Experimental Study on Concrete by incorporating Waste Broken Tiles

[1]Anurag Wahane, [2]Munazza Amir Khan, [3]Veena Dewangan, [4]Omprakash Rajak

[1]Assistant Professor, [2,3,4]UG Students
Department of Civil Engineering,
Shri Shankaracharya Institute of Professional Management and Technology, Raipur, Chhattisgarh, India

Abstract*: Ceramic materials, such as tiles, sanitary fittings, and electrical insulators, are becoming increasingly popular in recent constructions. However, due to its brittle nature, a significant amount of ceramic material is wasted during processing, transportation, and installation. As a result, recycling of these wastes in concrete production could be a good way to help the environment while also improving the concrete& its properties. The study deals with experimental study of the broken ceramic tilepartially added in concrete mix. The ceramic tiles are added in 20 % by weight in concrete cube in crushed form of size 10 -20 mm.The results shows that Waste ceramic tiles were used in concrete as a replacement for natural coarse aggregates. The optimum value of waste ceramic tile to be used in the concrete mix with a water/cement ratio of 0.3 was determined after analyzing the results. The compressive strength of concrete with waster tile is 5.5% more thanthe standard concrete of same grade. Therefore, it has concluded that using waste ceramic tile strength property of concrete is enhanced.

***Keywords*: Ceramic, Waste, And Concrete**

1. Introduction

Floor tile waste in concrete applications can substantially reduce the negative environmental effects and exhaustion of the natural resources. In order to reuse and so to reduce the volume of the ceramic waste which occurs during the production of ceramic, it is possible to use as aggregates in the production of concrete. In this study, the compressive strength property of concrete produced from floor tile waste aggregates were investigated. The properties of these concretes will compare to produce reference concrete.

Ceramic tiles are a mixture of clays and other natural materials, such as sand, quartz and water. They are primarily used in houses, restaurants, offices, shops, and so on, as bathroom wall and kitchen floor surfaces. They are easy to fit, easy to clean, easy to maintain and are available at reasonable prices.(wikipedia)Aggregate and Cement, which are the most important constituents used in concrete production, are the essentialmaterials needed for the construction industry. This certainly led to a continuous and increasing demand of natural materials used for their production. Parallel to the need for the utilization of the natural resources emerges a growing concern for protecting the environment and a need to preserve natural resources, such as aggregate, by using alternative materials that are discarded as a waste.(Md Daniyal, Shakeel Ahmad)Therefore, one of the most serious problems of the world has been related to remove the wastage and reusing of it. A large quantity of wastage is produced annually in all countries. In particular, Construction and Demolition (C&D) wastes contribute the highest percentage of wastes worldwide about 75%. Furthermore, ceramic materials contribute the highest percentage of wastes within the C&D wastes about 54%. The global production of ceramic tiles during 2011-12 in the world is about 11,166 million square meters. China is the largest ceramic tiles producer (5,200 million square meters) which is 46.6% of world production as well as consumer (4,250 million square meters) which is 38.9% of world consumption. Compared to China, India ranks third; accounting for just 691 million square meters tiles production which is 6.2% of world production and also ranks third in terms of consumption accounting for just 681 million square meters which is 6.2% of world consumption. This huge amount of productions has caused them to be among the most commonly-consumed materials in the world. Usually, the wastage related to tile, ceramic and sanitary ware are created in different forms some of which are produced in companies during and after production process due to errors in either construction, human activities, and also inappropriate rawmaterials. Some others are produced in transportation and distribution procedures and finally, the most bulk of them arecreated as a result of destroying constructions. It is predicted that about 30% of daily production of ceramic materials in India change into wastage and this amount reaches to millions ton per year.(Md Daniyal, Shakeel Ahmad) This waste is not recycled in any form at present. Therefore, they are useless in practiced and cause environmental and disposal problems. However, the ceramic waste is durable, hard and highly resistant to biological, chemical and physical degradation forces. The properties of these materials make them a good and suitable choice to be used in concrete. The use of waste ceramic tiles in concrete effects the properties of fresh and hardened concrete, and makes it economical and also solves some of the disposal problems.

2. Material and Methods

In this experimental study, first the grinded waste ceramic tile and then its grading were done in a way that the tile grading curve of the natural aggregates used in control concrete was completely in compatible with the ceramic tile aggregates as per IS 383-1970. After that, a range of experiments were done on natural aggregates and ceramic tile aggregates. Having been ready, in the first stage of the study, the ceramic tiles with percents of 0 and 20 were substituted for natural coarse aggregates with w/c ratio of 0.3.After that, a comparison was made betweencomprehensive strength, of new concrete and the reference samples. After that optimum percent of ceramic tile aggregate and w/c ratio were determined.

Cement: PPC 43 were used for experiment , which were have following properties as per Table

Table 1.1 Cement composition (SaraswathyVelu)

Compound	PPC %
SiO_2	28-32
Al_2O_3	7.0-10.0
Fe_2O_3	4.9-6.0
CaO	4.1-4.3
MgO	1.0-2.0
SO_3	2.4-2.8
Loss on ignition	3.0-3.5

Aggregate: The locally available river sand was used as fine aggregate and crushed quartzite aggregate of maximum nominal size of 20mm, was used as coarse aggregate as shown in Figure-1(a). The waste ceramic tiles used throughout this experimental study were gathered from the house construction site as shown in Figure-1(b).

Fig. 1 (a) Natural Coarse Aggregate

Fig. 1 (b) Waste Ceramic Tiles

3. Mix-Design

Quantities of the concrete materials used for the all concrete mixtures are shown in the Table-3. Six types ofconcrete mixes were prepared in order to carry out the research. All the concrete mixes were produced by keeping proportion of 1:1. 27:2.66(cement: fine aggregate: coarse aggregate), cement content (202 kg/m3), and quantity of fine aggregate constant and changing the proportions of coarse aggregate with waste ceramic tile aggregate with the w/c ratios of 0.3.

a) Grade designation. : M40 grade
b) Type of cement. : PPC 43
c) Maximum nominal size of C. A : 20 mm
d) Exposure conditions : moderate
e) Workability : 120 mm
f) Type of aggregate : angular
g) Maximum cement (OPC) content : 450 kg/m3

Test data for materials

A) Cement used : PPC 43
b) Specific gravity of cement : 3.15
c) Specific gravity of

1) Coarse aggregate (at SSD condition) : 2.82
2) Fine aggregate (at SSD condition) : 2.6

d) Water absorption
1) Coarse aggregate :0.5%
2) Fine aggregate. :1%

3.1 Target Strength for Mix Proportion

f'ck= fck + 1.65S

Target strength = 40+1.65*6

= 49.9 N/mm^2

3.2 Selection of Water Content

Water content for 20mm aggregate=186 Kg/m^3

Estimated water content for 120mm slump

= 186+9/100*186 = 202 Kg/m^3

3.3 Calculation of Cement Content

W/C Ratio = 0.3

I. Water content = 202 Kg / m^3

Cement content = $\frac{202}{0.3}$= 673.39 Kg

but 637.39 > 450 kg/m^3 hence consider 450 kg/m^3

3.4 Proportion of Volume of C. A And F. A Content

Volume (Vc) = 0.66 + 0.3 - 0.264 / 0.05 * 0.01

= 0.6673

Volume of fine aggregate per unit weight = 1 – 0.667

= 0.333

Mix Calculation:

Volume of concrete	= 1 m^3
Volume of cement	= 0.142 m^3
Volume of water	= 0.202 m^3
Volume of chemical admixture	= Nil
Volume of all in aggregate	= 0.650 m^3
Mass of coarse aggregate	=1188.5 kg
Mass of fine aggregate	= 574 kg

3.5 Casting and Testing of specimens

The workability of the fresh concrete was measured with a standard slump cone using the slump test. The total 6 test specimens were cast in steel cubic moulds (150 mm×150 mm ×150 mm) and to determine their compressive strength and after 28 days of curing. After approximately 24 hours, thespecimens were removed from the moulds. The concrete specimens were cured at 27 ± 2 ° C until the test age.

(a) **(b)**

Fig. 2 (a) Mould with Concrete (b) Without Mould

Table 2.2 - Mix Proportion

Cement	F.A.	C.A.	Water
450 Kg/m^3	573.76 Kg/m^3	1188.0Kg/m^3	202 Kg/m^3
1.518 kg/ cube	1.936 kg/**cube**	4.012 kg/**cube**	0.681 kg/**cube**

Table 2.3 – Nominal Concrete Mix

Material	For 1 Cube	For 3 Cube
Cement	1.51 Kg	4.53 Kg
Fine Aggregate	1.936 Kg	5.79 Kg
Coarse Aggregate	4.012 Kg	12.03 Kg

Table 2.4 - Partially replaced concrete Mix

Material	For 1 cube	For 3 cube	Material %
Cement	1.51 kg	4.53 kg	100 %
Fine Aggregate	1.936 kg	5.79 kg	100%
Coarse Aggregate	4.012 kg	9.624 kg	80%
Broken Tiles	0.802 kg	2.406 kg	20%

4. Result:

The result of design-mix is been represented below -

Table 3.1–Nominal Mix Concrete Compressive Strength

S.NO.	NO. OF CURING DAYS	SPECIMEN	LOAD (KN)	COMPRESSIVE STRENGTH (N/mm^2)
1	7	1	400	18.2
2	28	2	400	29.8

Table 3.2– Ceramic Mix Concrete Compressive Strength

S.No	NO. OF CURING DAYS	SPECIMEN	LOAD (KN)	COMPRESSIVE STRENGTH (N/mm^2)
1	7	2	450	21.4
2	28	1	450	32.6

5. Conclusion

Compressive strength were measured. The following conclusions canbe highlighted from the output of this research and can be summarized as follows:

➢ Compressive strength of concrete gradually increased with the increase of quantity of coarse waste ceramic tile aggregate up to certain limits i.e 20% for w/c ratio 0.3.The greatest compressive strength was observed for concrete.

➢ Also, it can be seen that using waste ceramic tiles in concrete production causes no remarkable negative effect in the properties of concrete. The optimal case of using waste ceramic tiles as coarse aggregates is found to be 10 to 30 percent. In these measures, not only an increase happens in compressive strength, but also a decrease in unit weight .

➢ Finally, using waste ceramic tiles in concrete is an effective measure with regard to reducing the costs of concreteand keeping the environment clean along with wastage management and decreasing the use of natural raw materials.

REFERENCES
[1] Khaloo, A. R., “Crushed tile coarse aggregate concrete”, Cement and Concrete Aggregate, Vol.17, pp.119-125, 1995.
[2] Lopez, V., Llamas, B., Juan, A., Moran, J.M. and Guerra, I., “Eco-efficient concretes: Impact of the use of white ceramic powder on the mechanical properties of concrete”, Biosystems Engineering, Vol.96, pp.559-564, 2007.
[3] Torgal, F.P. and Jalali, S., “Reusing ceramic wastes in concrete”, Construction and Building Materials, Vol.24, pp.832–838, 2010.
[4] Medina, C., Sanchez, M.I, and Frias, M., “Reuse of sanitary ceramic wastes as coarse aggregate in eco-efficient concretes”, Cement and
Concrete Composites, Vol.34, pp.48-54, 2012.
[5] Tavakolia, D., Heidari, A. and Karimian, M., “Properties of concretes produced with waste ceramic tile aggregate”, Asian Journal of Civil
Engineering, Vol.14, pp.369-382, 2013.
[6] Binici, H., “Effect of crushed ceramic and basaltic pumice as fine aggregates on concrete mortars properties”, Construction and Building Materials, Vol.21, pp.1191-1197, 2007.
[7] Correia, J.R., de Brito, J. and Pereira, A.S., “Effects on concrete durability of using recycled ceramic aggregates”, Material and Structure, Vol.39(2), pp.169-177, 2006.
[8] Fatima, E., Jhamb, A., and Kumar, R., “Ceramic dust as construction material in rigid pavement”, American Journal of Civil Engineering and Architecture, Vol.1(5), pp.112-116, 2013.
[9] Higashiyama H., Yamauchi k., Sappakittipakorn, M., Sano, M. and Takahashi, O., “A visual investigation on chloride ingress into ceramic waste aggregate mortars having different water to cement ratios”, Construction and Building Materials, Vol.40, pp.1021-1028, 2013.
[10] Ay, N. and Unal, M., “The use of waste ceramic tile in cement production”, Cement and Concrete Research, Vol.30, pp.497-499, 2000.
[11] Lavat, A.E., Trezza, M.A. and Poggi, M., “Characterization of ceramic roof tile wastes as pozzolanic admixture”, Waste Management, Vol.29, pp.1666-1674, 2009.
[12] Senthamarai, RM. and Manhoharan, P.D., “Concrete with ceramic waste aggregate”, Cement and Concrete Composites, Vol.27, pp.910-913, 2005.
[13] Torkittikul, P. and Chaipanich, A., “Utilization of ceramic waste as fine aggregate within portland cement and fly ash concretes”, cement and concrete composites, Vol.32, pp.440-449, 2010.
[14] Senthamarai, RM., Manhoharan, P.D. and Gobinath, D., “Concrete made from ceramic industry waste: durability properties” construction and building materials, Vol.25, pp.2413-2419, 2011.
[15] IS: 8112–1989, “Specification for 43grade Ordinary Portland Cement”, Bureau of Indian Standards, New Delhi, 1989.
[16] IS: 383-1970, “Specification for coarse and fine aggregates from natural sources for concrete”, Bureau of Indian Standards, New Delhi, 1970.
[17] IS: 2386 (Part I-VIII) -1963, “Indian standards method of testing for concrete”, Bureau of Indian Standards, New Delhi, 1963.
[18] IS: 10262-2009, “Indian standard concrete mix proportioning”, Bureau of Indian Standards, New Delhi, 2009.
[19] IS: 516-1959, “Method of tests for strength of concrete”, Bureau of Indian Standards, New Delhi, 1959.