Studying the Effects of Using Glass Powder and Granite Powder in Lieu of Traditional Cement in Both Wet and Dry Concrete

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Abstract - The many forms of industrial garbage produce huge amounts of solid trash annually. Only a small fraction of this garbage is really recycled before it ends up in open landfills. There are a number of environmental problems caused by this solid waste that has not been handled. One possible solution to the solid waste management issue might be the production of concrete from such industrial trash. With these advantages in mind, we are investigating potential substitutes for traditional concrete materials. The goal of this research is to find ways to use industrial waste in concrete, namely granite and glass powders, instead of traditional building materials like sand and cement. Powdered granite (WGP) collected from granite processing factories and glass (GP) collected from broken or broken bottles, jars, and windows in laboratories. The ideal proportions of fly ash (FS) and marble powder (MP) were used into glass granite concrete to achieve cost-effective and environmentally friendly concrete manufacturing. This study's experimental portion is divided into two primary parts. Part one of the study looked at how well WGP and GP-added concrete worked. As a substitute for cement, GP was added in increments of 5% up to 15%, while WGP was added at 0%, 10%, 20% and 30%by weight of sand. In the second phase of the study, researchers looked various blended mixtures with varying proportions of GP and WGP to determine the appropriate percentage of FS and MP. The binder was a set amount of FS (20%) and the filler was 10% MP. Although OPC was the focus of the experiments, PPC is now cement's most popular choice. As a result, we have tested fly ash. Basically, we were interested in learning how this optimal percentage affects the fly ash. A slump test of workability was conducted to investigate the new concrete's qualities. All of the mixtures were tested for mechanical performance by measuring their density, flexural strength, compressive strength, and splitting tensile strength.

Key Words: *Concrete, Glass Powder, Granite Powder, Workability, Fly ash, Marble Powder Mechanical Properties.*

1.INTRODUCTION

Concrete has been commonly preferred for betterment of infrastructure and life of a common person. For the cost-effective construction, it is mandatory to produce concrete which is sustainable and durable. A durability feature of concrete is directly related with long term performance of concrete in aggressive exposures condition. In construction industry, around 5-8 billion tons of natural River sand is consumed every year round the globe and this consumption is increasing exponentially. Availability of sand is becoming scarce day by day due to over exploration of river sand, leading to several environmental issues. Regulated used of river sand have been banned in some states, causing shortage of sand in construction industries. Across the world, various types of solid waste are generated in huge amount from different industries. In India, about 70 million tons of waste is produced every year, in which a very little amount of waste is recycled and the remaining part is dumped in open areas. This untreated solid waste creates problem to nearby areas. Many researchers have demonstrated that the industrial waste have potential to be taken as a binder and fine aggregate in concrete. Some of these are mentioned in various IS codes. IS 10262: 2019 recommended that 50% of OPC can be replaced by GGBFS. Same code suggests that 15% and 10% OPC to be replaced by Metakaoline and silica fume.

1.1 Selection of granite waste as fine aggregate

In construction industries a large amount of sand is consumed every year. Its availability is becoming scare day by day due to over exploration leading to several environmental issues. Therefore regulated used of river sand in many states have been banned, causing serve shortage of sand for construction industries. The major states of granite production in India are Rajasthan, Maharashtra, Assam, Andhra Pradesh and Bihar. Estimated 260-410 tons of granite waste is produced every year from the processing plant of granite. This fine granite powder (WGP) is simply carried out by air and hence creates the problem to human health and atmosphere. Table 1 shows the statistics for waste generated from granite industries, data obtained from MSME, Guntur. Waste granite processing (WGP) is gathered from various granite manufacturing businesses as a wet slurry.

The water existing in slurry of granite is evaporated with time. The main problem is the disposal of this waste. Improper disposal creates problem of pollution in air as well as unwanted deposit in area. Air pollution includes the problems of asthmatic and eye infections while land pollution contains filling holes of soil which stop the recharge of under-ground water and also it decreases the fertility of soil. A huge amount of natural sand is required to industries for making concrete. A report prepared by German company detailed that 1.4 billion tons of sand will be required by the year 2020. It has directed to an abandoned exploitation of natural sand, which in turn leads to shortage of sand. Hence, there is an urgent requirement to find an economic substitute of river sand due to the enormous use in the construction activities. Several researchers have investigated the concrete performance by replacing granite powder with fine aggregates. Some of them are indicated here. Use of WGP as substitute of FA in concrete reduced the workability of blended mix. The probable reason was rough texture, irregular shape and angularity of WGP. Concrete prepared with WGP as natural sand and FS, slag and SF as cement, indicated improvement in results of mechanical properties.

In one of the studies 25 % WGP increased 9% compressive strength of blended mix compare to control sample.

Table -1: Data collected from MSME, Guntur

Phase	Automatic mines using cutting equipment	Automatic mines using blasting	Automatic xrdi – mines using blasting	Overall statics
Cutting.	12%	16%	20%	18%
Polishing and Grinding	8%	6%	8%	6%

1.2 Selection of glass waste as binder

Cement production is an energy-concentrated procedure, which liberates about 5 to 8 percent of global CO_2 due to burning of fuel and raw material. causing a considerable impact on environment. So, keeping this thing in mind waste glass was considered as alternative of cement. Soda-lime glass is one of the most utilized glass worldwide. It is the composition of CaO, calcium oxide (lime) and SiO_2, sodium oxide (soda). The total world production of soda lime glass is assessed to be somewhere around 54 million metric tons in 2017. Only 70% glass can be recycled and remaining 30% is available as a waste in form of bottles, containers, jars and window panels Large amount of waste glass is available in India, in which a very small part is recycled and residual is dumped in open areas. The density, compressive strength, and flexural modulus of concrete that was made using 21% waste GP instead of FA were all increased. Research showed that compared to the control mix, the compressive strength of the produced specimen was 2% higher when 20% of the cement was replaced with coloured and transparent glass particles. The density, tensile, and compressive strengths were all enhanced when 15% GP was used as a cement, which is an indication of pozzolanic properties. Density, compressive strength, flexural modulus, and modulus of elasticity were all improved in concrete that included 17.5% recycled glass as coarse aggregate. An increase in the blended mix's compressive strength was seen when 20% liquid crystal display (LCD) glass was used in lieu of sand in concrete with a 0.28 w/c ratio. The initial strength of the concrete was increased when glass fume (GF) was added to it. As a result of producing more CSH, GF reduced the penetration of chloride attack in the same research.

1.3 Selection of Fly Ash as binder

One of the main ingredients needed to make cement is limestone. The manufacturing of 1 metric tonne of cement results in the emission of around 0.95 metric tonnes of carbon dioxide into the atmosphere. Cement output is growing at an exponential rate every year. Using mineral admixtures such as FS, MP, SF, and GP helps reduce the creation of CO2 that is produced during cement making, which is a major problem in today's world. This is only a small selection of the many studies that have looked into FS as a cement substitute. Concrete mixed with 25% FS improved the mixtures' compressive, splitting, and tensile strengths as well as their flexural strengths. Adding FS to concrete in the range of 0-30% with a fibre content of 0-0.60% improved the material's mechanical characteristics. Use of FS in percentages ranging from 0% to 25% with 5% intervals enhanced dry density, according to another study on fly ash.

1.4 Selection of marble powder as binder

The marble industry's production of waste MP has serious consequences for human and environmental health. A significant amount of waste powder is released into the atmosphere during the marble processing, and some of it converts into Ca(OH)2. A small number of the several researchers that have investigated marble dust as a filler material have their findings highlighted here. The compressive, flexural, and splitting tensile strengths of the concrete were improved when 10% dolomite was used as sand and 5% MP was used as a filler. Substituting MD for the control mix in SSC reduced its workability. The mechanical properties and longevity of concrete were enhanced by substituting 20% MD for sand. The use of 10% MP as sand in concrete is successful and maintains the workability of the material, according to one group of researchers. By including waste MP as additives and partially replacing 10% of the fine aggregate, the control mix achieved an exceptional compressive strength.

1.5 Objective and Scope of work

- In order to find out how the slump varies for GP concrete, WGP concrete, and GP+WGP concrete mixed together.
- In order to find out how the hardened state characteristics of concrete are affected by waste glass and granite powder, when mixed with cement and sand, respectively.
- To determine the influence of Secondary Cementitious Materials (Flyash and Marble dust) of best performing GP+WGP mix.

2. MATERIALS AND METHODS

2.1 Ordinary Portland Cement (OPC)

In this investigation, OPC grade:43 was used as a binder in concrete as per the provisions of (IS:8112,2013) The index properties; bulk density, fineness modulus, initial & final setting time and specific gravity of OPC grade 43 are revealed in Table 2. The fineness of OPC is specified as per the description mention in (IS 4031 Part-1, 1996). Chemical properties of OPC grade 43 is shown in Table 3.

River sand is generally preferred in concrete for the purpose of filling voids of CA and provide strength to the concrete. Sand was obtained from Vijayawada, A.P, for the purpose of experimental work. The gradation of sand was chosen as per the specification of (IS 383, 2016). From the gradation it was observed that the river sand was of Zone-II.

Fig -1: **OPC 43-Grade (Cement)**

Table -2: Index Properties of OPC

Property	**Cement**
Water absorption (%)	2.55
Specific gravity	3.15
Bulk unit weight (kg/m^3)	1440
Fineness modulus (FM)	2.25
Initial setting time (minute)	64
Final setting time (minute)	125

Fig -2: **CA in 10 mm & 20 mm size**

Fig -3: **Fine aggregate (natural sand)**

Table -3: Chemical composition of OPC, natural river sand, GP, WGP, FS and MP

Oxide	**OPC (%)**	**Natural river sand (%)**	**GP (%)**	**WGP (%)**	**FS (%)**	**MP(%)**
CaO	65.2	3.48	9.76	1.96	1.9	60.23
SiO_2	20.9	73.12	71.78	70.55	55.4	9.02
Al_2O_3	4.7	10.92	0.75	13.73	29.14	0.95
Fe_2O_3	2.8	3.56	0.78	2.59	4.94	0.95
MgO	1.3	1.32	2.42	1.12	0.89	13.52
SO_3	2.2	-	-	-	-	0.32
MnO	-	0.08	-	-	-	-
Na_2O	0.31	2.26	-	3.26	0.01	0.65
K_2O	0.44	2.04	-	0.1	-	0.02
TiO_2	-	0.36	-	-	-	-
P_2O_5	-	0.09	-	-	-	-
H_2O	-	-	-	-	-	-
Loss of ignious	3.02	-	1.39	-	1.85	-

3. RESULTS AND DISCUSSION

3.1 Ordinary Portland Cement (OPC)

Slump results are presented in Fig.4, 5 and 6 with incorporation of GP and WGP in concrete. From the outcomes it revels that the slump value of GP added concrte increased with increase GP in blended mixes. The slump value for conrol, GP5, GP10 and GP15 was achieved 80,86,90 and 94 respectively. The maxmimum slump value was achieved at GP15, which was 94mm. Less water absorption of glass particles compare to cement is probable reason of increase in slump.

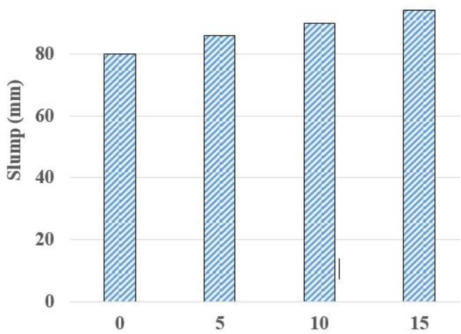

Fig -4: **Slump value of glass powder added concrete**

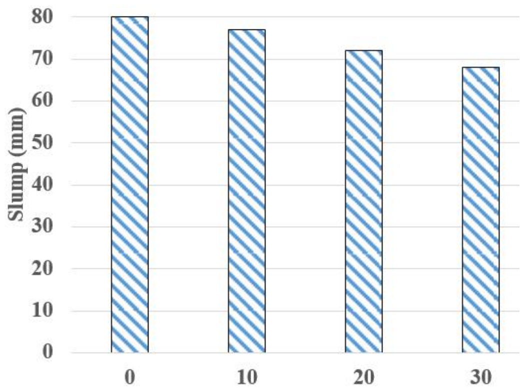

Fig -5: **Slump value of granite powder added concrete**

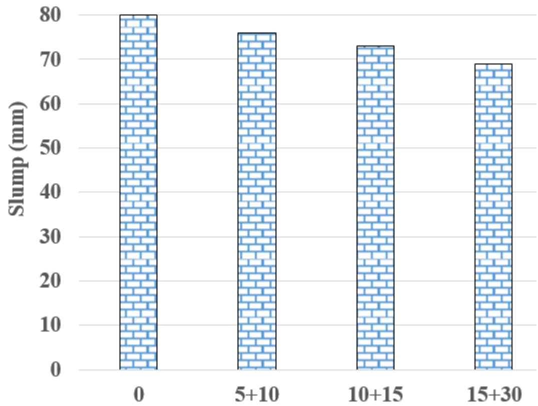

Fig -6: **Slump value of glass and granite powder added concrete**

Density of control and blended mixes of glass and granite powder are shown in Fig.7, 8 and 9. In first series of GP added concrete, the density of control, GP5, GP10 and GP15 mixes were attained as 2460, 2490 and 2510gm/cc respectively. It is seen that the density of blended concrete improved up to 20% replacement and reduced thereafter with the increase GP in concrete. The maximum density of 2540 gm/cc was achieved for 20% GP which was 3.25% higher to control concrete. The main reason of increased density was use of glass fines which filled the voids and reduce the porosity.

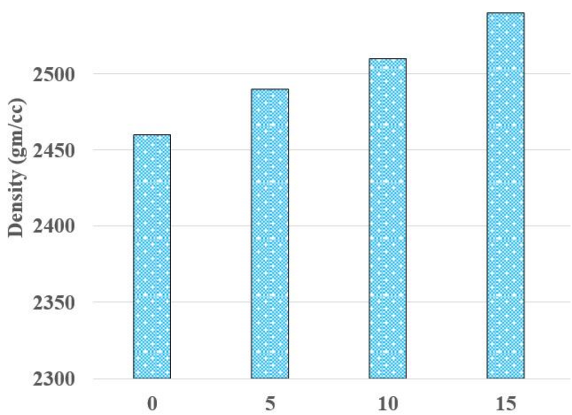

Fig -7: Density of glass powder added concrete

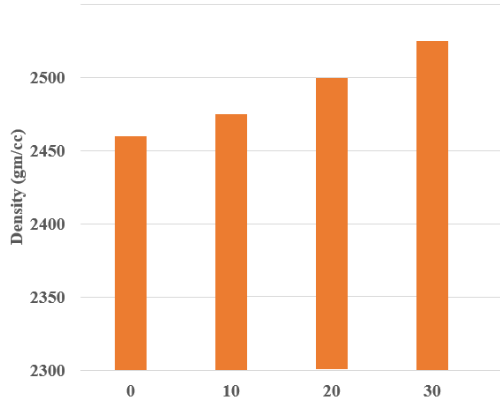

Fig -8: Density of granite powder added concrete

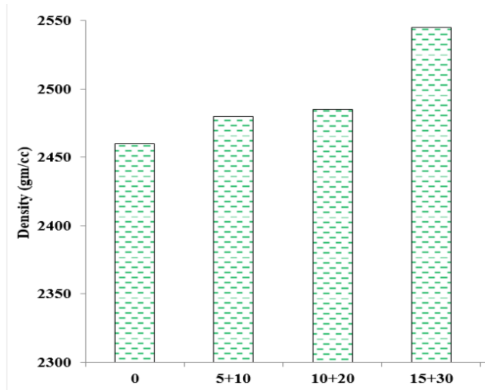

Fig -9: Density of glass and granite powder added concrete

Results of compressive strength test for 7, 28, 56 and 90 days are revealed in Fig. 10, 11 and 12. In granite added concrete compressive strength achieved for control mix, WGP10, WGP20 and WGP30 mixes was 34.8, 35.2, 35.9 and 36.5 N/mm^2 respectively. The magnitude of strength for blend WGP30 was observed higher as compared to control sample. Highest compressive strength achieved was 36.5 MPa which was 4.88% superior to control one.

Enhanced strength was observed due to the reduction of voids which shows compact and dense packing of structure, examined the effect of addition of 10%, 17.5% and 25% granite dust as fine aggregate replacement on compressive strength of concrete.

Observed that compressive strength increased by 11% at the age of 28 days when sand was replaced by 17.5% of granite dust. For other mixes insignificant decreased in compressive strength was observed for WGP20 and WGP30 mixes.

The reason was higher proportion of granite fines in concrete reduce w/b ratio, that effects the hydration process. Other series of GP and GP+WGP added concrete are presented in Fig 11 & 12.

The compressive strength of control and various GP mixes at 90 days was achieved as 34.8, 36.8, 39.6 and 41 N/mm^2 respectively.

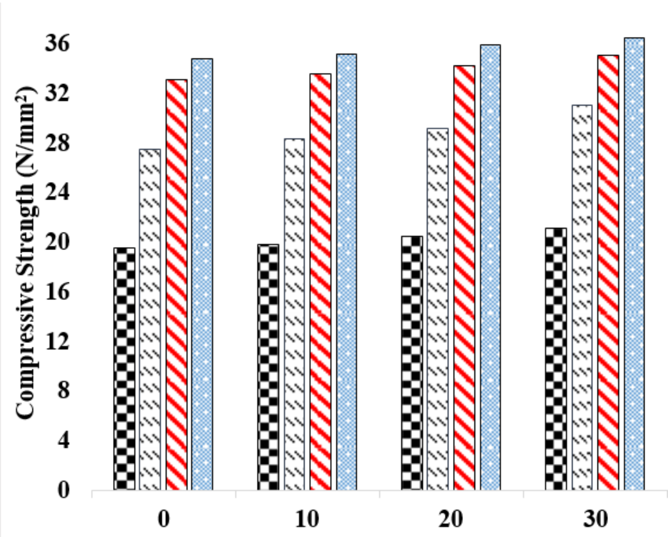

Fig -10: Compressive strength test results of WGP added concrete

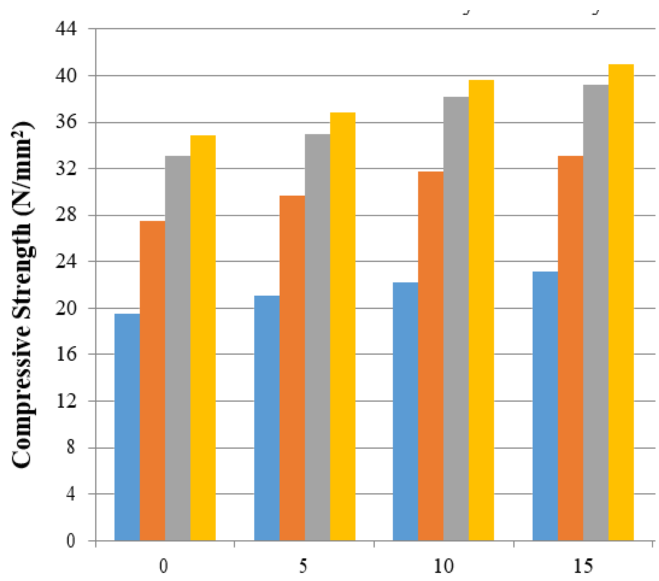

Fig -11: Compressive strength test results of GP added concrete

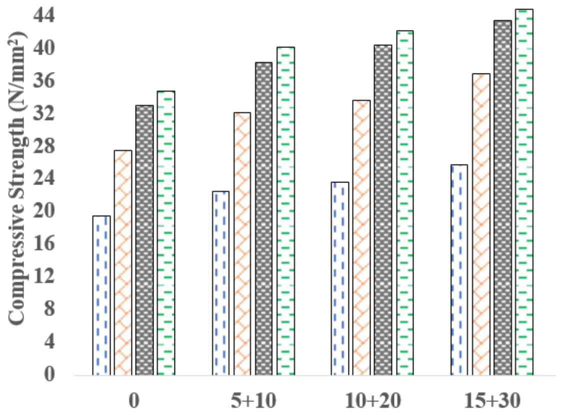

Fig -12: Compressive strength test results of GP+WGP added concrete

As presented in Fig.13, variation in flexural value for 28, 56 and 90 days of control and WGP mixes are shown. Flexural strength achieved at 84 days for control mix, WGP10, WGP20 and WGP30 was 5.56, 5.98, 6.54 and 6.84 N/mm^2 respectively. Blended mix WGP30 achieved maximum flexural strength of 6.84 N/mm^2 which was 23.02% greater than the control concrete. It may be due to more water absorption by granite fines because of large surface area that reduces water to cement ratio and hence improved flexural strength.

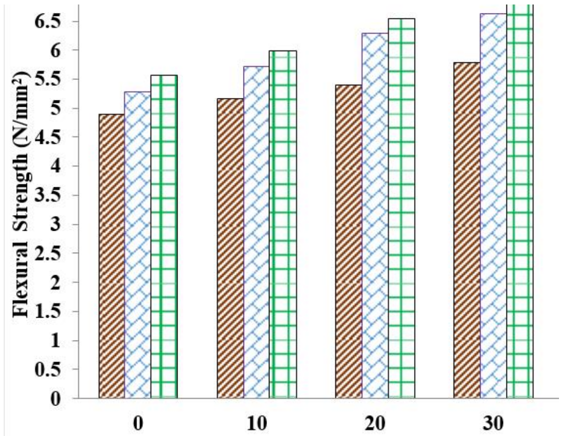

Fig -13: Flexural strength test results of WGP added concrete

4. CONCLUSIONS

1. Upto a certain optimum percentage replacement the use of Granite substituted concrete enhanced the compressive strength of the concrete as compared to the control concrete. The compressive strength started decreasing for substitution beyond this optimum replacement attaining even lesser value than the other mixes at veryhigh percentage replacements.
2. The maximum compressive was achieved at GrP30, GP20 and GP/GrP; 15/30 mixes. Reason was reduction of voids and compact packing of blended mixes compare to control concrete. Other reason was filler effect of granite fines that improve the packing and compactness of blended mixes. For other mixes reduced the compressive strength. The reason may be higher content of fines which reduced w/b ratio that unbalanced the hydration process.
3. The flexural strength of blended concrete was improved with increase of glass and granite fines in concrete. Reason of improved strength was pozzolanic behaviour of GP which converted additional CH into C-S-H gel.
4. Higher incorporation of glass and granite fines in concrete, reduced the flexural strength and it was observed in GP20, GP25.
5. The splitting tensile of blended mixes was increased with increase of waste glass and granite fines.
6. The slump value of FS & MP in (GP+GrP) added concrete concrte was decreased with increament of

their percentage. The decresed in slump value depends on various factor like surface texture, shape of particle, suface area, porosity.

7. The density of incorporation of optimum content of FS & MP in (GP+GrP) added concrete concrte increased with increament of their percentage. Flyash as a pozzolanicmaterial and marble as filler provided better results in different ratio of GP and GrP.
8. Compressive strength was found increased with incorporation of optimum percentage of FS & MP in (GP+GrP) made concrete. The reason of improved strength was pore filling and compact packing in blended mixes.
9. Flexural strength was found increased with incorporation of optimum percentage of FS & MP in (GP+GrP) made concrete. The reason was pore filling and compact packing in blended mixes.
10. Splitting tensile strength was found increased with incorporation of optimum percentage of FS & MP in (GP+GrP) made concrete. The reason was excess amount of SiO_2 presence in blended mix, which contributes to the production of C-S-H Gel.
11. Similarly it can be conclude that F(15+30) and M(10+20) mixes were also effective and it can be recommended for concrete manufacturing industries.

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