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Research Article

PERFORMANCE OF KADAPA FLOORING STONE POLISHING POWDER IN CEMENT MORTAR AS REPLACEMENT TO CEMENT

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A B S T R A C T

This article discusses the performance of polishing powder as a cement replacement in cement mortar. This cement is replaced with polishing powder in six different proportions of 5, 10, 15, 20, 25, and 30% by weight for research purposes. Cube compressive strengths are calculated for 3, 7, 14, 28, and 90 days. The split, flexural strengths are evaluated for 28 and 90 days. The study found that replacing 15% of the cement with stone polishing powder improves strength and XRD and SEM analysis were used to back up the findings.

INTRODUCTION

Cement, sand and coarse aggregates are essential building materials. Cement is an important ingredient in the preparation of mortar and concrete. It plays a critical role in the mix design process. Many alternative materials, for example, siliceous stone powder, fly-ash, copper slag, and so on, have already been used as partial replacement to cement. Researchers are looking to minimize the cement production and also to decrese emissions of CO_2 during the production of cement. In this concern research works are emphasized to use the waste materials as alternative to cement or partial replacement to cement. In this regard, herein would like to propose black marble stone powder as an alternative material for cement in cement mortar. Before moving into objectives and detailed experimental work, a brief overview of the field is provided below. Targan *et al*. (2003) conducted an experiment on the use of natural pozzolana, coal ash in concrete. They focused on compressive and bending strength, volume expansion, and setting time in this study. The experimental results show that when natural pozzolana is used as a replacement for cement, the final setting time for cement paste is faster. Compressive strength should be increased for a 5 percent replacement level of natural pozzolana. Nuno Almeida *et al*. (2007) investigated the effect of replacing sand in concrete with stone slurry. The effect of replacing stone slurry as fine aggregate by 20% without affecting its mechanical properties is investigated. According to the findings, replacing 5% of the sand content with stone slurry resulted in an increase in compressive and split tensile strength. Mustafa Karasahin and Serdal Terzi (2007) investigated the use of marble waste dust as filler in asphalt mixtures in an experimental study. The study found that locally available marble waste0dust could be used as a filler material in asphalt mixtures. Asphalt mixtures containing marble dust exhibit higher plastic deformations, making them suitable for secondary and local roads. HanifiBinici *et al*. (2008) investigated the durability of concrete using marble and granite as recycled aggregate. They used granite and marble as concrete replacement materials in this. They used various percentages of these materials and tested them. The study's findings revealed the effects of using granite and marble waste as a byproduct in the production of concrete. Kursat Esat Alyamac and RagipInce (2009) carried out an experimental study with marble powder in self-compacting concrete. The marble powder is a waste material obtained during processes such as polishing, cutting, and grinding. They worked on the relationship between fresh and hardened concrete. V.Corinaldesi, G.Moriconi, and T.R.Naik (2009) focused on the representation of marble powder for use in concrete. It was concluded that the marble powder was extremely effective in ensuring high mortar and solid binding capacity. Based on the low thixotropy qualities obtained, it appears that the use of marble powder would not be accompanied by an obvious propensity to vitality misfortune amid solid putting, as is typical for other ultrafine, mineral increments (for example, silica fume) that have the capacity to give high binding capacity to the solid mixture. After 28 days of curing, the results showed that a 10% replacement of sand with marble

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powder is effective. Bahar Demirel (2010) directed an experimental study on concrete that used marble dust waste as a replacement for fine sand. They replaced the sand with clean waste marble in various proportions. Furthermore, observed the quality of the solid in every extent and raised the extent to which quality achieved is greater. The results show that using waste marble dust (WMD) in cement improves its mechanical properties. Marmol *et al*. (2010) concentrated on the use of granite sludge wastes in the manufacture of coloured cement-based mortars. The experiments revealed that replacing the $CaCo_3$ filler with Granite sludge increased the compressive strengths. Compressive strength values range between 5.2 and 6.25 N/mm^2.NabilpM *et al*. (2010) investigated mortar mixes containing Jordanian burnt stones slurry (BSS).This research focuses on the properties of fresh and hardened concrete. The setting time workability decreased as the BSS content increased, while the strengths increased slightly. Naghabhushana and H.Sharadabai (2011) investigated the properties of mortar and concrete in which crushed rock powder (CRP) is used in place of natural sand. The quality of mortar with 40% CRP is far superior to ordinary mortar. The 40% CRP can successfully be used to replace normal sand without lowering cement quality. Tansia Hoque *et al*. (2013) investigated the effect of stone dust on the mechanical properties of mortar as a partial replacement for cement sand. The comparison of fresh mortar and modified mortar was the main focus of this investigation. The results showed that mortar containing 25% stone dust has a higher strength than normal mortar. However, replacing cement with stone dust reduces the strength of the mortar. Akshay C.Sankh *et al*. (2014) conducted research on the replacement of natural sand with various alternatives such as copper slag, washed bottom ash, quarry dust, building waste, spent fire bricks, and sheet glass powder. The results demonstrated that these materials could be used effectively in concrete mixes and building mortar. According to the literature review, no work has been done with the use of black stone marble powder for cement mortar as a replacement for cement. As a result, the current study will examine the behaviour of mortar mixes prepared with marble powder as partial replacement to cement in various proportions of 5, 10, 15, 20, 25, and 30% by weight. The specific objectives and program plan of the current experimental work are presented below.

Objectives of experimental investigation

1. To evaluate compressive, split and flexural strengths for different of replacements of cement with marble powder (5, 10,15,20,25 and 30% by weight).
2. To elicit the optimum replacement for cement with marble powder.
3. To examine the optimum strength mix (on 90 days aged samples) with micro analysis.

Materials, mix design and experimental program

Materials: Ordinary Portland cement of grade 53 was used in the experiment, and the laboratory test results revealed that the cement met the limits of IS 12269-1987.Manufactured sand was used as fine aggregate; tests revealed that the specific gravity was 2.58 and that it met the IS:383-1970 Zone-II grading classification. Casing and curing of cast specimens with portable water. Conplast SP430 (Fosroc) has been used in the proportion of 0.2 percent by weight of cement to make cement mortar mix easier and workable. Black Stone Polishing Powder (SPP) or Marble Powder (MP) obtained from the cutting and polishing industries. Waste stone powder was gathered from stone industries in and around Tadpatri (Town), Anantapur (Dist), Andhra Pradesh (State), and India (Country). Table 1 shows the chemical properties of the stone powder and cement.

Table 1 Chemical composition

Sl.No.	Chemical constituents	% of composition	
		Stone Polishing Powder (SPP)	Cement
1	Silica(SiO2)	22.35	24.62
2	Calcium Oxide (CaO)	38.91	63.15
3	Magnesium Oxide(MgO)	2.75	2.31
4	Ferric Oxide(Fe2O3)	1.30	3.86
5	Alumina(Al2O3)	2.80	4.50
6	Loss on Ignition(LOI)	30.52	1.56

Mix Proportion: The cement mortar has a 1:3 (Cement: Manufactured sand) mix proportion with a water cement ratio of 0.40.The standard consistency test resulted in a 28 percent consistency with portable water. The water needed for the mix was calculated using the formula (P/4+3) weight of cement mortar (Standard consistency (P) of a cement paste is defined as the consistency that allows a vicat plunger with a diameter of 10 mm and a length of 50 mm to penetrate to a depth of 33-35 mm from the top of the moulds). The super plasticizer dosage was 0.2 percent by weight of cement during matrix mixing to achieve workability (this arrived based on few trials).

Program of experimentation: For the evaluation of cube compressive strength, 105 cubes (70.5x70.5x70.5mm) and 42 cylinders (100mm diameter and 200mm height) and 42 prisms (40x40x150mm) were cast. Cubes are tested for 3, 7, 14, 28, and 90 days, while cylinders and prisms are tested for 28, and 90 days, respectively. The cubes, cylinders, and prisms are cured to the appropriate strengths.

DISCUSSION OF TEST RESULTS

Cube compressive strength

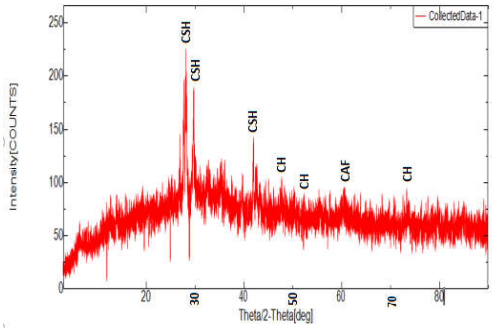
Table 2 shows the compressive strengths of various mixes. The compressive strengths of each SPP mix increase as the days lengthen. The compressive strengths increase from 5 to 15% SPP, while the strengths decrease for later replacements (20 to 30% SPP). The presence of stone polishing powder in the mix can act as pozzolona material, similar to known materials such as fly ash, silica fume, rice husk ash, and metakaoline. Observing all compressive strength results, the mix with 15% SPP demonstrated maximum compressive strengths on all test days. At 28 and 90 days, the mix with 15% SPP provided a 17.90 and 17.13 percent increase in compressive strength compared to the reference mix (0 percent SPP). The effectiveness of pozzolona materials can be observed between 60 and 90 days. The compressive strengths were measured at 90 days in the current study. However, based on the 28 and 90 day compressive strength results, it can be proposed that up to 25% SPP can be used for cement mortar works without affecting the reference mix strength(s). Strengths are lower in 30 percent SPP mixes when compared to the reference mix. To determine the cause of this behaviour, micro analysis was performed on reference and 15% SPP mixes aged for 90 days. When pozzolona materials are used as a replacement for cement in mortar or concrete mixes, the calcium hydroxide (CH) reacts with the silica present in the pozzolona materials to form a second phase of CSH product, which can increase the mix's strength. This can happen between 60 and 90 days, but this material primarily acting as a filler material up to 28 days. The same mechanism can be observed for stone polishing powder herein. The detailed micro analysis for the 15% SPP mix and reference mix is shown below.

Table 2 Compressive strengths (MPa)

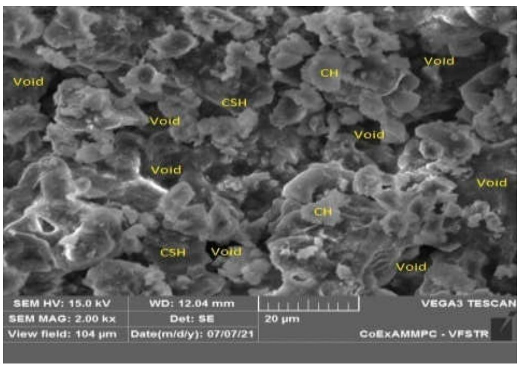
Sl.No.	%SPP	Days				
		3	7	14	28	90
1	0	28.96	38.44	44.35	51.10	52.16
2	5	32.22	41.28	48.50	55.69	56.91
3	10	35.23	44.25	51.71	59.32	60.50
4	15	38.93	47.57	55.45	60.25	61.10
5	20	36.56	43.57	51.64	57.11	58.92
6	25	31.23	38.50	45.57	51.92	54.58
7	30	26.43	35.29	42.10	47.08	48.65

XRD and SEM analysis

Micro analysis has been performed for reference (0%SPP) and optimum slab polishing powder sample through XRD & SEM images and presented in figure 1 and 2. For micro analysis 90 aged samples have taken because by this time the CH might fully react with SPP. From figure 1 it is observed that the CSH intensity (counts) is varied from 90 to 140. In addition to the CSH compound other compounds of silicon di-oxide (SiO2), calcium hydroxide (CH) and calcium alumino-ferrite (CAF) also identified. For the 15%SPP the CSH intensity is varied from 139 to 227. The calcium hydroxide may react with silica (which is present in the SPP) and forms CSH gel, which enhances the strength of the mix. From figure 1 (SEM), it is noticed that the reference sample having more voids than the sample with 15% SPP (fig 2). It inferences as the mix with 15% SPP exhibits dense microstructure and it led to possesses higher strength. In addition to the above, the SPP particles may fill the fine voids. Ultimately the presence of 15% SPP mix exhibited remarkable compressive strength compared to reference mortar strength.

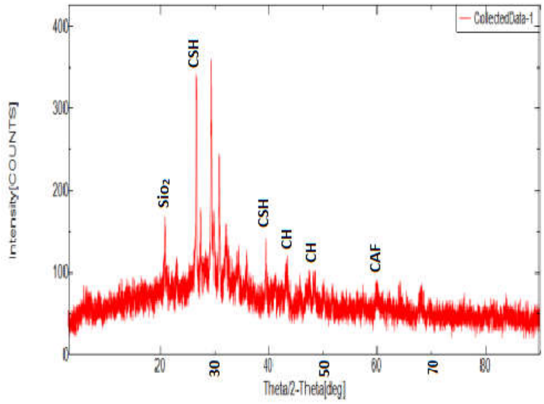


XRD pattern for 0%SPP

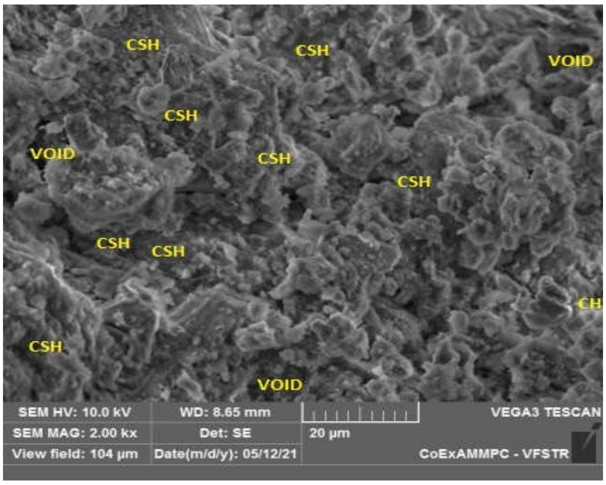


SEM image for 0%SPP

Figure 1 XRD and SEM images for 0%SPP



XRD pattern for 15%SPP



SEM image for 15%SPP

Fig 2 XRD and SEM images for potable water (15%SPP)

Tensile strengths

Table 3 shows the split and flexural strengths, and it can be seen that the strengths increase for all mixes at 28 and 90 days. When comparing different SPP replacements, the mix with 15% replacement demonstrated the highest split and flexural strengths compared to all other mixes, including the reference mix. The strengths of the mixes containing 5 to 15% SPP increased, whereas the strengths of the other mixes containing 20 to 30% SPP decreased.

Table 3 Tensile strengths

Sl.No.	% SPP	Split tensile strength (MPa)		Flexural strength(MPa)	
		28 days	90 days	28 days	90 days
1	0	3.91	4.36	5.61	5.91
2	5	4.08	4.56	5.85	6.17
3	10	4.21	4.71	6.04	6.35
4	15	4.29	4.81	6.17	6.50
5	20	4.12	4.64	5.93	6.28
6	25	3.93	4.47	5.65	6.04
7	30	3.75	4.22	5.38	5.70

In these strengths, the mix containing 25% SPP performed better than the reference mix. Without affecting the referene mix strengths, SPP can be used up to 25%, whereas to achieve maximum tensile strengths, 15% SPP can be used as a replacement for cement. For 28 and 90 days observations, the split and flexural strengths are 9.86 and 10.15 percent higher than the reference mix (0 percent SPP). Similarly, the flexural strengths are higher by 9.97 and 9.92 percent, respectively. Based on these findings, it is concluded that the use of SPP as a replacement for cement in cement mortar mixes is viable, as demonstrated in the preceding section with compressive strength by supporting micro analysis.

Observations

The stone polishing powder or marble powder is suitable for cement mortar mixes, and a 15% replacement of cement with stone polishing powder results in optimum compressive, split, and flexural strengths. The compressive, split, and flexural strengths of marble powder (as a replacement for cement) are increasing, while the strengths of other replacements (20, 25, and 30%) are decreasing. At 28 and 90 days, the mix with 15% marble powder increased compressive strength by 17.90 and 17.13 percent, respectively, when compared to the reference mix. When compared to a mix without stone polishing powder, the 28-day split and flexural strengths are increased by 9.86 and 9.97 percent, respectively. Similarly, the 90-day strength gains are 10.15 and 9.92 percent. Stone polishing powder can be used as a cement replacement up to 25% without affecting the reference mix strength.

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