STONE WASTE AS A GROUNDBREAKING CONCEPTION FOR THE LOW COST CONCRETE

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Abstract: **Stone wastes are generated as a waste during the process of cutting and polishing. Stone industry produces large amounts of Stone waste which causes environmental problems. To produce low cost concrete by replacing cement with Stone Waste & to reduce disposal and pollution problems. The innovative use of Stone Waste in concrete by replacing OPC and PPC cement with this material was the other alternative of the traditional concrete. The aim of this research is to replace the OPC and PPC cement 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. The Compression Strength Test is carried out to evaluate the mechanical properties for 7, 14 and 28 days. As a result, the compressive Strength increased up to 30% replacing of Stone Waste in OPC and 20% replacing of stone waste in PPC. This research work is concerned with the experimental investigation on strength of concrete and optimum percentage of the partial replacement by replacing OPC and 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 Cement with different proportions of Stone Waste in concrete by performing the tests like compression strength and also try to find the economic cost by replacing the Stone Waste with OPC and PPC cement.**

Keywords—Stone Waste, Eco-Friendly, Low Cost, Compressive Strength, OPC and PPC Cement

I INTRODUCTION

Use of stone waste in various engineering applications can solve the problem of disposals of stone waste and other purposes. Stone waste can be used in concrete to improve its strength and other durability factors. Stone waste can be used as a partial replacement of cement or replacement of fine aggregate and as a supplementary addition to achieve different properties of concrete. 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 25-30% in the form of dust. 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 area of land, especially after the powder dries up. So it is necessary to dispose the Stone waste quickly and use in the construction industry.

The use of the replacement materials offer cost reduction, energy savings, arguably superior products, and fewer hazards in the environment. Concrete is a composite construction material composed of cement, aggregate (generally a coarse aggregate made of gravels or crushed rocks such as limestone, or granite, plus a fine aggregate such as sand), water, and/or admixtures. Concrete is made by mixing: Cement, water, course fine aggregates and admixtures (if required). The objectives are to mix these materials traditionally to make concrete that is easy to: Transport, place, compact, finish and to give a strong and durable product. The proportionate quantity of each material (i.e. Cement, water and aggregates) affects the properties of hardened concrete.

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 porcelain is 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. 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.

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 can be used in concrete to improve its strength and other durability factors. Stone waste can be used as a partial replacement of cement or as a partial replacement of fine aggregates and as a supplementary addition to achieve different properties of 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, Gujarat

b) Cement (OPC)

The most common cement used is an ordinary Portland cement. The Ordinary Portland Cement of 53 grades conforming to IS: 8112-1989 is being used.

c) Cement (PPC)

The most common cement used is Portland pozzolana cement. The Portland pozzolana cement of 53 grades conforming to IS: 1489 (PART-1) 1991 is being used.

TABLE-2
CHEMICAL PROPERTIES OF (OPC and PPC) CEMENT

Sr. No.	Constituents	Chemical properties of OPC 53 Cement (%)	Chemical properties of PPC 53 Cement (%)
1	Chloride	0.07	0.01
2	SiO_2	28.7	23.5
3	Al_2O_3	13.5	12.9
4	CaO	53.6	47.0
5	MgO	2.21	1.74
6	Fe_2O_3	2.27	2.04
7	Loss on Ignition	2.05	1.05

Source: Geo Test House, Gorwa Estate, Baroda, Gujarat

d) 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 good gradation of aggregates. Good grading implies that a sample fractions 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 is mean less quantity of cement and less water, which are further mean increased economy, higher strength, lower shrinkage and greater durability.

e) 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 used. The Flakiness and Elongation Index were maintained well below 15%.

Figure: 2 Coarse aggregate

Figure: 3 Grit

f) Fine aggregate

Those fractions from 4.75 mm to 150 micron 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 wash and screen, to eliminate deleterious materials and over size particles.

Figure: 4 Fine aggregate

TABLE-3
PROPERTIES OF FINE AGGREGATE, COURSE AGGREGATE

Property	Fine Aggregate	Coarse Aggregate	
		20 mm	10 mm
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

g) 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 is required to be looked into very carefully.

III DESIGN MIX

A mix M25 grade was designed as per Indian Standard method (IS 10262-1982) and the same was used to prepare the test samples. The design mix proportion is done in Table 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.	Types of Concrete	Concrete Design Mix Proportion				
		W/C ratio	C	F.A.	C.A.	S.W.
1	A0	0.40	1.00	1.01	2.50	-
2	A1	0.40	0.90	1.01	2.50	0.10
3	A2	0.40	0.80	1.01	2.50	0.20
4	A3	0.40	0.70	1.01	2.50	0.30
5	A4	0.40	0.60	1.01	2.50	0.40
6	A5	0.40	0.50	1.01	2.50	0.50
7	B0	0.40	1.00	1.01	2.50	-
8	B1	0.40	0.90	1.01	2.50	0.10
9	B2	0.40	0.80	1.01	2.50	0.20
10	B3	0.40	0.70	1.01	2.50	0.30
11	B4	0.40	0.60	1.01	2.50	0.40

12	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 DESIGN

TABLE-6
DESIGN MIX PROPORTION FOR VARIOUS CONCRETE

Sr. No.	Types of Concrete	Cement Replacement with Stone waste
1	A0	Standard Concrete (OPC)
2	A1	10% replacement
3	A2	20% replacement
4	**A3**	**30% replacement**
5	A4	40% replacement
6	A5	50% replacement
7	B0	Standard Concrete (PPC)
8	B1	10% replacement
9	**B2**	**20% replacement**
10	B3	30% replacement
11	B4	40% replacement
12	B5	50% replacement

V EXPERIMENTAL METHODOLOGY

The evaluation of stone waste for use as a replacement of (OPC and PPC) cement material begins with the concrete testing. Concrete contains cement, water, fine aggregate, coarse aggregate and grit. With the control concrete, i.e. 0%, 10%, 20%, 30%, 40%, and 50% of the (OPC and 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 (OPC and PPC) cement with 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 (OPC and PPC) cement with stone waste as 0%, 10%, 20%, 30%, 40% and 50%.

Figure: 5 Setup of Compression Strength Testing Machine with Cube

TABLE -7
COMPRESSIVE STRENGTH OF CUBES (150X150X150) FOR M25 MIX AT 7, 14, 28 DAYS

Types of Concrete	Average Compressive Strength			% Change of Average Compressive Strength		
	7 days [N/mm^2]	14 days [N/mm^2]	28 days [N/mm^2]	7 days [N/mm^2]	14 days [N/mm^2]	28 days [N/mm^2]
A0	29.26	33.93	45.48	0	0	0
B0	27.56	30.22	44.44	0	0	0
A1	25.48	32.89	34.67	-12.91	-3.06	-23.76
B1	18.96	20.59	31.56	-31.20	-31.86	-28.98
A2	26.67	33.78	35.41	-8.85	-0.44	-22.14
B2	22.67	26.52	29.04	-17.74	-12.24	-34.65
A3	16.22	29.19	29.78	-44.56	-13.96	-34.52
B3	13.67	20.07	21.04	50.39	-33.58	-52.65
A4	15.85	17.78	22.07	-45.83	-47.59	-51.47
B4	12.44	19.41	19.85	-54.86	-35.77	-55.33
A5	11.41	16.44	16.59	-61.00	-51.54	-63.52
B5	6.81	10.07	10.81	-75.29	-66.67	-75.67

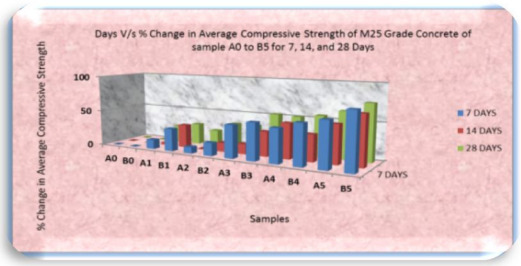

Figure: 6 % Change in Average Compressive Strength V/S % of Stone Waste Replacement of Concrete for M25 mix at 7, 14 and 28 days

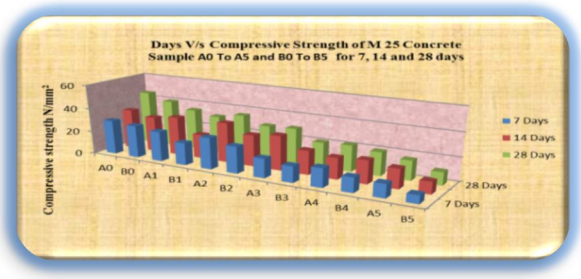

Figure: 7 % Replacement of stone waste V/S Compressive Strength (N/mm^2) of Concrete for M25 mix at 7, 14 and 28 days

VI. ECONOMIC FEASABILITY

TABLE- 8
COSTS OF MATERIALS

Sr. No.	Materials	Rate (Rs/Kg)
1	Cement (OPC 53 grade)	6.40
2	Cement (PPC 53 grade)	5.80
3	Fine aggregate (Regional)	0.60
4	Coarse aggregate (Regional)	0.65
5	Stone waste	0.20

TABLE - 9
TOTAL COST OF MATERIALS FOR M25 DESIGN 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.		
A0	479.00	485.75	718.22	-	4135.12	0
B0	479.00	485.75	718.22	-	3847.72	0
A1	431.10	485.75	718.22	47.90	3838.14	-7.18
B1	431.10	485.75	718.22	47.90	3579.48	-6.97
A2	383.20	485.75	718.22	95.80	3541.16	-14.36
B2	383.20	485.75	718.22	95.80	3311.24	-13.94
A3	335.50	485.75	718.22	143.70	3244.18	-21.54
B3	335.50	485.75	718.22	143.70	3043.00	-20.91
A4	287.40	485.75	718.22	191.60	2947.20	-28.72
B4	287.40	485.75	718.22	191.60	2774.76	-27.88
A5	239.50	485.75	718.22	239.50	2650.22	-35.90
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 (OPC) cement with this stone waste material provides maximum compressive strength at 30% replacement.
(c) From this test, replacement of (PPC) cement with this stone waste material provides maximum compressive strength at 20% replacement.
(d) The Cost change is 21.54% when replacement of stone waste percentage is 30% of the OPC cement compare to standard concrete.
(e) The Cost change is 13.94% when replacement of stone waste percentage is 20% in the PPC cement compare to standard concrete.
(f) Waste utilization making it more environmental friendly.
(g)Utilization of Stone waste and its application are used for the development of the construction industry, Material sciences.
(h) Lower manufacturing cost of PPC concrete compared to OPC concrete.
(i) It is the possible alternative solution of safe disposal of Stone waste.
(j) Due to Longer setting time making it more workable than OPC.

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