2 Days International Conference on CSIT-2019, ICSD-2019
Mahratta Chamber of Commerce, Industries and Agriculture Tilak Road, Pune (India)
2nd -3rd November 2019 www.conferenceworld.in ISBN : 978-81-943584-1-1

REPLACEMENT OF CEMENT WITH MARBLE POWDER IN CONCRETE

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ABSTRACT

Leaving the waste materials to the environment directly can cause environmental problem. Hence the reuse of waste material has been emphasized. Waste can be used to produce new products or can be used as admixtures so that natural resources are used more efficiently and the environment is protected from waste deposits. Marble stone industry generates both solid waste and stone slurry.

Whereas solid waste results from the rejects at the mine sites or at the processing units, stone slurry is a semi liquid substance consisting of particles originating from the sawing and the polishing processes and water used to cool and lubricate the sawing and polishing machines. Stone slurry generated during processing corresponds to around 40% of the final product from stone industry. This is relevant because the stone industry presents an annual output of 68 million tonnes of processed products. Therefore, the scientific and industrial community must commit towards more sustainable practices.

There are several reuse and recycling solutions for this industrial by-product, both at an experimental phase and in practical applications. These industrial wastes are dumped in the nearby land and the natural fertility of the soil is spoiled. The physical, chemical and mechanical properties of the waste are analysed.

Keywords: *Waste materials, Environmental problems, Admixtures, more sustainable practices, Reuse, Recycle, practical applications.*

1. INTRODUCTION

General

Concrete is the primary construction material in the world, it is widely used in all types of civil engineering works, like low and high-rise buildings, environment protection and local/domestic developments. Concrete is a manufactured product, essentially consisting of cement, aggregates, water and admixture(s). Among these, aggregates, i.e. inner granular materials such as sand, crushed stone or gravel form the major part. Traditionally aggregates have been readily available at economic price with the quality which is suitable for all the purposes. However, in recent years the wisdom of our continued wholesale extraction and use of aggregates from natural resources has been questioned at an international level. This is mainly because of the depletion in quality of cement powder and greater awareness of environmental protection. In spite of this, the availability of natural resource to future generations has also been realized.

Replacement of marble powder

The advancement of concrete technology can reduce the consumption of natural resources and energy sources and lessen the burden of pollutants on environment. Presently large amounts of marble dust are generated in natural stone processing plants with an important impact on environment and humans. This project describes the feasibility of using the marble sludge dust in concrete production as partial replacement of cement. In INDIA, the marble and granite stone processing is one of the most thriving industry the effects if varying marble dust contents on the physical and mechanical properties of fresh and hardened concrete have been investigated. Slump and air content of fresh concrete and absorption and compressive strength of hardened concrete were also investigated.

Necessity of the marble powder

Marble stone industry generates both solid waste and stone slurry. Whereas solid waste results from the rejects at the mine sites or at the processing units, stone slurry is a semi liquid substance consisting of particles originating from the sawing and the polishing processes and water used to cool and lubricate the sawing and polishing machines.
Stone slurry generated during processing corresponds to around 20% of the final product from stone industry. Therefore, the scientific and industrial community must commit towards more sustainable practices. There are several reuse and recycling solutions for this industrial by-product, both at an experimental phase and in practical applications.

2. EXPERIMENTAL PROCEDURE

Materials used in concrete

- 53 grade PPC is used as for cement
- Fine aggregate
- Coarse aggregate
- Concrete grade – M25

Cement

The Portland Pozzolana Cement conforming to IS: 4031 was used for the preparation of test specimens.

Fine Aggregate

The fine aggregate used in this experimental investigation was natural river sand confirming to zone II of IS: 383 – 1970.

Coarse Aggregate

Crushed granite aggregates particles passing through 20mm and retained on 4.75mm I.S sieve was used as natural aggregates which met the grading requirement of IS: 383 – 1970.

MIX DESIGN

DESIGNSTIPULATIONS

Maximum sizeofaggregate	=20mm (angular)
Degreeof workability	=0.90
Degree ofqualitycontrol	= Good
Typeof exposure	=Moderate

TEST DATA FOR MATERIALS

Specific gravityofcement	= 3.15
Specific gravity of coarse Aggregate	= 2.5
Specific gravity of fine aggregate	= 2.5

WATER ABSORPTION

Coarse aggregate	= 0.50%
Fine aggregate	= 1%

FREE SURFACE MOISTURE

Coarse aggregate	= NILL
Fine aggregate	= 1.5 %

Target mean strength

If specified characteristic cube strength

$$F_{ck} = f_{ck} + (t\times s)$$

= 25 + (1.65×4)

= 31.6 Mpa

Selection of water/cement ratio

As per 10262w/c ratio	= 0.43 As per IS 456 max w/c ratio =0.6
W/Cratio	=0.45

Selection sand content

For 20mm aggregate

Watercontent	= 186kg/m^3
Sand	=35%

For change in value in water cement ratio, compacting factor, for sand belonging to zone 3, following adjustment

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Change in condition	Percent adjustment required	
	Water content	Sand in total aggregate
For decrease in water content ratio by (0.6-0.5) ie 0.10	0	-2.0
For decrease in compacting factor (0.9-0.8) ie 0.1	+3	0
For sand conforming to zone 3	0	-1.5
Total	+3	-3.5

Required sand content = 30.5% Required water content = 191.58 kg/m^3

Determination of cement content

W/C = 0.45

Water = 191.58 C =W/0.45

=191.58/0.45 =425.73kg/m^3

Determination of course & fine aggregate contents

The amount of entrapped air in the wet concrete is 2%.
V =(W+C/sc+1/p×fa/sfa)×1/1000

= (191.58+425.73/3.15+1/0.3×fa/2.5)×1/1000 Fa =491.18

V = (W+C/sc+1/1- P×Ca/Sca)×1/1000

0.98 =(191.58+425.73/3.15+1/1-0.3×Ca/2.5)×1/1000

Ca =1146.08
For 1m^3 of concrete mix proportion then becomes,

Water:	Cement:	FA	:CA
191.5 :	425.73 :	491.18	:1146.08
0.45 :	1 :	1.154	:2.69

Water absorption: 0.5% for coarse aggregate	= 0.005 × 1146.08	=5.73 Free moisture: 1.5%
of fine aggregate	= 1.5/100 × 491	=7.36 Actual quantity of
coarse aggregate	= 1146.08 - 5.73	=1140.35 Actual quantity of
fine aggregate	= 491.18 - 7.36 = 498.54	

Actual quantities of mix proportions

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Cement: 425.73kg/m3 Water: 189.95kg/m3Fine aggregate: 498.54kg/m3 Coarse aggregate: 1140.35kg/m3

Grade	**Ratio/(Kg/m^3)**	**W/C**	**Cement**	**FA**	**CA**
M25	RATIO	0.45	1	1.154	2.69
	Kg/m^3	189.95	425.73	498.54	1140.35

Tests for Aggregates-Specific GravityTest

Specific gravity of aggregate is made use of in design calculations of concrete mixes. With the specific gravity of each constituent known, its weight can be converted into solid volume and hence a theoretical yield of concrete per unit volume can be calculated. Specific gravity of aggregate is also required to be considered when we deal with light weight and heavy weight concrete.

Average Specific gravity of rocks varies from 2.6 to 2.8

Specific Gravity of FineAggregate

Mass of Pycnometer is taken as (M1)g.Nearly half of the bottle is filled with fine aggregate and mass of Pycnometer plus aggregate is taken as (M2) g.

Remaining part of the bottle is filled with water and the mass of Pycnometer plus sand and water is taken as (M3) g.Then the aggregate in the bottle is cleaned and filled with water up to the lid. Then its mass is taken as (M4) g.

$$\text{SPECIFIC GRAVITY} = \frac{M4}{(M2 - M1) - (M2 - M3)}$$

Specific gravity results For Fine Aggregate is shown in Table 3.3

Specific Gravity of Coarse Aggregate

$$\text{SPECIFIC GRAVITY} = \frac{C}{(B-A)}$$

Where,

A = Weight in gram of saturated aggregate in water (A1-A2)

B = Weight in gram of the saturated surface dry aggregate in air and

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C = Weight in gram of oven dry aggregate.

Specific Gravity Results for Coarse Aggregates is shown in Table 3.4.

SieveAnalysis

Fineness modulus is a empirical factor obtained by adding cumulative percentage of aggregate retained on the standard sieves ranging from 40mm to 150 micron and dividing this by arbitrary No. 100.

The following limits may be taken guidance,

Fine sand = fineness modulus = 2.2 to 2.6 Medium sand = fineness modulus = 2.6 to 2.9 Coarse sand = fineness modulus = 2.9 to 3.2

CEMENT

Type	: 43 grade Portland Pozzolona Cement(PPC)
Initialsettingtime	: 100min
Finalsettingtime	: 460 min
Soundnesstest	: 3mm
Brandname	: JaypeeCement

2.5.1 Specific Gravity Result for Cement

S.NO	OBSERVATION	NOTATIONS USED	TRIAL I
1	Mass of density bottle	M1 (g)	35
2	Mass of bottle + cement	M2 (g)	45
3	Mass of bottle + cement + kerosene	M3 (g)	60
4	Mass of bottle + kerosene	M4 (g)	72
5	Mass of bottle + water	M5 (g)	84
	Specific Gravity 3.15		

TABLE 2.1 SPECIFIC GRAVITY RESULT FOR CEMENT

Specific Gravity Result for FineAggregate

Type: locally available river sand (confirming to IS 383:1970)

S.NO	OBSERVATION	NOTATIONS USED	TRIAL I
1	Mass of Pycnometer	M1 (g)	0.676
2	Mass of Pycnometer + FA	M2 (g)	0.876
3	Mass of Pycnometer +FA +water	M3 (g)	1.628
4	Mass of Pycnometer + water	M4 (g)	1.522
	Specific Gravity2.15		

TABLE 2.2 SPECIFIC GRAVITY RESULT FOR FINE AGGREGATE

Specific Gravity Result for CoarseAggregate

Type: locally available angular coarse aggregate (Confirming to IS 383:1970) Maximum size: 20mm Minimum size: 12.5mm

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S.NO	OBSERVATION	NOTATIONS USED	TRIALI
1	Mass of wire basket	M1 (g)	1535
2	Mass of wire basket + CA	M2 (g)	1815
3	Mass of surface dry CA	M3 (g)	455
4	Mass of oven dried CA	M4 (g)	452
	Specific Gravity 2.60		

TABLE 2.3 SPECIFIC GRAVITY RESULT FOR COARSE AGGREGATE

Fineness ModulusTest

The following limits are provided by the IS codes Finesand = fineness modulus = 2.2 to 2.6 Medium

sand =fineness modulus = 2.6 to 2.9

Coarsesand = fineness modulus = 2.9 to3.2

Fine Aggregate(Sand)

IS Sieve	Weight retained Kg	Cumulative weight Kg	Cumulative Percentage Retained %	Cumulative ercentage passing %
4.75	0.01	0.01	1	99
2.36	0.04	0.05	5	95
1.18	0.110	0.160	16	84
600	0.228	0.388	38.8	61.2
300	0.386	0.774	77.4	22.6
150	0.162	0.936	93.6	6.4
75	0.042	0.978	97.8	2.2
<75	0.022	1	100	0
FINENESS MODULUS = 2.31			**(ZONE II)**	

TABLE 2.4 FINENESS MODULUS FOR FINE AGGREGATE

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CoarseAggregate

IS Sieve	Weight retained Kg	Cumulative weight Kg	Cumulative percentage retained %	Cumulative percentage passing %
20	0.192	0.192	9.6	90.4
16	0.420	0.612	30.6	69.4
12.5	0.602	1.214	60.7	39.3
10	0.578	1.792	89.6	20.4
6.3	0.182	1.974	98.7	1.3
4.75	0.020	1.994	99.7	0.3
<4.75	0.006	2.000	100	0
FINENESS MODULUS = 4.88 (SINGLE SIZE)				

TABLE 2.5 FINENESS MODULUS FOR CA SIEVE ANALYSIS IS SHOWN BELOW

1. COARSEAGGREGATE

SIEVE SIZE (mm)	ANALYSIS OF CA FRACTIONS (%PASSING)		% OF DIFFERENT FRACTIONS			REMARK
	I	II	I 60%	II 40%	COMBINED 100%	
20	100	100	60	40	10	Conforming to table 2, IS:383-1970
10	0	71.20	0	28.5	28.5	
4.75	-	9.40	-	3.7	3.7	
2.36	-	-	-	-	-	

2. FINEAGGREGATE

SIEVE SIZES	FA(%PASSING)	REMARKS
4.75mm	100	Conforming to grading zone 3 of table 4 IS: 385-1970
2.36mm	100	
1.18mm	93	
600micron	60	
300micron	12	
150micron	2	

TABLE 2.6 SIEVE ANALYSES TESTING OF HARDENED CONCRETE

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Compression Test

One of the important properties of concrete is its strength in compression. The strength in compression has definite relationship with all other properties of concrete i.e. these properties are improved with the improvement in compression strength.

COMPRESSIVE STRENGTH = LOAD / AREA

Where, Load in N

Area in mm2

Split TensileStrength:

The tensile strength is one of the basic and important properties of the concrete. The concrete is not usually expected to resist, the direct tension because of its low tensile and brittle in nature. However, the determination of tensile strength of concrete is necessary to determine the load at which the concrete members crack. The cracking is a form a tensile failure. The main aim of this experimental test is to determine the maximum load carrying capacity of test specimens duringtension.

$$\text{SPLIT TENSILE STRENGTH} = \frac{2P}{\Pi \times d \times l}$$

Where,

P = Compressive load on cylinder L = Length ofthe cylinder=300mm

d = diameter of the cylinder = 150mm

Fig2.2 Split Tensile test FlexureTest

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The main aim of this experimental test is to determine the maximum load carrying capacity of beam specimen is subjected to two points loading and the failure of the load at the failure of the specimen is noted down

Conditions:

If, a > 13.3 cm, formula 1 is used. 11 < a < 13.3 cm,

Formula:

$f_b = P\ xl / bxd^2$ (1)

$f_b = 3P\ x\ a / bxd^2$ (2)

Fig 2.3 Flexure Test

Details of Cast Specimens:

Concrete size of cubes 150mmx150mmx150mm, size of cylinders 150mm diameter and 300mm height , size of prisms 100mmx100mmx500mm were casted and demoulded after 24 hours .by replacing 0%, 2%, 4%, 6%, 8% and 10% of marble powder three cubes were tested to find compressive strength at the age of 7days and 28 days, three cylinders were tested to find out the split tensile strength at the age of 7 days and 28 days and three prisms were tested to find out the flexural strength at the age of 7 days and 28 days.

Percentage of replacement (%)	**Cubes (150x150x150mm)**		**Cylinders (150x300mm)**		**Prisms (100×100×150)**	
	7 days	**28days**	**7 days**	**28 days**	**7 days**	**28 days**
0%	3	3	3	3	3	3
2%	3	3	3	3	3	3
4%	3	3	3	3	3	3
6%	3	3	3	3	3	3
8%	3	3	3	3	3	3
10%	3	3	3	3	3	3

TABLE 2.7 Details of Cast Specimens

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Fig 2.4 Specimens Cast

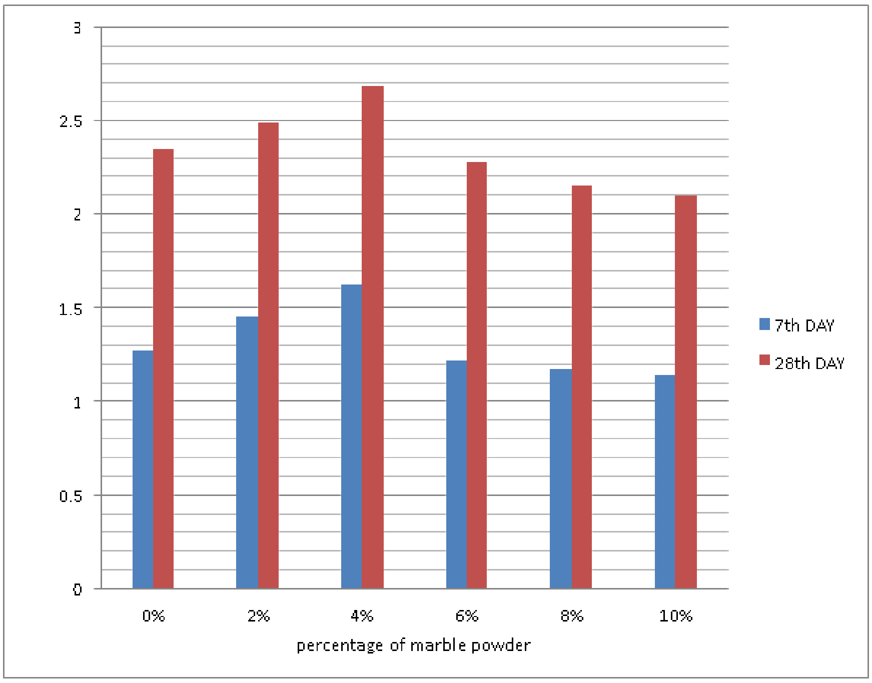
3. TEST RESULTS

TENSILESTRENGTH

tensile strength of the concrete

% marble powder	7 DAYS (Mpa)	28 DAYS (Mpa)
0%	1.27	2.35
2%	1.45	2.49
4%	1.62	2.68
6%	1.22	2.27
8%	1.17	2.15
10%	1.14	2.10

3.3 GRAPHICAL REPRESENTATION OF TENSILESTRENGTH



% of marble powder

4. CONCLUSION

The Compressive strength of Cubes are increased with addition of waste marble powder up to 10% replace by weight of cement and further any addition of waste marble powder the compressive strength decreases.

The Split Tensile strength of Cylinders are increased with addition of waste marble powder up to 10% replace by weight of cement and further any addition of waste marble powder the Split Tensile strength decreases.

Thus, we found out the optimum percentage for replacement of marble powder with cement and it is almost 10% cement for both cubes and cylinders.

We have put forth a simple step to minimize the costs for construction with usage of marble powder which is freely or cheaply available; more importantly.

We have also stepped into a realm of the environmental pollution by cement production; being our main objective as Civil Engineers.

When dumped (marble powder) on land, it adversely affects the productivity of land due to decreased porosity, water absorption, water percolation etc.,

Apart from occupational health problems, it also affects machinery and instruments installed in industrial areas. Slurry dumped areas cannot support any vegetation and remain degraded.

5. REFERENCE

[1] International Journal of Civil and Structural Engineering Volume 1, No 4,2011.

[2] InternationalJournalofthePhysicalSciencesVOL.5(9), PP. 1372-1380, 18August, 2010.

[3] Concrete Technology -M.S.Shetty

[4] Concrete Technology -M.L.Gambhir

[5] http://www.engineeringcivil.com/projecton partial replacement of cement with marble powder

[6] CE & CR August 2010 by M.ShahulHameed,Research Scholar and M.Vijayalaxmi, Faculty,Sethu[7] Institute of Technology,Kariapatti,Tamil Nadu And Dr.A.S.S.Sekar, Assistant Professor,Alagappa[8] Chetiyar College Of Engg. &Technology,Kariakudi, TamilNadu.

[9] Dr. Anurag Mishra,Mr. Rajesh Gupta, “Utilization of Marble Slurry in Construction Materials”

[10] Workshop on gainful utilization of Marble Slurry and other stonewaste.

[11] AkbulutH,Gurer C (2007).Use of aggregates produced from marble quarry waste in asphalt pavements. Build.Environ., 42(5):1921-1930.

[12] AlyamacKE,Ince R (2009).A preliminary concrete mix design for SCC with marble powders.Const. [13] Build. Mat., 23(3): 1201-1210.

[14] Ali Ergun (2011), “Effects of the usage of diatomite and waste marble powder as partial replacement of cement on the mechanical properties of concrete”,Construction and Building Materials, 25(2), pp806812