cube to gather information about its compressive strength. The term "crushing strength" describes this phenomenon well. Cubes of concrete measuring 150mm x 150mm x 150mm are used to determine the material's compressive strength.. Casting cylinders with a 150mm diameter and a 300mm diameter is used to determine the concrete's split tensile strength. This section presents the results of the 7-day and 28-day split tensile strength tests.

CONCLUSION

The guidelines set out by the European Federation for the Testing and Certification of Materials and Components in Construction (EFNARC-2005) are adhered to by the test Compressive strength improves with a lower W/P ratio (water to powder).

Self-compacting concrete is a modern kind of concrete with wide-ranging uses. Superior to regular concrete in almost every way, scc excels in compressive strength, self-compacting qualities, flowability, workability, and passability.

The water content of this super plasticizer is reduced to between zero and forty percent. Super plasticizer (GLENIUM B223), composed of poly-carboxylic ether, should be added to concrete at a rate of 1.5%. This rate, however, cannot be used if the concrete is to be left unpainted.

To get high-strength self-compacting concrete with excellent properties, it is suggested that 15 weight percent of fly ash may be used as a substitute for cement and 30 weight percent of copper slag can be used as a replacement for sand.

It is feasible to use copper slag and fly ash in construction, and doing so is both inexpensive and fruitful.

This research highlights the upsides of employing copper slag as a fine aggregate substitute.
As a result, self-compacting concrete (SCC) achieved greater compressive strength than regular concrete.

REFERENCES

1. De Matos, P. R., Foiato, M., & Prudêncio Jr, L. R. (2019). Ecological, fresh state and long-term mechanical properties of high-volume fly ash high-performance self-compacting concrete. *Construction and Building Materials*, *203*, 282-293.
2. Iqbal, S., Ali, A., Holschemacher, K., Ribakov, Y., & Bier, T. A. (2017). Effect of fly ash on properties of self-compacting high strength lightweight concrete. *Periodica Polytechnica Civil Engineering*, *61*(1), 81-87.
3. Selvaraj, S., & Sivaraman, S. (2019). Prediction model for optimized self-compacting concrete with fly ash using response surface method based on fuzzy classification. *Neural Computing and Applications*, *31*(5), 1365-1373.
4. Belalia Douma, O., Boukhatem, B., Ghrici, M., & Tagnit-Hamou, A. (2017). Prediction of

properties of self-compacting concrete containing fly ash using artificial neural network. *Neural Computing and Applications*, *28*(1), 707-718.

5. Wang, Q., Wang, D., & Chen, H. (2017). The role of fly ash microsphere in the microstructure and macroscopic properties of high-strength concrete. *Cement and Concrete Composites*, *83*, 125-137.
6. Rajeshwari, R., & Mandal, S. (2019). Prediction of compressive strength of high-volume fly ash concrete using artificial neural network. In *Sustainable Construction and Building Materials* (pp. 471-483). Springer, Singapore.
7. Dadsetan, S., & Bai, J. (2017). Mechanical and microstructural properties of self-compacting concrete blended with metakaolin, ground granulated blast-furnace slag and fly ash. *Construction and Building Materials*, *146*, 658-667.
8. Benli, A., Karataş, M., & Bakir, Y. (2017). An experimental study of different curing regimes on the mechanical properties and sorptivity of self-compacting mortars with fly ash and silica fume. *Construction and Building Materials*, *144*, 552-562.
9. Golewski, G. L. (2018). Green concrete composite incorporating fly ash with high strength and fracture toughness. *Journal of cleaner production*, *172*, 218-226.