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Strength Study on Concrete by using Partial Replacement of Silica Fume with Cement and Marble Powder with Fine Aggregate

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Abstract
The purpose of this study is to adjust the qualities of concrete by using silica fume in place of cement and marble powder as a waste material to replace some of the sand. In the concrete mixtures, marble powder was substituted for sand at a weight-per-replacement rate of 5%, 10%, 15%, 20% and 25% and silica fume for cement at a rate of 5%, 7.5% and 12.5%. Effects on the concrete are noted. Marble powder may be disposed of and makes concrete lighter when it is used in construction. Tests are carried out to determine the compressive and tensile strengths of concrete at 28, 56 and 90 days. Marble powder will help to improve the strength of concrete. The strongest results were 15% sand replacement for marble powder and 7.5% cement replacement for silica fume.

Keywords: Marble Powder, Silica Fume, Compressive Strength, Split Tensile Strength

1. Introduction

The use of waste materials in concrete mixtures is currently acknowledged as one of the useful methods for getting rid of solid waste produced by other industries. Concrete is a composite material made of coarse aggregate joined by a fluid cement that gradually becomes harder. The most common types of concrete are those created with hydraulic cements or lime-based concretes like Portland cement concrete. Cement-based materials are currently the most significant construction materials, and it is quite likely that they will maintain this status in the future. The components of concrete include cement, sand, gravel, and water. Other than wood and steel, concrete is the most crucial component in the construction business.

2. Objectives

The objectives of this study are as follows:
(a) To use marble powder to improve the fine aggregate.
(b) Adding silica fume to cement to improve it.
(c) To assess the results of the split and compressive tensile strength tests.

3. Materials

3.1. Cement: In concrete, which is used for building and sets and hardens to bond other materials, cement is primarily employed as a binder material. OPC (Ordinary Portland Cement) of 53 grade is used in construction purpose and its properties presented in Table 1.

Table 1: Physical Properties of OPC

Sr. No.	Description of Item	Values
1	Specific Gravity	3.15
2	Fineness	8%
3	Water Absorption	2.8%
4	Bulk Density	1392 kg/m^3

3.2. Fine Aggregate: Fine aggregate is the essential ingredient in concrete that consists of natural sand or crushed stone. The quality of fine aggregate density substantially determines the hardened qualities of the concrete.

3.3. Coarse Aggregate: The aggregate which is retained over IS Sieve 4.75 mm is termed as coarse aggregate. The normal maximum size is gradually 10-20 mm as per IS383:1970.

3.4. Water: Water is one of the most important elements in construction and is required for the preparation of mortar, mixing of cement concrete and for curing work etc. The quality of water used has a direct impact on the strength of the motor and cement concrete in the construction work.

3.5. Marble powder: When marble powder is sawed, shaped, and polished in the marble business, waste marble powder is created as an industrial byproduct. Limestone-derived waste marble powder is a waste product that is neither recycled nor utilised in any industries.

3.6. Silica fume: silica fume, commonly known as micro silica, is utilised as an artificial pozzolonic additive. Silica fume is a by-product of making ferro silicon alloys or silicon from coal and quartz reduction in an electric arc furnace. A by-product of making elemental silicon or silicon-containing alloys in electric arc furnaces is silica fume. High-purity silicon is converted into silicon dioxide vapour at a temperature of around 2000° C, which oxidises and condenses into silica fume at lower temperatures.

4. Results

4.1. Compressive Strength Test: The cube specimens of 150 mm × 150 mm × 150 mm were cast and tested in compression testing machine for 7 and 28 days of curing period for different proportions of concrete mix and presented in Table 2.

Table 2: Compressive Strength of Concrete with Marble Powder as Partial Replacement of Sand in Concrete

Sr. No.	% of Marble Powder	Compressive Strength, N/mm²		
		28 Days	56 Days	90 Days
1	0%	39.12	42.62	45.72
2	5%	40.46	43.79	47.29
3	10%	41.97	45.61	48.99
4	15%	43.95	47.75	51.22
5	20%	42.45	46.12	49.65
6	25%	40.73	44.25	47.60

Table 3: Compressive Strength of Concrete with Silica Fume as Partially Replaced of Cement in Concrete

Sr. No.	% of Silica Fume	Compressive Strength, N/mm²		
		28 Days	56 Days	90 Days
1	0%	39.12	42.62	45.72
2	5%	40.64	44.28	47.44
3	7.5%	44.38	48.28	51.78
4	12.5%	41.24	44.72	48.18

Table 4: Compressive Strength of Concrete for Combined Partial Replacement of Cement by 7.5% of Silica Fume and Fine Aggregate by 15% of Marble Powder

Mix No.	Combined Replacement (%)	Compressive Strength, N/mm²		
		28 Days	56 Days	90 Days
1	0%	39.12	42.62	45.72
2	15% MP + 7.5% SF	46.75	50.80	54.57

4.2 Split Tensile Strength Test: At the age of 7 and 28 days, the cylindrical specimens (150 mm diameter × 300 mm height) were tested for evaluating the split tensile strength. The experiment is performed by putting a cylindrical sample horizontally between a compression testing machines loading surface and the load is applied until the cylinder fails along the vertical diameter.

Table 5: Split Tensile Strength of Concrete with Marble Powder as Partial Replacement of Sand in Concrete

Sr. No.	% of Marble Powder	Split Tensile Strength, N/mm²		
		28 Days	56 Days	90 Days
1	0%	3.79	4.12	4.42
2	5%	4.02	4.35	4.66
3	10%	4.13	4.47	4.81
4	15%	4.31	4.69	5.03
5	20%	4.20	4.57	4.91
6	25%	4.01	4.37	4.69

Table 6: Split Tensile Strength of Concrete with Silica Fume as Partially Replaced of Cement in Concrete

Sr. No.	% of Silica Fume	Compressive Strength, N/mm²		
		28 Days	56 Days	90 Days
1	0%	3.79	4.12	4.42
2	5%	4.02	4.39	4.68
3	7.5%	4.37	4.75	5.07
4	12.5%	3.71	4.04	4.32

Table 7: Split Tensile Strength of Concrete for Combined Partial Replacement of Cement by 7.5% of Silica Fume and Fine Aggregate by 15% of Marble Powder

Mix No.	Combined Replacement (%)	Compressive Strength, N/mm²		
		28 Days	56 Days	90 Days
1	0%	3.79	4.12	4.42
2	15% MP + 7.5% SF	4.68	5.11	5.52

5. Conclusion

(1) At 15% replacement of marble powder with fine aggregate, the compressive strength of concrete at 28, 56 and 90 days are 43.95, 47.75 and 51.22 N/mm^2.

(2) At 15% replacement of marble powder with fine aggregate, the split tensile strength of concrete at 28, 56 and 90 days are 4.31, 4.69 and 5.03 N/mm^2.

(3) At 7.5% replacement of silica fume with cement, the compressive strength of concrete at 28, 56 and 90 days are 44.38, 48.28 and 51.78 N/mm^2.

(4) At 7.5% replacement of silica fume with cement, the split tensile strength of concrete at 28, 56 and 90 days are 4.37, 4.75 and 5.07 N/mm^2.

(5) By constant maintaining of 15% MP + 7.5% SF, the compressive strength of concrete value at 28, 56 and 90 days are 46.75, 50.80 and 54.57 N/mm^2.

(6) By constant maintaining of 15% MP + 7.5% SF, the split tensile strength of concrete value at 28, 56 and 90 days are 4.68, 5.11 and 5.52 N/mm^2.

7. References

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