Stone Waste :Effective Replacement of Cement for Establishing Green Concrete

Ankit Nileshchandra Patel, Jayeshkumar Pitroda

Abstract*—Stone waste is one of the most active research areas that encompass a number of disciplines including civil engineering and construction materials. In India, stone dust is settled by sedimentation and then dumped away which results in environmental pollution, in addition to forming dust in summer and threatening both agriculture and public health. Therefore, utilization of the stone dust in various industrial sectors especially the construction, agriculture, glass and paper industries would help to protect the environment. It is most essential to develop eco-friendly concrete from stone waste.In this research study the(PPC) cement has been replaced by stone waste accordingly in the range of 0%, 10%, 20%, 30% 40%, & 50% by weight for M-25 grade concrete. Concrete mixtures were produced, tested and compared in terms of workability and strength to the conventional concrete. These tests were carried out to evaluate the mechanical properties for 7, 14 and 28 days. As a result, the compressive strength increased up to 20% replacing of stone waste. This research work is concerned with the experimental investigation on strength of concrete and optimum percentage of the partial replacement by replacing (PPC) cement via 0%, 10%, 20%, 30%, 40% and 50% of stone waste. Keeping all this view, the aim of the investigation is the behavior of concrete while replacing of waste with different proportions of stone waste in concrete by using tests like compression strength.

***Keywords*—Industrial Waste,Stone Waste, Eco-Friendly, LowCost, Compressive Strength, PPC Cement**

I. INTRODUCTION

The advancement of concrete technology can reduce the consumption of natural resources and energy sources and lessen the burden of pollutants on the environment. The cost of natural resources is also increased. They have forced to focus on recovery, reuse of natural resources and find other alternatives. Presently large amounts of Stone waste are generated in natural stone processing plants with an important impact on environment and humans. The use of the replacement materials offer cost reduction, energy savings, arguably superior products, and fewer hazards in the environment.

The Portland Pozzolana Cement is a kind of Blended Cement which is produced by either intergrinding of OPC clinker along with gypsum and pozzolanic materials in certain proportions. PPC is produced when pozzolans are used in the mixture. Pozzolans are the siliceous and aluminous material which in itself possesses little, or no cementitious properties but will in finely divided form and in the presence of moisture, chemically react with calcium hydroxide at ordinary temperature to form compounds possessing cementitious properties.

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A pozzolans is a cement extender improving the strength and durability of the cement or even reducing the costs of producing concrete. PPC may take a longer time to settle than OPC, but it will eventually produce similar results given time.

Stone blocks are cut into smaller blocks in order to give them the desired shape and size. During the process of cutting, in that original Stone mass is lost by 25% in the form of dust. Every year 250-400 tons of Stone waste are generatedon site. The Stone cutting plants are dumping the powder in any nearby pit or vacant spaces, near their unit although notified areas have been marked for dumping. This leads to serious environmental and dust pollution and occupation of a vast areaof land, especially after the powder dries up so it is necessary to dispose the Stone waste quickly and use in the construction industry.

II. EXPERIMENTAL MATERIALS

A. Materials

a) Stone waste

The principle waste coming into the stone industry is the stone itself, specifically in the forms of overburden, screening residual, stone fragments. Stone wastes are generated as a waste during the process of cutting and polishing. It is estimated that 175 million tons of quarrying waste are produced each year, and although a portion of this waste may be utilized on-site, such as for excavation pit refill or berm construction, The disposals of these waste materials acquire large land areas and remain scattered all around, spoiling the aesthetic of the entire region. It is very difficult to find a use for all scrap stone and fines produced.

Stone waste canbe used in concrete to improve its strength and other durability factors.Stone waste can be used asapartial replacement of cementorasapartialreplacementoffineaggregatesandasa supplementary additiontoachievedifferent propertiesof concrete.

Figure: 1. Stone waste

Source: Uma Marble, GIDC, Vallabh Vidyanagar, Anand, Gujarat

Table–1
Properties Of Stone Waste

Constituent	Value (%)
SiO_2	36.96
Al_2O_3	0.49
Fe_2O_3	3.40
CaO	28.60
MgO	6.08
SO_3	0.15
LOI	22.16
TOTAL	97.78

Source: GEO TEST HOUSE, Gorwa estate Baroda

b) Cement (PPC)

The most common cement used is an Portlandpozzolana cement. ThePortlandpozzolana cementof 53 grade (SANGHI cement PPC) conforming to IS: 1489 (PART-1) 1991is beingused. Many tests were conducted on cement; some of them are consistency tests, setting tests, soundness tests, etc.

Figure: 2 SANGHI Cement (PPC 53 grade)

Table-2
Properties Of (Ppc) Cement

Sr. No.	Physical properties of SANGHI PPC 53cement	Result	Chemical properties of SANGHI PPC 53cement	Result (%)
1	Specific gravity	2.93	SiO_2	23.5
2	Standard consistency (%)	31.5 %	Al_2O_3	12.9
3	Initial setting time (hours, min)	200 min	CaO	47.0
4	Final setting time (hours, min)	230 min	MgO	1.74
5	Compressive strength N/mm^2 at 28 days	51 N/mm^2	Fe_2O_3	2.04
6	-	-	Loss on Ignition	1.05

c) Aggregate

Aggregates are the important constituents in concrete. They give body to the concrete, reduce shrinkage and effect economy. One of the most important factors for producing workable concrete is a good gradation of aggregates. Good grading implies that a sample fraction of aggregates in required proportion such that the sample contains minimum voids. Samples of the well graded aggregate containing minimum voids require minimum paste to fill up the voids in the aggregates. Minimum paste means less quantity of cement and less water, which are further mean increased economy, higher strength, lower shrinkage and greater durability.

d) Coarse Aggregate

The fractions from 20 mm to 4.75 mm are used as coarse aggregate. The Coarse Aggregates from crushed Basalt rock, conforming to IS: 383 is being use. The Flakiness and Elongation Index were maintained well below 15%.

Figure: 3 coarse aggregate

Figure: 4 Grit

e) Fine aggregate

Those fractions from 4.75 mm to 150 microns are termed as fine aggregate. The river sand is used in combination as fine aggregate conforming to the requirements of IS: 383. The river sand is washed and screen, to eliminate deleterious materials and oversize particles.

Figure: 5 Fine aggregate

Table-3
Properties Of Fine Aggregate, Course Aggregate

Property	Fine Aggregate	Coarse Aggregate	
		20 mm down	10 mm down
Fineness modulus	3.35	7.54	3.19
Specific Gravity	2.38	2.76	2.69
Bulk Density (gm/cc)	1753	1741	1711
Water absorption (%)	1.20	1.83	1.35

f) Water

Water is an important ingredient of concrete as it actually participates in the chemical reaction with cement. Since it helps to from the strength giving cement gel, the quantity and quality of water are required to be looked into very carefully.

III. DESIGN MIX

A mix M25 grade was designed as per Indian Standard method (IS 10262-2009) and the same was used to prepare the test samples.The design mix proportion is done in Tab 4.

Table-4
Design Mix Proportion For (M25 Mix)

	W (Lit)	C (Kg/m^3)	F.A. (Kg/m^3)	C.A. (Kg/m^3)
By weight, [gms]	191.60	479	485.75	1197.03
By volume, [m^3]	0.40	1	1.01	2.50

W= Water, C= cement, F.A. = Fine Aggregate, C.A. = Coarse Aggregate

Table-5
Concrete Design Mix (M25 Mix) Proportions

Sr.No.	Concrete Type	Concrete Design Mix Proportion				
		W/C ratio	C	F.A.	C.A.	S.W.
1	B0	0.40	1.00	1.01	2.50	-
2	B1	0.40	0.90	1.01	2.50	0.10
3	B2	0.40	0.80	1.01	2.50	0.20
4	B3	0.40	0.70	1.01	2.50	0.30
5	B4	0.40	0.60	1.01	2.50	0.40
6	B5	0.40	0.50	1.01	2.50	0.50

C= cement, F.A. = Fine Aggregate, C.A. = Coarse Aggregate,S.W. = Stone waste

IV. EXPERIMENTAL SET UP

Table-6 Design Mix Proportion For Various Concrete

Sr.No.	Concrete Type	PPC cementReplacement with Stone waste
1	B0	Standard Concrete
2	B1	10% replacement
3	**B2**	**20% replacement**
4	B3	30% replacement
5	B4	40% replacement
6	B5	50% replacement

V. EXPERIMENTAL METHODOLOGY

The evaluation of stone waste for use as a replacement of (PPC) cement material begins with the concrete testing. Concrete contains cement, water, fineaggregate, coarse aggregate and grit. With the control concrete, i.e. 10%, 20%, 30%, 40%, and 50% of the (PPC) cement is replaced with stone waste,the data from the stone waste is compared with data from a standard concrete without stone waste. Three cube samples were cast on the mould of size 150*150*150 mm for each 1:1.01:2.50 concrete mix with partial replacement of (PPC) cement with a w/c ratio as 0.40 were also cast. After about 24 h the specimens were de-moulded and water curing was continued till the respective specimens were tested after 7,14 and 28 days for compressive strength test.

Compressive strength

Compressive strength tests were performed on compression testing machine using cube samples. Three samples per batch were tested with the average strength values reported in this paper. The loading rate on the cube is 35 N/mm^2 per min. The comparative studies were made on their characteristics for concrete mix ratio of 1:1.01:2.50 with partial replacement of (PPC) cement with stone waste as 10%, 20%, 30%, 40% and 50%.

Figure: 6 Setup of Compression Strength Testing Machine

Table -7 Compressive Strength Of Cubes(150x150x150)For M25 Mix At 7, 14, 28 Days

Concrete Type	Average Ultimate Compressive Strength at 7 days [N/mm^2]	Average Ultimate Compressive Strength at 14 days [N/mm^2]	Average Ultimate Compressive Strength at 28 days [N/mm^2]
B0	27.56	30.22	44.44
B1	18.96	20.59	31.56
B2	22.67	26.52	**29.04**
B3	13.67	20.07	21.04
B4	12.44	19.41	19.85
B5	6.81	10.07	10.81

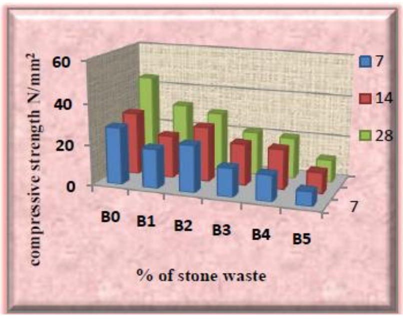

Figure: 7 % Replacement of stone waste V/S Compressive Strength (N/mm^2) of Concrete for M25 mix at 7, 14 and 28 days

VI. ECONOMIC FEASABILITY

Table- 8 Costs Of Materials

Sr. No.	Materials	Rate (Rs/Kg)
1	Cement (SANGHI PPC 53 grade)	5.80
2	Fine aggregate (Regional)	0.60
3	Coarse aggregate (Regional)	0.65
4	Stone waste	0.20

Table - 9
Total Cost Of Materials For M25designe Mix Concrete (1:1.01:2.50) Per M^3

C. T.	Consumption of Design Mix Proportions For M25 Concrete (1:1.01:2.50)				Total Cost /m^3	% Cost change
	C	F.A.	C.A.	S.W.		
B0	479.00	485.75	718.22	-	3847.72	0
B1	431.10	485.75	718.22	47.90	3579.48	-6.97
B2	383.20	485.75	718.22	95.80	3311.24	-13.94
B3	335.50	485.75	718.22	143.70	3043.00	-20.91
B4	287.40	485.75	718.22	191.60	2774.76	-27.88
B5	239.50	485.75	718.22	239.50	2506.52	-34.85

C.T. = Concrete Types,C= Cement, F.A.= Fine Aggregate, C.A.= Coarse Aggregate, S.W. =Stone waste

VII.CONCLUSION

Based on limited experimental investigations concerning the compressive strength of concrete, the following observations are made regarding the resistance of partially replaced stone waste:

(a) Compressive strength increase when replacement of stone waste percentage increases when compare to traditional concrete.
(b) From this test, replacement of (PPC) cement with this stone waste material provides maximum compressive strength at 20% replacement.
(c) Waste utilization making it more environmentally friends.
(d) Utilization of Stone waste and its application are used for the development of the construction industry, Material sciences.
(e) Lower manufacturing cost of PPC compared to OPC
(f) It is the possible alternative solution of safe disposal of Stone waste.
(g) Due to Longer setting time making it more workable than OPC

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