

Investigation on Strength Properties of Concrete using Marble Powder for Ecofriendly Environment

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Abstract. The development of a country is well exhibited through its infrastructure and technology, where civil engineering plays an influencing role in the development of a nation. In the field of construction, concrete is the major material that is used for building purpose. Particularly, natural aggregates are involved in making concrete sound better. The natural aggregates are getting diminished due to its extensive practice. If the same situation prolongs, the natural aggregate gets extinct. This paper majorly focuses on making the environment better and in order to achieve sustainability and to preserve the environment, marble powder is employed as partial material in the place of fine aggregate. On the other side, it aims at attaining the strength properties using M20 grade without any compromise. The test results clearly exhibits that incorporation of marble waste in making concrete is eco friendly as well as economical.

Introduction

The main source of making concrete is natural aggregate. There in making concrete, fine aggregate, coarse aggregate and cement are majorly added. In addition to it, admixtures and other materials are added if needed. Owing to the over exploitation of river sand, the natural resources are getting depleted. If the same situation prevails, after certain years there would not be any natural materials. And on the other side, the waste and the byproducts coming out from various industries are dumped into the land even without proper treatment which is causing adverse impact on environment. In order to balance the ecosystem and the depletion of resources, the attempt in incorporating industrial byproducts and municipal byproducts which have become successful [1]. Even though, it is successful, the research is being conducted in finding its optimum percentage of usage and identifying the suitable admixture to achieve the strength and required property [2]. This incorporation of certain raw materials and byproducts provides new dimension to the construction field and promotes the environment towards sustainability [3].

Marble waste is one of the wastes coming out from marble manufacturing industry, which is found in abundant places [4]. These wastes may differ in size. And according to its nature of size and treatment adopted, it may be incorporated in making concrete either as fine aggregate or coarse aggregate as partial replacement [5]. The strength and properties are found to be the same for the marble waste and this makes clear that the strength of concrete does not get affected [6]. By making use of these options we can make protect our environment and the generation of waste also gets decreased. Here lies the emerging concept of wealth from waste which paves way for economy of the nation and provides better sustainability [7]. Also, this helps in building the economy of a nation thereby paving way for energy conservation.

Objective

1. To adopt the concept of wealth from waste for energy consumption.
2. To identify an alternative material for natural aggregate.
3. To indicate the properties of marble waste.
4. To find the optimum percentage of replacement.

Materials and properties

Concrete is a building material composed of homogeneous mixture of natural aggregates with cement, the binding material. In order to bind these materials together and to make it workable, water is added to the mixture [8]. The mixture is prepared and the cube is casted according with mentioned proportions.

Portland Pozzolana cement

Portland Pozzolana Cement conforming to IS standard is adopted and the test is conducted [9]. The cement adopted is free from lumps and dust.

Table 1. Physical properties of OPC cement.

Composition	Percentage
Calcium Oxide, CaO	61-67%
Silicon oxide, SiO ₂	19-23%
Aluminium Oxide, Al ₂ O ₃	2.5-6%
Ferric Oxide, Fe ₂ O ₃	0-6%
Sulphate	1.5-4.5%

Table 2. Chemical properties of OPC cement.

Property	Value
Consistency	30%
Setting time - Initial	30 minutes
Setting time - Final	600 minutes
Fineness Modulus	3.5 %
Specific gravity	3.15

Fine aggregate

The fine aggregate confining to IS: 2386 (Part III) - 1963 of zone-II grading has been successfully adopted and various tests have been conducted [10]. Fine aggregate free from dust and impurities are used.

Table 3. Physical properties of fine aggregate.

Property	Value
Specific gravity	2.43
Fineness modulus	2.88
Grading	Zone –II

Coarse Aggregate

The coarse aggregate conforming to IS: 383-1970 of Zone-II grading were used [11]. The coarse aggregate of size 20mm size is adopted.

Table 4. Physical properties of coarse aggregate.

Property	Value
Specific gravity	2.71
Fineness modulus	6.68
Grading	Zone -II

Marble powder

Marble is one of the floor finishing materials used in the construction field. It is generally a metamorphic rock obtained as a transformation of pure limestone [12]. The color of the marble purely depends on its purity. Marble powder is obtained during the time of marble production at the industry [13].

Water

Water is another significant material in the process of concrete preparation. This makes all the materials to mix together and make it workable. It is also important to ensure proper water cement ratio in order to attain the required strength [14]. The water used should be clean. It has to be free from dust, impurities and chemical contaminants.

Strength test

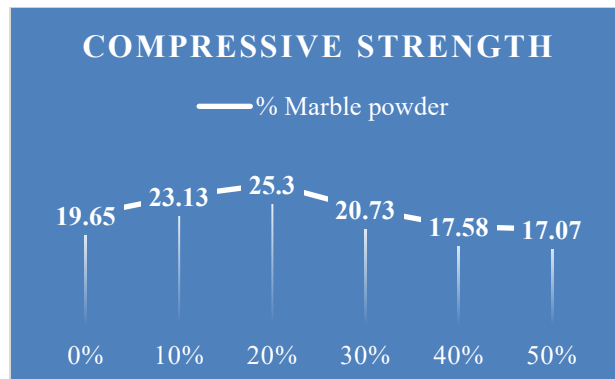
Compressive strength

Compressive strength of concrete is one of the prominent characteristics of concrete. The compressive strength of the concrete is determined using cube mould [15]. The mixture is prepared with different proportions of 10, 20, 30, 40 and 50% of marble powder with fine aggregate. The cube is casted and proper curing is done at 7th, 14th and 28th day of interval [16].

The compressive strength of concrete with different proportions of 10, 20, 30, 40 and 50% of marble powder with fine aggregate are shown below.

Table 5. Results of Compressive strength test

Mix	Compressive strength (N/mm ²)			Average compressive strength(N/mm ²)		
	7 days	14 days	28 days	7 days	14 days	28 days
CM	10.58	16.97	20.08	11.42	17	19.65
	12.35	17.29	19.77			
	11.33	17.09	19.02			
10%	13.37	20.08	22.2	12.9	19.62	23.13
	12.75	19.77	24.04			
	12.59	19.02	23.15			
20%	16.8	22	24.96	16	22.83	25.3
	16.26	22.01	25.91			
	14.96	24.05	25.06			
30%	16.96	22.94	23.95	17.05	24.38	20.73
	16.24	23.82	19.33			
	17.97	26.4	18.93			
40%	14.48	23.83	17.15	15.7	22.02	17.58
	16.8	22.06	18			
	15.8	20.17	17.06			
50%	15.56	11.02	15.37	14.55	15.23	17.07
	12.71	14.51	14.44			
	15.39	20.17	21.42			



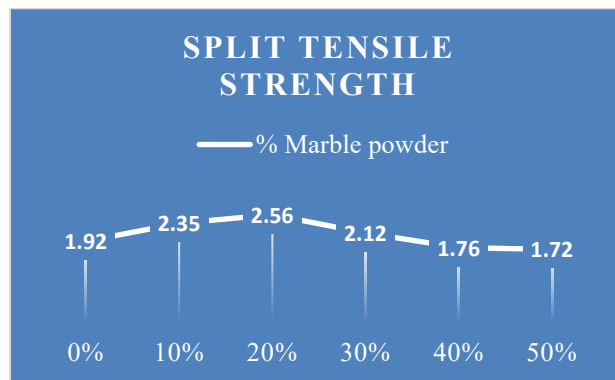
From the examination, it is clearly witnessed that the compressive strength increased gradually and after a stage on additional increase in percentage of marble powder, the compressive strength gets decreased.

Split tensile strength

The split tensile strength of hardened concrete is useful in determining the performance of concrete [17]. Split tensile strength test is obtained by casting and appropriate curing at different ages of 7, 14, 28 days [18].

Table 6. Results of Split tensile strength test

Mix	Split tensile strength (N/mm ²)			Average Split tensile strength(N/mm ²)		
	7 days	14 days	28 days	7 days	14 days	28 days
CM	1.34	1.59	2.02	1.35	1.67	1.92
	1.4	1.71	1.92			
	1.3	1.70	1.82			
10%	1.42	2.01	2.21	1.43	1.95	2.35
	1.42	1.95	2.49			
	1.44	1.90	2.35			
20%	1.48	2.19	2.53	1.51	2.27	2.56
	1.5	2.20	2.62			
	1.54	2.41	2.52			
30%	1.1	2.28	2.45	1.16	2.39	2.12
	1.18	2.38	1.99			
	1.2	2.52	1.92			
40%	1.3	2.41	1.75	1.31	2.21	1.76
	1.32	2.21	1.82			
	1.32	2.02	1.71			
50%	1.18	1.15	1.57	1.15	1.56	1.72
	1.16	1.41	1.41			
	1.1	2.11	2.19			



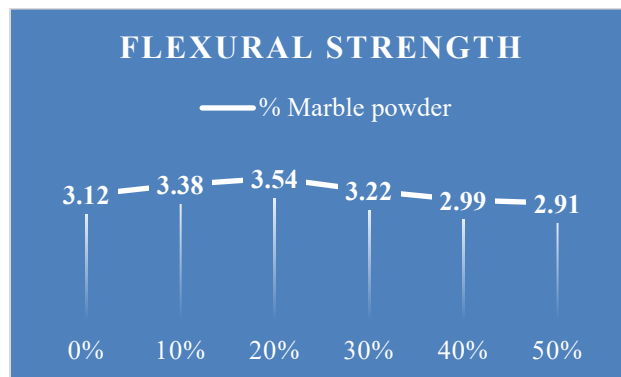
From the test conducted, it is clearly perceived that the split tensile strength increased gradually and after a stage on further increase in percentage of marble powder, the split tensile strength gets decreased.

Flexural strength

The flexural strength of hardened concrete is useful in determining the performance of concrete [19]. Flexural strength test is obtained by casting and appropriate curing at different ages of 7, 14, 28 days [20].

Table 7. Results of Flexural strength test

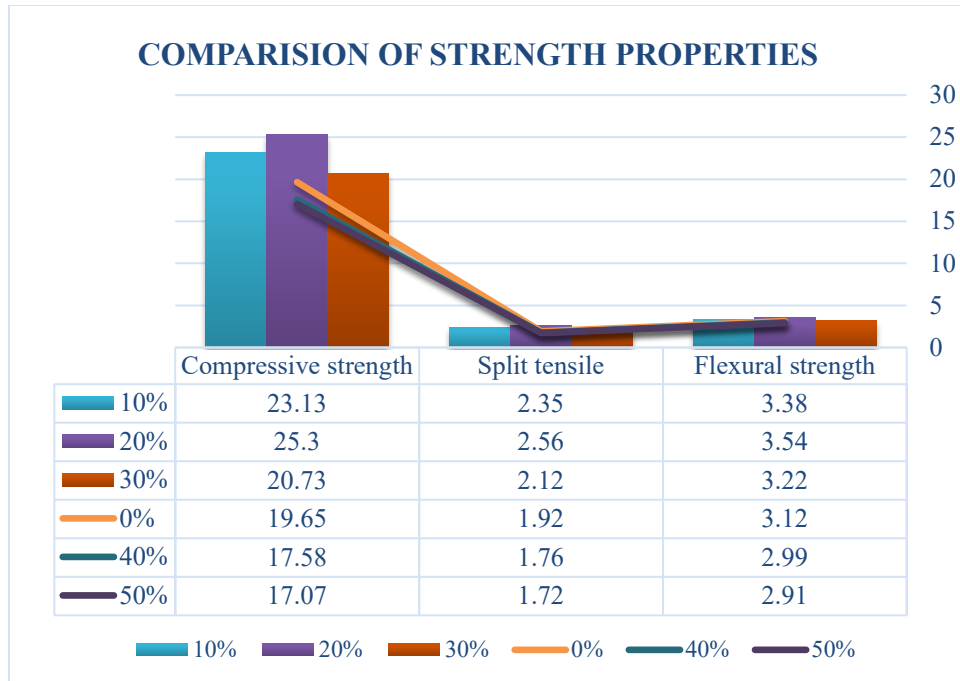
Mix	Flexural strength (N/mm ²)			Average Flexural strength (N/mm ²)		
	7 days	14 days	28 days	7 days	14 days	28 days
CM	2.29	2.89	3.14	2.38	2.90	3.12
	2.48	2.91	3.12			
	2.37	2.90	3.09			
10%	2.61	3.15	3.31	2.54	3.11	3.38
	2.51	3.11	3.44			
	2.50	3.07	3.39			
20%	2.90	3.29	3.52	2.83	3.33	3.54
	2.85	3.28	3.58			
	2.73	3.41	3.51			
30%	2.87	3.35	3.45	2.88	3.46	3.22
	2.81	3.42	3.15			
	2.95	3.61	3.07			
40%	2.69	3.42	2.95	2.77	3.29	2.99
	2.84	3.29	3.12			
	2.79	3.16	2.89			
50%	2.78	2.35	2.81	2.69	2.68	2.91
	2.53	2.65	2.72			
	2.75	3.05	3.20			



From the test conducted, it is clearly witnessed that the flexural strength increased gradually and after a stage on further increase in percentage of marble powder, the flexural strength gets decreased.

Conclusion

The tests had been conducted on hardened concrete with different proportion of marble powder as partial replacement for fine aggregate and the results have been noted. From the results, the following observations are made.



- The compressive strength of concrete increases up to 20% of replacement.
- The split tensile strength of concrete increases up to 20% of replacement.
- The flexural strength of concrete increases up to 20% of replacement.

From these results, it has become evident that, the optimum percentage of replacement for fine aggregate by marble powder is 20. Also, it has been observed that, the decrease in strength beyond 20% is due to the nature and strength of the material. This evidently paves way for attaining better strength and sustainability.

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