Review Article

Concrete Made with Partially Substitutions of Granite Powder (GP), Copper Slag (CS) and Iron Powder (IP) : State of the Art Review

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ABSTRACT

Large quantities of waste are created during the production of granite rocks, copper, and iron. These waste products are known as granite powder, copper slag, and iron powder, respectively. For environmental reasons, the disposal of this waste material becomes problematic. Investigating workable alternative disposal options is thus necessary. They can also be used to reduce the amount of cement and natural aggregates used in the production of concrete. Numerous studies concentrate on using Granite Powder (GP), Copper Slag (CS), and Iron Powder (IP) in concrete, either as filler materials or as cement substitutes. This article seeks to identify the impact of admixtures on the performance of conventional concrete by reviewing the literature on Granite Powder (GP), Copper Slag (CS), and Iron Powder (IP).

KEYWORDS

granite powder (GP), copper slag (CS), and iron powder (IP), sand, cement, compressive strength, and split tensile strength

1. INTRODUCTION

Concrete should have enough compressive strength and flexural strength to support applied loads. At the same time it should have good durability to increase its design life and reduce maintenance costs. In general, durable concrete will have good resistance to freeze and thaw, abrasion, sulfate reactions, ultraviolet radiation, seawater, alkali-silica reaction, and chlorides. The gradation and maximum size of aggregates are important parameters in any concrete mix. They affect relative proportions in mix, workability, economy, porosity and shrinkage of concrete. Granite powder, a waste material from the granite polishing industry, is a promising material for use in concrete similar to those of pozzolanic materials such as silica fume, fly ash, slag, and others. These products can be used as a filler material (substituting sand) to reduce the void content in concrete. Granite powder is an industrial byproduct obtained from crushing of granite stone and granite stone polishing industry in a powder form. It is also generated from recycling marble tops, terrazzo, granite pavers, and stone scraps and discards. If left on its own and is not properly collected and stored, the fine granite powder can be easily be airborne and will cause health problems and environmental pollution.

Inhalation of granite powder fine particles is a health hazard and is a cause of lung diseases especially for people living near granite mills. In this present work, granite powder is used as partial replacement of sand in concrete in different percentage and the associated compressive strength, flexural , and splitting tensile strengths of concrete have been evaluated. By doing so, natural resources of sand can be preserved and the health hazards of these industrial wastes are minimized.

Recycling of granite dust will prevent these wastes from ending up in land fills and provides affordable, eco-friendly, solid stone for various uses. Recycled tiles made from recycled glass or wastes from mines or factories have been used for floors, countertops, and walls [2]. Ceramic tiles may be made from factory waste (known as post-industrial waste) generated by the production of conventional tiles. Debris series from fire clay tiles combine post-industrial and post-consumer recycled wastes. The Debris series tile consists of 26% recycled granite dust (post-industrial waste) from a granite cutting operation. It also contains 26% recycled glass (post-consumer waste).

Results from this study and from studies by others referenced in this introduction showed that there are advantages to concrete when granite powder is used to partially replace sand in the concrete mix. The benefits of using granite powder as partial replacement of sand not only can enhance strength but also preserve the natural resources of sand and also keeps these powder particles from being airborne into the atmosphere causing health hazard to humans, in particular children.

2. LITERATURE REVIEW

Jawad Ahmad , Ali Majdi , Ahmed Farouk Deifalla , Haytham F. Isleem and Cut Rahmawati (July 2022)

Copper slag (CPS) is a large amount of waste material produced during the manufacture of copper. The disposal of this waste material becomes a problem for environmental concerns. Therefore, it is necessary to explore feasible alternate disposal options. They may also be utilized in concrete manufacturing to cut down on the usage of cement and natural aggregates. A lot of researchers focus on utilizing CPS in concrete, either as a cement replacement or as a filler material. This article aims to summarize the literature already carried out on CPS in conventional concrete to identify the influence of CPS on the fresh, hardened and durability performance of cement concrete. Result indicates that CPS improved the strength and durability performance of concrete but simultaneously decreased the slump value of concrete. Furthermore, an increase in the durability performance of concrete was also observed with CPS. However, the higher dose results declined in mechanical and durability aspects owing to a scarcity of flow ability. Therefore, it is suggested to use the optimum dose of CPS. However, a different researcher recommends a different optimum dose ranging from 50 to 60% by weight of fine aggregate depending on the source of CPS. The review also recommends future researcher guidelines on CPS in concrete.

Rahul Vardhan, Swati Chaudhary (2022)

Natural pozzolans like metakaolin have recently attracted interest as partial substitutes for cement. Among the varied methods of accelerating the sturdiness of concrete and making high-performance concretes, the utilization of metakaolin could be a relatively new strategy. Metakaolin, also referred to as heat treatment clay, is used as a further grouting agent in concrete to save lots of cement costs and increase strength. The porosity of the concrete are often reduced with MetaKaolin. In this present study analysis work we use metakaolin & copper slag as replacement materials in the concrete. Testing of concrete and cements are done. Consistency, initial setting time and final setting time were performed for cement and at fresh and harden stage of concrete was tested on different days. Cement is replaced with Metakaoline at various percentages like 0%, 3%, 6%, 9% and 12%. Fine aggregates are replaced with copper slag at various percentages like 0%, 3%, 6%, 9% and 12%.

Raj Kumar, Suganya Natarajan, Rahul Singh, Vinod Singh Rajput, Ganesh Babu Loganathan, Sanjeev Kumar, T. Sakthi, and Akter Meem Mahseena (2022)

Mineral admixtures are frequently utilized as cement substitution materials in high-performance concrete (HPC), and so many studies have explored the influence of mineral admixtures on the rheological behavior of HPC. Investigations were done to examine the impact of nanosilica less than 100 nm on HPC by substituting copper slag at a fixed substitution of forty percent for fine aggregate. Concrete samples were cast by substituting cement with nanosilica at (0.5, 1, 1.5, 2, 2.5, and 3) percentages. Examinations on mechanical properties and durability were done on specimens. The above tests demonstrated an increase in water demand because of the increase in the nanosilica substitution percentage. Mechanical and durability properties were improved at a larger rate with the incorporation of nanosilica. The outcomes indicated that colloidal nanosilica is an effective material that enhances the microstructure and acts as a catalyst for pozzolanic activity. The incorporation of nanosilica improves the strength up to two percentage substitution level.

Vindhya Shree M P, Sai V Kalal, Prashanth Mugali, Sharath S, Prashanth Kumar. (2020)

Since, the large demand has been placed on the building material industry especially in the last decade owing to the increasing population, increase in infrastructure and also increase in new infrastructural projects. Which causes a chronic shortage of building material; the civil engineering has been challenged to convert waste to use full building and construction material like brick. Recycling of such wastes as raw material alternative may contribute in the exhaustion of the natural resources which will help to create awareness towards clean environment. In the review of utilization of those waste, this paper reviewed recycling various waste like copper slag and sculpture waste with red soil in brick. All mixtures are subjected to oven curing until the testing age. However, the brick specimen size is 220mm*100mm*100mm. Bricks are one of the oldest types of building blocks. They are an ideal building material because they are relatively cheap to make, very durable, and require little maintenance. A brick is a block of ceramic material used in masonry construction, usually laid using various kinds of mortar. Bricks dated 10,000 years old were found in the middle east. Examples of the civilizations that used mud brick are the ancient Egyptians and the Indus Valley Civilization, where it was used exclusively. The first sun-dried bricks were made in Iraq, in the ancient city of Ur in about 4000 BC. Bricks are a widely used construction and building material around the world. Conventional bricks are produced from clay with high temperature kiln firing or from ordinary Portland cement (OPC) concrete, and thus contain high embodied energy and have large carbon footprint. In many areas of the world, there is already a shortage of natural source material for production of the conventional bricks.

Venkata Narsireddy Sagili, Habtamu Melesse Dicha, Binaya Patnaik, Venkatesh Kannekanti. (2020).

Non-conventional building materials are in huge demand these days because of rapid urbanization and huge cost associated with conventional building materials. Sand is majorly used fine aggregate in the preparation of concrete, however heavy depletion of river beds and rising cost of sand have made the builders and construction industry to think about alternative form of fine aggregate. Many alternatives like industrial wastes, different types of slags, stone dust and agro wastes etc. have been tried to fully or partially replace river sand in preparation of concrete and the results have been encouraging. Out of the non-conventional materials, copper slag is one such type which has a capable future to be used as a fine aggregate in preparation of concrete. The initial strength studies carried out have shown that the optimum percentage of copper slag as a partial replacement of sand in concrete is 40%. To ascertain any material as a building material it is highly important that along with the strength aspects of the material the durability characteristics also verified. So as part of durability studies of copper slag concrete, an attempt has been made here to examine the impact of acid attack on copper slag concrete and the effects have been compared with that of normal concrete. M30 grade of concrete has been used for this experimental investigation. The test results indicate that durability of the copper slag concrete found to be higher resistant to HCl as compared H2SO4 and also normal concrete has better resistance to acid and sulphate attack compared to copper slag concrete.

Srinivas C. H. , S. M Muranal (2020)

Copper slag is one of the materials which is considered as waste materials in the production of copper, which can be used as partial replacement of fine aggregates in concrete. This paper presents the results of an experimental study on various durability tests on concrete containing copper slag as partial replacement of sand. In this report, M30 grade of concrete was designed and tests were conducted with different percentage of copper slag as fine aggregate in concrete. The results indicate that workability increases with increases in the copper slag percentages. The Compressive Strength is increased upto 8.63 % as compared to normal concrete. The Rapid chloride penetration test is carried out to know the chloride ion penetrability. Also, accelerated corrosion process by galvano static weight loss method is carried out to know the corrosion rate of concrete.

R. Urmila, B. Balraj, Prudhvi Vasanth Saikumar, R. Sridhar, P. Vetriselvan. (2020).

Now-a-days environmental problems are very common in India due to generation of industrial by-products. Due to increase in industrialization the waste products also increase and to utilize these waste products is a big concern. Iron granules and marble dust are some of the industrial by-products from the iron and marble making industries. Large number of studies are going on to improve the performance of concrete with the help of innovative chemical admixtures and supplementary materials. The materials are used in majority of by-products or industrial waste from other processes. This paper presents experimental investigation on effect of addition of marble and iron as partial replacement of fine aggregates on the mechanical properties of concrete such as compressive strength, split tensile strength and flexural strength. The concrete specimen is casted for 7 days, 14 days and 28 days curing to obtain the test results. Optimum strength of concrete is achieved at 15%. Compressive strength of concrete is carried out by varying the percentage of iron and marble at 5%,15%, 25% &35% by increase in weight as a partial replacement of sand.

Grzegorz Prokopskia , Vitaliy Marchukb , Andriy Hutsa (2020).

The article considers the possibility of significant improvement of technical properties of granite concrete with the addition of granite dust. Concrete investigations were carried out in the "Portland cement - granite dust - sand" system. It is established that the fresh properties of concrete mixtures and the kinetics of concrete hardening on the basis of granite dust slightly differs from the consistency and character of the strength increase of regular concrete. It is characterized by a more intensive of strength gain and a mixture of "sticky" consistency. The addition of granite dust leads to an increase in the average density of concrete. Due to the partial replacement of sand with dust, the microstructure of the cement matrix is compacted, which is the main reason for increasing the strength of concrete with dust. Granite dust has a positive effect on both the early and grade strength of concrete, as well as the strength after 90 and 180 days of hardening. The results of experimental research of concrete filled with granite dust at use of CEM I 32,5 R and CEM I 42,5 R are presented. It can be noted that by using CEM I 32,5 R, the strength increase at the age of 3, 7 and 28 days is 24 – 25 %, which is slightly higher compared to using CEM I 42,5 R, where the increase in strength is 17 – 19 % compared to control samples without granite dust. The introduction of granite dust into the concrete mixture leads to a reduction of water absorption by 32 – 38 % and water penetration by 60 – 70 %.

3. OBJECTIVE OF VIEW

1. A study reviewing past research on replacing sand with Granite Powder (GP), Copper Slag (CS) and Iron Powder (IP) . Their review showed that Granite Powder (GP), Copper Slag (CS) and Iron Powder (IP) has increased the mechanical properties of concrete and has the potential to produce durable concrete.
2. Their review of previous research showed that Granite Powder (GP), Copper Slag (CS) and Iron Powder (IP) concrete exhibits enhanced dense and compact concrete matrix at optimum percentage replacement levels.

4. PROBLEM STATEMENTS

1. The experimental research conducted in this study showed the mechanical properties of concrete have improved when Granite Powder (GP), Copper Slag (CS) and Iron Powder (IP) were used as partial replacement of sand in specified percentages.
2. When used in certain proportions, Granite Powder (GP), Copper Slag (CS) and Iron Powder (IP) have shown to increase the compressive strength, flexural strength, and splitting tensile strength of concrete.

5. MATERIALS USED

5.1 Concrete

Concrete is a product obtained artificially by hardening of the mixture of cement, Sand, gravel and water in predetermined proportions. When these ingredients are mixed, they form a plastic mass which can be poured in suitable moulds, called forms, and so on standing into hard solid mass. The chemical reaction of cement and water, in the mix is relatively slow and require time and favorable temperature for its completion. The time, known as setting time may be divided into three distinct phases.

. The proportions of materials of nominal mix concrete as given in Table 01 are prevalent in field. However, IS: 456 restrict its use only up to M-20 grade.

Table no. 01 Mix Proportions of Cement Concrete

Grade of concrete	Mix proportion	Perspective characteristic Strength
M10	1:3:6	10
M15	1:2:4	15
M20	1:1.5:3	20
M25	1:1:2	25

Depending upon the strength (N/mm²) of concrete cubes (150 mm side) at 28 days, concrete is classified as given in Table 02.

Table no. 02 Grades of Cement Concrete

Grade of concrete	Characteristic Strength(in Mpa)
M5	5 Mpa
M7.5	7.5 Mpa
M10	10 Mpa
M15	15 Mpa
M20	20 Mpa
M25	25 Mpa
M30	30 Mpa
M35	35 Mpa
M40	40 Mpa
M45	45 Mpa
M50	50 Mpa

Figure.01 fresh concrete

5.2 Cement

Cement is a well-known building material and has occupied an indispensable place in construction works. There are a variety of cements available in the market and each type is used under certain conditions due to its special properties. A mixture of cement and sand when mixed with water to form a paste is known as cement mortar whereas the composite product obtained by mixing cement, water, and an inert matrix of sand and gravel or crushed stone is called cement concrete. The distinguishing property of concrete is its ability to harden under water. The cement commonly used is Portland cement, and the fine and coarse aggregates used are those that are usually obtainable, from nearby sand, gravel or rock deposits. In order to obtain a strong, durable and economical concrete mix; it is necessary to understand the characteristics and behavior of the ingredients.

Ordinary Portland Cement (IS: 269)

The properties of various types of Portland cement differ because of relative proportions of the four compounds and the fineness to which the cement clinker is ground. The Ordinary Portland Cement or the Setting Cement is the basic Portland cement and is manufactured in larger quantities than all the others.

Table no. 03 Ordinary Portland Cement

Cement Type	OPC
Grade of Cement	53 grade
Company Name	ACC Cement
Dealer Name	Anupam Traders Jabalpur MP
Market Price	Rs 305/bag

Figure 02 Ordinary Portland Cement (IS: 269)

Table no.04 properties of Cement

S.No	Properties	Value	Permissible limit as per IS:12269-1987
1	Specific Gravity	3.14	Varies from 3.1 to 3.15
2	Initial setting time	63 min	Should not be less than 30 Min
3	Final setting time	321 min	Should not be more than 600 Min
4	Fineness test	1% retained	<10%

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5.2 Fine Aggregate

Fine aggregates are essentially any unrefined sand that has been extracted from the earth by mining. Natural sand or any crushed stone particles that are 14 inch or smaller make up fine aggregates ", or less. This item is frequently referred to as 1/4' "minus because it describes the grading or size of this specific aggregate.

Figure 03 Sand

Table no. 05 Sand or Fine Aggregate

Sand Type	**Narmada River Sand (Natural)**
Grade of Sand	Zone III
Company Name	Anupam Traders Jabalpur MP
Dealer Name	Anupam Traders Jabalpur MP
Market Price	Rs 48 /Cubic feet

5.3 Coarse Aggregates

Coarse aggregates are those which range from 10-mm size upwards to 80-mm maximum size, namely all material that is retained on a 10-mm IS sieve. Coarse aggregate may consist of natural picked gravel, crushed gravel, crushed stone and the like. Coarse aggregates also have to be graded from 10-mm up to the maximum size used on the job, usually 63-mm. The grading of aggregates varies with the mix desired.

Figure 04 Coarse Aggregates

Table no. 06 Coarse Aggregates

Coarse aggregates Type	**Crushed stone 10 mm to 20 mm**
Company Name	Bhanot Crusher Stone Services Jabalpur MP
Dealer Name	Anupam Traders Jabalpur MP
Market Price	Rs 24/Cubic feet

5.4 Water

Water is also mixed in concrete to release the heat of hydration and make it hard. Water is normally measured by volume, and specified as so many liters' per bag of cement. For a given quantity of water to be mixed in concrete, adjustment should be made for the amount of water present in Sand and aggregate. 1he amount o ne water present in the aggregate, due to hygroscopic action etc. should be subtracted from the total required quantity of water. However, the aggregate s dry, and found to absorb water, extra water should be added to account for this. The percentage absorption should be determined first.

Figure 05 Water

5.5 Granite Powder

Granite powder, a waste material from the granite polishing industry, is a promising material for use in concrete similar to those of pozzolanic materials such as silica fume, fly ash, slag, and others. These products can be used as a filler material (substituting sand) to reduce the void content in concrete. Granite belongs to igneous rock family. The density of the granite is between 2.65 to 2.75 gm/cm3 and compressive strength will be greater than 200MPa. Granite powder obtained from the polishing units and the properties were found. Since the granite powder was fine, hydrometer analysis was carried out on the powder to determine the particle size distribution. From hydrometer analysis it was found that coefficient of curvature was 1.95 and coefficient of uniformity was 7.82. The specific gravity of granite powder was found to be 2.5.

Figure 06 Granite powder

5.6 Iron powder

Iron powder has several uses; for example production of magnetic alloys and certain types of steels. Iron powder is formed as a whole from several other iron particles. The particle sizes vary anywhere from 20-200 µm. The iron properties differ depending on the production method and history of a specific iron powder. There are three types of iron powder classifications: reduced iron powder, atomized powder, and electrolytic iron powder. Each type is used in various applications depending on their properties. There is very little difference in the visual appearances of reduced iron powder and atomized iron powder.

Iron powder is also used for the following:

- Bearings and filter parts.
- Machine parts .
- Hand Warmers.
- High strength/wear-resistant parts.
- Magnetic materials.
- Friction parts (mainly automobile parts).
- As a fuel.

Figure 07 Iron powder

5.7 Copper Slag (CS)

A by-product of the smelting process used to extract copper is copper slag. Impurities turn into slag, which floats on the molten metal, during the smelting process. When slag is quenched in water, it produces angular granules that can either be wasted or used in the ways that are described below.

Concrete can be made using copper slag in place of some of the sand. Copper slag is formed into blocks and used as a building material. Such use was widespread in smelting regions, such as Cornwall[2] and St Helens in England. Fumed and settled granulated copper slag from the Boliden copper smelter is used as a road construction material in Sweden (Skillet region). In order to prevent pavement cracks during the winter, it is possible to use the granulated slag's (3 mm size fraction) insulating and drainage properties. The use of this slag reduces the need for primary materials and the depth of construction, both of which increase energy demand during construction. The same factors that make granulated slag problematic.

Figure 07 Copper Slag

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