

## Use of Granite Waste as Partial Substitute to Cement in Concrete

Y.Yaswanth Kumar<sup>1\*</sup>, C.M. Vivek Vardhan<sup>1</sup>, A.Anitha<sup>1</sup>

<sup>1</sup>Assistant professor, Annamacharya Institute of Technology and Sciences, Tirupati, Andhra Pradesh

### ABSTRACT

With the ever increasing cost of construction materials there is a need to curtail the same by using cheaper substitutes. In this investigation Granite Slurry (GS) was used as partial substitute in proportions varying from 5% to 20% by weight to cement in concrete and tested for compressive strength, tensile strength and flexure strength. It was observed that substitution of 10% of cement by weight with GS in concrete resulted in an increase in compressive strength to 48 N/mm<sup>2</sup> compared to 35 N/mm<sup>2</sup> of conventional concrete. Tensile strength too followed a similar pattern with a 10% substitution with GS increasing the tensile strength to 3.6N/mm<sup>2</sup> compared with a 2.4 N/mm<sup>2</sup> of conventional concrete. However flexure strength of 10% GS replacement exhibited a good improvement of flexural strength to 4.6 N/mm<sup>2</sup> compared to a 3.2 N/mm<sup>2</sup> of conventional concrete. Further investigations revealed that to attain the same strength of conventional concrete a 20% substitution with GS is effective. So it can be concluded that when locally available GS is a good partial substitute to concrete and improves compressive, tensile and flexure characteristics of concrete, while simultaneously offsetting the overall cost of concrete substantially.

### I. INTRODUCTION

Concrete has been a leading construction material for over a century. Its annual global production is about 3.8 billion m<sup>3</sup> - roughly 1.5 tonnes per capita according to data obtained from Portland Cement Association (<http://www.cement.org/>). In the past few years, great emphasis was given on green concrete as it results in sustainable development. Green concrete implies by application of industrial wastes to reduce consumption of natural resources, save energy and minimize pollution of the environment. Among the various varieties of solid industrial wastes generated the marble and granite wastes, have potentiality for utilisation in concrete. These wastes can be used as a filler (substituting sand) to reduce the total voids content in concrete and/or pozzolanic material (substituting cement) in the concrete mix while maintaining its physical and mechanical properties.

Granite waste is an industrial waste which is obtained from the granite polishing industry in a powder form.

The waste is produced at Dhone and surrounding areas of Kurnool. Total waste produced by all industries in this region may be approximately 2000 tonnes per week. This waste is easily carried away by the air and hence causes problems to human health and environment.

With the enormous increase in the quantity of waste needing disposal, coupled with acute shortage of dumping sites, and sharp increase in the transportation and dumping costs the quality of environment, has got seriously deteriorated preventing sustainable development. As granite powder waste (GPW) is a fine material, it will be

easily carried away by the air and will cause nuisance causing health problems and environmental pollution. Granite powder waste (GPW) is a fine material; it gets easily carried away by air and causes nuisance and health problems as well as environmental pollution. The major effects of air pollution are lung diseases and inhaling problems with the majority of people living in and around being affected the worst. In this present work, GPW to cement. To find in this investigation have used granite waste as partial replacement to different percentage the compressive strength, split tensile strength and flexural strengths of concrete have been determined. By doing so, the objective of reduction of cost construction can be met and it will help to overcome the environmental problem associated with its disposal including the environmental problems of the region.

### 1.1 REVIEW OF LITERATURE

Several industrial wastes, such as flyash, quarry dust waste, recycled aggregate, used soft drink bottle caps as fibre reinforced concrete have been tried by various researches. The results have been encouragingly increased in terms of improvement in strength parameters like compressive strength, split tensile strength and flexural strength.

B.Vidivelli et.al., [2] had studied on flyash concrete using SEM analysis as partial replacement to cement and had reported a significant increase of 20% compressive strength respectively.

Lalit Gamashta et.al., [3] developed the concrete strength by using masonry waste material in concrete mix in construction to minimize the environmental damages due to quarrying. It is highly desirable that the waste materials of concrete and bricks are further

reutilized after the demolition of old structures in an effective manner especially realizing that it will help in reducing the environmental damages caused by excessive reckless quarrying for earth materials and stones. Secondly, this will reduce pressure on finding new dumping ground for these wastes, thus further saving the natural environment and eco-systems. Durability, reliability and adequate in service performance of these reused waste materials over the stipulated design life of designed structures are of paramount importance to Structural Designers. This paper critically examines such properties in reused concrete and brick masonry waste materials and suggests suitable recommendations for further enhancing life of such structures, thereby resulting in sufficient economy to the cost of buildings.

M.L.V. Prasad et.al., [4] had studied mechanical properties of fiber reinforced concretes produced from building demolished waste and observed that target mean strength had been achieved in 100% recycled concrete aggregate replacement.

M. Mageswari et.al., [5] using the combination of waste Sheet Glass Powder (SGP) as fine aggregate and Portland cement with 20% optimum replacement of fly ash as cementations binder offers an economically viable technology for high value utilization of industrial waste. Using of SGP in concrete is an interesting possibility for economy on waste disposal sites and conservation of natural resources. Natural sand was partially replaced (10%, 20%, 30%, 40% and 50%) with SGP and 20% optimum replacement of fly ash in Portland cement. Compressive strength, Tensile strength (cubes and cylinders) and Flexural strength up to 180 days of age were compared with those of concrete made with natural fine aggregates. Fineness modulus, Specific gravity, Moisture content, Water absorption, Bulk density, Percentage of voids, Percentage of porosity (loose and compact) state for sand and SGP were also studied. The test results indicate that it is possible to manufacture low cost concrete containing SGP with characteristics similar to those of natural sand aggregate concrete provided that the percentage of SGP as fine aggregate up to 30% along with fly ash 20% optimum in cement replacement can be used respectively.

Ustev.J et.al., [6] determined the performance of concrete made with coconut shell as a replacement of cement. Cement was replaced with coconut shell in steps of 0%, 10%, 15%, 20%, 25% and 30%. The results obtained for compressive strength was increased from 12.45 N/mm<sup>2</sup> at 7days to 31.28 N/mm<sup>2</sup> at 28 days curing and it met the requirement for use in both heavy weight and light weight concreting.

Amitkumar D. Raval et.al., [7] explained the compressive strength by replacing cement with ceramic waste and utilizing the same in construction industry.

Dr. G.Vijayakumar et.al., [8] had found that use of glass powder as partial replacement to cement was effective.

Ankit Nileshchandra Patel et.al., [9] examined the possibility of using stone waste as replacement of Pozzolana Portland Cement in the range of 5%, 10%, 30%, 40% and 50% by weight of M 25 grade concrete. They reported that stone waste of marginal quantity as partial replacement to the cement had beneficial effect on the mechanical properties such as compressive strength values for 7, 14, 28 days were less than the ppc cement.

Venkata Sairam Kumar et.al., [10] investigated the effect of using quarry dust as a possible substitute for cement in concrete. Partial replacement of cement with varying percentage of quarry dust (0%, 10%, 15%, 20%, 25%, 30%, 35%, 40%) by weight of M 20, M 30 and M 40 grade of concrete cubes were made for conducting compressive strength. From the experimental studies 25% partial replacement of cement with quarry dust showed improvement in hardened of concrete.

Jayesh kumar et.al., [11] studied the performance of fly ash as partial replacement of cement. The values of compressive strength and split tensile strength are found by partial replacement of cement with varying percentage of 0%, 10%, 20%, 30% and 40% by weight of cement of M 25 and M 40 mix. The compressive strength of the samples was recorded at the curing age of 7, 14, 28 days and for split tensile strength of the sample were conducted test on age of 56 days. It was observed that the compressive strength was better on age of 14 days than the other proportions of cement.

Debarata Pradhan et.al., [12] determined the compressive strength of concrete in which cement was partially replaced with silica fume (0%, 5%, 10%, 15%, and 20%). The compressive strength test was conducted on age of 24 hours, 7 days and 28 days for 100 mm and 150 mm cubes. The results indicated that the compressive strength of concrete increased with additional of silica fume up to 20% replaced by weight of cement further addition of silica fume was found that the compressive strength may increase or decrease.

Amudhavalli et.al., [13] examined the performance of concrete made with silica fume as the partial replacement of cement. Cement was replaced with silica fume in steps of 0%, 5%, 10%, 15% and 20% by weight by M 35 mix. The reported from this percentage mixes in compressive strength, split tensile strength and flexural strength at age of 7 days and 28 days. The results indicated that use of silica fume in concrete has improved the performance of concrete in strength and durability aspects.

Md Moinul Islam et.al., [14] investigated the usage of fly ash as substitutes for the cement was replaced with fly ash in steps of 10%, 20%, 30%,

40%, 50% and 60%. Compressive strength and tensile strength were determined at 3, 7, 14, 28, 60 and 90 days. The reported from this paper shows the results that strength increased with increased of fly ash up to an optimum value, beyond which the strength value starts decrease from with further addition of fly ash. The six fly ash mortars, the amount of optimum amount of cement replacement in mortars is about 40% higher compressive strength and 8% higher tensile strength as compared to Ordinary Portland Cement mortar.

D.Gowsika et.al., [15] investigated the usage of eggshell powder from egg production industry as partial replacement for Ordinary Portland Cement in cement mortar of mix proportions 1:3 in which cement is partially replaced with egg shell powder as 5%, 10%, 15%, 20%, 25% and 30% by weight of cement. The compressive strength was determined at curing ages 28 days. There was a sharp decrease in compressive strength beyond 5% egg shell powder substitution. The admixtures used are Saw Dust ash, Fly Ash and Micro silica to enhance the strength of the concrete mix with 5% egg shell powder as partial replacement for cement. In this direction, an experimental investigation of compressive strength, split tensile strength, and Flexural strength was undertaken to use egg shell powder and admixtures as partial replacement for cement in concrete.

Ghassan K. Al-Chaar et.al., [16] determined the use of natural pozzolanic cement substitute in concrete materials. By means of a test series, four mixes using three types of natural pozzolanic, as well as a Class F fly ash, are evaluated. The effectiveness of each pozzolanic in controlling alkali-silica reactions has been studied. Correlations have been revealed between the mechanical properties of the proposed mixes and a Portland cement control mix. The results are also compared with industry standards for mortars made with fly ash and silica fume. It is findings to indicate that one type of pozzolanic may be used as a substitute for fly ash, but not for silica fume.

Biruk Hailu et.al., [17] investigated the usage of sugar bagasse ash is as by-product of sugar factories as a possibilities for the cement was replaced with sugar bagasse in steps of 0%, 5%, 15% and 25% of the Ordinary Portland Cement were prepared with water to cement ratio of 0.55 and cement content 350 kg/m<sup>3</sup> for the control mix. The test results indicated that up to 10% replacement of cement by bagasse ash results in better or similar concrete properties and further environmental and economical advantages can also be exploited by using bagasse ash as a partial cement replacement material.

Seyyedeh Fatemeh Seyyedaliipour et.al., [18] investigated the usage of paper waste as a partial replacement of cement to controlling environmental aspects has become a major priority. The concrete

mixes prepared with adequate amount of these wastes, cement, aggregate and water compared in terms of some tests especially strength with the conventional concrete. At the end, the advantages and disadvantages of the use of pulp and paper industry wastes in concrete formulations as an alternative to landfill disposal were discussed. The research on use of pulp and paper industry wastes can be further carried out in concrete manufacturing as a new recycled material.

Faseyemi Victor Ajileye et.al., [19] examined the usage of microsilica as a partial replacement of cement in concrete. Cement was replaced with coconut shell in steps of 0%, 5%, 10%, 15%, 20%, and 25%. The compressive strength and of the samples was recorded at the curing age of 3, 7, 14, 28 days. The results indicated that the compressive strength of concrete increased with additional of silica fume up to 10% replaced by weight of cement further addition of microsilica was found that the compressive strength will be decreasing from 10% replacement of cement.

Prof. Vishal S. Ghutke1 et.al., [20] examined the usage of silica fume as a partial replacement of cement in concrete. It is suitable for concrete mix and improves the properties of concrete i.e., compressive strength etc. The objectives of various properties of concrete using silica fume have been evaluated. Further to determine the optimum replacement percentage comparison between the regular concrete and concrete containing silica fume is done .It has been seen that when cement is replaced by silica fume compressive strength increases up to certain percentage (10% replacement of cement by silica fume). But higher replacement of cement by silica fume gives lower strength. The effect of Silica fume on various other properties of Concrete has also been evaluated.

Dilip Kumar Singha Roy et.al., [21] investigate the strength parameters of concrete made with partial replacement of cement by Silica Fume. Very little or no work has been carried out using silica fume as a replacement of cement. Moreover, no such attempt has been made in substituting silica fume with cement for low/medium grade concretes (viz. M 20, M 25). Properties of hardened concrete viz Ultimate Compressive strength, Flexural strength, Splitting Tensile strength has been determined for different mix combinations of materials and these values are compared with the corresponding values of conventional concrete.

It has been found that utilization of recycled waste water in concrete construction have lately gained worldwide consideration and attention, Mohamed Elchalakani et.al., [22] explained about sustainable concrete by using recycled waste water from construction and demolition waste.

Marcia Silva et.al., [23] examined to add the recycling of sewage treatment water in concrete mix to determine the concrete strength. Concrete is the most widely used construction material in the world. Production of Portland cement used in concrete produces over 2.5 billion tons of carbon dioxide and other green-house gases worldwide. In addition, concrete is one of the largest water consuming industries. Approximately 150 liters of water is required per cubic meter. of concrete mixture, without considering other applications of water at the concrete industry. A detailed research agenda has also been developed for additional knowledge on this topic in order to understand and to reduce the environmental impacts of the concrete industry.

G.Murali, C.M. Vivek Vardhan et.al. [24] studied the influence of various effluents on concrete structures. Laboratory scale concrete blocks of M 25 grade were moulded and used for strength analysis. Effluents from automobile industry (E1), powder coating industry (E2) and chocolate factory (E3) were used for curing concrete and its strength parameters like compression, tension and flexure were tested after 28 days. It was observed that E3 enhanced the compressive strength of concrete by 3.84%, tensile strength by 2.46% and flexural strength by 1.96% compared to conventional water curing, indicating its direct applicability in concrete curing sector.

## II. EXPERIMENTAL INVESTIGATION

### 2.1 CEMENT

Ordinary Portland cement 53 grade Dalmia Brand conforming to B.I.S standards is used in the present investigations. Fineness test was conducted for cement and it was found to be 2.8% which conforms to IS 8122-1989.

### 2.2 GRANITE WASTE

Granite waste was obtained from granite polishing industries at Dhone of Kurnool district in Andhra Pradesh, India. The specific gravity of granite waste was 2.53 respectively and its size was less than 90 microns. The fineness modulus of granite waste was 2.43 respectively.

### 2.3 FINE AGGREGATE

Hundri River near Kurnool was used as fine aggregate in this project investigation. The sand was free from clayey matter, silt and organic impurities etc. The sand was tested for specific gravity, in accordance with IS 2386-1963 and it is 2.65, where as its fineness modulus was 2.31. The sand confirms to zone-III.

### 2.4 COARSE AGGREGATE

Machine crushed angular Basalt metal obtained from Tammaraju near Panyam was used as coarse aggregate. The coarse aggregate was free from clayey

matter, silt and organic impurities. The coarse aggregate was also tested for specific gravity and it was 2.72. Fineness modulus was 4.20. Aggregate passing through 12.5mm and retained from 4.75mm was used in the experimental work, which is acceptable according to IS 383-1970.

### 2.5 WATER

This locally available potable water, which was free from concentrated of acid and organic substances, was used for mixing the concrete

### 2.6 PLASTICIZER

#### 2.6.1 PURPOSE OF PLASTICIZER:-

The action of plasticizers is to fluidify the mix and improve the workability of concrete, mortar or grout. Flowing concrete is also referred as self compacting concrete,. This concrete has a slump value equal to 200mm or more, a compaction factor of 0.98. Plasticizing admixtures are added to a concrete mixture to make plastic concrete extremely workable without additional water and corresponding loss of strength which makes it ideal for use in ready mixed concrete where workability is an important factor especially in places of congested reinforcement like beam column junction, heavy rafts and machine foundation, foundation of heavy structures.

The use of plasticizers in ready mixed concretes and construction industry reduces the possibility of deterioration of concrete in terms of its appearance, density and strength. On the other hand, it makes the placing of concrete more economical by increasing productivity and reducing cost of labour during handling and moving operations at the construction site.

Plasticizer used in the present project is conplast sd110

### 2.7 PREPARATION OF TEST SPECIMENS

The granite powder collected from polishing units was dried. As per the mix proportions, given in table-1 the quantities of various ingredients were weighed. Initially cement and granite powder were mixed thoroughly. Further sand and coarse aggregate were added to the mix. Once all the materials were mixed well, 0.5% of super plasticiser was added to water and water containing super plasticiser was added to the dry mix to form concrete. Cubes of size 150mmX150mmX150mm and cylinder were cast. The specimens were cured in curing tank for a period of 28days.

## III. TEST RESULTS

### 3.1 COMPRESSIVE STRENGTH

In the present investigation granite waste has been used as replacement of cement up to a maximum of 20%. The compressive strength for different percentage of silica fume and percentage

increase or decrease in strength with respect to M30 grade concrete listed in the table. By taking normal M30 grade as referring percentage, percentage of increase or decrease in compressive strength other percentage is calculated. Considering the normal M30 grade with zero percentage admixtures the compressive strength is 35.8 N/mm<sup>2</sup>.

When 5% replacement is used, the compressive strength is 47.06N/mm<sup>2</sup> and increase in strength is 31.4N/mm<sup>2</sup>. Considering 10% replacement, the compressive strength is 48.9N/mm<sup>2</sup> and there is an increase in the strength 36.59N/mm<sup>2</sup>. With 15%

replacement, the compressive strength is 42.9/mm<sup>2</sup> and there is a increase in strength 19.83N/mm<sup>2</sup>. With 20 % replacement, the compressive strength is 38.7and there is a little increase in the strength. However, 10% can be taken as optimum dosage which can be mixed in cement concrete for giving optimum possible compressive strength at any stage. Mix design for different proportions of ingredients is presented in Table 1. The value of compressive strengths of cubes made with different percent replacement of granite powder for cement is presented in Table 2.

**Table 1 Mix design values for different proportion mix**

Mix design	Nominal mix	Mix-1	Mix-2	Mix-3	Mix-4
% replacement of granite powder	0	5	10	15	20
w/c ratio	0.39	0.39	0.39	0.39	0.39
Cement content (kg)	4.76	4.522	4.284	4.046	3.80
Fine aggregate(kg)	8.77	8.77	8.77	8.77	8.77
Coarse aggregate	17.42	17.42	17.42	17.42	17.42
Water (lit)	1.848	1.848	1.848	1.848	1.848
Plasticizer (lit)	0.095	0.095	0.095	0.095	0.095
Compressive strength 28 days (N/mm <sup>2</sup> )	35.8	47.06	48.9	42.9	38.7

**Table 2 Compressive strengths of cubes with different proportions of GPW**

S.NO	%Replacement of cement with granite powder	Compressive strength (N/mm <sup>2</sup> )	% increase in strength
1	0	35.8	-
2	5	47.06	31.4
3	10	48.9	36.59
4	15	42.9	19.83
5	20	38.7	8.1

### 3.2 SPLIT TENSILE STRENGTH

Split tensile strength of concrete is usually found by testing plain concrete cylinders. Cylinders of size 150mm x 300 mm were used to determine the split tensile strength. After curing, the specimens were tested for split tensile strength using a calibrated compression testing machine of 2000kN capacity. It can be observed that at a 10% replacement of granite powder, an optimum of 3.43 N/mm<sup>2</sup> split tensile strength was obtained. The details of same are represented in table 3.

**Table 3 Split tensile of granite powder values for different propositions**

S.NO	%age Granite powder	Split tensile Strength (N/mm <sup>2</sup> )
1	0	2.43
1	5	2.95
2	10	3.43
3	15	2.75
4	20	2.27

### 3.3 FLEXURAL STRENGTH OF CONCRETE

The determination of flexural strength is essential to estimate the load at which the concrete members may crack. The flexural strength at failure is the modulus of rupture.

The modulus of rupture is determined by testing standard test specimens of size 100 X 100 X 500 mm over a span of 400 mm under two point loading.

$$\text{Bending Tensile Stress or Flexural Strength } (\sigma_{bt}) = \frac{P l}{b d^2} \text{ when } a \geq \text{or } = 40/3 \text{ cm}$$

$$\frac{3P a}{b d^2} \text{ when } 40/3 \geq a \geq 11 \text{ cm}$$

Where P is load, l length, b breadth and d is depth of concrete block tested.

The results of flexural strength obtained on different percentage substitutions of granite powder with cement are presented in Table 4. On mediation of the results, it can be observed that at 10% partial substitution, a maximum of 4.62 N/mm<sup>2</sup> flexural strength was obtained.

**Table 4 Flexural strength of granite powder values for different propositions**

S.NO	%age granite powder	Flexural Strength (N/mm <sup>2</sup> )
1	0	3.23
2	5	3.61
3	10	4.62
4	15	3.49
5	20	3.24

### IV. CONCLUSIONS

Based on the experimental investigation concerning the compressive strength, split tensile strength and flexural strength of the concrete, the following observation were made regarding the resistance of partially replaced with granite powder.

1. Compressive strength increases with replacement of granite wastes, at 10% and is comparable to normal concrete (47.06 N/mm<sup>2</sup>).
2. Split tensile strength and flexural strength also got increased at 10% of replacement of cement and gave values of 3.43 N/mm<sup>2</sup> and 4.62 N/mm<sup>2</sup> respectively.
3. Thus Waste was utilized and makes more environmental friendly.

Thus granite powder aggregate is the best choice where there are available.

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