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Durability Studies on Self Compacting Concrete Incorporating Granite Powder

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Abstract Self compacting concrete (SCC) has gained popularity in recent years due to its unique ability to flow and contract under its own weight without the need for mechanical connections. SCC is a material that is widely used, however its durability is essentially lacking. The current research looked on how granite powder affected SCC's durability traits. Granite powder was added to regular Portland cement in different proportions, ranging from 0% to 20% with 5% increments. Abrasion, water absorption, and accelerated corrosion tests were used to evaluate the durability of the cementitious SCC matrix including granite powder. When compared to the other mixes, the results indicate that the SCC mixes with 10% granite powder have shown remarkably better durability behavior.

According to the present research, 10% granite particle content is ideal for replacing some of the cement in SCC, leading to improved or equivalent durability characteristics. There are several benefits to using granite powder in the building sector. It preserves natural resources by acting as a competitive substitute for cement. It also does away with the need for land management in order to dispose of granite powder.

Keywords: *Durability, Self-compacting concrete, Granite powder, Accelerated corrosion, Abrasion, Water absorption*

1 INTRODUCTION

To tackle issues with cast set up concrete, the development business would need to see the improvement of self-compacting concrete (SCC). Self-compacting cement might be siphoned further in view of its extraordinary smoothness and protection from isolation, and it is unaffected by laborer skill, the amount and type of supporting bars, or the design of a structure (Bartos, 2000). The model for self-compacting concrete was made in 1988 in Japan by teacher Ozawa (1989) at the College of Tokyo, while the thought was at first put out by teacher Hajime Okamura (1997) in 1986. At that time, self-compacting concrete was created to increase the longevity of concrete constructions. Since then, a number of studies have been conducted, and SCC has been applied to real-world buildings in Japan, mostly by major construction firms. From the standpoint of standardizing concrete, research has been done to develop a logical mix-design process and self-compaction testing procedures.

Concrete that self-compacts is cast in a way that eliminates the need for extra vibration, either from the inside or the outside. After putting, it has a very smooth surface and glides like "honey." The ingredients of ready-mixed concrete are the same as those of conventional flexible concrete: cement, aggregate and water; The only difference is in the amount of chemicals and minerals used. Chemical admixtures that change the structural properties of concrete often cause high water content (superplasticizers) and reduce the quality of admixtures. In addition to cement, mineral salts are also used as a good additive and sometimes as a substitute. In this study conducted in 1, minerals that increase the strength of concrete and reinforcing materials such as fly ash, slag cement and silica fume were partially used instead of cement.

1.1 Granite powder

During the cutting and grinding of granite, a waste product known as granite dust is created by the granite stone industry. This fine powder is not biodegradable. The granite industry generates a lot of garbage and dust. The environment is being exposed to garbage from granite polishing facilities, which poses a health risk. When preparing concrete, this granite powder may be used in lieu of some of the fine particles. The cutting and polishing of granite produces granite powder, which is then exposed to environmental factors that pose health risks. The open disposal of waste material takes up a significant amount of area, looks horrible, and poses health and environmental risks.

In the current study, a number of experiments are conducted to compare different qualities to concrete mix that is made with granite dust substituted for some of the sand. According to the current study's findings, concrete cubes containing granite dust had greater compression strength than concrete cubes including river sand as fine aggregate.

During the process, granite grains combine with water and form sediment. The flow-through process significantly reduces mud water during placement and the waste becomes a dry heap without granite dust. The strength behavior of the cube with granite powder added instead of the fine part of Portland cement and coarse aggregate is clearly seen from the results.

The main purpose of this study is to evaluate the properties of concrete made with granite powder mixed into concrete and to evaluate the performance of concrete made with granite powder. Comparison of the new and dynamic properties of concrete made with granite powder in M30 SCC class and finally evaluation of the durability of concrete made with granite powder.

2. LITERATURE STUDIES

1.Bertil Persson (2001) Experimental and computational studies have been conducted comparing the mechanical parameters of concrete, such as strength, elastic modulus, creep and shrinkage, with normal concrete.Eight mixed or closed air samples with water absorption rate (w/b) ranging from 0.24 to 0.80 were included in the study. SCC constitutes 50% of the mixture and NCC constitutes the remaining 50%. The age of the concrete during creep tests varied from two days to ninety days during loading. Relative humidity and energy were also discovered. The results showed that there was no significant difference between the elastic, creep and shrinkage models of SCC and the corresponding parameters of NCC.

2.Nan Su et al (2001) suggested a novel approach to self-compacting concrete mix design. To guarantee that the concrete produced has the necessary flow, self-compaction, and other SCC qualities, the necessary number of aggregates was first calculated, and the binders' paste was then added to the aggregate voids. The main variables affecting the properties of SCC are the amount of aggregate, binder and mixing fluids used, as well as the type and amount of superplasticizer. SCC performance was evaluated using droplet, V-funnel, L-flow, U-box, and compression forces. The results of the study showed that the proposed method can be used to produce high-quality SCC.

MATERIALS USED AND MIX DESIGN OF CONCRETE

3.1 Materials used

3.1.1 Cement

Since cement is a binding ingredient that is often utilized in all construction, selecting high-quality cement is essential to achieving optimum strength. We utilized OPC 53 Grade cement for this investigation, as shown in the figure below.

Figure 1: OPC 53 Grade ACC Cement

3.1.2 Coarse aggregate

The material on the IS 4.75mm is a complete set. The size of the coarse aggregate used in this study was 20 mm and was collected from areas around Warangal. The coarse aggregates used in this investigation are shown in figure 3.2 below. Self-compacting concrete mixtures are made from coarse particles that are kept on a 10mm IS sieve after passing through a 12.5mm sieve.

Figure 2: Coarse aggregates

3.1.3 Fine aggregates

Materials that pass through a 4.75mm screen are considered fine aggregates. Figure 3 below illustrates the fine aggregates that were employed in this investigation. In the present research, self-compacting concrete mixtures are made using fine aggregates (sand) with particle sizes less than 1.18 mm, in accordance with the mix design of M35 grade concrete.

Figure 3: Fine aggregates

3.1.4 Granite powder

The material on the IS 4.75mm is a complete set. The size of the coarse aggregate used in this study was 20 mm and was collected from areas around Hyderabad. Granite powder is a highly dispersed mineral that fills the spaces between grains to form a stable structure that increases the density and rheological properties of cement paste..

Nevertheless, granite powder ends up in landfills since it isn't utilized very often these days.

Figure 4: Granite powder

3.1.5 Super plasticizer

Nowadays, superplastic is used by many people to strengthen concrete. In this study, I used a mixture called Betan Polymix PCE 3000, which has a cement content of 2% according to the self-compacting concrete (SCC) design.

Figure 5: Super plasticizer used in this research

3.2 Mix design and mix trials used in this study

The contents of cement fly ash, fine aggregate, coarse aggregate, water, SP 430, are listed below.

- Cement = 294kg/ m3
- Fly ash = 196kg/ m3
- Fine aggregate = 900 kg/ m3
- Coarse aggregate = 847.65kg/ m3
- Water = 220.5 lit/ m3
- SP 430 = 7.35 lit/ m3

SP430 dosage =2.5% of cementation materials

Final mix of M30 grade SCC 1: 1.8367:1.73

4 EXPERIMENTAL STUDY

4.1 Casting of the specimens

Prisms, cubes, and cylinders are cast for M35 grade concrete. Granite powder is replaced for cement in the following proportions: 0%, 5%, 10%, 15%, and 20% when forming cubes for ordinary concrete.

Figure 6: Casting of samples (cubes and prisms)

Figure 7: Cylindrical specimens after casting

4.2 Curing the test specimens

Allow the sample to harden for at least 24 hours after pouring. Test samples must be disposed of carefully to avoid affecting various tests for altering municipal waste. Damaged samples should then be immersed in a recovery reservoir. In this study, I compared strength using water pooling (WSC) at ages 7, 14, and 28 years.

Figure 8: Curing of specimens for 7 days, 14 days and 28 days age

4.3 Compressive strength of concrete

To test the compressive strength of concrete, cube samples measuring 150 millimeters x 150 millimeters x 150 millimeters are used. This testing is performed using a 200T capacity Compression Testing Machine (CTM). In this study, the compressive strength of M30 concrete is determined based on the percentage of granite waste from 0% to 20% using the IS 516-1959 code book.

Figure 9: Testing of 10%MSW specimen at 7 days curing

4.4 Split tensile strength

The split tensile strength calculation necessitates a cylindrical specimen with a radius of 150 mm and a height of 30 mm. In compliance with IS 516-1959 code, a compression testing machine (CTM) with a 200T capacity is used for this test. M330 grade concrete is utilized in this test, with different percentages of granite refuse (from 0% to 20%) added.

Figure 10: Split tensile strength testing at 5% Plastic at 14 days curing

4.5 Flexural strength

The flexural strength of the concrete is evaluated using prism specimens of 150 mm by 150 mm by 700 mm. The flexural strength is computed for a range of GW percentages, from 0% to 20%, using IS516-1959.

Figure 11: Flexural strength of prism specimen

4.6 Durability of concrete

4.6.1 Accelerated corrosion test on concrete

Steel corrodes in concrete quite slowly. It will take years for the corrosion process to begin, even with less resistant concrete. Therefore, accelerating corrosion is the sole method for measuring corrosion or doing corrosion-based analysis. There are several ways to hasten corrosion in a specimen made of reinforced concrete. The impressed current method is one of them. One of the most well-known and often used accelerated corrosion techniques in concrete technology research is impressed current method.

Figure 12: Testing of corrosion test

4.7 Water Absorption test

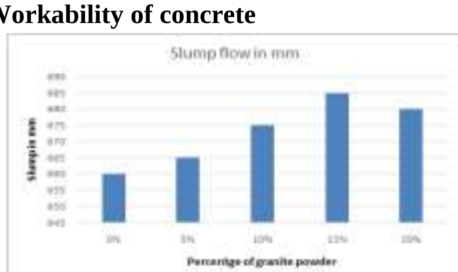
Concrete water absorption test determines the water absorption capacity of the sample. This testing is important to determine the durability and water resistance of concrete and ensure it performs as intended in the environment.

4.8 Abrasion Test

The durability and wear resistance of concrete surfaces are assessed using abrasion resistance testing. It shows how resistant concrete is to erosion, abrasion, and surface deterioration as well as how well it can tolerate abrasive pressures. Usually, the test entails applying controlled abrasive action to the concrete surface. The weight loss of the samples both before and after they are exposed to abrasion is known as the abrasion value.

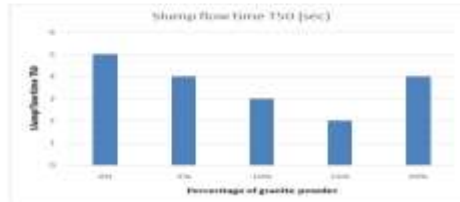
5 RESULTS AND ANALYSIS

5.1 Workability of concrete



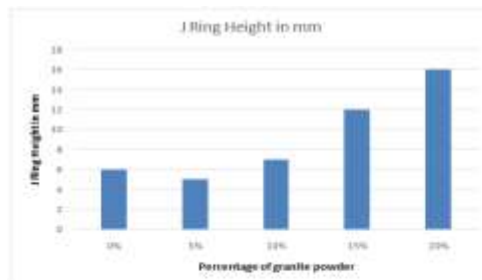
Graph 1: Comparison of slump flow test

The aforementioned graph shows that as the proportion of granite powder in M30 grade concrete grows from 0% to 15%, the value of slump progressively reduces to 20% granite powder.



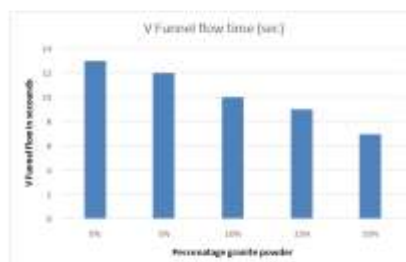
Graph 2: Comparison of slump flow time (T50) test

The aforementioned graph shows that when the proportion of granite powder in M30 grade concrete is increased from 0% to 15%, the value of slump flow t50 decreases and then progressively climbs to 20%.



Graph 3: Comparison of J ring height in mm

The graph above shows that as the amount of granite powder in M30 grade concrete increases from 0% to 20%, the value of the J ring height increases as well.



Graph 4: Comparison of V funnel flow time height

The graph above shows that as the amount of granite powder in M30 grade concrete increases from 0% to 20%, the value of the V funnel flow time reduces.

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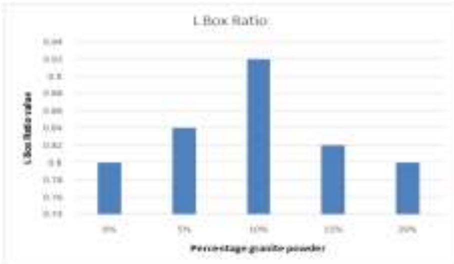
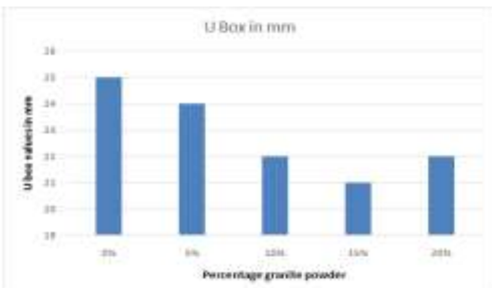


Graph 5: Comparison of L Box Ratio test

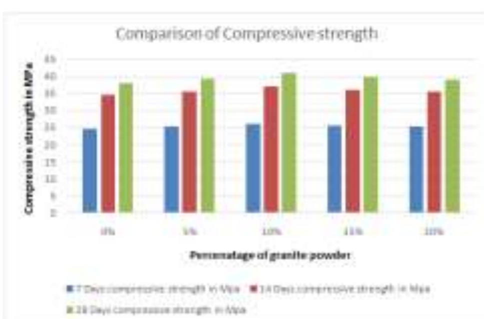
It is evident from the preceding graph that the value of the L box ratio rises up to 10% granite and then falls after 10% granite powder.



Graph 6: Comparison of U box test

The graph and table above compare the U box value test results as the amount of granite powder in M30 grade concrete increases from 0% to 20%. The value of the U-box ratio drops up to a 15% replacement with an increase in the proportion of granite powder, and thereafter it rises.

5.2 Compressive strength of concrete



Graph 7: Comparison of compressive strength

Using a universal testing machine (UTM), the compressive strength of concrete after curing is determined for tests 1 to 5. The compressive strength of concrete after 7, 14 and 28 days of curing is shown in the figure below. The results of the experimental effort are shown in the table below. Based on the above observations, it was concluded that the best compressive strength was achieved in M30 grade concrete after seven, fourteen and twenty-eight days of curing on 10% granite powder.

5.3 Split tensile strength of concrete

Graph 8: Comparison of split tensile strength

Cylinder samples are used to compare the tensile strength of M30 class concrete mix tests from test 1 to test series. The dimensions of the cylinder were determined to be 300 mm long and 150 mm in diameter. The difference in strength after 7, 14 and 28 days is shown in the graph below. Split tensile strength test results are shown in the table and diagram above. Based on the above observations, it was concluded that the best splitting value was obtained after 7 days, 14 days and 28 days of curing for 10% granite powder in M30 concrete.

5.4 Flexural strength of concrete

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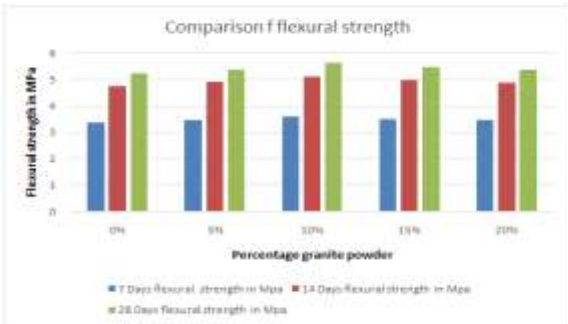
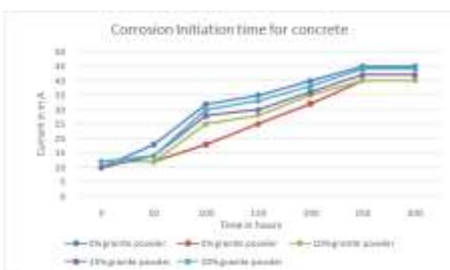


Graph 9: Comparison of flexural strength

The strength of conventional concrete is evaluated using prism samples with lengths of 150 mm, 150 mm and 700 mm. The flexural strength of the prism for M30 concrete was measured for tests 1 to 5. The figure below shows the concrete strength after 7 days. , 14 days 28 days recovery. The results of the strength tests are shown in the table below. Based on the above, it is concluded that 10% granite powder in M30 grade concrete gives good results after 7 days, 14 days and 28 days of curing.

5.5 Durability of concrete

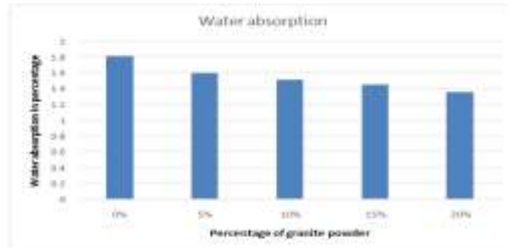
Accelerated corrosion test



Graph 10: Comparison of corrosion Initiation time

This research uses an accelerated corrosion test to determine how durable concrete is. The value of current from the accelerated corrosion test in M30 grade concrete increases as the amount of granite powder increases.

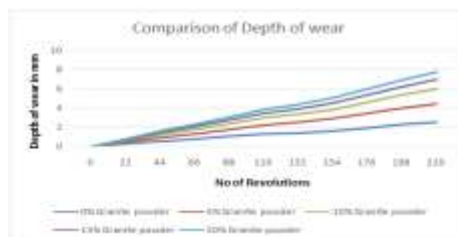
5.6 Water absorption test results



Graph 11: Comparison of water absorption

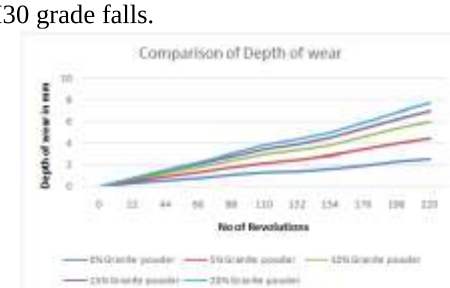
Test specimens consisting of cubes with varying percentages of granite powder (0%–20%) in M30 grade concrete are used for the water absorption test. When the proportion rises from 0% to 20%, the water absorption value of concrete containing granite powder in M30 grade falls.

5.7 Abrasion test results



Graph 12: Comparison of depth of wear

Test specimens consisting of cubes with varying percentages of granite powder (from 0% to 20%) in M30 grade concrete are subjected to an abrasion test. As the proportion increases from 0% to 20%, the abrasion value of concrete containing granite powder in M30 grade falls.



Graph 13: Comparison of percentage loss in weight

Test specimens consisting of cubes with varying percentages of granite powder (0%–20%) in M30 grade concrete are used to measure weight loss. As the proportion rises from 0% to 20%, the weight value loss of concrete containing granite powder in M30 grade reduces.

6 CONCLUSIONS

It stands out worldwide for supporting sustainable development in the construction industry, where green, environmentally friendly, practical work is carried out. Due to its resistance effect, it is necessary to use granite powder as a partial substitute for cement in casting. The main features of partial replacement studies are as follows.

- The slump value is increases till mix 4 (15% granite powder) mix after this mix the slump value gradually decreases.
- The T50 test value decreases till 15% granite powder after this mix the T50 value increases with increase in the percentage of granite powder.
- The value of J ring height increases from 0% granite powder to 20% granite powder mix then after that the value of J ring gradually decreasing.
- The V funnel flow value gradually decreases from 0% granite powder to 60% granite powder for M30 concrete mix.
- Maximum value of L Box ratio test was obtained at 10% granite powder for M30 grade self compacting concrete. Maximum value of U Box ratio test was obtained at 0% granite powder for M30 grade self compacting concrete.
- With 10% granite powder and the rest of the test, the tensile strength, uniform strength distribution and positive value of flexural strength increase from 0% to 20% after 7 days, 14 days and 28 days.
- As the amount of granite powder in M30 class concrete increases from 0% to 20%, the water absorption value decreases.
- When the amount of granite powder in M30 concrete is increased from 0% to 20%, the weight loss and length of the fabric increases.

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