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Investigation on Development of Powdered Glass and Granite that Prioritizes to Environmental Preservation

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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.

Part-1: 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.

Part-2: The GP is added to concrete as an additive, the compressive strength of the concrete is enhanced. With 10% GP addition level, the 3-day compressive strength reached a maximum of 23.03 N/mm2, whereas at 2.5% GP addition level, it dropped to a minimum of 20.47 N/mm2. The compressive strength after 28 days was found to be 28.29 N/mm2 at a GP addition level of 10% and 27.40 N/mm2 at a GP addition level of 2.5%. After 56 days, the concrete with 10% GP added had a peak compressive strength of 33.40 N/mm2. As the percentage of GP replacements increased, the concrete became less workable.

***Key Words*:** *Concrete, Glass Powder, Granite Powder, Workability, Fly ash, Marble Powder Mechanical Properties, River Sand, Compressive Strength*

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. 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. Use of steel slag, iron slag, bottom ash and recycled aggregate as FA and CA, in both plain and reinforced concrete to certain amount has been permitted by IS 383:2016. 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. Honourable Supreme Court of India has banned the mining of river sand in Rajasthan since 2017. 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. 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. Cement production is an energy-concentrated procedure, which liberates about 5 to 8 percent of global CO2 due to burning of fuel and raw material. causing a considerable impact on environment. The density, compressive strength, and flexural modulus of concrete that was made using 21% waste GP instead of FA were all increased. The density, tensile, and compressive strengths were all enhanced when 15% GP was used as a cement, which is an indication of pozzolanic properties. 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 correct binding and pozzolanic activity of the LCD glass could be to blame. A related investigation found that GP and SF, instead of cement, improved compressive strength. 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.

1.1 Objectives of the study

- 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. COLLECTION OF LITERATURE DATA

Zafar et.al (2020) GCW is used instead of river sand that is found in nature. The researchers in this study used granite cutting debris to create five distinct mixtures. In increments of five, the proportion of waste granite was used as follows: 0%, 5%, 10%, 15%, and 20%.

Jain et.al (2019) explored the possibility of using GCW in place of fine aggregate in concrete. As FA, the percentage of GCW was used as0%,20%,40%,60%,80%, and 100%. Slump, mechanical characteristics, water absorption, water permeability, and microstructural analysis were used to assess the control and blended mix parameters.

Mashaly et al. (2018) prepared concrete using granite sludge (GS) obtained from different industries of granite. The percentage of GS was used as 0%, 10%, 20%, 30% and 40% by weight of cement.

Li et al. (2018) investigated the durability and mechanical performance of mortar incorporating granite dust in percentage of 5%, 10% and 15% by weight of cement. Total four combinations were used with w/b ratio of i.e. 0.40, 0.45, 0.50 and 0.55.

Ghannam et al. (2016) used granite powder (P) as a fine aggregate obtained from granite stone crushing and polishing industry. Granite powder was added in interval of five as 5%, 10%, 15% and 20% by weight of cement in concrete.

Narde et al. (2017) investigated on granite cutting waste (GCW) as a river sand under adverse exposure conditions. In this study carbonation, chloride ion penetration (CIP), acid attack and sulfate attack at different temperature and condition were investigated.

Reddy et al. (2015) casted M25 grade concrete using granite powder (WGP) in four different proportions of 2.5%, 5%, 7.5% and 10% by weight of cement. Properties assessed slump, compaction factor, and mechanical parameters.

Raghvendra et al. (2015) used granite powder (WGP) in concrete with (FS) and (GGBFS). The GP was used in interval of five percent as 5%, 10%, 15%, 20% and 25% respectively by weight of FA.

Shankar and Mohan (2015) prepared cement mortar using granite powder (WGP) as cement substitute. The proportion of WGP used was as 20%, 25%, 30%, 35% and 40% respectively. The test such as sulphate resistance, corrosion resistance and fire resistance, were performed on 1:3 mix proportion.

Kayathri et al. (2014) utilized granite powder (WGP), copper slag (CS) and (FS) as a FA in blended mixes. The percentage of substitution was 0%, 25%, 50% and 75% respectively.

Hamaiedeh and Khushefati (2013) used granite powder (WGP) as addition and replacement of cement in % of 0%, 10%, 20% and 30%. The ratio prepared was 1:1.44:2.52 as binder, FA, and CA for making concrete respectively.

Bacarji et al. (2013) prepared concrete by using marble powder (MP) and granite powder (WGP) as cement. Total three type of mix were prepared in this investigational work.

Lakshmi et al. (2013) investigated the use of waste (WGP) as a substitute of FA in concrete. WGP was used in the range of 0 to 25% in interval of five percent.

Ramos et al. (2013) investigated mortar with 5-10% granite powder (PG) and superfine granite powder (PGS) as substitute of cement. The value of D90 was 55.46µm and 13.34µm for PG and PGS, respectively.

Divakar et al. (2012) this study utilized granite fines (GF) as FA in concrete. Five different percentages were used like 5%, 15%, 25%, 35% and 50% respectively.

Abukersh & Fairfield (2011) reported about red granite dust (RGD) as alternative of cement in concrete. The red granite particles were used after passing through 75 µm sieve. The substitute level of red granite dust was 20%, 30%, 40% and 50% as cement.

Raman et al. (2011) prepared high strength concrete (HSC) using rice husk ash (RHA) and quarry dust (QD) obtained from granite crushing process. Initially RHA was used as cement in range of 10 to 30%.

Marmol et al. (2010) used the granite powder as filler and pigment in masonry and plaster mortar, respectively. A total of 10% $CaCO_3$ filler was used in masonry mortar which was replaced by dried granite sludge by 2%, 5% and 10%.

Williams et al. (2008) investigated on high performance concrete (HPC) with granite powder (WGP) as FA varying from 0 to 100%. Cement was also substituted with 10% fly ash (FS), 7.5% silica fume (SF), 10% waste slag and 1% super plasticizer at each replacement level of fine aggregate.

Patel et.al (2019) studied on glass waste as a substitute of cement in concrete. In this work they prepared five different mixes with incorporation of glass waste in the powder form.

Fathi et al. (2017) in this study prepared concrete with glass as a coarse aggregate CA and added polypropylene fiber to increase its behaviour at different percentages (0%, 0.5%, 1% and 1.5%).

Aliabdo et al. (2016) used waste glass powder (GP) as an alternative of cement. The waste GP was acquired from containers, windows, bottles and jar of glass.

Lavanya and Karuppasamy (2016) investigated using waste glass as an alternative of cement and glass powder (GP) as a sand. The grade preferred for work was M20, M30 and M40.

Xie et al. (2017) prepared concrete using fine sand (FS) and mixed color waste glass (MCWG). They used FS as a part of cement and MCWG as a fine aggregate (FA).

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Harbec et al. (2017) used waste glass fume (GF) as a pozzolanic substantial. In this study GF was preferred in 0, 5, 10, 20 and 40% by weight of cement.

Yang et al. (2013) investigated on fly ash, GGBS and SF as part of concrete. The range of substitution level was 3-70% for fly ash, 3-80% for GGBS and 3-40% for silica fume. Performance of concrete was checked on various parts of strength and durability.

3. METHODOLOGY

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 1. 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 2.

Fig-1 OPC 43-Grade (Cement)

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

Table-1: Index properties of OPC

Coarse aggregate is used in concrete as they provide strength to concrete. In this work CA of rough texture with angular shape were obtained from Guntur, A.P. The size of aggregate ranging from 4.75 mm sieve size to 20 mm was taken for experimental work. Gradation of aggregate was selected as per (IS 386, 2016). The particle size curve of the CA is presented in Fig. 3.5. Index properties of CA, specific gravity, density and water absorption are shown in Table 3

Fig-2 CA in 10 mm & 20 mm size

Assets	CA	
	10mm	20mm
Density (kg/m^3) (In Oven dry)	1354	1480
Density (kg/m^3) (In Surface saturated dry)	1485	1575
Bulk Density (kg/m^3)	1530	1485
Sg. Gravity (In Oven dry)	2.64	2.63
Sg. Gravity (In Surface saturated dry)	2.67	2.67
Water absorption (%)	0.75%	0.75%

Table-2: Index properties of OPC

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-3 Fine aggregate (natural sand)

Granite powder (GP) was obtained from nearby area Guntur, A.P. Granite powder was used as an alternative of sand, after sieving through 4.75 mm sieve.

Fig-4 Glass and granite powder

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Property	Sand	OPC	GP	WGP	FS	MP
Water absorption (%)	1.15	2.55	0.70	1.25	3.01	2.22
Specific gravity	2.64	3.15	2.60	2.58	2.2	2.72
Bulk density (kg/m^3)	1552	1440	1385	1595	1120	1380
Fineness modulus	2.67	2.25	0.95	2.43	0.90	1.75

Table 3: Index properties of 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	1.90	60.23
SiO_2	20.9	73.12	71.78	70.55	55.40	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	-

Table 4 Chemical composition of OPC, natural river sand, GP, WGP, FS and MP

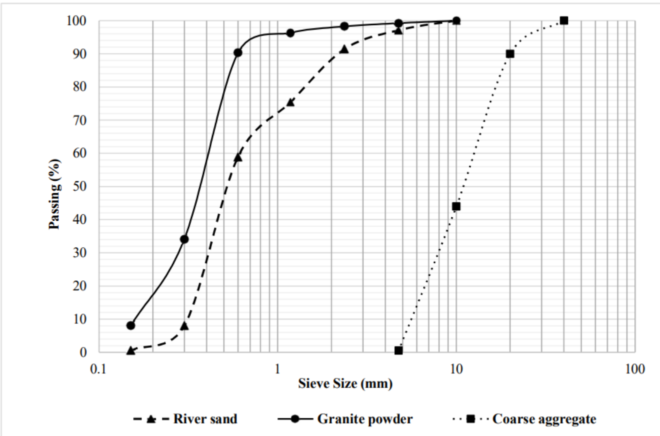

Fig-5: Particle size distribution for WGP, natural river sand and CA

Workability test of slump was performed as per the guidline mention in (IS 1199, 1959). The appratus of cone shape was filled with concrete in four layers.

Each layer of concrete was filled in equal height. Each part of layer was tapped 25 times with the help of steel rod. Compaction of concrete kept uniform throughout the tempering.

This procedure was repeated three times for each mix of control and blended concrete. The difference in height of appratus and highest point of concrete is known as slump value.

Calculation of slump value in mm was measured with the help of gauging scale.

Fig-5 Slump value observation

4. RESULTS AND DISCUSSIONS

4.1 Phase-I (GP and WGP added concrete results)

- Slump results are presented in Fig.4.1, 4.2 and 4.3 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.
- In similar studies presented that there is a systematic increase in the concrete slump as the glass powder passed through 300 micron sieve in the mix increase.
- The slump ranged from around 40 mm for the reference mix from 0% glass powder to 160 mm at 40% glass powder reported that the slump of glass powder added concrete was increased compared to control mix.
- The higher water absorption of granite quarry dust is a major factor behind the decreased workability of the concrete, also reported irregular and rough texture of WGP particles due to which friction is introduces and this reduces the workability, mentioned more water absorption by WGP and high porosity, increases the water requirement and reduce the workability of blended mixes.

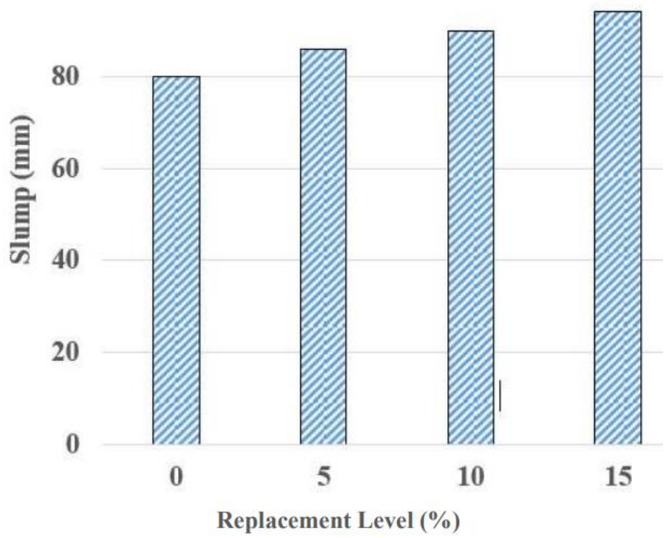

Fig-6 Slump value of glass powder added concrete

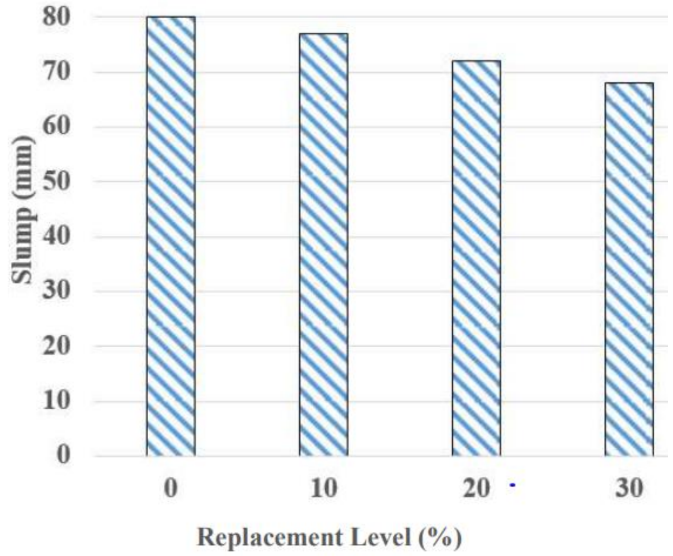

Fig-7 Slump value of granite powder added concrete

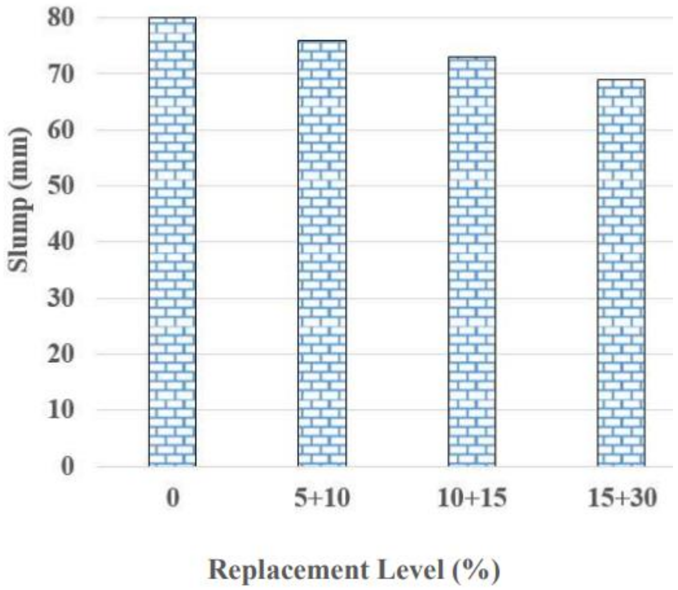

Fig-8 Slump value of glass and granite powder added concrete

Density of control and blended mixes of glass and granite powder are shown in Fig.6, 7 and 8. 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.

For an increment of glass fines more than 15%, density was reduced because of reduction in the amount of cement and less specific gravity of glass powder. Density of WGP added concrete for control, WGP10, WGP20 and WGP30, mixes was attained as 2460, 2475 and 2500 gm/cc respectively.

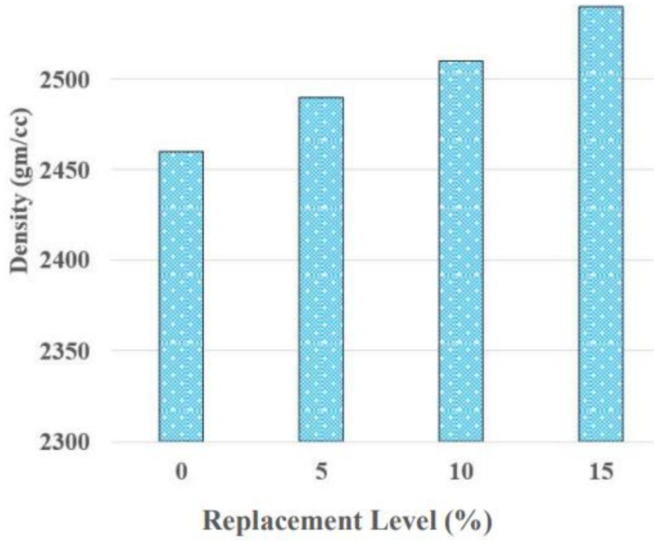

Fig-9 Density of glass powder added concrete

Results of compressive strength test for 7, 28, 56 and 90 days are revealed in Fig. 4.7, 4.8 and 4.9. 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/mm2 respectively.

The magnitude of strength for blend WGP30 was observed higher as compared to control sample.

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.

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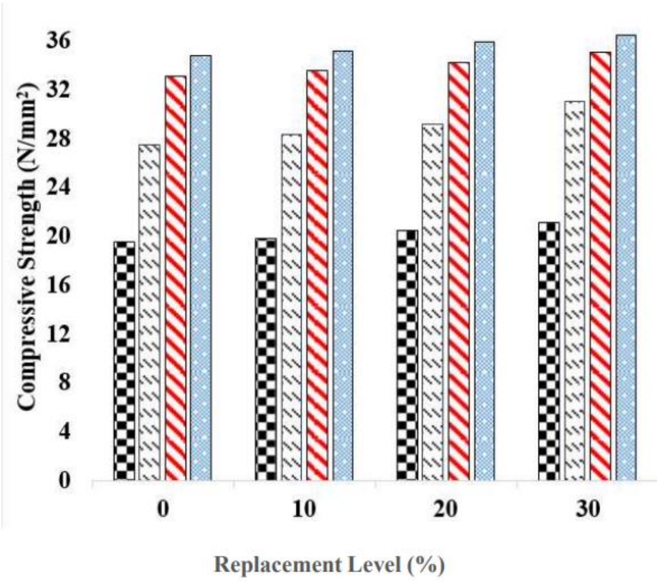

Fig. 10 Compressive strength test results of WGP added concrete

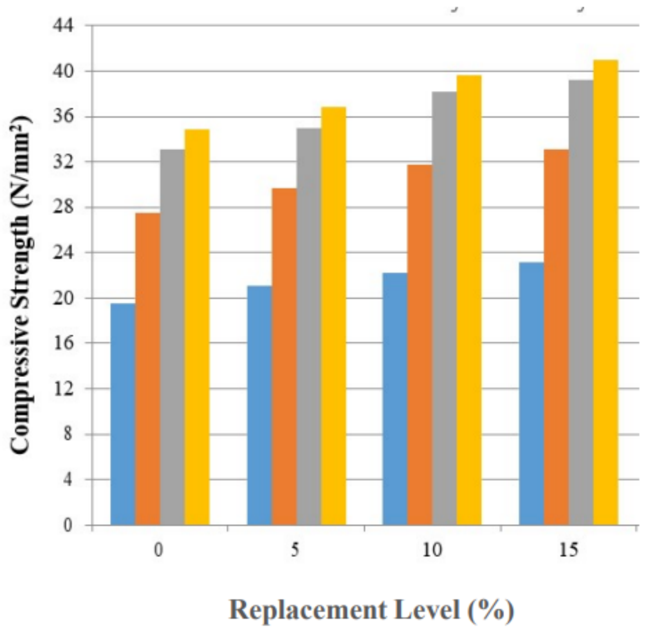

Fig-11 Compressive strength test results of GP added concrete

4.2 Phase-I (GP and WGP added concrete results)

The project's Ordinary Portland Cement was of the Dangote brand. The consistency and soundness of the cement were evaluated. To find out how much water a certain cement needs to make a paste with a standard consistency, as well as the cement's initial setting time, ultimate setting time, and soundness, scientists conduct the standard consistency test.

Consistency (%)	Initial Setting Time (minutes)	Final Setting Time (minutes)	Soundness (mm)
32	51	657	1.7

Table 5 Result for setting time and soundness of cement

Granite						
Sample No.	M_1 (g)	M_2 (g)	M_3 (g)	M4 (g)	G_S	Average Gs
1	24.7	34.7	79.7	72.4	2.8	2.8
2			79.7	72.5	2.8	
River Sand						
1	24.7	34.7	79.6	72.4	2.7	2.7
2	21.4	31.4	79.7	72.5	2.7	

Table 6 Specific gravity of granite powder

AGGREGATE CRUSHING VALUE						
S/No.	Wt. of empty cylinder W1 (kg)	Wt. of cylinder +sample W2 (kg)	Wt. of sample passing sieve W2	Wt. of sample W– W_1 (kg)	ACV	Average(%)
1	2281	2926	126	646	19.35	19.1
2	2281	2921	121	641	18.98	
3	2281	2916	116	636	18.45	
AGGREGATE IMPACT VALUE						
1	2281	2921	116	641	18.32	16.2
2	2281	2901	91	621	14.87	
3	2281	2911	91	631	14.82	

Table 7. Aggregate Crushing & Impact Value (ACV) of Coarse Aggregate

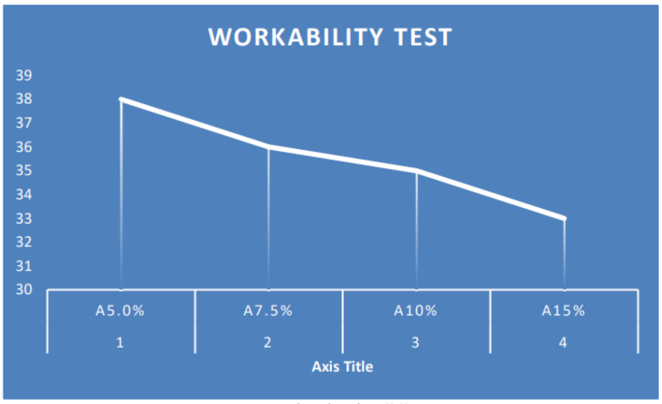

Fig-12 Compressive strength test results of GP added concrete

5. CONCLUSION

5.1. SCOPE FOR FURTHER STUDY

- Using flyash, GGBFS, or RHA instead of particles smaller than 4.75 mm is a potential extension of the current study. Additional applications include replacing crusher stone with coarse slag (e.g., copper, ferrochrome, oxygen, etc.) as the coarse aggregate, and enhancing the material's elastic characteristics with crumb rubber or tire waste.
- 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.
- 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.

- The splitting tensile of blended mixes was increased with increase of waste glass and granite fines.
- 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.
- 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 pozzolanic material 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.
- 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.
- 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 SiO2 presence in blended mix, which contributes to the production of C-S-H Gel.
- 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.
- After 56 days of curing, the concrete that had 10% GP added to it had a peak compressive strength of 33.40 N/mm2. Consequently, out of all the concrete mixes that are grade 30 concrete equivalent—that is, concrete that may be used with post tensioned tendons—GP at a 10% addition is the best option.
- Third, the three-day compressive strength was greatest at a 10% GP addition level (23.03 N/mm2) and lowest at a 2.5% GP addition level (20.47 N/mm2).
- The compressive strength after 28 days was found to be 28.29 N/mm2 at a GP addition level of 10% and 27.40 N/mm2 at a GP addition level of 2.5%.

RECOMMENDATIONS FPR FUTURE WORK

- After reaching the gradation specified by standards, sustainable concrete may be made using a mixture of granite powder and glass powder.
- In addition to glass granite, fly ash and GGBFS may partially substitute for cement in concrete.

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