EXPERIMENTAL STUDY ON PARTIAL REPLACEMENT OF FINE AGGREGATE WITH MARBLE POWDER

Mr. Shailesh Harishchandra Nakade, Ms. Pragati Prakash Chafale, Ms. Swati Natthuji Mool, Ms. Pallavi Anadarao Mohod, Prof. Priyanka Nagdeve
Final Year Student, Civil Engineering department, SCET, Nagpur
Prof. Civil Engineering department, SCET, Nagpur

Abstract The experimental parameter was the percentage of granite powder substitution. The cubes and cylinders were prepared by 0 %, 5 %, 10 %, 15 %, 20 % and 25 % of fine/natural aggregate substituted by the GP by-product. To fully understand the influence of GP by-product on behavior of concrete, several tests such as density, slump cone, split tensile strength, flexural strength; Ultrasonic pulse velocity (UPV) and compressive strength tests have been conducted. The GP by-product showed a very high specific surface value of about 351 m2/kg and the chemical analysis results showed the examined material contains about 72.14 % of silica (Sio2), and 17.13 % of alumina. Experimental results revealed that, rough texture and high specific area of the GP by-product significantly decreased the workability of the concrete, especially for the substitution rate of 20 % and 25%. The obtained test results shows that the substitution of GP by-product up to 15 % does not affect the mechanical properties of the concrete and the substitution of beyond 15 % is not beneficial. However the determination of its durability properties will ensure the reliability of its usage in aggressive environments. With the intention, this study also focused to determine the influence of GP waste on the durability properties of concrete. The cubes and cylinders were prepared by 0 %, 5 %, 10 %, 15 %, 20% and 25 % of fine/natural aggregate substituted by GP waste. The experimental results were shown that substitution of granite and marble powder waste up to 15 % of any formulation of concrete is favorable form the normal concrete making and it is concluded that granite powder waste can be used as alternative aggregates for normal concrete. However, more research is needed to understand the flexural and axial behaviour of GP concrete in structural member scale. To fill this gap this research work intended to examine the structural aspects related to flexural and axial behaviour of reinforced concrete beam containing granite industry waste. From the test results obtained, it is recommended that the replacement of natural sand by the GP waste up to 15 % of any formulation is favorable for the concrete making without adversely affecting the structural behaviour of concrete

Index Terms- Marble Powder, Different Test, Different Proportion Mix.

I. INTRODUCTION

Throughout the world, as a result of growth in infrastructure development and the consequent increase in consumption have led to the fast decline in the available natural resources (Hanifi Binici et al 2008). So that the engineers are constrained to implement a new materials and techniques to efficiently combat this problem. In contrast the construction and environmental industry concerned about the increasing volume of industrial waste in the form of solid, liquid and gaseous. Using different type of cutting methods, granite stones are machined from the quarries and that block are transported to the nearby processing plants. Then the stones are industrially processed such as sawing and polishing, finally processed stonesare used to decorative purposes. The granite stone processing is shown in Figure 1.1 to 1.4. During this industrial process, the fine granite particle and the water mixed together and become a granite colloidal waste by-product. When the stone slurry is disposed in landfills, its water content is drastically reduced and the waste becomes a dry mud consisting of very fine powder that can be easily inhaled by human being and animals. In addition to that, it is anon-biodegradable waste that causes pollution and environmental damage. The data available from the literature, the amount of wastes in the different production stages of the granite industry reaches some 20 to 25 % of its global production, meaning millions of tons of colloidal waste per year and disposal of those fine wastes is one of the environmental problems worldwide today.

II.LITERATURE REVIEW

Ilker Bekir Topcu et al. (2009) studied the effect of waste marble dust content as filler on properties of self-compacting concrete. Day by day, the amount of the marble dust (MD) as a waste material is significantly of increasing in Turkey. Therefore, the utilization of the waste MD in self compacting concrete (SCC), as filler material, is the main objective of this study. Besides, the MD is used directly without attempting any additional process.

Thus, this would be another advantage for this objective. For this purpose, MD has replaced binder of SCC at certain contents of 0, 50, 100, 150, 200, 250 and 300 kg/m3. After then, slump-flow test, L-box test and V funnel test are conducted on fresh concrete. Furthermore, compressive strength, flexural strength, ultrasonic velocity, porosity and compactness are determined at the end of 28 days for the hardened concrete specimens.

The effect of waste MD usage as filler material on capillarity properties of SCC is also investigated. The conclusions of this study can be said as follows: When the properties of fresh SCC such as slump-flow, V-funnel time, blocking ratio, air content and unit weight are considered as a criterion to determine the optimum usage ratio of MD in SCC, it can be said that the usage amount below 200 kg/m3 content is suitable for improving all of these properties. Even the slump flow values of the SCC incorporating high volume of fly ash are very high; their viscosities are also quite high.

Therefore, the risk of blocking is increased. In the case of using high amounts of MD, blocking risk is decreased by reducing the viscosity similar to the usage of stone dust as filler material in SCC. Filling capability and passing ability are between acceptable values of SCC containing up to 200 kg/m3 MD content. It is generally well-known that filling capability and passing ability increase in the SCC produced with high volume of fly ash.

In the case of using high volumes of stoned dust, filling capability and passing ability decrease due to the decrease in the segregation resistance. The filling capability and passing ability of the SCC would decrease by using MD 200 kg/m3 content. If the properties of hardened SCC such as compressive strength, flexural strength, capillary coefficient and compactness would be taken into account, the usage amount can be said as 200 kg/m3 content again. It is known that fly ash as a pozzolanic material increases the late age compressive strengths of SCC. However, it decreases the early age compressive strengths. Stoned dust and MD increase both early and late age compressive strengths by filling voids. If the stone dust and MD are utilized in SCC at very high volumes, the loss in compressive strength is led to be obtained due to the increase in the demand for cementitious material related to the finenesses of these materials as filler.

Therefore, the maximum and the optimum usage amount of MD can be said as 200 kg/m3 content in order to obtain the best performance for both fresh and hardened properties of SCC. Consequently, if the positive effects of MD on fresh and hardened concrete properties of SCC are considered, it can be reported that a new usable method for MD is developed.

Huseyin Yilmaz Aruntas et al. (2010) studied the Utilization of waste marble dust as an additive in cement production. In this experimental study, the usability of waste marble dust (WMD) as an additive material in blended cement has been investigated. For this purpose, waste marble dust added cements (WMDCs) have been obtained by inter grinding WMD with Portland cement clinker at different blend ratios: 2.5 %, 5.0 %, 7.5 % and 10 % by weight. 40×40×160 mm mortar prisms has been produced with the obtained cements. Strength tests have been carried out on mortar specimen at 7, 28, and 90 days.

WMDCs have been compared to each other as well as to control cements of CEM I and CEM II with respect to their physical, chemical and mechanical properties. Obtained results showed that WMDCs conform to EN 197-1 standard and thus 10 % WMD can be used as an additive material in cement manufacturing.

Valeria Corinaldesi et al. (2010) investigated the Characterization of marble powder for its use in mortar and concrete. From the physical and chemical point of view they have characterized the marble powder using it in mortar and concrete production. A powder obtained as a by-product of marble sawing and shaping was characterized from a chemical and physical point of view in order to use it as a mineral addition for mortars and concretes, especially for self compacting concrete. This marble powder showed a very high Blaine fineness value of about 1500 m2/kg, with 90 % of particles finer than 50 micron and 50 % under 7 micron. For rheological studies, several cement pastes were prepared using marble powder, with and without the addition of an acrylic-based superplasticizer. Water to cementitious materials ratio was also varied. In order to evaluate the effects of the marble powder on mechanical behaviour, many different mortar mixtures were tested, all prepared with sand to cement ratio of 3:1 at about the same workability.

Mixtures were evaluated based upon cement or sand substitution by the marble powder. Due to its quite high fineness, marble powder proved to be very effective in assuring very good cohesiveness of mortar and concrete, even in the presence of a superplasticizing admixture, provided that water to cement ratio was adequately low. On the basis of the low thixotropy values obtained, it seems that the use of marble powder would not be accompanied by an evident tendency to energy loss during concrete placing, as it is usual for other ultra-fine mineral additions (such as silica fume) that are able to confer high cohesiveness to the concrete mixture.

In terms of mechanical performance, 10 % substitution of sand by the marble powder in the presence of a superplasticizing admixture provided maximum compressive strength at the same workability level, comparable to that of the reference mixture after 28 days of curing. Moreover, an even more positive effect of marble powder is evident at early ages, due to its filler ability. Results obtained show that 10 % substitution of sand by the marble powder provided maximum compressive strength at about the same workability.

Felix Kala and Partheepan (2010) examined the possibility of using granite powder as replacement of sand and partial replacement of cement with fly ash, silica fume, slag and superplasticiser in concrete. The percentage of granite powder added by weight was 0, 25, 50, 75 and 100 as a replacement of sand used in concrete and cement was replaced with 7.5 % silica fume, 10 % fly ash, 10 % slag and 1 % superplasticiser. The effects of water ponding temperatures at 26°C and 38°C with 0.4 water-to-binder (w/b) ratios on mechanical properties, plastic and drying shrinkage strain of the concrete were studied and compared with natural fine aggregate concrete.The test results obtained indicate that granite powder of marginal quantity as partial sand replacement has a beneficial effect on the mechanical properties such as compressive strength, split tensile strength, modulus of elasticity and also considerable advantages in plastic and drying shrinkage.

III. RESULT AND DISCUSSION

The concrete mixtures were prepared by Portland cement, natural sand, coarse aggregate (Blue metal) and GP waste. Among the six series of mixtures, one was the control mixture and the remaining five mixtures were containing GP waste substitution in various proportions such as 5 %, 10 %, 15 %, 20 % and 25 %. Among the 6 mixtures, five mixtures were prepared with natural sand substituted by GP waste and the remaining one was control mixture (CM). To identify the mixtures easily, the each mixture was designated by the names such as CM, CGP 5 %, CGP 10 %, CGP 15 %, CGP 20 % and CGP 25 %. For example CGP 10 % specifies that the concrete mixture made with 10 % of natural sand is substituted by GP waste.

Table 4.1 Concrete Mixture Proportions with All Material

Mixture	Control Mixture	CGP 5 %	CGP 10 %	CGP 15 %	CGP 20 %	CGP 25 %
W/C ratio	0.4	0.4	0.4	0.4	0.4	0.4
Water (lit/m^3)	186	186	186	186	186	186
Cement (kg/m^3)	465	465	465	465	465	465
Sand (kg/m^3)	603	572	542	512	482	451

Coarse Aggregate (kg/m3)	1086	1086	1086	1086	1086	1086
Granite Powder (GP) (kg/m3)	0	31.94	63.88	95.83	127.7	159.7

Table 4.4 Mechanical Properties of Concrete Mixtures

Mixture No.	Density of Hardened Concrete (kg/m3)	Compressive Strength (MPa)		
		7 Days	28 Days	90 Days
CM1 Average	2536	22.75	39.46	42.07
CGP 5 % Average	2531	24.75	39.32	41.66
CGP 10 % Average	2520	25.11	39.83	42.9
CGP 15% Average	2490	24.07	38.55	41.17
CGP 20 % Average	2468	22.95	37.59	38.93
CGP 25 % Average	2437	21.74	35.06	36.73

Table 4.5 Different Test Result

Mixture No	UPV (m/sec)	Dynamic Youngs Modulus	Split tensile Strength (MPa)	Flexural Strength (MPa)
	28 Days	28 Days	28 Days	28 Days
CM1 Average	4351	43.22	3.4	6.1
CGP 5 % Average	4348	43.25	3.2	5.97
CGP 10 % Average	4335	42.88	3.3	5.77
CGP 15 % Average	4234	40.9	2.9	5.53
CGP 20 % Average	4194	39.62	2.2	4.23
CGP 25 % Average	3983	35.48	1.6	3.26

The results obtained revealed that the tensile strength of the concrete decreased with the increase in the GP substitution rate; however, the tensile strength values of the mixtures with the substitution rate of 15 %, are approximately equal to the strength value of CM as shown in Figure 4.12. At the age of 28 days, compared to CM, the decrease in tensile strength of the concrete mixtures CGP 5 %, CGP 10 % and CGP 15 % was 6.53 %, 3.03 % and 9.08 %, respectively, and this difference in strength is not relatively high. However the obtained tensile strength of the concrete mixtures CGP 20 % and CGP 25 % was shown to be very poor when compared to the CM observed at all ages of concrete, and the mixtures showed tensile strength that was decreased by 54.38 % and 95.32 %, respectively. Similar behaviour was observed in compressive strength in addition the correlation made between the tensile strength and the compressive strength was quite strong, as shown in Figure 4.9.

IV. CONCLUSION

- The high specific surface area and rough and angular texture of the GP waste, have led to the significant losses in slump in addition the workability of the concrete decreases with the increases in the substitution rate.

- The early age (i.e. 7 days) compressive strength of the mixtures CGP 5 %, CGP 10 %, CGP 15 % showed better gain in strength when compared to the CM. The reason may be attributed to the dense matrix of the GP waste and the better dispersion of the cement grains.
- The split tensile strength of the concrete mixtures CGP 5 %, CGP 10 %, CGP 15 % were equal or slightly lesser than the control mixture, however, significant losses in tensile strength was observed beyond the substitution rate of 15 %.
- UPV values of the mixtures CGP 5 %, CGP 10 %, CGP 15 % were relatively equal to the control mixture and the concrete was classified as good and the measured values were greater than 3500 m/s. Furthermore the UPV values of the concrete decrease with the increase in substitution rate due to its high porosity.
- Based on the test results of six mixtures, the correlation between the compressive and flexural strength was formulated.
- The appropriate substitution of GP waste can lead to the least effect on mechanical properties of the concrete such as compressive, flexural and split tensile strength.
- It is recommended that the replacement of natural sand by the GP waste up to 15 % of any formulation is favorable for the concrete making.

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