Impact Factor (SJIF): 4.542

International Journal of Advance Research in Engineering, Science & Technology

e-ISSN: 2393-9877, p-ISSN: 2394-2444

Volume 4, Issue 4, April-2017

"Comparative study on concrete by partial replacement of marble waste with fine aggregate and ceramic waste with coarse aggregate"

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Abstract *—the global consumption of aggregate is very high due to the extensive use of concrete. In particular, the demand of aggregate is quite high in developing countries due to rapid infrastructural growth. The shortage of aggregate and steep rise in its cost. So, overall project cost of construction is also increase. These factors have resulted in finding an alternate source of material for aggregate in the construction field. In other side the ceramic and marble industries have problem of dumping waste generated from production. An attempt has been made to find the suitability of the possible substitute for ceramic wastes as conventional coarse aggregate and marble waste as fine aggregate with 0%, 10%, 20%, 30%, 40%, 50% and grade is M25, M30 and M35 with curing period of 7and 28 days. The compressive, flexural and split tensile strength of concrete with ceramic and marble waste is determine and compare them with conventional concrete.*

Keywords-Ceramic Waste, Marble Waste, Concrete. Physical Properties, Mechanical Properties.

Abbreviation:-CCA-Ceramic coarse aggregate, MFA-Marble fine aggregate.

I. INTRODUCTION

Concrete is a widely used material in the world. Based on global usage, it is placed at second position after water. Aggregate is an essential component of concrete. The most commonly used fine aggregate is natural river or pit sand and coarse aggregate is conveyed from rock crushing site.

The ceramic waste is durable, hard and highly resistant to biological, chemical and physical degradation. Different types of ceramic products are:

- Wall And Floor Tiles
- Bricks And Roof Tiles
- Table-And Ornamental ware (Household Ceramics)
- Refractory Products
- Sanitary ware
- Vitrified Clay Pipes
- Expanded Clay Aggregates

In the ceramic industry, nearly 30% waste material generated from the full production. These wastes are not recycled in any course at present owning a problem in present-day society. Thus, a suitable form of management is required in society to attain sustainable growth. In other side the natural aggregate are not easily available in metro cities. Thus it will transport from rock quarry side and cost will be increase and overall project cost also increase.

Marble has been commonly used as a building material since the very large times. The industry's disposal of the marble powder material, consisting of very fine powder, today constitutes one of the environmental problems around the world. Marble blocks are cut into smaller blocks in order to give them the desired smooth shape. During the cutting process about 25% the original marble mass is lost in the form of dust. Therefore, utilization of the marble dust in various industrial sectors especially the construction, agriculture, glass and paper industries would help to protect the environment In addition to marble powder, silica fume, fly ash, pumice powder and ground granulated blast furnace slag are widely used in the construction sector as a mineral admixtures instead of cement. Marble dust can be used either to produce new products or as an admixture so that the natural sources are used more efficiently and the environment is saved from dumpsites of marble waste.

When a range of byproducts are available at disposal it becomes critical to have a comparative study of the individual features. However any such comparative study bringing out contrasting properties and distinguishing characteristics of the byproducts is still lacking. This paper tries to find the suitability of the possible substitute for ceramic wastes as conventional coarse aggregate and marble waste as fine aggregate.

II. MATERIAL

A. Marble Waste

Marble Waste used in dissertation is locally available for special plaster in construction. The physical properties of Marble Waste conforming to Zone II as per IS 383 (1987), with a fineness modulus of 3.22 and a specific gravity of 2.62, were used.

B. Ceramic Waste

Ceramic waste used in dissertation is taken from wintel ceramic industry and crushed of maximum 20 mm size manually with hammer. The ceramic coarse aggregate with a maximum size 20 mm having a specific gravity 2.33. The bulk density values obtained are 1170 Kg/m3, water absorption of 0.89%.

Figure 1: Marble Waste

Figure 2: Ceramic Waste

C. Fine Aggregate

Locally available river sand passed through 4.75mm IS sieve is applied as fine aggregate conforming to the requirements of IS 383(1987). The specific gravity of sand is 2.72 and fineness modulus is 3.69. The bulk density values obtained are 1757 Kg/m3 and water absorption is 0.78%.

D. Coarse aggregate

The Coarse aggregate are obtained from a local quarry, conforming to IS 383:1970 is used. The coarse aggregate with a maximum size 20 mm having a specific gravity 2.74. The bulk density values obtained are 1465 Kg/m3, water absorption of 0.51%.

E. Super Plasticizer

Conplast P211 water reducing admixure made by Fosroc chemicals was added to the mixture M35 to improve the workability of fresh concrete.

III. METHODOLOGY AND MIX PROPORTIONS

In first phase, the physical properties of ceramic waste and marble waste are tested and compared them to natural coarse and fine aggregate respectively. The mix design of M20, M30 and M35 are prepared and cubes of size 150*150*150 mm for compressive strength beams of size 500*100*100 mm for flexural strength and cylinder of diameter 150mm and depth 300 mm are prepared. 3 specimens for each. Total 495 specimens are prepared. The replacement percentages are 0%, 10%, 20%, 30%, 40% and 50% for coarse aggregate with ceramic waste. At optimum % ceramic aggregate take constant and fine aggregate is replace with marble waste at replacement percentage of 10%, 20%, 30%, 40% and 50%. To determine the workability, density, compressive, flexural and split tensile strength of concrete with ceramic and marble waste and to compare them with conventional concrete.

Mix	M25	M30	M35
W/C ratio	0.50	0.47	0.43
Cement (kg/m3)	394.32	419.15	458.14
Water (liter)	197	197	197
Fine aggregate (kg/m3)	700.78	692.51	653.15
Coarse aggregate 20 mm (kg/m3)	691.08	682.91	672.18
Coarse aggregate 10 mm (kg/m3)	460.71	455.27	448.12
Super Plasticizer (kg/m3)	Nil	nil	7.5

Table 1: Mix Proportions

Figure 3: Mechanical strength testing

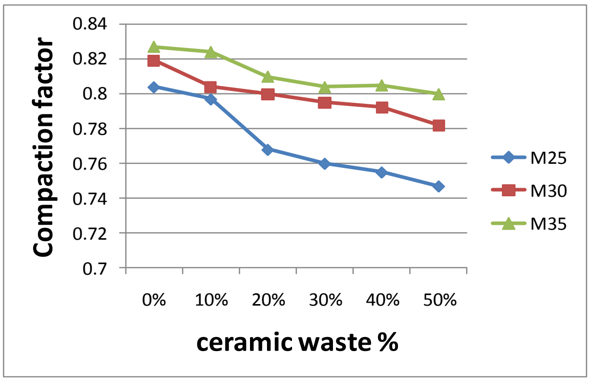
IV. RESULT AND DISCUSSION

A. Physical properties of marble waste and ceramic waste

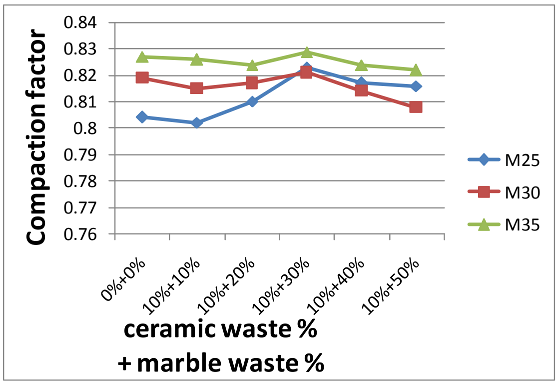
From the physical properties the properties of ceramic waste are well within the range of the values of coarse aggregates. Similarly the properties of marble waste are also within the range of the values of fine aggregates.

B. Workability

From the result workability of fresh concrete, the workability of concrete is decrease as increase % of ceramic aggregate. From the result workability of fresh concrete, the workability of concrete is increase as increase % of marble waste aggregates till 30% replacement after that workability decreases.



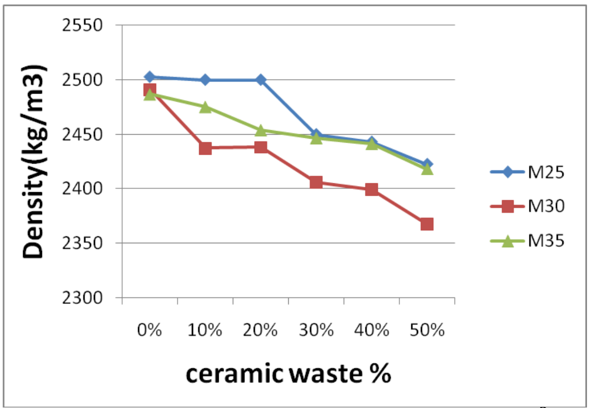
Graph 1 :- % of ceramic waste → compaction factor



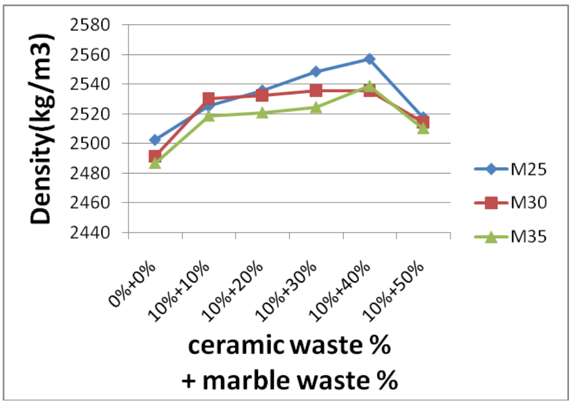
Graph 2:- ceramic waste % + marble waste % → compaction factor

C. Density

The density of concrete decrease as increase % of ceramic aggregates. Similarly, the density of concrete increase as increase % of marble waste aggregates till 40% replacement after that density decreases.



Graph 3:- % of ceramic waste → density (kg/m^3)



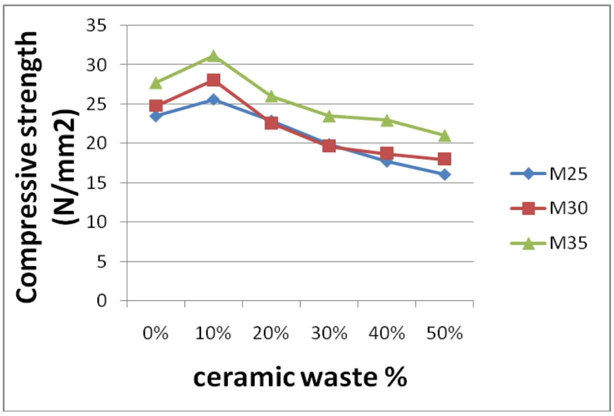
Graph 4:- ceramic waste % + marble waste % → density (kg/m^3)

D. Compressive strength

The 7 days compressive strength of M25, M30 and M35 grade is increase 9.02%, 13.21% and 12.40% respectively at 10% replacement of ceramic aggregates compare to normal concrete. The 7 days compressive strength for all grades is nearly equal to normal concrete at 20% replacement of ceramic aggregates. After that it decreases as increase % of ceramic aggregates.

Ceramic waste %	compressive strength (N/mm^2)		
	M25	M30	M35
0%	23.481	24.785	27.718
10%	25.6	28.059	31.155
20%	22.89	22.563	26.044
30%	19.896	19.673	23.511
40%	17.703	18.711	22.977
50%	16.04	17.985	21.052

Table 2: 7 days compressive strength of Ceramic Waste replacement

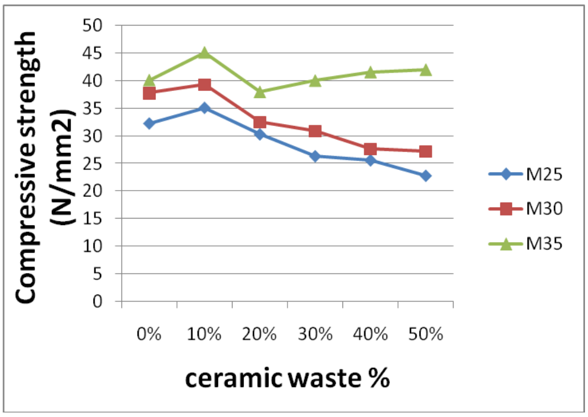


Graph 5:- % of ceramic waste → 7 days compressive strength (N/mm^2)

The 28 days compressive strength of M25, M30 and M35 grade is increase 8.81%, 3.95% and 12.56% respectively at 10% replacement of ceramic aggregates compare to normal concrete.

ceramic waste %	Compressive strength (N/mm^2)		
	M25	M30	M35
0%	32.281	37.807	40.13
10%	35.125	39.30	45.17
20%	30.296	32.518	37.970
30%	26.31	30.874	40.03
40%	25.57	27.6	41.6
50%	22.755	27.185	42.027

Table 3: 28 days compressive strength of Ceramic Waste replacement

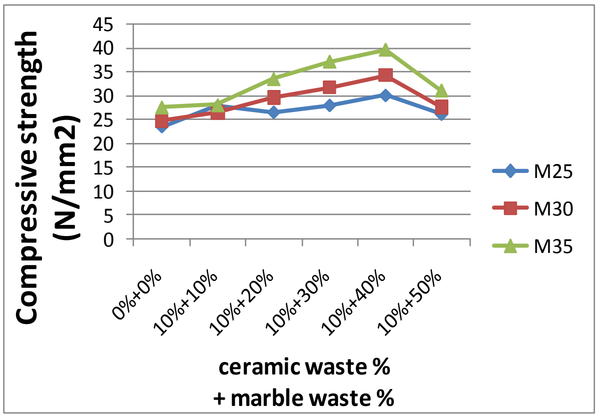


Graph 6:- % of ceramic waste → 28 days compressive strength (N/mm^2)

The 7 days compressive strength of M25, M30 and M35 grade is increase 28.36%, 38.55% and 43.12% respectively at 10%CCA+ 40%MFA compare to normal concrete. The 7 days compressive strength of M25, M30 and M35 grade is increase 17.73%, 22.38% and 27.33% respectively at 10% CCA+40% MFA compare to 10% ceramic aggregate concrete only.

ceramic waste % + marble waste %	Compressive strength (N/mm^2)		
	M25	M30	M35
0%+0%	23.481	24.785	27.718
10%+10%	27.83	26.53	28.16
10%+20%	26.53	29.66	33.58
10%+30%	28.01	31.87	37.2
10%+40%	30.14	34.34	39.67
10%+50%	26.13	27.73	31.23

Table 4: 7 days compressive strength of Ceramic Waste + marble waste replacement

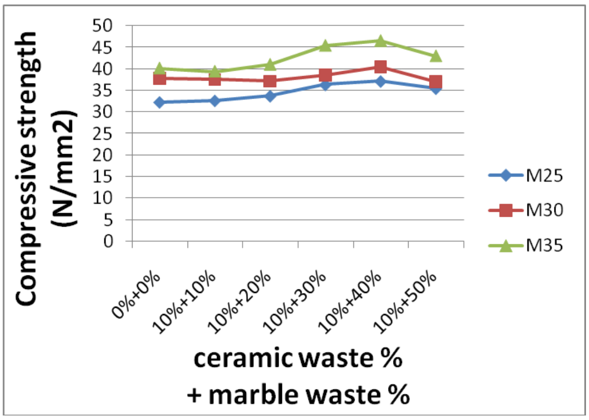


Graph 7:- ceramic waste % + marble waste % → 7 days compressive strength (N/mm^2)

The 28 days compressive strength of M25, M30 and M35 grade is increase 15.08%, 7.15% and 15.97% respectively at 10%CCA+ 40%MFA compare to normal concrete. The 28 days compressive strength of M25, M30 and M35 grade is increase 5.76%, 3.07% and 3.03% respectively at 10% CCA+40% MFA compare to 10% ceramic aggregate concrete only.

ceramic waste % + marble waste %	Compressive strength (N/mm²)		
	M25	M30	M35
0%+0%	32.281	37.807	40.13
10%+10%	32.63	37.57	39.40
10%+20%	33.71	37.14	41.02
10%+30%	36.35	38.63	45.42
10%+40%	37.15	40.51	46.54
10%+50%	35.47	37.03	43.00

Table 5: 28 days compressive strength of Ceramic Waste + marble waste replacement



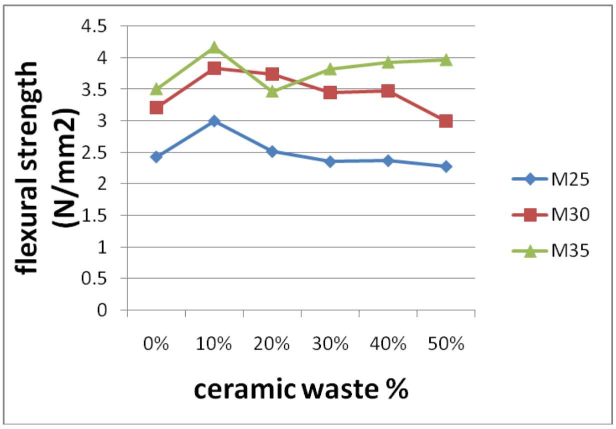
Graph 1:- ceramic waste % + marble waste % → 28 days compressive strength (N/mm²)

E. Flexural strength

The 28 days flexural strength of M25, M30 and M35 grade is increase 23.35%, 19.55% and 18.95% at 10% replacement of ceramic aggregates respectively compare to normal concrete.

ceramic waste %	flexural strength (N/mm²)		
	M25	M30	M35
0%	2.432	3.212	3.508
10%	3.00	3.84	4.173
20%	2.516	3.748	3.468
30%	2.356	3.452	3.826
40%	2.372	3.48	3.932
50%	2.28	3.00	3.972

Table 6: 28 days flexural strength of Ceramic Waste replacement

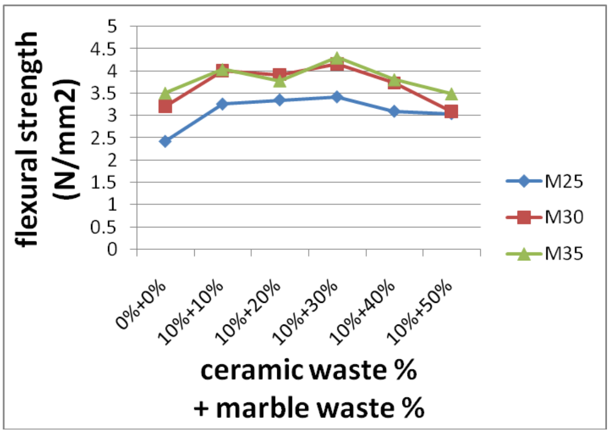


Graph 9:- % of ceramic waste → flexural strength (N/mm²)

The 28 days flexural strength of M25, M30 and M35 grade is increase 40.91%, 29.51% and 22.74% respectively at 10% CCA+ 30% MFA compare to normal concrete. The 28 days flexural strength of M25, M30 and M35 grade is increase 14.22%, 8.33% and 3.18% respectively at 10% CCA+ 30% MFA compare to 10% ceramic aggregate concrete only.

ceramic waste % + marble waste %	flexural strength (N/mm²)		
	M25	M30	M35
0%+0%	2.432	3.212	3.508
10%+10%	3.267	4.00	4.04
10%+20%	3.36	3.920	3.786
10%+30%	3.427	4.16	4.306
10%+40%	3.106	3.733	3.813
10%+50%	3.053	3.093	3.493

Table 7: 28 days flexural strength of Ceramic Waste + marble waste replacement



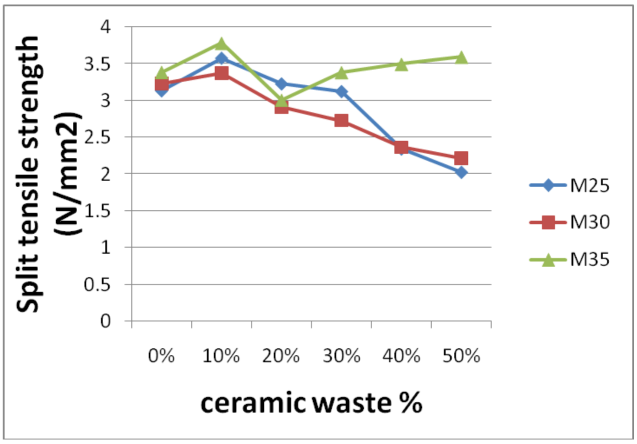
Graph 10:- ceramic waste % + marble waste % → flexural strength (N/mm²)

F. Split tensile strength

The 28 days split tensile strength of M25, M30 and M35 grade is increase 14.15%, 4.36% and 11.72% respectively at 10% replacement of ceramic aggregates compare to normal concrete.

ceramic waste %	Split tensile strength (N/mm^2)		
	M25	M30	M35
0%	3.131	3.230	3.385
10%	3.574	3.371	3.782
20%	3.225	2.904	3.003
30%	3.121	2.725	3.381
40%	2.339	2.362	3.494
50%	2.023	2.21	3.593

Table 8: 28 days split tensile strength of Ceramic Waste replacement

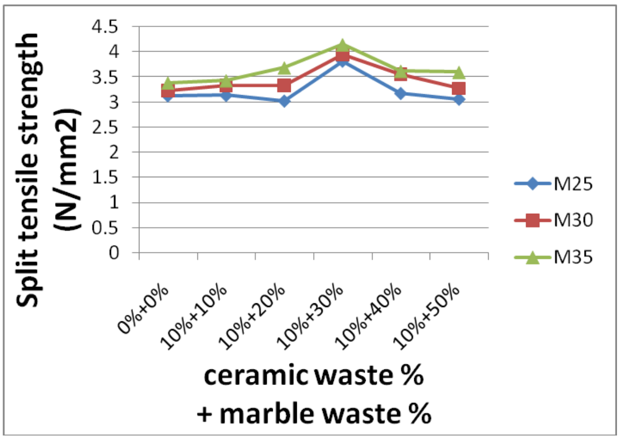


Graph 11:- % of ceramic waste → split tensile strength (N/mm^2)

The 28 days split tensile strength of M25, M30 and M35 grade is increase 22.00%, 22.47% and 22.59% respectively at 10% CCA+ 30% MFA compare to normal concrete. The 28 days split tensile strength of M25, M30 and M35 grade is increase 6.88%, 17.35% and 9.73% respectively at 10% CCA+ 30% MFA compare to 10% ceramic aggregate concrete only.

ceramic waste % + marble waste %	Split tensile strength (N/mm^2)		
	M25	M30	M35
0%+0%	3.131	3.230	3.385
10%+10%	3.14	3.34	3.43
10%+20%	3.027	3.338	3.687
10%+30%	3.82	3.956	4.15
10%+40%	3.178	3.556	3.62
10%+50%	3.065	3.277	3.598

Table 9: 28 days split tensile strength of Ceramic Waste + marble waste replacement



Graph 12:- ceramic waste % + marble waste % → split tensile strength (N/mm^2)

V. CONCLUSION

- The 28 days strength for all grade are also nearly equal to normal concrete at 20% replacement of ceramic aggregates. After that strength decrease as increase % of ceramic aggregates for M25 and M30 grade and increase as increase % of ceramic aggregates for M35 grade of concrete.
- The ceramic waste as coarse aggregate is replaced with natural coarse aggregate at 10% is advisable for lower grade.
- The ceramic waste as coarse aggregate at 10% and Marble waste as fine aggregate at 40% in combination are advisable in concrete.
- Ceramic aggregate concrete and CCA+MFA concrete both gets early strength compare to normal concrete.

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