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An Experimental Investigation On The Mechanical Properties Of Granite Powder Concrete

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Abstract

Usually the disposal of granite powder waste (GPW) from the granite stone processing industry in Tamilnadu state leads to land pollution. About 30% to 40% of waste stone slurry is generated by granite stone processing industry. To solve the problem of the GPW (Stone slurry after drying) disposal from the granite industries, the investigations were carried out for the possibility of using GPW as partial replacement (10%,20%,30%,40% and 50%) for Manufactured sand (M-Sand) in concrete. Cement was replaced by silica fume (10% by weight) and Super plasticizer (varying percentage by weight of binder) was added for good workability. Mechanical properties such as Compressive strength, Split tensile strength, Flexural strength, modulus of elasticity of concrete mix (M60) were evaluated. The result showed that 10% replacement of granite powder improves the mechanical properties of concrete.

Keywords: M-Sand, pozzolana Portland cement, Granite waste powder, Silica fume, Super plasticizer, durability.

1. Introduction

In this research, the river sand was completed replaced by manufactured sand (M-Sand). The use of M-Sand represents a higher strength than the corresponding natural sand concrete at all test ages [1]. Hyper plasticizer with varying percentage was used to get the medium constant workability. In this research cement was partially replaced by silica fume (10 % by weight). Nowadays, ordinary Portland cement (OPC) was replaced by pozzolana Portland cement (PPC) due its more performance. Compressive strength under normal water exposure, the control PPC showed superior quality than OPC at later ages. The waste generated from stone processing industry is increasing every year in India mainly in Tamilnadu state. The stone wastes are classified as solid waste and granite powder (i.e. Stone slurry after drying).The granite powder disposal on land is a serious problem. Normally stone slurry is disposed in landfills, its water content is reduced and the resulting stone dust causes several environmental impacts. The main aim of this study is to experimentally investigate the appropriateness of granite power waste (GPW) as an auxiliary material for fine aggregate in concrete mix.The presence of stone slurry particle in normal concrete improves the performance of hardened concrete [2]. Mechanical property such as compressive strength, Split tensile strength, Flexural strength, Modulus of elasticity of concrete mix (M60) were studied with partial replacement of M sand with GPW of 10%, 20%, 30%, 40% and 50%.

2. Experimental program

Materials

Cement

Portland pozzolana cement conforming to IS 1489 (Part 1): 1991[3] was used.

Silica fume

Silica fume of grade 920- D obtained from Elkem India private limited, Mumbai, India was used as mineral admixture.

Fine and coarse aggregates

Manufactured sand (M-Sand) from locally available Quarry industry conforming to IS 383:1970 [4] was used as fine aggregate. Crushed aggregate of 20 mm size conforming to IS 383:1970 was used as coarse aggregate.

Granite powder

Granite powder obtained from local granite stone processing industry was used fine aggregate. Sieve analysis results in percentage are shown in Table 1.

Table 1.Seive analysis

Sieve size	M-Sand	Granite powder
4.75mm	100	100
2.36mm	100	100
1.18mm	80	93
600µm	43	57
300µm	8	45
150µm	9	20

Hyper plasticizer

A polycarboxylic acid based superplastizicer commercially available as cera hyper plast xwr 40 was used to maintain medium workability as per IS 456 – 2000[5].

3. Mix proportions

The control mix without Granite powder waste (M60) was designed as per Indian standard specification I.S 10262-2009[6]. Concrete mixtures were calculated as shown in table 2.The specimen were tested at age of 7, 28, 56 days as per IS 516–1959[7] (partial replacement of M sand with Granite powder waste of 10%, 20%, 30%, 40% and 50%) to evaluate the effective use of Granite powder waste in concrete.

Table 2.Concrete mix

Mix ratios	SF %	Silica fume [kg]	Cement [kg]	GPW%	Granite Powder [kg]	F.A. [kg]	C.A. [kg]	Super plasticizer %	Water [litre]
GPW 0 (Control mix)	10	43.59	392.34	0	0	672.34	1238	0.8	139.5

4. Experiment method

Flow property (Workability)

The workability of concrete (slump test) was retained as medium value by using variable percentage of hyper plasticizer.

Mechanical properties of specimens

Compressive strength of concrete was determined on cubes (72 nos) of size 150mm x 150 mm x 150 mm at the age of 7, 28,56 and 90 days using Compression Testing Machine(CTM) of capacity 4000 kN as per IS:516 – 1959.Split tensile strength of concrete was determined on cylinder(72 nos) of size 150mm x 300mm at the age of 7, 28,56 and 90 days using CTM as per IS:5816 – 1999[8].Young’s modulus of concrete was determined on cylinder (36 nos) of size 150mm x 300mm at the age of 28 and 56 days using Universal testing machine(UTM) as per IS:516 – 1959.AS per IS 456 - 2000 ,the elastic modulus of concrete was determine based on compressive strength of concrete. Flexure tensile strength of concrete was determined on prism (45 nos) of size 100mm x 100mm x 500mm at the age of 28, 56 and 90 days using UTM as per IS:516 – 1959.

5. Results and Discussion

Workability

The workability of concrete mixture was decreased when M sand was replaced with

GPW (Table 3).The rough and angular surface of the granite powder waste increase the friction in concrete and the increased specific surface area of the powder increasing the water demand.The slump was maintained as constant value 80 mm to get the medium workability for pumped concrete as per IS 456 – 2000 (75 mm to 100 mm for pumped concrete).

Table 3.Workability

GPW %	HP %	Slump mm
0	0.8	100
10	0.9	80
20	1	80
30	1.1	80
40	1.2	80
50	1.3	80

Compression strength

The addition of granite powder waste in concrete does not affect the strength behavior and also enhance the compressive strength of concrete up to the use 10% GPW. Figure 1 shows that the compressive strength of concrete for the replacement of 10 % was more than the control mix (GWP 0) at all the ages.

From the past report about 25% granite powder as a replacement of river sand with 7.5% silica fume, 10% fly ash, 10% slag and 1% superplasticiser as a replacement of cement in concrete mixture is higher strength than that of conventional concrete [9].The compressive strength has increased by 22% with the use of 35% replacement of fine aggregates with granite fines [10]

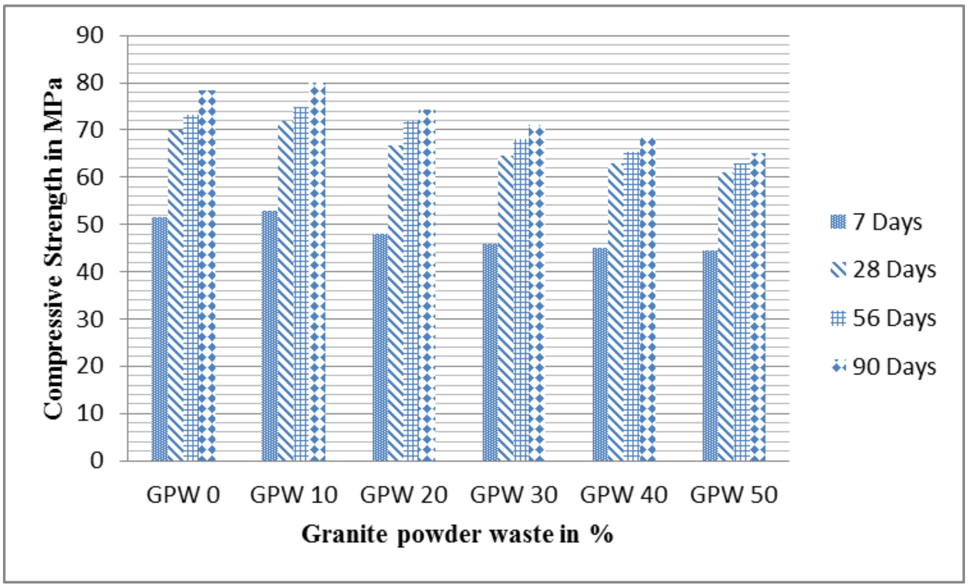

Figure 1: Compressive strength in MPa

Split tensile strength

The decrease in split tensile strength is mainly due to the presence of micro-voids in the concrete mixes as the percentage of granite powder increased. From the figure 2, the tensile strength of concrete for 10% replacement of granite waste powder (GPW 10) with M-sand was higher than the control mix (GPW 0).The tensile strength of the concrete mixture up to 10% granite powder (GP 10) replacement was close to GP0.[11]

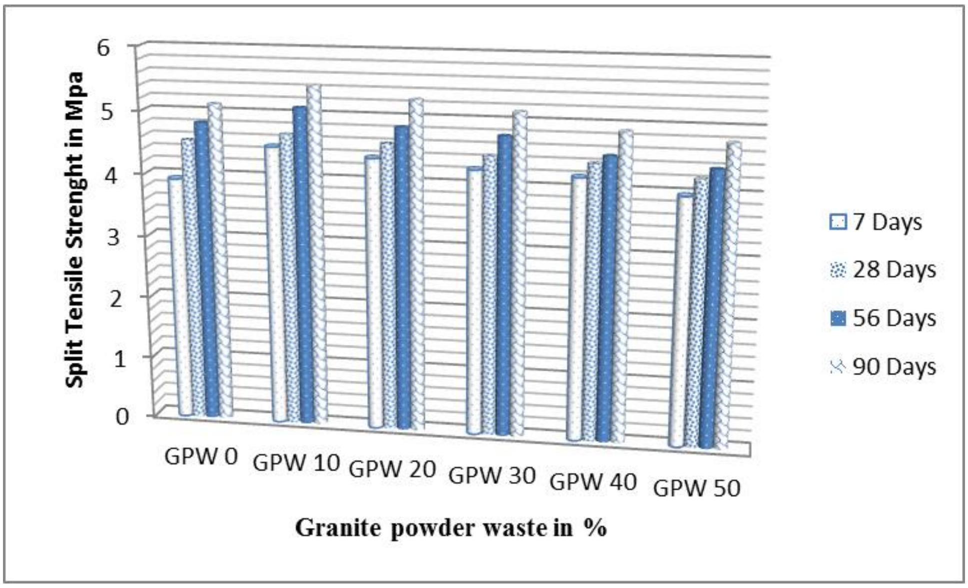

Figure 2: Split Tensile strength in MPa

Modulus of elasticity

Figure 3 shows that the value of modulus of elasticity of concrete for GPW 10 was more than the control mix GPW0. But a clear observation of Figure 3 reveals that the increases in GPW

affects the strength beyond 10% due to presence of voids in the concrete mixes.The tests shows that the modulus of elasticity of all the concrete mixtures was almost similar or higher than that of GP0 both for 7 and 90 days and with a 25 % granite powder (GP25), modulus of elasticity of concrete mixture is 2%higher than that of GP0 at 90 days of curing [12].

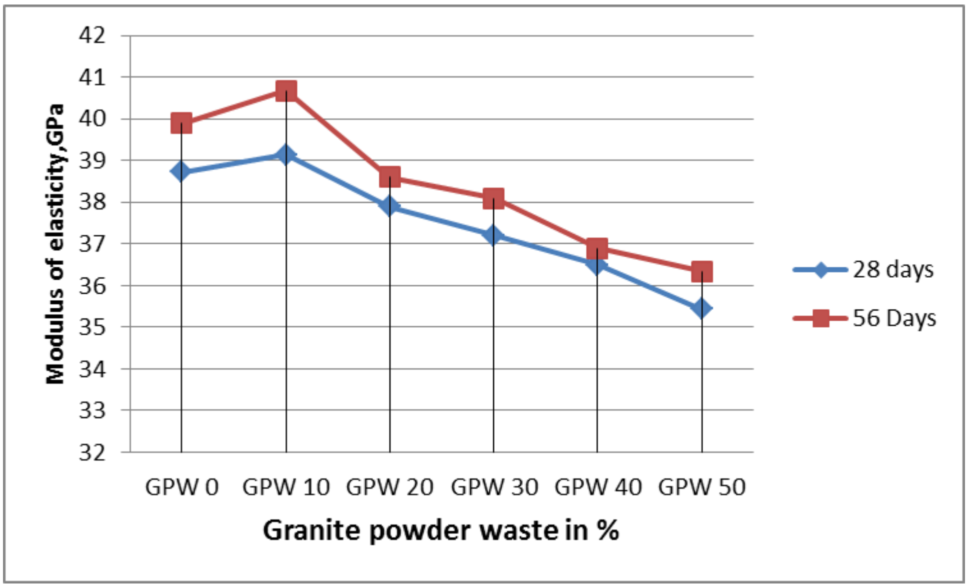

Figure 3: Modulus of elasticity in GPa

Flexural strength

The flexural strength of concrete was reduced when the M-sand replacement by large quantities of granite powder and for 10% M-sand replacement by granite powder waste (GPW) shows increase in flexural strength. From the Fig 4 it was observed that GPW replacement at all the ages for 10 % replacement was more the control mix (GPW0).The flexural strength of the concrete mixtures CGP 5%, CGP 10%, CGP 15% were little lower than the control mixture however significant losses in flexural strength was observed beyond the substitution rate of 15%[11].

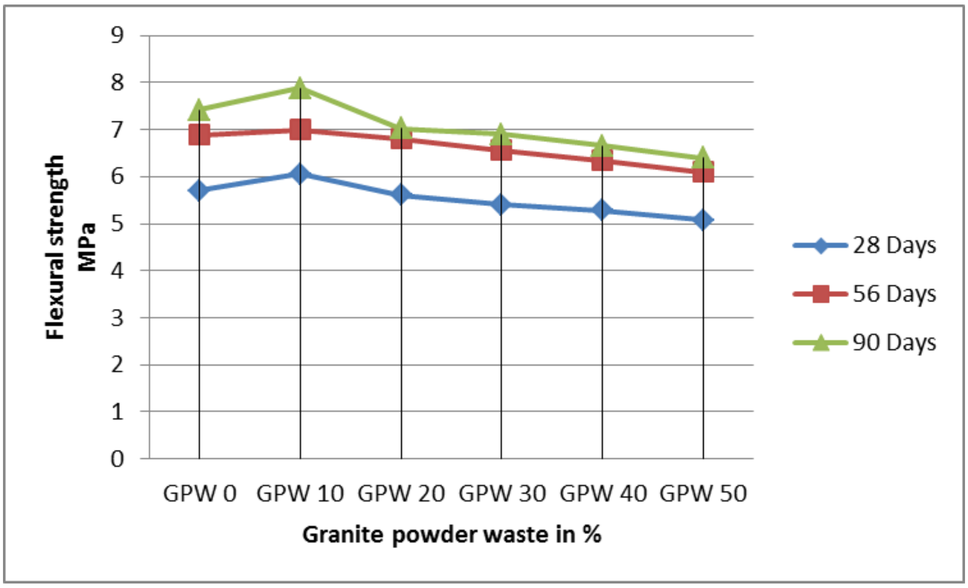

Figure 4: Flexural strength in MPa

6. Conclusion

The research work was conducted to assess the mechanical properties of the GPW in concrete to confirm the consistency of its usage to avoid the pollution and waste management to safeguard the environment from severe impact due to the disposal of granite powder waste. Based on the sufficient experimental test results of different mixes the following conclusion may be prepared.

The workability of concrete for GPW was very low at initial mix due its more roughness. To get medium workability of 80mm (for pumped concrete), the high range water reducing admixture (hyperpasticizers) at different percentage was used.

The compressive strength and split tensile strength of concrete for the Mix GPW10 was more than the control mix GPW0 and also other mixes at all the age of curing due to its high density matrix (less voids).

The Modulus of elasticity and flexural strength of GPW10 shows that the strength of concrete was increased by using the waste granite powder as marginal replacement with M-sand.

In this research for the effective use of granite powder waste as replacement for M-sand in concrete to produce a mix M60 with Hyper plasticizer for good workability to avoid land pollution and also effective solid management, it was recommended to use the Mix GPW10 as a prime value.

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