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EFFECT OF MARBLE DUST AND SILICA FUME ON PROPERTIES OF CONCRETE

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ABSTRACT

Green Concrete is one of those concrete which is produced from environmentally friendly materials. This concrete is being utilized in modern world so often that reduces the detrimental effect of conventional concrete such as reduction in carbon footprint, reduction in energy consumption, reduction of utilization of natural resources etc. The adaptation of the waste product from different industries in concrete is not a new concept these days. The present research work is carried out to use marble dust (10%, 20%, 30%, 40% and 50% by weight) replacing sand and silica fume (4%, 6% and 8%) as cementitious material for producing M30 grade of concrete. To evaluate the performance of replacement concrete, strength parameter of concrete was determined in the laboratory. The maximum compressive strength at 28 days was 43.13 MPa for M12, which is 6.42% higher than the control mix. The maximum split tensile strength at 28 days was 4.12 MPa for M12, which is 5.10% higher than the control mix. The maximum flexural strength at 28 days was 5.34 MPa for M13, which is 17.88% higher than the control mix.
Keywords: Replacement Concrete, Marble Dust, Silica Fume.

INTRODUCTION

Green Concrete is one of those concrete which is produced from environmentally friendly materials. This concrete is being utilised in modern world so often that reduces the detrimental effect of conventional concrete such as reduction in carbon footprint, reduction in energy consumption, reduction of utilization of natural resources etc. The life of green concrete is same as conventional concrete. "Green concrete" is a game-changing building material in the history of the construction industry. Dr. WG, in 1998, was the first to invent the green concrete in Denmark. Conventional concrete uses natural materials, which causes the depletion of mineral resources and impacts on the environment. However, the concrete industry is very crucial in the modern world thus need for alternate concrete rises.

Concrete wastes include slag, waste from nuclear reactors, recycled concrete, waste from mining and building, waste glass, burning residue, red mud, burnt clay, dust, combustor ash, and foundry sand. Reducing concrete's environmental impact is the goal of the Centre for Green Concrete. To make this possible, new technologies are being created. The method considers every facet of the life cycle of a concrete construction, including structural design, specification, manufacture, and maintenance, in addition to every facet of performance, including:

- Mechanical parameters of concrete such as strength, creep, shrinkage, etc
- Resistance to fire such as spalling, transfer of heat, etc.
- The degree of workmanship such as workability, curing and strength development.
- Durability parameters such as protection from corrosion, frost and other deterioration processes.
- Thermodynamic parameters.

- Environmental aspects of concrete including CO2-emission, energy consumption, recycling etc.)

Green concrete buildings have a plethora of environmental regulations to adhere to: Reducing CO2 emissions by at least 30% is necessary. Remaining elements that can be utilized as aggregate should make up at least 20% of the concrete, use of waste from the concrete industry, utilization of novel forms of leftover materials that were previously disposed of or landfilled in other ways. At least 10% of the fuel used to create cement should come from waste sources rather than fossil fuels. In addition, a lot of actions are taken to benefit the environment. The Environmental Protection Agency's "no-no" list of contaminants should not be found in materials, and recycling rates for green concrete shouldn't be lower than those of conventional concrete. The water used for green concrete should not be containing more detrimental substances than the water which is being used for normal concrete production. After half an hour, many number of tests are to be conducted on concrete such as % of air content, workability, strength parameters, setting time, density and many more. After performing all the basic and initial tests, tests for frosting, chloride penetration, air voids in concrete are to be done which is performed in the 'Aggressive Surrounding' class. The parameters like water to cement proportion, water to binder proportion and the proportion of chloride depend on the concrete design mix and the type of concrete.

Since ancient times, marble has been a widely utilized building material. As a result, marble trash is a very significant by-product that needs to be disposed of in an environmentally responsible manner. Furthermore, recycling waste without adequate management can lead to environmental issues that go beyond the waste itself. One by-product of the marble-making process is marble dust. The cutting operation produces a significant amount of powder. As a result, dust losses amount to around 25% of the initial marble mass. If these waste materials are let to enter the environment, they may lead to many environmental issues like increased soil alkalinity, negative effects on plants, and negative effects on human health, among other things.

The CAS number for silica fume, often known as micro silica, is 69012-64-2, and the EINECS number is 273-761-1. It is not crystalline since it is an amorphous polymorph of silica, or silicon dioxide. Made from spherical particles with an average particle diameter of 150 nm, it is an ultrafine powder which is a byproduct of the alloying process of silicon and ferrosilicon.The main use of silica fume in concrete is as a pozzolanic material due to its very fine particles, which improves the mechanical and durability properties of concrete and helps in producing high-performance concrete. This by-product can be added directly to the concrete mixture or as a blend of cement and silica fume. The utilization of silica fume in concrete has become a common scenario in the construction industry. This, not only solves the problem of large disposal problems but also solves the environmental issues of conventional concrete. Due to many important mechanisms, silica fume, when employed as a cementitious ingredient in concrete, can greatly improve the strength and other mechanical qualities of the concrete.

MIS DESIGNATION:

Different designations of various concrete mixes are represented below:

Table: 1. Various Mix Designations.

Mix Designation	Group of Concrete mixes	Replacement of sand with Marble Dust (MD)	Addition of Silica Fumes (SF)
CM	Control Mix	0	0
M1	Group 1	10	4
M2		20	4
M3		30	4
M4		40	4
M5		50	4
M6	Group 2	10	6
M7		20	6
M8		30	6
M9		40	6
M10		50	6
M11		10	8

M12	Group 3	20	8
M13		30	8
M14		40	8
M15		50	8

MATERIAL USED:

Cement: Ordinary Portland Cement of grade 43 was obtained and used in this study which confirms to Indian Codal Provisions of IS: 8112. Different parameters of cement such as setting time and fineness of cement were find out through various laboratory tests.

Table: 2. Physical Properties of OPC 43 grade.

Property	Cement
Unit weight, Kg/m^3	3150
Specific gravity	3.15
Initial Setting Time (min.)	92
Final Setting Time (min.)	221

Fine Aggregates: Crushed sand was taken as fine aggregates. The determination of zone of sand was carried out with sieve analysis (gradation) according to the specifications of Indian Codal provisions of IS: 383-1970.

Table: 3. Physical Properties of Fine Aggregates

Test	Value Obtained
Specific Gravity	2.51
Fineness Modulus	2.29
Silt Content	4.13 %

Coarse aggregates: Crushed aggregates of nominal size 20mm and 10mm of angular shape were mixed together in proportion of 2:1 and gradation was done by sieve analysis.

Table: 4. Physical Properties of Graded Coarse Aggregates

Test	Results
Specific Gravity	2.75
Water Absorption	0.57 %

Marble Dust: Marble dust, used as a replacement material, was obtained from Vishwa karma Marble tiles &sanitary ware, Rajasthan. The specific gravity of marble dust is 2.79 g/cc.

Silica Fume: Silica fume, a cementitious material, was obtained Rajasthan. The specific gravity of Silica Fume is 2.3 g/cc.

RESULTS AND DISCUSSION

Slump test results:
To determine the workability of differentmixes of concrete, the slump flow test was performed and the test results are shown below.

Table: 5. Slump Flow Test Results.

Mix Designation	Slump Value (mm)
CM	86
M1	82
M2	84
M3	85
M4	81
M5	79
M6	83
M7	81
M8	78
M9	76
M10	77
M11	87
M12	84
M13	82
M14	79
M15	76

Table: 5 shows that the variation in slump values of all the concrete. It has been observed that the variation in the slump value of all the mixes was slight. The slump value of control concrete mix was 86 mm.Observations revealed that with the addition of replacement materials, the slump value decreases. But despite the decrease in the slump value, workable mix was produced at all replacement levels.

Compressive Strength Test:
Compressive strength test was performed in the laboratory to determine the compressive strength of concrete at all the replacement levels. For this, 3 cube specimens of each mix were tested at 7 days and 28 days of curing period.

Table: 6. Compressive Strength Test Results.

Mix Designation	At 7 days (MPa)	At 28 days (MPa)
CM	27.95	40.53
M1	28.12	41.28
M2	28.89	41.54
M3	29.10	42.03
M4	27.67	40.19
M5	26.03	38.58
M6	28.77	41.84
M7	29.25	42.65
M8	29.19	42.57
M9	28.32	41.67
M10	26.58	39.84
M11	28.97	42.54
M12	29.35	43.13
M13	28.85	42.87
M14	27.35	41.00
M15	26.76	38.19

Table: 6 illustrates the variation in the compressive strength values at 7 and 28 days. It can be clearly seen that the compressive strength of control mix was 27.95 MPa and 40.53 MPa at 7 days and 28 days respectively. The percentage increase or decrease can be found by comparing the compressive strength value of replacement concrete with the normal concrete value. The percentage increase/decrease is given by:

$$\frac{(\text{C.S.of green concrete} - \text{C.S. of normal concrete})}{\text{C.S. of normal concrete}} \times 100$$

The maximum percentage increase at 7 days comes out to be 5.01% for M12 concrete mix when compared to the control mix. Whereas, the maximum percentage increase at 28 days comes out to be 6.42% for M12 concrete mix when compared to the control mix.

Split Tensile Strength:

Three cylindrical concrete specimens were prepared for all the concrete mixes so that the split tensile strength could be determined which were cured at 7 days and 28 days in the laboratory.

Table: 7. Spit Tensile Strength Test Results.

Mix Designation	At 7 days (MPa)	At 28 days (MPa)
CM	3.01	3.92
M1	2.65	3.67
M2	2.51	3.51
M3	2.72	3.77
M4	2.58	3.48
M5	2.34	3.19
M6	3.08	3.76
M7	2.99	3.95
M8	2.86	3.81
M9	2.76	3.62
M10	2.49	3.33
M11	3.02	3.88
M12	3.15	4.12
M13	2.97	4.06
M14	2.89	3.81
M15	2.55	3.52

Table: 7 illustrates the variation in the Split tensile strength value at 7 and 28 days. It can be seen the split tensile strength of control mix was 3.01 MPa and 3.92 MPa at 7 days and 28 days respectively. The percentage increase or decrease can be found by comparing the split tensile strength value of replacement concrete with the normal concrete value. The percentage increase/decrease is given by:

$$\frac{(\text{S.T.S.of green concrete} - \text{S.T.S. of normal concrete})}{\text{S.T.S. of normal concrete}} \times 100$$

The maximum percentage increase at 7 days comes out to be 4.65% for M12 concrete mix when compared to the control mix.Whereas, the maximum percentage increase at 28 days comes out to be 5.10% for M12 concrete mix when compared to the control mix.

Flexural Strength:

Beam specimens were casted for all the concrete mixes so that the flexural strength was determine at different curing period i.e. 7 days and 28 days. The results of the test were obtained and represented below.

Table: 8. Flexural Strength Test Results.

Mix Designation	At 7 days (MPa)	At 28 days (MPa)
CM	3.28	4.53
M1	3.16	4.74
M2	3.27	4.91
M3	3.35	4.99
M4	3.19	5.05
M5	3.08	4.69
M6	3.26	4.91

M7	3.34	5.08
M8	3.47	5.24
M9	3.31	5.01
M10	3.12	4.84
M11	3.33	4.99
M12	3.42	5.16
M13	3.53	5.34
M14	3.38	5.1
M15	3.24	4.92

Table: 8 illustrates the variation in the flexural strength values at 7 and 28 days. It can be seen that the flexural strength of control mix was 3.28 MPa and 4.53 at 7 and 28 days respectively. The percentage increase or decrease can be found by comparing the flexural strength value of replacement concrete with the normal concrete value. The percentage increase/decrease is given by:

$$\frac{(\textbf{F.S.of green concrete} - \textbf{F.S. of normal concrete})}{\textbf{F.S. of normal concrete}} \text{ x } 100$$

The maximum percentage increase at 7 days comes out to be 7.62% for M13 concrete mix when compared to the control mix. Whereas, the maximum percentage increase at 28 days comes out to be 17.88% for M13 concrete mix when compared to the control mix.

CONCLUSION

The final conclusions which have been drawn for the present study are as follows:

1. The slump value of control concrete mix was 86 mm and the variation in slump values of all the replacement levels of concrete mixes is very less. Observations revealed that with the addition of replacement materials, the slump value decreased. However, despite the decrease in the slump value, workable mix was produced at all replacement levels.
2. The compressive strength of the control mix was 27.95 MPa and 40.53 MPa at 7 days and 28 days respectively. The maximum compressive strength at 7 days was 29.35 MPa for M12, which is 5.01% higher than the control mix. Similarly, at 28 days, the maximum compressive strength was 43.13 MPa for M12, which is 6.42% higher than the control mix.
3. The split tensile strength of the control mix was 3.01 MPa and 3.92 MPa at 7 days and 28 days respectively. The maximum split tensile strength at 7 days was 3.15 MPa for M12, which is 4.65% higher than the control mix. Similarly, at 28 days, the maximum split tensile strength was 4.12 MPa for M12, which is 5.10% higher than the control mix.
4. The flexural strength of the control mix was 3.28 MPa and 4.53 MPa at 7 days and 28 days respectively. The maximum flexural strength at 7 days was 3.53 MPa for M13, which is 7.62% higher than the control mix. Similarly, at 28 days, the maximum flexural strength was 5.34 MPa for M13, which is 17.88% higher than the control mix.

It can be finally concluded that the addition of marble dust and silica fume enhances the strength parameters of concrete. Therefore, in the end, it is recommended to use the 20% marble dust and 8% silica fume to obtain the optimum strength of concrete of grade M30.

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