International Journal of ChemTech Research
CODEN (USA): IJCRGG ISSN: 0974-4290
Vol.8, No.3, pp 1417-1422, 2015

Durability Studies on Cement Mortar with Granite Powder as A Partial Replacement of Cement

S.Vishnu Shankar[1], K.Saravana Raja Mohan[2]

School of Civil Engineering, SASTRA University, Thanjavur 613401, India

Abstract: Nowadays many researchers are being carried out to find an alternative that could be used as a partial replacement of cement in concrete and mortar, since production of cement causes major environmental concerns. Granite powder (dust) which is a waste product obtained during the cutting and polishing of granite, is a result of such researches. This paper focuses on the durability studies on cement mortar in which cement is partially replaced with granite powder. The replacement levels are taken as 20%, 25%, 30%, 35% and 40% by the weight of cement. Suitable specimens for various durability tests such as corrosion resistance test, fire resistance test, sulphate resistance tests, are cast. After curing for 28 days in water, the various tests are performed as per the standards. The results concluded that 30% replacement level showed better performance in terms of durability compared to other mixes.
Keywords: cement mortar, granite dust, durability, waste utilization.

1.Introduction

Cement mortar is the basic building material used worldwide. Production of cement levelsare three billion tons per year which results in the growing environmental demands. The construction material cost is increasing drastically in the recent days. The cement cost was Rs.1.25/kg during 1996 in India, but now it increased six times the previous[1]. Various solid wastes generated from mining, agricultural activities, domestic usage, industrial are mainly due to population growth, urbanization increases and technological innovations.Therefore partial replacement of cement with some other waste material will meet the increasing demand in the future. It has been estimated that Tamilnadu has nearly 50% of granite quarry compared to any other states in India.Granite dust are considered as waste particles during the production of granite products[2]. In granite quarry, shaping and polishing of granite produces enormous amount of waste. In worst casescenarios, dumping of these granite waste causes degradable damages to the environment. Transporting these wastes to a particular dumping yard involves huge expenses. These wastes had been successfully used in cement mortar mix to reduce their hazards. Many waste materials such as silica fume, fly ash, blast furnace slag and rubber have been used in mortar preparation, since they possess pozzolonic activity[3]. These granite waste particles have beneficial effect on mortar properties, and it includes durability aspects.

In the present research work, cement is partially substituted with granite powder at 20%, 25%, 30%, 35% and 40% by the weight of cement, in mortar. Durability test such as Fire resistance, Sulphate resistance and Corrosion resistance, were carried out in the cement mortar having a mix ratio of 1:3 and the results are discussed[4].

2.Materials

2.1. Portland cement

The Ordinary Portland cement (OPC) was supplied by Ramco Cements has been used in this study. According to the code IS 8112:1989, the specific gravity of Portland cement has been experimented and

obtained the value about 3.14. Fine aggregate getting through 2.36mm sieve and obtained a specific gravity of 2.47 has been used in this study.

2.2. Granite Powder

The by-productproduced from granite industry i.e., granite dust has been used in this experimental work. The chemical and physical characteristics of the granite powder were analyzed. It showed that the granite powder has a specific gravity of 2.386. The specific surface of granite powder was found to be 352m^2/kg, which is almost equal to the finesse of cement. The grain size distribution analysis of granite powder showed that 55% of granite powder particles has size less than 150µm and 31% particles of size less than 50µm. The chemical analysis of granite powder using XRF shown the following results (Table 1)

Table 1

S.No	Characteristics	Results
1.	Silica (as Sio2), % by weight	71.48
2.	Aluminium oxide (as Al2O3), % by weight	16.04
3.	Calcium oxide (as CaO), % by weight	7.56
4.	Magnesium oxide (as MgO), % by weight	0.99
5.	Sodium (as Na2O), % by weight	1.46
6.	Potassium (as K2O), % by weight	0.49

3.Experimental program

3.1 Preparation of specimens

Mortar specimens for 5 different mixes, namely 20%, 25%, 30%, 35% and 40% partial replacement of cement with granite powder, were cast. 1:3 mix ratio was adopted for all these mixes. Cement mortar cylinders of size 50 mm x 100 mm with steel reinforcement in the center, were used for estimating the corrosion resistance, as per the galvanostatic technique. For estimating the fire resistance and sulphate resistance, cubes of size 70 mm x 70 mm were used, as per ASTM E119 and ASTM C1012 respectively.

3.2 Testing procedure

For estimating the corrosion, the specimens were cast and cured for 28 days in water. Then, the specimen is immersed in a container containing sodium chloride solution. The specimen is covered using the steel perforated sheet. 12 V DC supply from the source to the reinforced steel rod and the perforated steel sheet. The steel rod acts as anode and the perforated sheet acts as cathode. On supplying the current, the steel rod starts to corrode and the duration for excessive corrosion, which is visually examined, for each sample, is noted.

Fire resistance can be determined by measuring the residual compressive strength after exposure to heat. For each mix, 4 specimens were cast, cured for 28 days and kept in the oven for 24 hours. Then, each of 4 specimens for each mix, are kept in the muffle furnace at temperatures 200 ºC, 400 ºC, 600 ºC and 800 ºC respectively. Now, the compressive strength test for each specimen is carried out and the readings are noted down. The weights before and after the exposure to heat in the muffle furnace, is noted down. The residual compressive strength is given by the following formula.

$$\text{Residual compressive strength} = \frac{\text{Compressive strength of mortar with exposure}}{\text{Compressive strength of mortar at room temp.}}$$

For estimating the sulphate resistance of the cement mortar, the specimens are cured in water for 28 days followed by 56 days curing in sodium sulphate and magnesium sulphate solution separately. Finally, the compressive strength test is performed on these specimens and the reading are noted down. The deterioration due to exposure to sulphate environment can be seen from the compressive strength test results.

3.3 Mix proportions

The mix proportions of the various mixes are given below in Table 2

Table 2 :

Mixture	G20%	G25%	G30%	G35%	G40%
W/C ratio	0.45	0.45	0.45	0.45	0.45
Water (ml)	450	450	450	450	450
Cement (gm)	800	750	700	650	600
Sand (gm)	1000	1000	1000	1000	1000
Granite powder (gm)	200	250	300	350	400

4. Results and discussion

4.1 Corrosion resistance test

The experimental setup for corrosion resistance test is shown in the Fig.1. The experiment is carried out as mentioned earlier and the time take for excessive corrosion is noted down. .

S. NO	%	Wt. Before curing	Wt. After curing	Hours Taken
1.	20%	703.0	711.9	51Hours
	20%	726.7	733.0	53Hours
	20%	729.2	735.2	50Hours
2.	25%	744.3	756.2	54Hours
	25%	750.1	760.2	56hours
	25%	746.3	752.2	53Hours
3.	30%	711.8	730.2	73Hours
	30%	702.1	722.3	72Hours
	30%	708.1	714.3	73Hours
4.	35%	758.2	765.2	49Hours
	35%	754.2	768.4	48Hours
	35%	762.2	775.6	50Hours
5.	40%	768.2	778.5	50Hours
	40%	772.6	780.5	49Hours
	40%	782.5	794.5	48hours

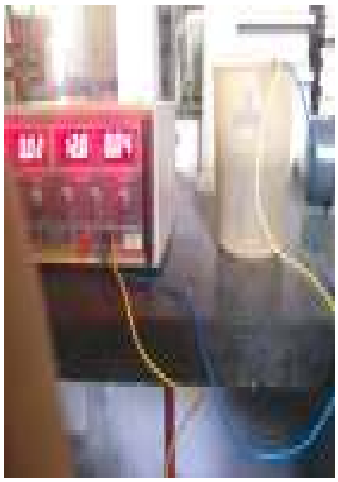
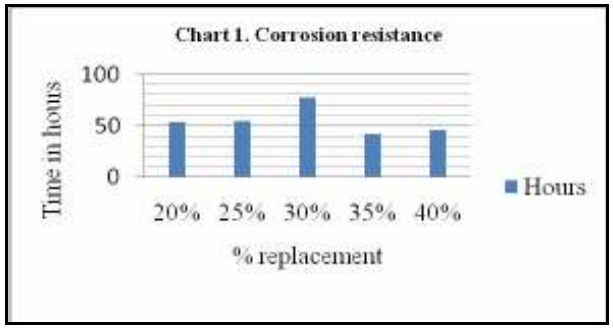


Fig 1. Corrosion resistance test setup

Fig 2.Corroded specimen after the tests



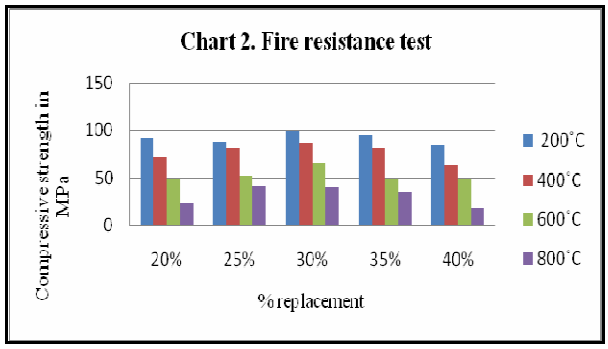
From the above table, it can be seen that for 30% of granite content, it takes average of 70hours to get corroded and for remaining percentage of granite content, it takes average of 50-60hours for the excessive corrosion to take place.

4.2 Fire resistance test

Fig 3. Specimen in muffle furnace

Fig 4.Specimen after heat exposure

Fire resistance is the measure of amount of heat that the specimen can withstand. The procedure of fire resistance test is as mentioned earlier. Figure 3 shows the specimen subjected to a heat of 800 ºC in the muffle furnace and figure 4 shows the specimen after the heat exposure. The fire resistance test results show thatupto 200 ºC there is not much difference and variation in weight loss. At 400 ºC, the yellow color will be formed in the cement mortar cube and considerable weight loss is observed. At 600 ºC, the hair line cracks has formed. At 800ºC, the concrete color is changed into black colour. The weight loss is increased while the temperature is increased and the residual compressive strength is high for the 30% of granite content.(Chart 2)

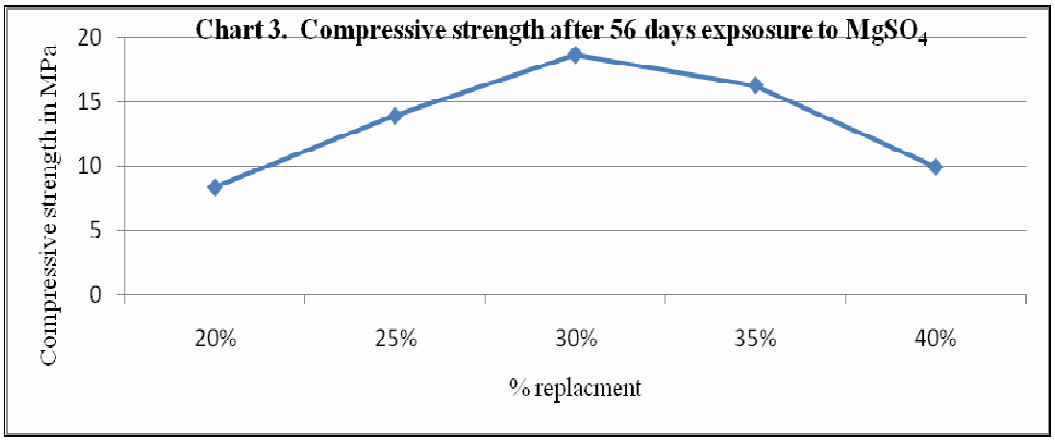


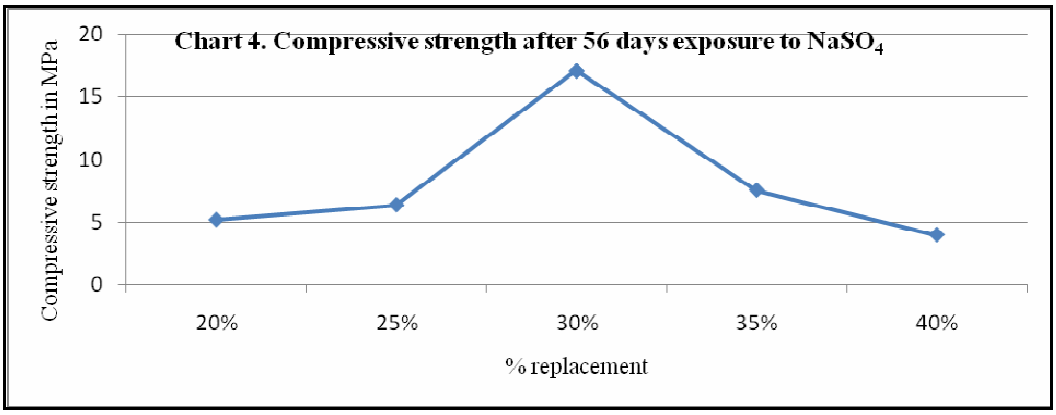
4.3 Sulphate resistance test

As mentioned earlier, the sulphate resistance test is performed by measuring the compressive strength of speciemens after 28 days curing in water followed by 56 days curing in magnesium sulphate and sodium sulphate solution separetely. Figure 5 shows the sulphate attacked specimen.

The results obtained are shown below in charts 3 and 4.

Fig 5. Sulphate attacked





From the results obtained, it can be seen that the compressive strength of mortar cubes with 30% cement replacement performed better in both magnesium sulphate and sodium sulphate solution.

5. Conclusion

- Through an visual examination of corroded specimens, the granite content of 30% in the cement mortar samples had taken 72 hours for the excessive corrosion to take place, which is at an average 24% more time than the other mixes. Therefore it can be concluded that 30% replacement of cement with granite powder showed better results in terms of corrosion resistance compared to other mixes.
- Fire resistance test results show that the residual compressive strength of the cement mortar with granite content 30%, is higher than other mixes. Next to this level of replacement, 35% replacement showed good results.
- On comparing the compressive strength after 56 days exposure in magnesium sulphate and that of sodium sulphate solution for 30% replacement, it was seen that cement mortars performed better in magnesium

sulphate solution thereby making them more vulnerable to sodium sulphate exposure. But compared to other percentage of replacement levels, 30% replacement showed good performance.

- Overall it can be concluded that the mortar with cement replaced with 30% granite powder shows good durability characteristics than other levels of replacement.

References

1. Telma Ramos,Ana Mafalda Matos,Bruno Schmidt,Joao Rio,Joana Sousa-Coutinho,Granitic quarry sludge waste in mortar: Effect on strength and durability, Construction and Building Materials 47 (2013) 1001–1009.
2. Marmol, Ballester, Cerro, Monros, Morales, Use of granite sludge wastes for the production of coloured cement-based mortars, Cement&Concrete Composites 32 (2010) 617–622.
3. HanifiBinici,TahirShah,Orhan Aksogan,Hasan Kaplan, Durability of concrete made with granite and marble as recycle aggregates, journal of materials processing technology 208(2008)299–308.
4. T. Felixkala,Partheeban,Granite powder concrete , Indian Journal of Science and Technology Vol. 3 No. 3 (Mar 2010).
5. M. Vijayalakshmi, A.S.S. Sekar, G. Ganesh prabhu, Strength and durability properties of concrete made with granite industry waste,Construction and Building Materials 46 (2013) 1–7.

*****