Experimental Investigation on Self Compaction Concrete using Marble Dust as Partial Replacement to Cement

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Abstract— This study presents an experimental investigation on self-compacting concrete (SCC) with various partial replacements of fly ash, marble dust and combination of both fly ash and silica fume. Also the study made with partial replacement of cement by silica fumes with fly ash percentage as 30%. After various replacements, cube and cylinder specimens are cast and cured. The specimens are cured in water for 3, 7 & 28 days. The slump, V-funnel and L-Box test are carried out on the fresh SCC and in harden concrete compressive strength and split tensile strength values are determined. Attempts have been made to study the properties of such SCCs and to investigate the suitability of various replacements of fly ash, marble dust to be used in SCC.

Key words: Self Compaction Concrete, Marble Dust, Fly Ash

I. INTRODUCTION

Concrete mixture, characterized by high resistance to segregation and which can be cast without compaction or vibration are termed as Self-Compacting Concrete (SCC). Better quality concrete and substantial improvement in working conditions are observed due to the exclusion of compaction or vibration. SCC mixes contains a very high content of fine fillers, including cement, which further leads to high compressive strength concrete.

The pozzolanic action of marble dust can be explained in terms of hydration of cement producing calcium hydroxide and its voids can be filled by micro silica or other powder material particles.

The Indian standard IS: 456-2000 permits the use of mineral admixtures for modifying the properties of concrete. The use of industrial waste products such as fly ash and silica fume, which has both pozzolanic and cementitious properties, lead to cost and energy saving. In this study an influence of marble dust on fresh and hardened properties of fly ash induced SCC have been studied.

II. LITERATURE REVIEW

In past studies different researches had been done with marble powder for the improvement in concrete mix. Mainly marble powder is replaced with constituents of concrete to test the mechanical properties and also its economic value.

Er. Raj P. Singh Kushwah, Prof. (Dr.), Ishwar Chand Sharma, Prof (Dr.) PBL Chaurasia (2015) presented in his paper that the marble can be utilized in concrete mix by replacement of fine aggregates. Different mechanical properties of marble slurry are determined like specific gravity, fineness modulus was founded and it also showed that utilization of marble slurry by replacing it with sand upto 30% which shows equal strength as of conventional concrete i.e. 1:2:4 cement concrete ratio with 0% marble slurry. It concludes that marble slurry can easily be utilized in cement concrete mix.

Bahar Demirel (2010) presented the use of marble dust as in place of fine aggregate in concrete ix and check the mechanical properties of mix. In this experimental study, the effects of using waste marble powder have been studied as a fine material on the mechanical properties of the concrete. Four different series of concrete-mixtures were prepared by replacing the fine sand (passing 0.25 mm sieve) with waste marble powder at different proportions like 0, 25, 50 and 100% by weight. For determining the effect of the waste marble powder on the compressive strength with respect to the curing age, compressive strengths of the samples were recorded at the curing ages of 3, 7, 28 and 90 days. Different properties like the porosity values, ultrasonic pulse velocity (UPV), and dynamic modulus of elasticity and the unit weights of the series were determined and compared with each other. It had been observed that the addition of WMD such that would replace the fine material passing through a 0.25 mm sieve at particular proportions enhances the effect on compressive strength. Marble powder is a by-product of marble production facilities and it creates large amount of environmental pollution. To prevent this problem marble powder can be utilized by mixing in the concrete mix.

Baboo Rai, Khan Naushad (2011) studied the influence of marble powder in cement concrete mix. In this paper the effect of use of marble powder and granules has been studied by partially replacing with mortar and concrete constituents. And check the different properties like relative workability and compressive and flexure strengths. By partial replacing the constitution it reveals that increased waste powder or waste marble granules ratio result in increased workability and compressive strengths of the mortar and concrete.

Hassan A. Mohamadien (2012) investigate the effect of marble powder and marble dust of different percentages as partial replacement for cement on mortar. It represents the different types of mortar mixtures with same workability, cement to sand ratio of 1:3 and water cementitious material ratio of 0.4, prepared with marble powder and silica fumes used in the mixes separately. By replacement of marble powder and marble dust with cement content separately at 0%, 5%, 10%, 15%, 20%, 30% and 50 % by weight were investigated. Different mechanical properties of mortar were measured in terms of compressive strength at 7 and 28 days and it revealed that the strength developments at 7, and 28 days and maximum development rate of compressive strength was observed at 15% replacement ratio for each the marble powder and marble dust separately. It showed that compressive strength was increased by 31.4%, 48.3% at 7, and 28 days respectively at 15% replacement ratio of marble dust with cement content and also in replacement of marble powder with cement content the compressive strength

increased by 22.7%, 27.8% at 7, and 28 days at 15% replacement ratio of marble powder with cement content respectively.

Noha M. Soliman (2013) presented the effect of using Marble Powder in Concrete Mixes and also its effect on the strength of R.C. Slabs. This research aims to study the effect of using marble powder as partially replace of cement on the properties of concrete. The behavior of reinforced concrete slabs by using marble powder is also investigated. The main consideration in this investigation is the percentage of marble powder as partial replacement of cement constituent in concrete mixes. The experimental results showed that, the use of definite amount of marble powder as a replacement of cement content increases the workability, compressive strength and tensile strength. Use of marble powder enhances the structural performance of the tested slabs as it increased the stiffness and the ultimate strength compared to the control slabs.

V. M. Sounthararajan and A. Sivakumar (2013) adds lime content in marble powder and check its effects on concrete mix. In this research work, the waste marble powder upto 10% by weight of cement was investigated for hardened concrete properties. The effect of different percentage replacement of marble powder on the compressive strength, splitting tensile strength and flexural strength was calculated. It can be noted that the influence of fine to coarse aggregate ratio (F/C) and cement-to-total aggregate ratio (C/TA) had a higher influence on the improvement in strength properties. The immense increase in the compressive strength of 46.80 MPa at 7 days for 10% replacement of marble powder in cement content was calculated and also showed an improvement in mechanical properties as compared to the conventional concrete.

Animesh Mishra, Abhishek Pandey, Prateek Maheshwari, Abhishek Chouhan, S. Suresh, Shaktinath Das (2013) uses marble dust in green cement for sustainable concrete. They showed that the feasibility of the usage of marble sludge dust as hundred percent substitutes for natural sand in concrete. The compressive strength and mechanical properties were investigated in this study. The hydration products of cements were examined by means of scanning electron microscopy. Compressive strength was discussed as a function of different parameters like curing time, binder composition. It gives the result that the blended cements developed higher strength, at 28 days compared to 7 days. It observed that strength increases as the marble content increased. So, it helps in the lower consumption of the natural resources and also the pollution.

Prof. Veena G. Pathan, Prof. Md. Gulfam Pathan studied feasibility of marble powder as the constituent of concrete mix. He studied that the compressive strength and split tensile strength of concrete can be increases as the addition of waste marble powder as the replacement of cement by 10%. This research also investigates that the marble dust had a great impact on the properties such as consistency, settling time, insoluble residue and soundness. The use of cheaper constituent like wastes can solve the ecological problems as well as environmental problems. Therefore there is a scope for more researches in the field of durable concrete with this waste.

III. EXPERIMENTAL INVESTIGATION

Six controls mixes with partial replacement of cement with marble dust were prepared. In all fifty four cube samples of self-compacting concrete with six different weight percentages of marble dust(0%, 2%, 4%, 6%, 8% and 10%) were cast to study the effect on compressive strength at 7,14, 28 days. The fly ash content in all mixes was fixed at 30%.

Further, thirty six cylindrical specimen were also cast to study the effect on cylindrical compressive strength and split tensile strength.

To achieve the desirable properties likes flowability chemical admixture (HRWR AND VMA) was also used. The Indian standard mixed proportioning guide line as mentioned in IS 10262:2009 has been used for mix proportioning.

The succeeding subsections describes in detail about the materials used.

A. Cement

The Cement used was Jaypee Ordinary Portland Cement (OPC) of grade 43 conforming to IS: 8112-1989. The various laboratory tests confirming to IS: 4031-1996 (PART 1 to 15) specification was carried out and the physical properties were found as such:

- Fineness - 0.225 m^2/g
- Consistency - 30%
- Initial setting time - 30 min
- Final setting time - 600 min
- Specific gravity - 3.15

B. Fine Aggregates

Ordinary sand from local river bed having the following characteristics has been used

- Specific gravity - 2.66
- Fineness modulus - 2.60
- Water absorption - 1.35

C. Coarse Aggregates

Locally available crushed stone from Anakapalle quarry with 16 mm graded size have been used as coarse aggregate. The physical properties for the coarse aggregate as found through laboratory test are

- Aggregate crushing value = 24%
- Aggregate impact value = 29%
- Specific gravity = 2.84
- Water absorption = 0.755

D. Chemical Composition

Polycarboxylic ether based super plasticizer with viscosity modified admixture supplied by BASF India limited with a brand name of Master Glenium SKY 8630/8632 was used in the present research work.

E. Fly Ash

Fly ash samples taken from NTPC were used in this study. Fly ash was not processed and, used as received.

F. Marble Dust

Component %	Marble Powder
SiO_2	2.72
Al_2O_3	0.46
Fe_2O_3	0.39
CaO	76.30

MgO	1.11
K_2O	0.10
Na_2O	0.34
SO_3	0.32
TiO_2	0
P_2O_5	0.09
LOI	17.90

Table 1: Chemical Properties

Property	Marble Powder
Colour	2.72
Specific Gravity	2.78
Specific Surface Area	2.42
Form	Powder
Odour	Odourless

Table 2.Physical Properties

G. *Mix Proportion*

Mix No.	Cement(Kg)	% of Fly Ash	% of Marble powder	W/C	W/B	C A (kg)	FA(Kg)	Water (Lts)	% of HR WR	% of VM A	extra water due to correction
1	390.8	30	0	0.49	0.36	805.31	836.21	191	0	2.2	18.92
2	382.96	30	2	0.50	0.36	798.97	835.13	191	1.5	0.7	18.91
3	375.15	30	4	0.51	0.36	798.05	834.28	191	1.5	0.7	18.90
4	367.33	30	6	0.52	0.36	796.24	832.35	191	1.5	0.7	18.86
5	359.52	30	8	0.53	0.36	795.35	831.44	191	1.5	0.7	18.83
6	351.70	30	10	0.54	0.36	794.35	830.08	191	1.5	0.7	18.80

Table 3: Mix Calculations

IV. RESULTS

A. *Slump Flow Test Results*

Mix No.	% of Marble dust by Weight of Cement	Slump Flow Test (time in sec)			Spread Diameter in mm
		300 mm	500 mm	700 mm	
1	0	1	3	4	705
2	2	0.4	1.3	3.6	725
3	4	0.5	1.5	3.8	680
4	6	0.65	1.8	4.2	672
5	8	0.8	2.1	5.02	655
6	10	0.72	1.86	4.4	670

Table 4: Slump Flow Results

B. *L Box & V – Funnel Test Results*

Mix No.	% of Marble Dust by Wt of Cement	L Box Test	V-Funnel Test
		H_2/H_1	Time in sec
1	0	0.8	10.8
2	2	1	8.6
3	4	0.98	9.7
4	6	0.94	10.2
5	8	0.86	10.8
6	10	0.93	10.4

Table 5: L Box & V-Funnel Results

C. *Compressive Strength Test Results*

Mix No.	% of Marble dust by Weight of Cement	Compressive Strength Test Results of Cube (28 Days)
1	0	42.86
2	2	43.85
3	4	44.94
4	6	45.82
5	8	46.77
6	10	44.77

Table 6: Compressive Strength Test Results

V. CONCLUSION

From the present investigation and limited observations reported, on the effect of partial replacement of cement with silica fumes in SCC cast with fly ash percentage replacement to cement at 30% by weight of cement, and with water to powder ratio for all mixes maintained at 0.36 with Super plasticizer dosage at 2.2% by weight of cement, following conclusions can be drawn:

1) The slump flow varied between the ranges of 655-725 mm
2) Addition of marble dust nullified the stickiness observed in mixes without silica fumes and further, the mixes were highly cohesive.
3) Increase in percentage of silica fumes content from 0% to 8 %, an increase in compressive strength was recorded.
4) At 6% replacement of marble dust by weight of cement the increase in compressive strength was 7% while the increase was about 9% when percentage replacement was 8% as compared with reference mix.
5) At 10% replacement of silica fumes with cement there was slight decrease in compressive strength as compared to 4, 6 and 8% replacement of silica fumes by weight of cement
6) The values of splitting tensile-strength range between 3 and 4 MPa,
7) The increase in split tensile strength is almost 10% at 2% replacement and 13% at 4% replacement of marble dust by weight of cement.
8) The increase in split tensile strength is almost 20% at 6% and 8% replacement of marble dust by weight of cement.
9) However at 10% replacement the increase in split tensile strength is only about 9%.

VI. RECOMMENDATIONS

A comparative study has been carried out to understand the performance behavior of Fly Ash -Modified SCC Mixes with marble dust as cementitious material. Four properties of concrete namely flowability, compressive strength, and split tensile strength has been selected for study in the present investigation however, long term effects need to be evaluated. 6% replacement of marble dust by weight of cement is recommended.

VII. SCOPE FOR FUTURE WORK

However, some properties such as the characteristics of absorption and thermal conductivity need to be tested before such SCC Mixes are accepted for use in wider applications.

The other types of non-pozzolanic fillers, viz., stone dust powder, and ground glass (as recommended by EFNARC) may be tried in different combinations and the properties of the SCC mixes may be investigated.

The cementing efficiency factor of 0.5 for fly ash has been considered in the present study however, the

''cementing efficiency factor'' of marble dust need to be assessed.

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