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An Experiment and Study of M30 Grade of Concrete by Partially Replacing Fine Aggregate with Marble Dust Powder and Phosphogypsum in Rigid Pavement

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Abstract: ***The Project is to study about M30 grade of concrete by adding waste materials. Marble dust powder and phosphogypsum which is easily available marble which are standard among the most imperative materials, utilized as a part of the development business. Marble dust is a waste material from the construction site is mixed with concrete as a replacement material. Marble dust powder is acquired from sawing and moulding of marble rock. Phosphogypsum is produced as an outgrowth of the production of fertilizer from phosphate rock. There is a high gypsum content and gypsum is a widely used material in constructions. It is weakly radioactive in nature because it is a by-product of phosphate fertilizers. In the M30 grade of concrete fine aggregate is partially replaced by marble dust powder and phosphosgypsum in some proportions. The fine aggregate is replaced by 10%, 20% and 30% in which marble dust powder and phosphogypsum and are added in an equal proportion.***

Keywords: Marble dust powder, phosphogypsum, grade of concrete, rigid pavement, green concrete.

I. INTRODUCTION

In this era, the betrayal of waste material to nature can especially lead to ecological imbalances. To control its belonging we need to utilize this waste marble dust powder and phosphogypsum are produced in abundant quantity and it can be utilized so that the ecological imbalance would control and pollution can be reduced and the cost efficiency is also reduced.

A. Marble Dust Powder

The white marble dust powder contains a high amount of calcium carbonate (CaCo3) and can cause pollution. When the marble dust is mixed with rainwater it forms slurry and it runs in an exposed ground surface leads to water blockage of the soil and it increases soil alkalinity also affect photosynthesis and transpiration which affects soil fertility and plant productivity.

Marble is one of the non-foliaceous changeable rocks which is formed due to the recrystallization of carbonate mineral that is most commonly calcite or dolomite. Geologists use the term marble as the metamorphosed limestone. Marble is generally used as a part of an art gallery for statues and sculptures. In future, it can be used more frequently as construction material.

To increase the strength of the concrete the marble dust powder can be used as an admixture and it makes concrete resistance free from the attack of sulfide and some other chemicals. It is a solid waste material generated from marble processing and it has also good adhesive and binding properties like cement and it can be a better option for the replacement of cement as well as fine aggregates while preparing concrete.

B. Phosphogypsum

Phosphogypsum is a waste product from the phosphate fertilizer industry and is obtained through the distillation of phosphate rock. Plants that produce phosphoric acid and phosphate fertilizers have ammonium phosphate, superphosphate, etc.

The phosphogypsum consists large amount of “calcium sulfate” and is created as decay from the phosphoric decay plants by the response of a mixture of phosphate with sulphuric acid. In the process where phosphogypsum is arranged in open yards, it might take a risk to the environment, especially amid blustery season if proper measures are not taken. Other than ecological causes, taking care of and vest region required and also the potential for the arrival of residue, fluoride and over heavy metal.

Phosphogypsum can be utilized as an admixture in a fly ash brick to protect it from sly affect condition. There is a requirement for advising the rules for safe dealings like including transportation, storage room, dumping, and legitimate uses of phosphogypsum.

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II. OBJECTIVE

A. To study the influence of partial replacement of sand with marble dust powder and phosphogypsum in the same proportion and to compare with a compressive test of high strength concrete mixture.

B. To find the percentage of marble dust and phosphogypsum, replaced in concrete that makes the strength of the concrete maximum.

C. Advantageous disposal of industrial waste.

D. Solving the problem of environmental pollution.

III. METHODOLOGY

A. Material Used

1) *Cement*: The ordinary Portland cement ACC SURAKSHA Cement, 43 grade confirming to IS 10262:2019 and IS 456:2000. The cement was used from local markets which are high maintenance and need consistency throughout the investigation. The cement has a specific gravity of 3.15.

2) *Fine Aggregate*: The locally available sand confirmed to IS 383:2016 is used as fine aggregate in this project work. The sand is free from all impurities like clay matter, silt, and organic impurities. The fine aggregate has a specific gravity of 2.61

3) *Coarse Aggregate*: Machine crushed 20 mm nominal size angular shape gravel from local source confirming to IS 383:1970 is used as coarse aggregate. The coarse aggregate has a specific gravity of 2.64

4) *Water Cement Ratio*: Water used for the project work is taken from the college campus. It is free from any sort of alkalinity.

5) *Marble Dust Powder*: Marble dust powder is obtained from the marble art gallery which is tested according to IS 383:1970 and initiated to satisfy the requirement of IS 383:1970. The chemical and physical properties of marble dust powder are shown in the table below.

Table -1: physical properties of MDP

PHYSICAL PROPERTIES	RESULT
COLOR	WHITE
FORM	POWDER
ODOR	ODORLESS
MOISTURE CONTENT (%)	1.59

Table -2: chemical properties of MDP

CHEMICAL PROPERTIES	PERCENTAGE (%)
SiO2	28.35
Al2O3	0.42
Fe203	9.70
CaO	40.45
MgO	16.25

6) Phosphogypsum

Phosphogypsum was obtained from the fly ash brick industry from Sirasakala, Bhilai, Chhattisgarh, India. It was tested according to IS 383:1970 and initiated to satisfy the requirements of IS 383:1970. The chemical and physical composition of phosphogypsum is shown in the table below.

Table -3: physical properties of PG

PHYSICAL PROPERTIES	RESULT OBTAINED
Colour	White
Specific gravity	2.3 - 2.6
Compactive Characteristics	1470 - 1670 kg/m3
Maximum dry density	1474 - 1666 kg/m3
Optimum Moisture	15 - 20%

Table -4: chemical properties of PG

CHEMICAL PROPERTIES	PERCENTAGE (%)
CaO	31.2
SiO_2	3.92
SO_3	42.3
P_2O_3	3.6
MgO	0.49
PO_4 , F^-	18.49

B. Mix Design of M30 Grade Concrete

1) Grade of concrete = M30
2) Characteristic compressive strength of concrete at 28 days = 30 Mpa or N/mm^2
3) Grade of cement = 43
4) Type of exposure = Moderate
5) Size of coarse aggregate = 20mm
6) Cement used = ACC Suraksha cement (OPC)
7) Specific gravity of cement = 3.15
8) Specific gravity of water = 1.0
9) Specific gravity of fine aggregate = 2.61
10) Specific gravity of coarse aggregate = 2.64
11) Water absorption of fine aggregate = 0.80
12) Water absorption of coarse aggregate = 0.82
13) Admixture used = Marble dust powder and Phosphogypsum

- *Target Mean Strength For Mix Proportion*

(From Table-1 of IS 456:2000)
f'ck = fck + 1.65 s
Where,
f'ck = Mean target compressive strength at 28 days
fck = Characteristic compressive strength at 28 days.
s = standard deviation.
[standard concrete grade designation = 30: specified characteristic compressive strength of 150 mm^3 concrete at 28 days in N/mm^2 and 1.65 is the tolerance factor]
f'ck = 30 + 1.65×5 (where, s = 5.0) {Table-8 of IS 456:2000}
= 38.25 N/mm^2

7) Determination Of Water-Cement Ratio

[From IS 456:2000 (Table 5)]
Maximum water cement ratio = 0.5 {for moderate condition}
Based on experience adopt water-cement ratio = 0.5

- *Determination Of Water Content*

(From IS code 456:2000)
For road construction 25 to 40mm slump.
20mm size of aggregate = 186kg

- *Calculation Of Cement Content*

[As per Table-5 of IS 456:2000 (pg.20)]
For moderate exposure,
Cement = 300kg/m^3
Water cement ratio = 0.5
Water content = 186kg

Cement content = $\frac{water\ content}{water\ cement\ ratio}$

= 372 N/mm^2
Which is > 300; hence ok.

- *Computation of Volume of Coarse and Fine Aggregate Content*

(From Table-3 of IS 10262:2009)
For 20mm aggregate volume of coarse aggregate per unit volume = 0.62
Water cement ratio = 0.5 = 0.62
Actual water cement ratio = 0.5
Volume of coarse aggregate = 0.62m^3
Volume of fine aggregate = 1 - 0.62 = 0.38m^3

- *Design Mix Calculation*

Mix design calculation:

- Volume of concrete = 1m^3
- Volume of cement = 0.118 m^3
- Volume of water = 0.186 m^3
- Volume of entrapped air = 1% = 0.01m^3
- The total volume of aggregate (coarse aggregate + fine aggregate)

  = Volume of concrete – (Volume of cement + Volume of water + Volume of entrapped air)
  = 1 – (0.118 + 0.186 + 0.01)
  = 0.686m^3
- Mass of coarse aggregate =

  = 0.686 × 0.62 × 2.64 × 1000
  = 1122.845Kg/m^3
- Mass of fine aggregate =

  = 0.686 × 0.38 × 2.61 × 1000kg
  = 680.375Kg/m^3

Proportion of trial mix:
Cement (kg/m^3): 372
Water (kg): 186
Fine Aggregate (kg/m^3): 680.375
Coarse Aggregate (kg/m^3): 1122.845
Water-Cement Ratio: 0.5

RATION OBTAINED: CEMENT : FINE AGGREGATE : COARSE AGGREGATE = 1 : 1.832 : 3.024

Table -5: fine aggregate, marble dust powder and phosphogypsum

S.NO.	% OF FA	% OF MDP	% OF PG
1(A_0)	100	0	0
2(A_1)	90	5	5
3(A_2)	80	10	10
4(A_3)	70	15	15

C. Test for Concrete

1) Sieve analysis
2) Specific gravity
3) Water absorption
4) Slump Cone test
5) Compaction factor test
6) Compressive strength test

IV. RESULT AND DISCUSSION

A. Slump and Compaction Factor Test Result

It is the workability test, the ease with which we can work with concrete, and the following test results are obtained for testing the slump value and compaction factor test of fresh concrete:

Table -6: slump and compaction factor value

S.NO.	SAMPLE	SLUMP (mm)	CFV
1	A0	37	0.88
2	A1	35	0.85
3	A2	32	0.82
4	A3	31	0.79

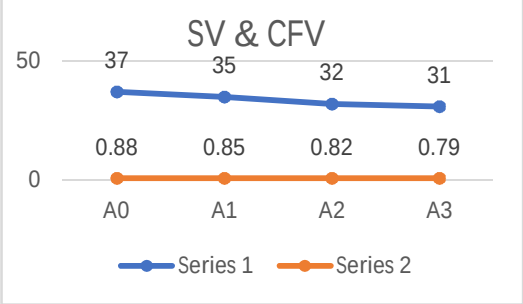


Figure 1: Slump and compaction factor value

B. Compressive strength test

Mechanical test which measures the maximum amount of load in which specimen fails are shown in the table below values in (N/mm^2)

Table -7: 7 days compressive strength test

SAMPLE	0%	5% MDP 5% PG	10% MDP 5% PG	15% MDP 15% PG
	A_0	A_1	A_2	A_3
7 DAYS	17.03	21.01	16.20	14.05
	18.05	20.00	16.44	13.77
	19.01	21.10	17.28	14.60

Table -8: 14 days compressive strength test

SAMPLE	0%	5% MDP 5% PG	10% MDP 5% PG	15% MDP 15% PG
	A_0	A_1	A_2	A_3
14 DAYS	26.57	30.25	29.68	27.00
	28.82	32.00	31.62	27.36
	26.00	33.25	31.00	26.92
AVG	27.13	31.83	30.78	27.13

Table -9: 28 days compressive strength test

SAMPLE	0%	5% MDP 5% PG	10% MDP 5% PG	15% MDP 15% PG
	A_0	A_1	A_2	A_3
14 DAYS	30.28	35.28	32.35	28.32
	32.85	34.67	33.114	28.66
	31.00	36.88	32.00	27.32
AVG	31.37	35.6	32.85	28.19

V. CONCLUSION

A. Phosphogypsum and Marble dust powder is an industrial waste, which is available in large quantities, imparts strength and hence, it can be employed as the replacement material for fine aggregate to reach a better economy.

B. The result obtained from this experimental work is that after the addition of marble dust powder up to 5% and phosphogypsum up to 5% as a replacement material by weight of fine aggregate, the compressive strength values reached the normal M30 grade strength, and after the addition of more percentages of Marble dust powder and Phosphogypsum, its strength reduced. But if we are adding the marble dust powder and phosphogypsum in different proportions the strength of concrete perhaps increases.

C. Both the waste materials are available abundantly in the atmosphere and it reduces the cost of fine aggregate.

D. The compressive strength value of concrete is increased, when the percentage of marble dust powder and Phosphogypsum was 5% and 5%. After on, increasing the percentage of marble dust powder and phosphogypsum, the compressive strength values decreased.

E. At 10% substitution of fine aggregate, the maximum compressive strength was achieved. The authentic percentage of fine aggregate in concrete was 90%, in which maximum compressive strength and was obtained.

VI. FUTURE SCOPE

A. Investigators have tried to make the concrete eco-friendly and economical by partially replacing either fine aggregate or coarse aggregate as well as cement with other waste materials.

B. Phosphogypsum and marble dust powder both are replaced with fine aggregate and it can be replaced with other waste material as well as to achieve a better economy.

C. Other waste materials such as ceramic, steel slag dust, ferroalloy dust, fly ash, quarry dust, glass powder, etc., can also be taken into consideration as a replacement material for the fine aggregate.

D. Different water-cement ratios can be adopted and other tests can also be performed and different grades of concrete can also be used and strength can be compared.

VII. RECOMMENDATIONS

A. The 5% mixture of marble dust powder and phosphogypsum has shown a positive result of more than that of 0% marble dust and phosphogypsum. It can be used in construction.

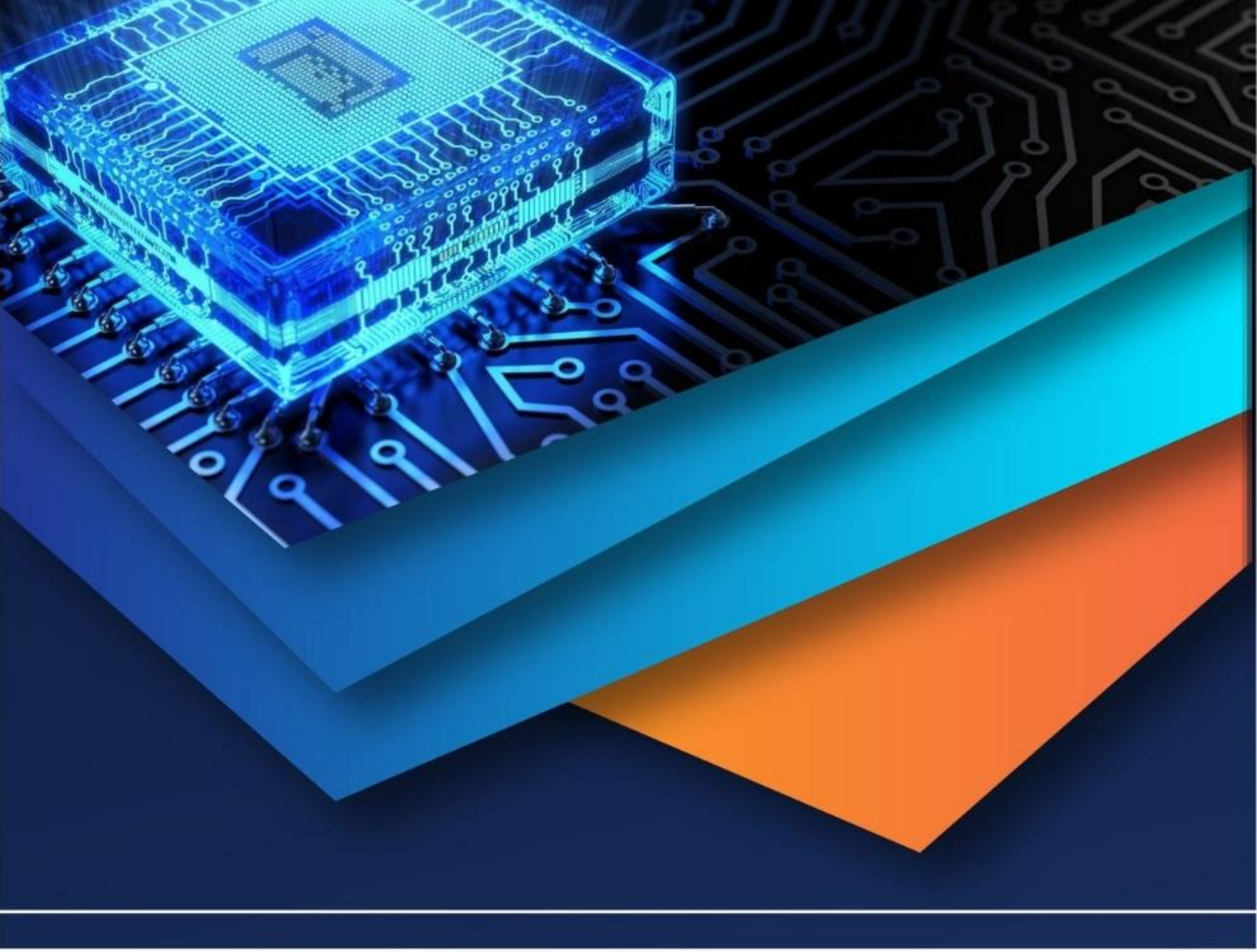
B. Adding marble dust and phosphogypsum in different proportions increases the strength of concrete.

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