STRENGTH STUDIES ON CONCRETE USING GRANITE POWDER AS PARTIAL REPLACEMENT OF SAND

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ABSTRACT

In this study, partial replacement of sand by granite powder has been done inorder to enhance economy in construction. More once, the solution of disposal of granite powder waste from granite industry is also achieved. Further various physical properties of granite powder as Specific gravity, Finess modulus has been studied to make the study fruitfull concrete of grade M_{20} is used to study the strength properties of concrete with granite powder. Replacement of sand by granite powder has been done instages starting from 0% to 25% each stage possessing the variation of 5%. For testing the compression strength behaviour of a granite powder, concrete cubes specimens of size 150mm x 150mm x 150mm are cast for all the said replacement ratio after 7 and 28 days of curing, the cube specimens are tested for compression. Similarly for testing of splitting tensile test, concrete cylinders of size 100mm diameter and 200 height are cast and tested at 7 and 28 days of curing. For Flexural strength determination, beam specimens of size 500mm x 100mm x 100mm are cast and tested at 7 and 28 days of curing. From the test results, it has been found that cement concrete mix with 15% granite powder replaced by sand gives better strength in compression, tension and in flexural.

KEYWORDS: *Compressive strength[1], Split tensile strength[2], Flexural strength[3], Granite powder[4]*

I. INTRODUCTION

Granite is one of the construction material and used for flooring. In India, good quality granite deposits are wide spreading here and there. It is fine grained rock have uniform granular structure. Due to the increase in demand for construction materials like marble, a lot of companies both local and international companies dealing with marble are increasing in numbers every day. A good quality marble has all the properties of a good building stone. In the marble industries, to give a uniform shape to granite, the granite blocks are cut to small blocks. During the cutting and shaping process of granite, more than 25% of the granite blocks are converted into powder. This powder settles due to sedimentation, and then it is dumped somewhere within the industry which causes environmental pollution. In addition to this, it becomes a threat for agriculture and human health. Therefore it becomes absolutely necessary to dispose this marble waste properly or reuse it.

Many research works have been carried out to utilize this granite waste powder as a economical and eco-friendly material and have succeeded. When the granite dust is used as a replacement of fine aggregate in concrete, it has displayed an enhancing effect on compressive strength. Some researchers found that, when granite dust is used as a replacement of cement, it has increased the compressive strength to a considerable amount. The partial replacement of fine aggregate by granite powder or granite granules results in increase in workability and compressive strength of mortar and concrete. When granite and lime stone dust is used an additive in concrete,

the abrasion resistance and sodium sulphate resistance has been considerably increased Hence an attempt is made here to study the strength properties of cement concrete using granite powder as a partial replacement of sand.

II. LITERATURE REVIEW

1) Title: Quarry dust as river sand replacement in cement masonry blocks: Effect on mechanical and durability characteristics

Authors: Kosalya Sundaralingam, Arvinthan Peiris, Arulanantham Anburuvel, Navaratnarajah Sathiparan

Journal: Elsevier journal, Materialia book
Volume 21, March 2022, 101324

Abstract: Natural sand or river sand constitutes as major fine aggregate in cementitious construction. Especially, masonry block production requires 70–90% sand as raw material. While the demand for river sand increases rapidly, the supply of good quality river sand is limited due to the restrictions in sand mining in river beds. Because excessive extraction of river sand to cater the increasing demand has brought undesirable environment-related consequences. The persisting issues encouraged the researchers to find a sustainable alternative for river sand. Quarry dust is one of the alternatives as it has some advantages over river sand such as better contribution to the strength of the cementitious material, better workability, lesser cement consumption and eco-friendly**. The present study explored the feasibility of using quarry dust as fine aggregate in manufacturing cement blocks. Cement blocks with four different quarry dust composition levels 0, 33.3%, 66.7 and 100%, were prepared and tested**. The testing included determination of mechanical characteristics (compressive and flexural strength) and durability aspects (sorption, evaporation, wet and dry cycle, resistance against salt, alkaline and acid solution). The test results exhibited that mechanical characteristics and resistance against wet and dry cycles improved when quarry dust completely replaced river sand as fine aggregate. When quarry dust content increased, the cubes subjected to severe environmental conditions exhibited higher strength reduction rates compared to that of normal environmental condition. The final strength, however was higher than the corresponding cubes with river sand. In addition to strength improvement, quarry dust replacement yielded lesser cost and sustainable benefits, which would promote the deployment of quarry dust in cement-sand block production.

2) Title: A review on Properties of Sustainable Concrete using granite dust as replacement for river sand.

Authors: Sarbjeet Singh, Ravindra Nagar, Vinay Agrawal.

Journal: Elsevier journal ,Journal of Cleaner Production book.
Volume 126, 10 July 2016, Pages 74-87

Abstract: Granite dust is a waste produced during cutting and grinding process of granite stone. The waste generation from granite stone industry is in the form of non-biodegradable fine powder, the utilisation of this waste in concrete will help in sustainable and greener development.
Published literature shows huge potential of granite dust as a replacement of natural fine aggregate. The depletion of reserves of sand and stricter mining laws have made the need for substitution of natural sand in concrete an absolute necessity. A comprehensive overview of the published literature on the use of granite dust in concrete is being presented. Effect of granite dust on the properties of concrete such as workability, setting times, compressive strength, split tensile strength, flexural strength, shrinkage, durability & microstructure of concrete have been presented.

3) Title: Partial replacement of sand by granite powder in concrete.

Authors: Narmatha. M, Vishali. G, Noveena. S and Uthra Megala. R

volume 3, Issue 1 (Jan- May) 2018), PP. 16-20

Journal: International Journal of Precious Engineering Research and Applications (IJPERA)

Abstract: The main objective of Waste Management System is to maximize economic benefits and at the same time to protect the environment. Granite process industry generates a large amount of wastes mainly in the form of powder during sawing and polishing processes, which pollute and damage the environment. This work aims to characterize and evaluate the possibilities of using the granite sawing wastes, generated by the process industries from Salem District, as alternative raw materials in the production of concrete. This granite powder waste can be utilized for the preparation of concrete as partial replacement of sand. In order to explore the possibility of utilizing the granite powder as partial replacement to sand, an experimental investigation has been carried out. **The percentages of granite powder added to replace sand by weight were 0, 5, 10, 15, 20 and 25. This attempt has been done due to the exorbitant hike in the price of fine aggregate and its limited availability.**

4) Title: Experimental study of concrete made with granite and iron powders as partial replacement of sand.

Authors: Shehdeh Ghannam, Husam Najm and Rosa Vasconez.
sustainable Materials and Technologies 9 (2016) 1–9.

Journal: Elsevier journal, Sustainable Materials and Technologies book.

Abstract: Granite Powder (GP) and Iron Powder (IP) are industrial byproducts generated from the granite polishing and milling industry in powder form respectively. These byproducts are left largely unused and are hazardous materials to human health because they are airborne and can be easily inhaled. An experimental investigation has been carried out to explore the possibility of using the granite powder and iron powder as a partial replacement of sand in concrete. Twenty cubes and ten beams of concrete with GP and twenty cubes and ten beams of concrete with IP were prepared and tested. **The percentages of GP and IP added to replace sand were 5%, 10%, 15%, and 20% of the sand by weight. It was observed that substitution of 10% of sand by weight with granite powder in concrete was the most effective in increasing the compressive and flexural strength compared to other ratios. The test resulted showed that for 10% ratio of GP in concrete, the increase in the compressive strength was about 30% compared to normal concrete.** Similar results were also observed for the flexure. It was also observed that substitution of up to 20% of sand by weight with iron powder in concrete resulted in an increase in compressive and flexural strength of the concrete.

5) Title: A review on substitution of natural sand with granite fines in sustainable concrete.

Authors: Ziyang Li, Junying Lao, Lijie Wang, Namyo Salim Lim, Kang Hai Tan, Shunzhi Qian
Volume 346, 5 September 2022, 128417.
Journal: Elsevier journal **,** Construction and Building Materials book.

Abstract: A mass amount of granite fine (GF), a byproduct of the cutting and grinding process in the masonry industry, is generated every year all around the world. Most of these wastes are landfilled which will cause serious environmental problems. The usage of GF as the sand substitution in concrete may ideally not only help minimize the environmental issues but also provide economic benefit. Due to significant variations on the properties of the material being used and different understanding of GF substitutional concrete existing among different researchers based on their experimental works and local material sources, a more conclusive and reconciled understanding should be established to improve industrial stakeholders' confidence in applying this material for construction. In this paper, the laboratory tests and findings from various latest research papers and industrial reports are gathered to shed light on the effects of GF on the performance of concrete as natural sand (NS) substitute. Comprehensive reviews of GF concrete on the fresh property (e.g., slump, bleeding), hardened property (e.g., compressive strength, flexural strength, splitting tensile strength) as well as the durability (e.g., water permeability, water absorption, resistance to sulphate attack, and acid attack, carbonation, and chloride permeability) are presented. A comparative life cycle impact assessment study of four concrete mixes with different GF replacement levels is conducted by considering the cradle-to-gate boundary for the Singapore scenario. **The results turn out that around 20% environmental impact reduction can be realized via the replacement of 25.6%−50% NS with GF.**

III. MATERIALS USED

The various materials used in the proportion of concrete are as follow.

1.Cement.

2.Coarse Aggregate.

3.Fine Aggregate.

4.Granite powder.

5.Water.

IV. EXPERIMENTAL PROGRAMME

- **Mix Design**

To investigate the strength of granite powder as partial replacement of sand and the properties of conventional concrete the mix design is done according to 10262-2019. Strength properties of M_{20} grade concrete were studied.

- **Casting of test specimens**

In present study the specimens of standard size of cubes 150 x 150 x 150mm and size of cylinders 100mm diameter, 200mm height and size of prisms 500 x 100 x 100mm were casted. The specimens were tested after 7 and 28 days of curing.

1) Mixing

Measured quantities of coarse aggregate and fine aggregate were spread over an impervious concrete floor. The dry PPC were spread out on the aggregate and mixed thoroughly in dry state turning the mixture over and over until the uniformity of color was achieved. Water was measured exactly and it was thoroughly mixed to obtain homogenous concrete. The mixing shall be done for 10 to 15 minutes.

2) Placing and Compacting

The moulds are cleaned and all care is taken to avoid irregular dimensions. The mix was placed in 3 layers and the layer was contacted using table vibrator to obtain dense concrete.

3) Curing

The test specimens were stored for 24 % hours from the time of addition of water to dry ingredients. After 24 hrs the specimens were demoulded and immediately immersed in clean, fresh water tank for 7 and 28 days.

4) Testing

All the tests performed are as per IS specification. After 7 and 28 days the specimens are taken for the test. After 7 and 28 days of curing specimens were tested compressive strength for cubes and split tensile strength for cylinder and flexural strength for prisms.

V. PROCEDURE FOR PREPARATION OF CONCRETE

1.Specimens are to be prepare by adopting 5%, 10%, 15%, 20% and 25% adding of Granite powder as partial replacement of sand.

2. Cube samples of size 150mm x 150mm x 150mm and size of cylinder 100mm diameter, 200mm height and size of prisms 500 x 100 x 100mm are to be prepare for testing of Compressive strength, Split tensile strength, flexural strength of concrete for 7 and 28 days.

3. All the materials used to be prepared by the samples are as per IS specifications.

4. All the tests performed are as per IS specification.

VI. EXPERIMENTAL ANALYSIS

1. Compressive Strength Test:

Compressive strength of concrete is important property of concrete. The other properties of concrete have definite relationship with the compressive strength. If the compressive strength of concrete is improved there is an improvement in other properties of concrete also, therefore compressive strength is an essential test.

Compressive strength of concrete also depends on size of specimen, the height of test specimen is related to its lateral slender the specimen lower will be the crushing strength value. Therefore, two types of standard test specimens that is cubes and cylinders are used m this study.

Apparatus: Compression testing machine, Preparation of cubes of dimensions: 150mm x 150mm x 150mm.

Procedure:

- Concrete mix is design for M_{20} grade as per IS standards and the proportions are indicated m the observation.
- Calculate the material required for cubes using the concrete of proportion 1:2.06:4.09 by mass and water to cement ratio 0.46.
- Take Coarse Aggregate, Fine aggregate, cement, water, granite powder required quantity and mix it thoroughly.
- Apply oil uniformly to the inside of the moulds om all the surfaces.
- If mixing is by hand the cement and the fine aggregate shall be mixed dry to the uniform colour and then the coarse aggregate is to be added, mix until the coarse aggregate is uniformly distributed. Now water shall be added and whole mix is mixed until the resulting concrete is uniform.
- Fill concrete in moulds in 3 layers each of approximately tamping each layer with 25 blows evenly distributed over the surface.
- Stike off the excess concrete with a straight metal edge flash with top of the moulds.

Curing:

After 24hrs of casting specimens. The specimens are immersed in water for curing. Specimens are removed from the mould after 24hrs and cured in water for 7 and 28 days.

Testing:

- After 7 and 28 days of curing place the cubes on compressive testing machine
- Apply the load gradually until the failure.

$$\text{Compressive Strength} = \frac{\text{Load}}{\text{Area}} \quad N/mm^2$$

Fig-1 Compressive Strength Test

2. Tensile Strength Test:

The tensile strength is one of the basic and important property of concrete. The concrete is sot usually expected to resist the direct tension because of its low tensile strength and brittle nature. In the design of structure concrete is exploited so as not to relay on its tensile strength which is low. Split tensile strength for split tensile strength of concrete, 100mm diameter and 200mm height of cylinders were used. The split tensile strength on cylinder were conducted on a Compressive testing machine.

Curing:

After 24hrs of casting specimens. The specimens are immersed in water for curing. Specimens are removed from the mould after 24hrs and cured in water for 7 and 28 days.

Testing:

- ❖ After 7 and 28 days of curing place the cylinders on compressive testing machine
- ❖ Apply the load gradually until the failure.

$$\text{Split Tensile Test} = \frac{2P}{\pi DL} \quad N/mm^2$$

Fig-2 Split Tensile Strength Test

3. Flexural Strength Test:

Flexural strength for prism flexural testing of concrete, 500 x 100 x 100mm size were used. All the prisms were tested in saturated condition, after wiping out the surface moisture. They were tested at the age of 7 days and 28 days of curing using compression testing machine of 2000 KN capacity.

Curing:

After 24hrs of casting specimens. The specimens are immersed in water for curing. Specimens are removed from the mould after 24hrs and cured in water for 7 and 28 days.

Testing:

- ❖ After 7 and 28 days of curing place the cylinders on compressive testing machine
- ❖ Apply the load gradually until the failure.

$$\text{Flexural Strength Test, } \sigma = \frac{M}{I} \; y \quad N/mm^2$$

Fig-3 Flexural Strength Test

VII. RESULT AND COCLUSION

1. Compressive Strength Test on Concrete Cubes as partial replacement of sand

FOR 7 DAYS

S.NO	% OF GRANITE POWDER	CURING DAYS	COMPRESSIVE STRENGTH OF CONCRETE (N/mm^2)
1.	0%	7 DAYS	17.18
2.	5%	7 DAYS	11.40
3.	10%	7 DAYS	8.44
4.	15%	7 DAYS	10.67
5.	20%	7 DAYS	10.51
6.	25%	7 DAYS	8.44

FOR 28 DAYS

S.NO	% OF GRANITE POWDER	CURING DAYS	COMPRESSIVE STRENGTH OF CONCRETE (N/mm^2)
1.	0%	28 DAYS	26.22
2.	5%	28 DAYS	21.92
3.	10%	28 DAYS	20.92
4.	15%	28 DAYS	25.77
5.	20%	28 DAYS	18.07
6.	25%	28 DAYS	17.78

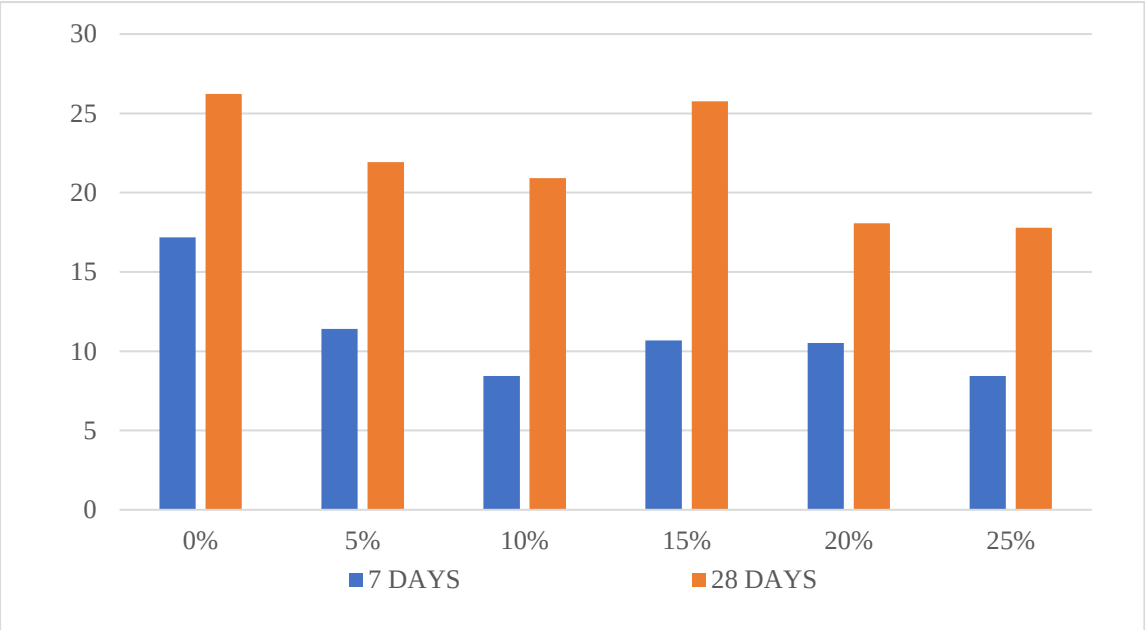

Fig-4 Comparison Results of Compressive Strength Test at 7 and 28 Days

2. Split Tensile Strength Test on Concrete Cylinders as partial replacement of sand

FOR 7 DAYS

S.NO	% OF GRANITE POWDER	CURING DAYS	SPLIT TENSILE STRENGTH OF CONCRETE (N/mm^2)
1.	0%	7 DAYS	0.58
2.	5%	7 DAYS	0.53
3.	10%	7 DAYS	0.31
4.	15%	7 DAYS	0.47
5.	20%	7 DAYS	0.29
6.	25%	7 DAYS	0.26

FOR 28 DAYS

S.NO	% OF GRANITE POWDER	CURING DAYS	SPLIT TENSILE STRENGTH OF CONCRETE (N/mm^2)
1.	0%	28 DAYS	2.11
2.	5%	28 DAYS	1.90
3.	10%	28 DAYS	1.37
4.	15%	28 DAYS	2.11
5.	20%	28 DAYS	1.69
6.	25%	28 DAYS	1.48

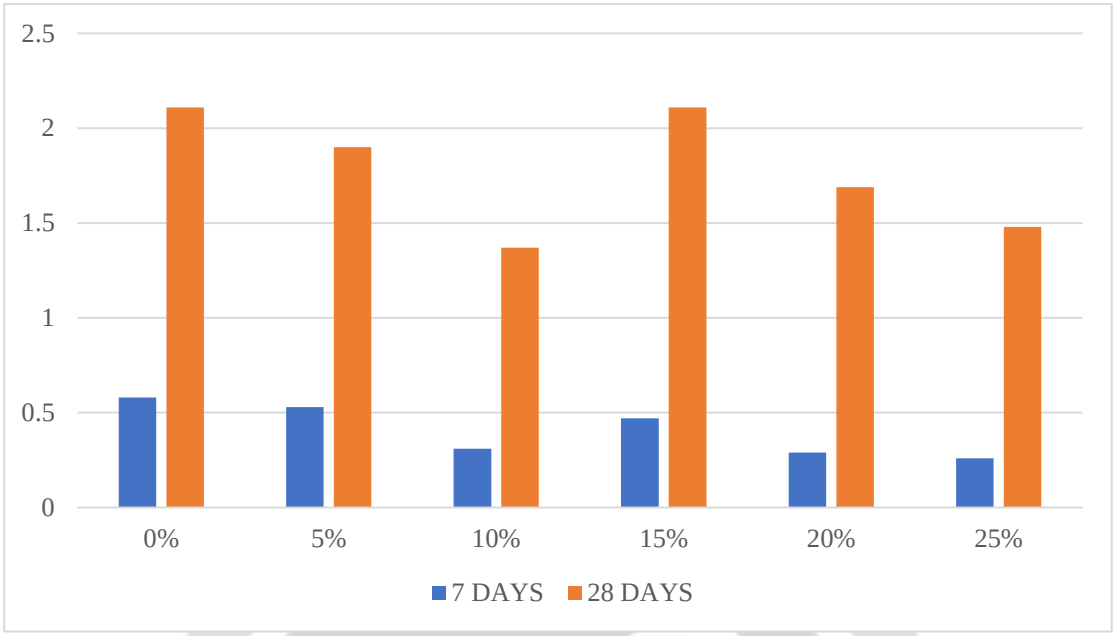

Fig-5 Comparison Results of Split Tensile Strength Test at 7 and 28 Days

3. Flexural Strength Test on Concrete Prisms as partial replacement of sand

FOR 7 DAYS

S.NO	% OF GRANITE POWDER	CURING DAYS	FLEXURAL STRENGTH OF CONCRETE (N/mm^2)
1.	0%	7 DAYS	4.70
2.	5%	7 DAYS	4.22
3.	10%	7 DAYS	3.32
4.	15%	7 DAYS	4.16
5.	20%	7 DAYS	3.82
6.	25%	7 DAYS	3.26

FOR 28 DAYS

S.NO	% OF GRANITE POWDER	CURING DAYS	FLEXURAL STRENGTH OF CONCRETE (N/mm^2)
1.	0%	28 DAYS	5.60
2.	5%	28 DAYS	5.42
3.	10%	28 DAYS	4.88
4.	15%	28 DAYS	5.44
5.	20%	28 DAYS	4.76
6.	25%	28 DAYS	4.48

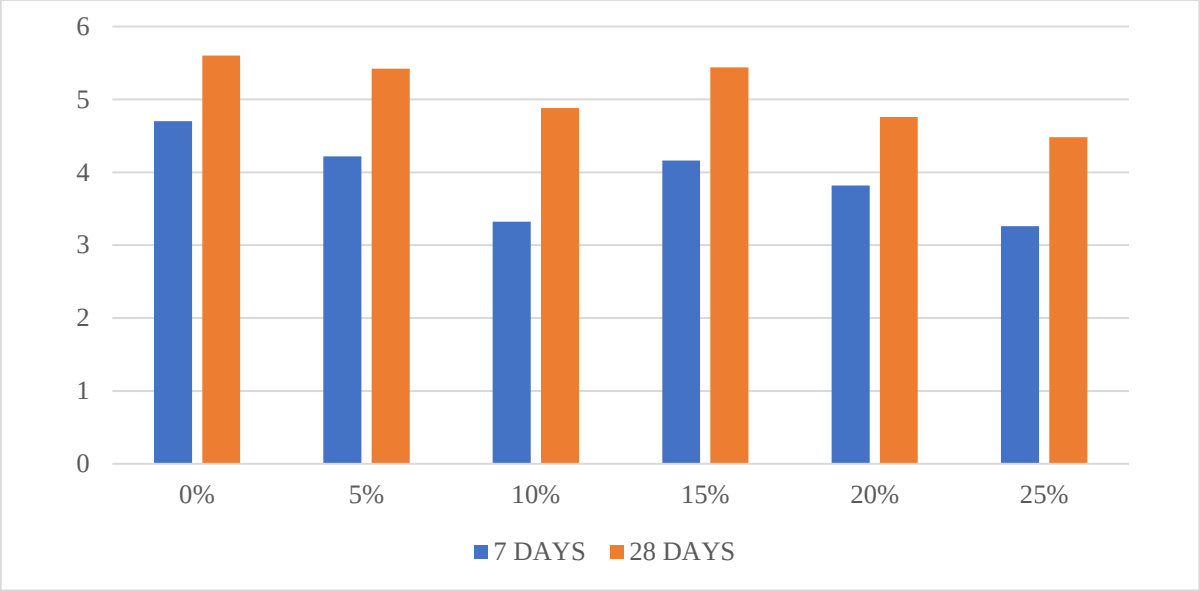

Fig-6 Comparison Results of Flexural Strength Test at 7 and 28 Days

VIII. CONCLUSION

The conclusions based on the observations from the present investigation on strength properties of cement concrete with partial replacement of sand by granite powder are as follows.

(i) The compression, flexural and split tensile strengths initially increases and then start decreases with increase in marble powder. Cement mortar of 1:3 mixes with 85% sand and 15% Granite powder gives good values in all the three strength tests.

(ii) Since, marble powder is one of the industrial waste materials and obtained at free of cost, the replacement of sand by granite powder proves to be more economical than conventional cement mortar mix.

(iii) A solution of disposing the industrial waste is found out and the problem of threat to agriculture and health is minimized to a greater extent.

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