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Experimental Study on Self-Consolidating Concrete by 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. Also the study made with partial replacement of cement by with fly ash percentage as 30%. After various replacements, cube and cylinder specimens are cast and cured. The specimens are cured in water for 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.

KEYWORDS: Self Compaction concrete, Marble Dust, Fly Ash.

INTRODUCTION

Marble blocks are extracted from the quarries and processed at marble factories. Dust and broken aggregates are the by-products of marble, produced in the marble processing like cutting and polishing stages. Around 20–30% of the marble blocks transform into powder residue. Millions of tons of waste material are produced in this process which is blindly disposed of to a nearby environment. Due to the high degree of fineness of the slurry particles, pores within fertile soil are filled by these particles which prevent the water percolation in the soil and reduce its fertility. Slurry particles when dried are lifted into the air, by winds, and can bring about respiratory issues to nearby people .To cope with such overexploitation of the resources and negative impacts of WMP on the environment, it is therefore important to consume and treat these wastes in a well-planned manner and legitimize the use of WMP in the development of auxiliary concrete mixes

Environmental Problems Attributed to Waste Marble Powder (WMP)

The WMP imposes serious threats to ecosystem, physical, chemical and biological components of environment. Some of the problems encountered are:

- It adversely affects the productivity of land due to decreased porosity, water absorption, water percolation etc.
- When dried, it becomes air borne and cause severe air pollution. It introducesoccupational health problems and also affects the machinery and instruments installed in industrial areas.
- It affects the quality of water during rainy season, and reduces storage capacities and damaging aquatic life.
- It adversely affect social and industrial activities of people since the heaps of powder remain scattered all round the country are an eye sore and spoil aesthetics of entire region.

Dumping of marble dust

Identification

Marble dust is characterized by its fine powdery texture, similar to that of crushed limestone. Since marble is a hardercrystallized rock, the dust is not comprised of soft particles. The dust also has a slight shimmer to itShimmer to itbecause of the crystallized particles, and it can also be discolored with brown, grey, yellow, pink or even greenish particles due to impurities in the original marble.

Physical Properties

Table 1

COLOR	WHITE
FORM	POWDER
ODOR	ODORLESS
MOISTURE CONTENT (%):	1.59

ChemicalProperties

Table 2

Oxide compounds	Marble Dust (Mass %)
SiO_2	28.35
Al2O3	0.42
Fe203	9.70
CaO	40.45
MgO	16.25
Density (g/cm3)	2.80

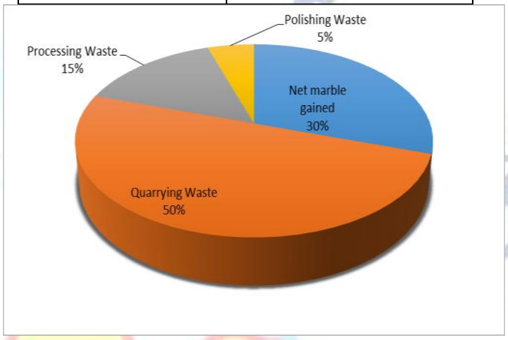


Fig. 3 Marble Product and Waste (% of mined out)

Self-consolidating concrete

The Self-consolidating concrete (SCC) was first developed in Japan in the late 1980s . Over the last decades, SCC as a new generation of high-performance concrete, has been known as a significant progress in concrete industry and consequently considered as the subject of extensive research studies. SCC's unique property gives it significant constructability, economic and engineering advantages . Moreover, SCC can be pumped to a great distance and increases the speed of construction. The fines content of SCC is higher than in normally-vibrated concrete (NVC) and the absence of compacting lowers the risks inherent in the process, either from excessive vibration or from insufficient vibration. In order to avoid separation of large particles in SCC, viscosity increasing additives or fillers are utilized. An additive to increase the viscosity is often used when concrete is cast under water and for SCC in tunnels.

Mineral admixtures like fly ash, glass filler, limestone powder, silica fume or quartzite fillers may be used in the mixture to increase the viscosity of SCC .It enables the properties of the concrete to beimproved, especially in the aspect of resistance to the aggressive influence of the environment, as well as to obtain significant economic benefits.

ADVANTAGES OF SELF-COMPACTING CONCRETE

The use of SCC offers many advantages to the construction industry. Its application is increasing day by day. The various advantages of SCC are

1. Exclusion of compaction or vibration works.
2. Reduces the efforts and cost of placement.
3. Shortens the time of construction.
4. Eliminate noise due to vibration.
5. Reduction in site man power.
6. Easier placing
7. Improved durability.
8. Safer working environment.
9. Using self-compacting concrete reduced the expenses by use of chemical and mineral admixture.
10. High level of homogeneity is achieved
11. Ease of flow around congested reinforcement.
12. Minimizes hg concrete voids.

DISADVANTAGES OF SELF-COMPACTING CONCRETE

The various disadvantages can be summarized as

1. The selection process for materials is rigorous.
2. In terms of concrete material cost, SCC is Costlier than conventional concrete.
3. Accurate measurement of the constituent materials are required
4. Additional trial batches are required in case of SCC at construction sites.

METHODOLGY

The experimental work planned in this investigation consisted of comparing mix proportioning of fly ash induced self compacting concrete with marble dust by IS method for a given design strength in terms of cement consumption and strength achieved. The methodology adopted for the experimental work includes.

1. Mix proportioning for self compacting concrete to achieve high flow-ability without segregation and bleeding using chemical admixture.
2. Use of marble dust as a partial replacement to cement in different dosages will be used to study the flow ability and strength of the mix proportion.
3. Slump Flow Test, J Ring Test, V Funnel Test and L Box Test will be conducted to find out the passing ability, filling ability and resistance to segregation of SCC.
4. The flowability test results will be compared with the limits of European standards recommended by EFNARC.
5. Compressive strength test will be conducted to examine the Compressive strength characteristics of SCC.
6. Split tensile strength test will be conducted to examine the tensile strength characteristics of SCC.

LITERATURE REVIEW:

Valeria (2005): He observed that marble dust powder had very high Balinen fineness value of about 1.5m2/g, with 90% of particles passing through 50 micron sieve and 50% through 7micron sieve. It was observed that marble powder had a high specific surface area.

Baboo Rai (2011): Baboo Rai have done their research on Influence of Marble dust powder/granules in Concrete mix. Partial replacement of cement and usual fine aggregates by varying percentage of marble powder reveals that increased waste marble powder result in increased workability and compressive strengths of the mortar and concrete.

Vaidevi C (2013): Vaidevi C found that the use of this waste was proposed in different percentages both as an addition to and instead of cement, for the production of concrete mixtures. The study showed the cost of these cementitious material decreases costof construction when replaced by different percentages of MD. Compressive test and tensile tests were conducted. 10% replacement gives the best result and for every 10 bags of cement, the addition of 10% of marble dust saves 1bag of cement and 1 bag cost.

V.M.Sounthararajan (2013): By partial replacement of cement by MDP compressive strength, splitting tensile strength and flexural strength was evaluated. Fine to coarse aggregate ratio and cement to total aggregate had a higher influence on the improvement in strength properties. A phenomenal increase in the compressive strength of 46.80 MPa at 7 days for 10% replacement

TABLE 3 MIX PROPORTION OF SELF COMPACTING CONCRETE

Mix No.	Cement(Kg)	% of Fly Ash	% of Marble powder	W/C	W/B	C A (kg)	FA(Kg)	Water (Lts)	% of HRWR	% of VMA	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

FLOWABILITY TEST RESULTS

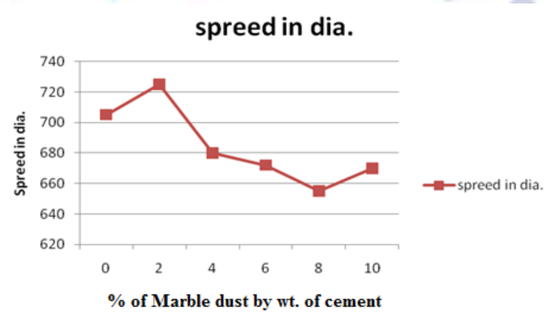
Workability is the primary requirement of SCC. The various aspects of workability characteristic are

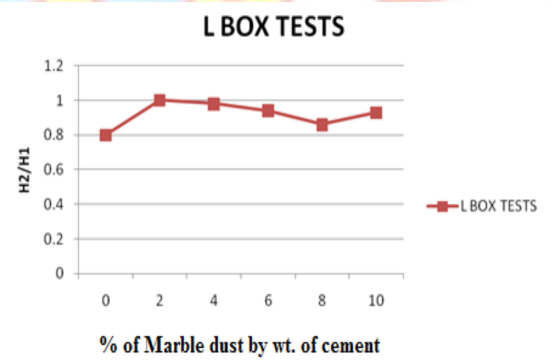
- Flowability
- Viscosity
- Passing ability and
- Segregation resistance

CONCRETE TABLE : SLUMP FLOW TEST RESULTS

Mix No.	% of Marble dust by Weight of Cement	SLUMP FLOW TEST (time in sec)			Spread Diameter in mm
		300mm	500mm	700mm	
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

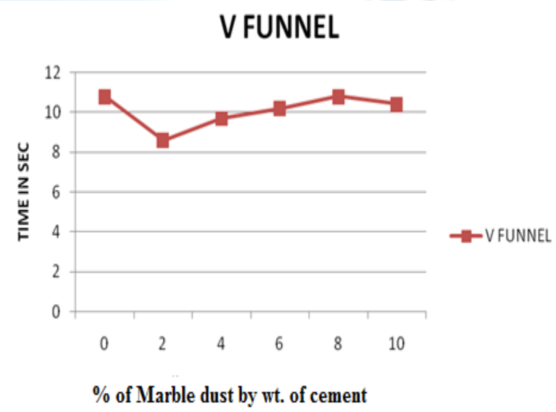
Further, no segregation was observed during the J- Ring test. The V-Funnel time and the L-Box blocking ratio were also within the specified range laid down by EFNARC (2002).





Slump flow test results

TABLE :L-BOX AND V-FUNNEL TEST RESULTS



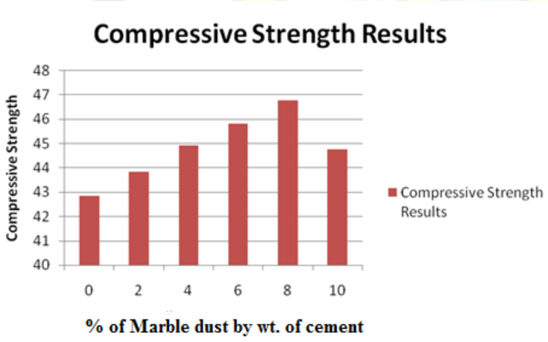
From visual inspection during mixing process and during the flowability test it was observed that the addition of marble dust nullified the stickiness observed in mixes without marble dust and further, the mixes were highly cohesive.

COMPRESSIVE STRENGTH TEST RESULTS

Cube specimens prepared for compressivestrength were tested in laboratory and different crushing strengths were found which aresubstantiated in table 4.3.

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



It can be seen that the compressive strength increased gradually with addition of silica fume. An increase in strength is expected due to the pozzolanic action of silica fume.

It is clear that 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.

Decrease in compressive strength was observed when marble dust replacement was 10% as compared to 6% and 8% replacement of marble dust by weight of cement.

Fig. Compressive Strength Test Results

SPLIT TENSILE STRENGTH TEST RESULTS

The splitting-tensile strength of concrete is an important mechanical property that greatly affects the size and extent of tension related failure behavior, such as flexural cracking in beams.

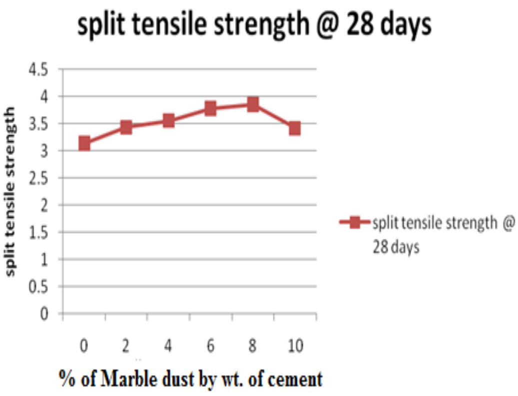
From 28-day splitting tensile strengths of the SCC specimens it can be observed that the values of splitting tensile-strength range between 3 and 4 MPa.

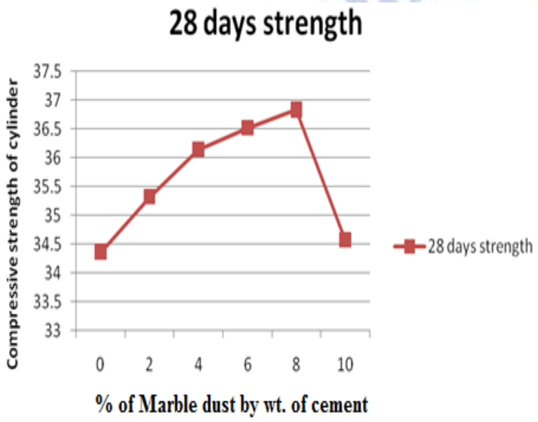
It is clear that the splitting-tensile strengths of marble dust SCC mixtures are increasing. The increase is almost 10% at 2% replacement and 13% at 4% replacement of marble dust by weight of cement. The increase in split tensile strength is almost 20% at 6% and 8% replacement of marble dust by weight of cement. However at 10% replacement the increase in split tensile strength is only about 9%.

SPLIT TENSILE AND COMPRESSIVE STRENGTH OF CYLINDER

Mix No.	% of marble dust by Weight of Cement	Split Tensile Strength of Cylinder at 28 Days	Compressive Strength of Cylinder at 28 Days
1	0	3.14	34.36
2	2	3.44	35.32
3	4	3.56	36.15
4	6	3.78	36.52
5	8	3.86	36.84
6	10	3.42	34.57

The cylinder splitting- strengths of about 2–6 MPa have been reported in the literature, corresponding to compressivestrengths of about 20– 80 MPa.





SUMMARY

A comparative study of the test results had been carried out to study the influence of marble dust as partial replacement of cement in SCC with fly ash.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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