A Pilot Strength Studies on Granite Powder and Silica Fume Based Concrete

Chava Venkatesh, Vankeswaram Ramanjaneyulu, Komma Hemanth Kumar Reddy, Chereddy Sonali Sri Durga, Polu Sathish

Abstract: ***The current work focused on utilization of granite powder as a mineral admixture in concrete. Granite stones are highly precious natural resource, which are used in construction industries. While crushing or cutting of granite stones more than half of the granite wasted in the form of granite dust or powder. Utilization of large amount of granite powder (GP) in concrete as replacement to the cement can control the pollution due to cement industries. The current work granite powder was replaced by cement with 0% to 20% with interval of 5%. Based on the results, the optimum replacement of granite powder was 15% and which is kept as constant. Silica fume (SF) used as a ternary mineral in current mix and it is replaced by cement was 0% to 8% with interval of 2%. The optimum replacement of silica fume in granite powder concrete was 6%. The presence of higher content of calcium and silica in mix helps to develop C-S-H gel formation; this is reason for enhancement of mechanical properties in present concrete mixes.***

Index Terms**:** ***Granite Powder, Silica Fume, Compressive Strength, C-S-H gel, Split Tensile Strength.***

I. INTRODUCTION

As an environment concern, the by-product of various industries is being used in the concrete as mineral admixtures like granite powder. In India from last 5 years onwards more than 75 million tons of granite powder or dust was produced. The massive amount of granite powder creates lot of problems to industries as well as neighbours in the form of pollution and occupying the lot of land for disposal. Utilization of large amount of granite powder in concrete as a replacement to the cement can control the pollution due to cement industries. The primary benefit for using granite powder as constructional material, can minimize the silica content air and also risk of silicosis[1] [2].Many developed and developing centuries like Spain, Italy, turkey and Iran are using granite waste in the forms of construction material [3].several studies on granite powder utilized in construction industries[4][5][6] [7] [8].

Dr. G. Elangovan [9] study reported that, optimum replacement of granite powder was 15%. Similar study conducted by Y.Yaswanth Kumar et al, 2015 [10] reported that the 10% granite powder replacement shown higher strength. Increased the granite powder content in concrete decreased the workability of concrete [6]. Williams CK study reported that granite powder was replaced different proportions from 25% to 100% and this reported that 25% replacement shown higher compressive strength [11]. E. Serelis et al,2018[12] conducted a study on ultra light weight concrete using granite powder and reported that increases the dosage of granite powder decreases density of concrete and also this reported that there is negative impact on concrete. Some of the studies also conducted on granite powder used as replacement to fine aggregate. Kala 2013[13] study concluded that 25% of granite powder replaced by the fine aggregate shown greater strengths as compared to 0% of granite powder concrete. Another study conducted by vijayalakshmi et al, in this study granite powder was replaced by fine aggregate and investigated all durability as well as mechanical properties. Study concluded that 15% of granite powder shown better results [6].

Silica fume co-producers from the ferrosilicon and silicon industries, at 2000ºC temperature applied on pure quartz it converted into silicon then it forms silicon dioxide vapours[14]. Silica fume is well known mineral admixture which improves strength as well as durability and pore structure of concrete [15][16][17]. In silica fume does not shown any negative effect on workability of concrete upto replacement of 10% Amrkhail et al, 2015[18]. Kumar and Dhaka 2016 [18] reported that the optimum replacement silica fume in concrete was 12% in his study. Katkhuda et al, 2009[20] reported that 15% of silica fume replaced in cement shown higher split tensile strength. The current work used granite powder as partial replacement in cement with 0% to 20% and based on the results analysis silica fume used as ternary mineral in granite powder based concrete, which is replaced by 0% to 8%.

II. MATERIALS AND METHODS

Current work used OPC 53 grade cement which confirmed by IS12269-1987. All the physical and chemical tests are within limits of IS4031-I (1996). River sand was used as a fine aggregate according to IS 383:2016.20mm size crushed stones are used as coarse aggregates and all the

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Chava Venkatesh, Department of civil Engineering, Vignan's foundation for science, technology & research, vadlamudi, Guntur, Andhra Pradesh, India.

Vankeswaram Ramanjaneyulu, Department of civil Engineering, Narasaraopeta Engineering College, Narasaraopeta, Andhra Pradesh, India.

Komma Hemanth Kumar Reddy, Department of civil Engineering, Vignan's foundation for science, technology & research, vadlamudi, Guntur, Andhra Pradesh, India.

Chereddy Sonali Sri Durga, Department of civil Engineering, Vignan's foundation for science, technology & research, vadlamudi, Guntur, Andhra Pradesh, India.

Polu Sathish, Department of civil Engineering, Vignan's foundation for science, technology & research, vadlamudi, Guntur, Andhra Pradesh, India.

physical and chemical properties of aggregates within limits of IS2386-1963, IS 383-2016. The specific gravity of both FA and CA are 2.64 and 2.72.

A. Granite Powder

Granite powder is by product of granite stones crushing or processing plants. In the current study, raw granite powder taken from the processing plants and dried in hot air plant at temperature of 105ºC in 24 hours. After that the granite powder was crushed very finely in ball mills then the granite powder was sieved in 75µm sieve. The specific gravity and specific surface of granite powder are 2.58 and 13750m^2/kg as shown in table 1.the chemical composition of granite powder was showed in table 2.

B. Silica Fume

Silica fume used in current work is conforming to ASTM C240-15. Specific surface area and Specific gravity of silica fume are 18000m^2/kg and 2.2 respectively. The chemical composition of silica fume used in current work is shown in Table 2.

Table 1: Physical properties of materials used in concrete

Material	Specific gravity	SSA (m^2/Kg)	Initial setting time(Min)	Final setting time(Min)
OPC	3.12	930	55	525
Granite Powder	2.58	13750	50	500
Silica Fume	2.2	18000	45	450

Table 2: Chemical composition

Chemical compounds	OPC (%)	Granite Powder (%)	Silica Fume (%)
CaO	63.29	5.21	-
SiO_2	20.93	63.5	92.1
Fe_2O_3	3.95	5.52	0.23
Al_2O_3	4.73	12.5	0.48
Na_2O	0.22	5.12	0.63
MgO	0.45	0.42	0.87
K_2O	0.21	5.17	1.21
Others	2	2.56	2.51

A. Mix calculations

Mix	OPC*	GP*	SF*	FA*	CA*	Water*	Admixture*
GP 0%	383.15	-	-	706	1255.11	153.26	3.83
GP 5%	363.99	19.15	-	706	1255.11	153.26	3.83
GP10%	344.84	38.31	-	706	1255.11	153.26	3.83
GP 15%	325.68	57.47	-	706	1255.11	153.26	3.83
GP 20%	36.52	76.63	-	706	1255.11	153.26	3.83
SF 0%	325.68	57.47	-	706	1255.11	153.26	3.83
SF 2%	319.17	57.47	6.51	706	1255.11	153.26	3.83
SF 4%	312.66	57.47	13.02	706	1255.11	153.26	3.83
SF 6%	306.14	57.47	19.54	706	1255.11	153.26	3.83
SF 8%	299.63	57.47	26.05	706	1255.11	153.26	3.83

* All are in Kg/m^3

In the current work all the samples are prepared for compressive strength with size of 150×150×150mm according to the IS 516-2013. All prepared Samples are tested in compressive strength testing machine with rate of loading was. For split tensile the samples was prepared with height of 300mm and 150mm diameter according to IS 5816-1999. For flexural strength the samples was prepared with size of 150×150×750mm according to IS: 516-1959. All the samples are cured in normal water according to IS1903 (1978).

I. RESULTS AND DISCUSSION

A. Compressive strength

The current work conducted for to know the compressive strength of granite powder based concrete and granite powder cum silica fume based concrete. In case of granite based concrete, increased the strength with increases the granite powder upto 15%. Then after words strength reduction was observed. At 15% of granite powder mix showed 42.85% strength increment as compared to normal concrete and which is optimum replacement as shown in figure 1. High content of calcium present in the mix which helps good pozzolanic reaction in concrete. In case of granite powder cum silica fume concrete, in all mixes 15% granite powder was replaced by cement and which was kept constant. In the same mix silica fume used as a ternary mineral in granite powder concrete, which replaced at 0% to 8% with interval of 2%. Based on results, the SF 6% mix shown higher strength as compared to others and which is the optimum replacement as shown in figure 2. The reason for strength increment was high amount of silica and calcium present in the current mix.

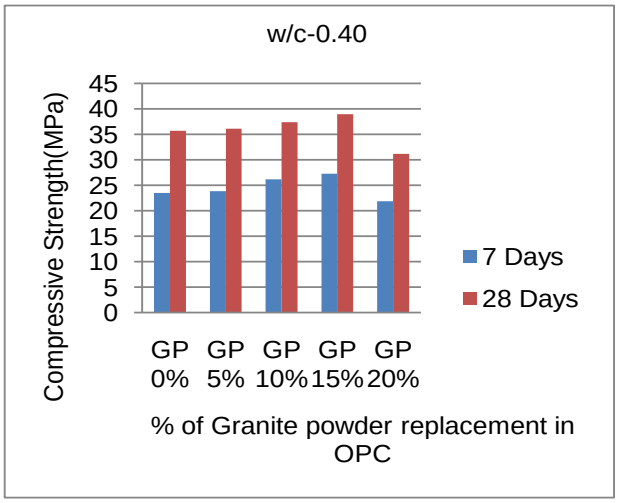

Fig 1: Compressive strength of granite powder based concrete

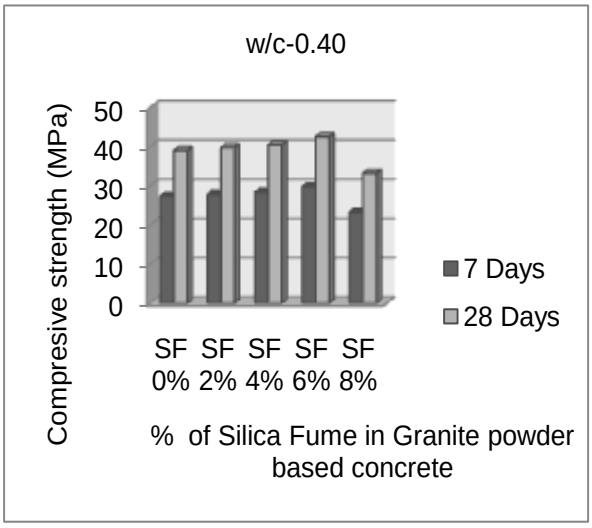

Fig 2: Compressive strength of granite OPC+GP+SF concrete

A. *Split tensile strength*

Split tensile strength conducted for all the samples in current work, in case of granite powder based concrete, based on the results , GP 15% shown 28.87% of strength increment as compared to GP 0% of mix and which is optimum replacement as shown in Figure 3. In case of granite powder cum silica fume concrete, SF 6% mix shown 41.34% of strength increment as compared to SF 0% mix and which is optimum replacement as shown in Figure 4. The reason for strength increment in both the case was fineness of the both silica fume and granite powder. In current work, both granite powder and silica fume mineral particles are very finer and which was able to resist the micro cracks formation in concrete.

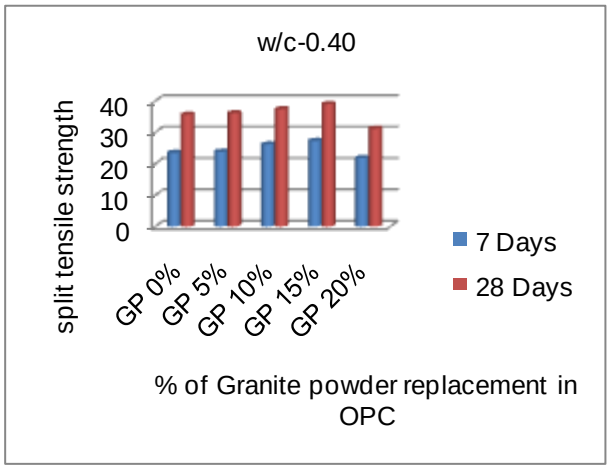

Fig 3: Spit tensile strength of granite powder based concrete.

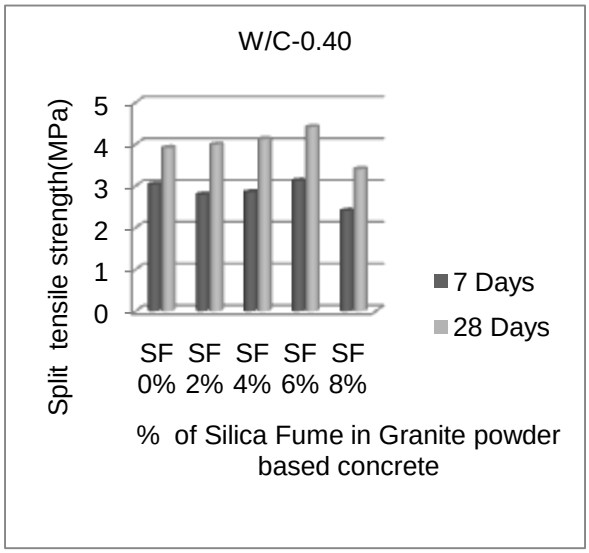

Fig 4: Split tensile strength of granite OPC+GP+SF concrete

B. *Flexural strength*

The flexural strength conducted for all the mixes in current work, in case of granite based concrete, Increased the flexural strength of concrete with increases replacement of granite powder in cement. In current work, the optimum replacement of granite powder in cement was 15% confirmed by the results analysis. The GP15% showed 21.62% of strength increment as compared to GP 0% mix as shown in figure 4. In case of granite cum silica fume concrete, SF 6% shown 21.72% of strength increment as compared to the SF0% mix and which the optimum replacement of silica fume in granite powder concrete as shown in figure 4. The reason for strength increment in both the cases was formation of good C-S-H gel in current concrete mixes.

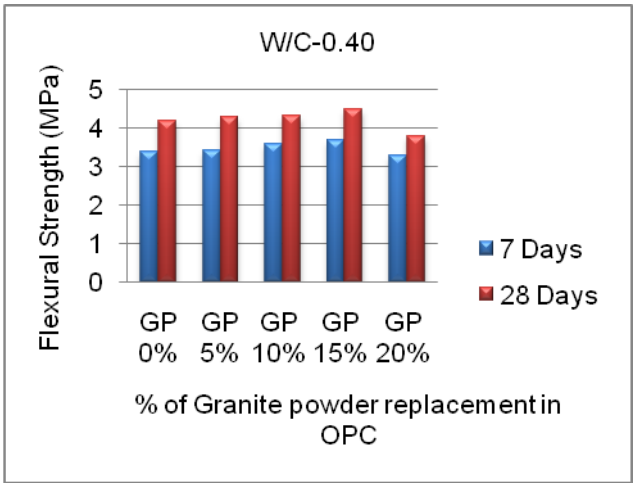

Fig 5: Flexural strength of granite powder based concrete

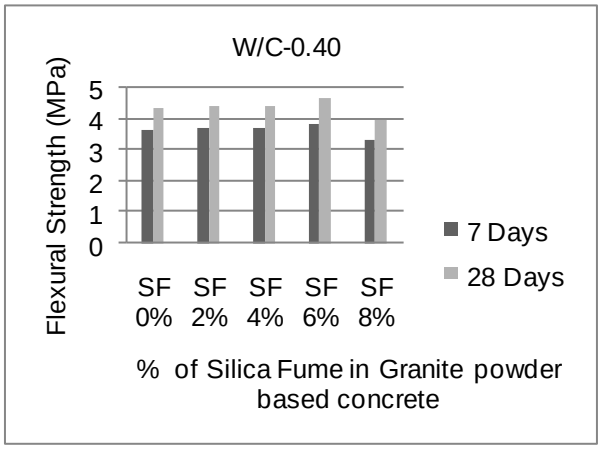

Fig 6: Flexural strength of granite OPC+GP+SF concrete

II. CONCLUSION

Based on the results analyses following conclusions are made in the current work.

- Higher content of calcium oxide and silica oxide present in all mixes which accelerated the pozzolanic reaction in concrete.
- Optimum replacement of granite in cement was 15% and optimum replacement silica fume in granite cum silica fume was 6%.
- The reason for split tensile strength increment in both the case was fineness of the both silica fume and granite powder. Which can able to minimize the micro cracks present in concrete.
- The reason for flexural strength increment in both the cases was formation of good C-S-H gel in current concrete mixes.

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