Use of Ceramic Waste as Coarse Aggregate in Concrete

Ravi Shanker Chourasia[1] Jobin Joy[2]
[1]Senior highway engineer [2]PG Student
[1]MSV International INC [2]Rajiv Gandhi Proudyogiki Vishwavidyalaya, Bhopal

Abstract— Concrete is a mixture which is produced by blending adequate proportion of cement, water and aggregate. Every ingredient is used to significantly increase the performance of concrete. Apart from performance of concrete, the developers also accounts cost of concrete which is proportional to the cost of each ingredient. Considering the rising cost of these ingredients and scarcity of natural resources, the utilization of alternative materials in production of concrete, is opted. The present paper emphasizes on studying the characteristics of concrete blended by replacing coarse aggregate with ceramic waste. Ceramic waste is produced from industries during production of ceramic artefacts. The industries produce approx. 30% of waste material of production, which is usually not recycled and used in landfills. In construction sector the ceramic can be effectively used in place of coarse aggregate in production of cost effective and eco-friendly concrete.

Key words: Coarse Aggregate, Ceramic, Ceramic Wastes, Cost Effective, Eco-Friendly

I. INTRODUCTION

The development of world is accounted not only by modern technologies and instruments but also by infrastructure. The construction of these building consumes concrete which is produced by proper mixing of cement, water and aggregates. As the rate of construction is increasing the consumption of concrete is also increasing. In production of concrete, coarse aggregate is as important as cement, water and fine aggregate. It plays a major role in development of concrete's strength and other characteristics. In concrete, coarse aggregate is utilized in bulk and increase in production of concrete has increased the consumption of coarse aggregate, which has ignited the concern for natural resource of coarse aggregate. Apart from depletion of natural resources, the economic and environmental concern has motivated the utilization of alternative coarse aggregate such has e-waste, coconut shell, ceramic wastes etc. In sustainable development the effective use of wastes is also a primary concern. The disposal of waste material into environment is hazardous and therefore, its management require special attention [1, 2]. The application of such material in construction sector is proved to be beneficial. In this paper, the use of ceramic waste as coarse aggregate in concrete is studied.

Ceramic products such as ceramic sanitary wares, tiles, utensils, flower pots etc. are widely used material across the world [3]. In production of these products approx. 30% of production is dumped as waste material [4, 5], from ceramic industries. The effective utilization of these waste material is seldom due to lack of knowledge about its characteristics. The ceramic wastes are inert, non-metallic substance which can withstand dreadful conditions. Hence, it is durable, hard and strong material, which can be used as alternative of coarse aggregate [6, 2].

II. LITERATURE SURVEY

Brito et al. [1], investigated the mechanical performance of non-structural concrete prepared with reprocessed ceramic waste. They presented and compared the major characteristics of ceramic waste aggregate and stone aggregate. Along with the properties of aggregate, they also compared the concrete made with ceramic waste aggregate and conventional concrete made with stone aggregate. The results obtained through experimental study showed that the ceramic waste aggregate can be used in concrete pavement slab where primary requirement is tensile strength and abrasion resistance over compressive strength.

Correia et al. [7], studied the effect of using recycled ceramic aggregate on durability of concrete. They presented the water absorption test through capillarity and immersion for long term durability of concrete.

Senthamarai and Manoharan [4], studied the characteristics of concrete incorporated with ceramic waste aggregate. The characteristics of ceramic waste incorporated concrete such as tensile strength, flexural strength, compressive strength and elastic modulus was determined and compared them with concrete produced with crushed stone aggregate. They also compared the properties of ceramic waste and crushed stone aggregate. It was concluded that ceramic waste concrete had improved workability and as good as strengths of conventional concrete with crushed stone aggregate.

Giridhar et al. [8], investigated the influence of properties of ceramic waste aggregate on strength characteristics of concrete. They replaced crushed stone aggregate with ceramic waste aggregate at 0%, 20%, 40%, 60%, 80% and 100% in M20 grade of concrete. According to their conclusion strength characteristic declined but were greater than targeted value.

III. EXPERIMENTAL PROGRAM

A. Materials:

1) Cement

Ordinary Portland cement of grade 43 and specific gravity 3.15 was used for present work and all properties were checked as per IS 8112-1989 [9].

2) Water

For present study portable water is used as per IS 456-2000 [10].

3) Fine Aggregate

Fine aggregate classified under zone III and having specific gravity 2.63, is used. Its properties are found as per Indian standards. The aggregate was washed and surface dried.

4) Coarse Aggregates

In this study crushed angular stone of size 20 mm and specific gravity 2.65, is used. The aggregate used were washed and surface dried. Its properties were ensured as per Indian standards.

5) Ceramic waste aggregate (CWA)

Ceramic waste collected from local dealer was used in present study. The waste was of ceramic tiles and was manually crushed to obtain the required size of 20 mm. The waste was tested in lab and was found suitable to use as per IS 383 [11].

IV. MIX DESIGN

Mix design was calculated for M30 concrete as per IS 10262:2009 [12]. Total 6 mixes are prepared by replacing crushed stone aggregate with ceramic waste aggregate from 0% to 50% of volume of coarse aggregate. The mix proportion of each batch is given in Table 1.

Batch ID	Cement (kg)	Water (kg)	Fine Aggregate (kg)	Crushed Stone Aggregate (kg)	Ceramic Waste Aggregate (kg)	Percentage of replacement (%)
CWA00	438.13	197.2	807.95	1147.57	0	0
CWA10	438.13	197.2	807.95	1032.82	114.76	10
CWA20	438.13	197.2	807.95	918.06	229.51	20
CWA30	438.13	197.2	807.95	803.30	344.27	30
CWA40	438.13	197.2	807.95	688.54	459.03	40
CWA50	438.13	197.2	807.95	573.79	573.79	50

Table 1: Mix proportions

V. RESULTS AND DISCUSSIONS

Each concrete batch is prepared and tested for workability, compressive strength, flexural strength and tensile strength. The obtained results are discussed in following sections.

A. Workability:

The workability of concrete prepared by replacing crushed stone aggregate with ceramic waste aggregate, is determined through slump test as per IS 1199:1959 [13]. The obtained result is given in Table 2.

Batch ID	Ceramic Waste Aggregate (%)	Slump (mm)
CWA00	0	122
CWA10	10	115
CWA20	20	108
CWA30	30	107
CWA40	40	104
CWA50	50	98

Table 2: Slump value of concrete incorporated with CWA

B. Compressive Strength:

The compressive strength of concrete was determined through compressive strength testing machine as IS 516:1959 [12]. For each mix, three cubes were tested for both 7 and 28 days strength.

Batch ID	Ceramic Waste Aggregate (%)	Compressive Strength	
		7 Day Strength (MPa)	28 Day Strength (MPa)
CWA00	0	30.86	47.49
CWA10	10	28.92	46.75
CWA20	20	28.11	44.79
CWA30	30	26.73	44.23
CWA40	40	25.09	43.90
CWA50	50	23.84	41.01

Table 3: Compressive strength of concrete incorporated with CWA

C. Flexural Strength:

The flexural strength of concrete was determined through universal testing machine as IS 516:1959 [14]. For each mix, three beams were tested for both 7 and 28 days strength.

Batch ID	Ceramic Waste Aggregate (%)	Flexural Strength	
		7 Day Strength (MPa)	28 Day Strength (MPa)
CWA00	0	4.03	4.92
CWA10	10	3.88	4.77
CWA20	20	3.71	4.74
CWA30	30	3.69	4.68
CWA40	40	3.51	4.61
CWA50	50	3.44	4.52

Table 4: Flexural strength of concrete incorporated with CWA

D. Tensile Strength:

The tensile strength of concrete was determined through universal testing machine as IS 5816:1999 [15]. For each mix, three cylinders were tested for both 7 and 28 days strength.

Batch ID	Ceramic Waste Aggregate (%)	Tensile Strength	
		7 Day Strength (MPa)	28 Day Strength (MPa)
CWA00	0	3.76	4.64
CWA10	10	3.69	4.43
CWA20	20	3.61	4.35
CWA30	30	3.52	4.28
CWA40	40	3.39	4.10
CWA50	50	3.24	3.93

Table 5: Tensile strength of concrete incorporated with CWA

VI. CONCLUSION

Based on results obtained following conclusion were made:

1) From laboratory investigation it is found that ceramic waste aggregate satisfies the requirement as per 383:1970 and can be used as alternative of crushed stone aggregate.

2) The workability of concrete declined as amount of CWA is increased.
3) Compressive strength of concrete with CWA decreased as replacement percentage is increased. But it was also observed that strength are greater than target strength. Compressive strength on 28 day at 50% of crushed stone aggregate with CWA is 41.01
4) The flexural strength of concrete incorporated with CWA decreased as that of compressive strength but, evaluated with acceptable range.
5) Tensile strength of concrete also decreased as CWA is increased.

REFERENCES

[1] J. De Brito, A. S. Pereira and J. R. Correia., "Mechanical behaviour of non-structural concrete made with recycled ceramic aggregates," Cement and Concrete Composites, vol. 27, no. 4, pp. 429-433, 2005.
[2] A. Khaloo, "Crushed tile coarse aggregate concrete," Cement, Concrete and Aggregate, vol. 7, no. 2, pp. 119-125, 1995.
[3] C. Medina, S. d. Rojas and M. Frias, "Reuse of sanitary ceramic wastes as coarse aggregate in eco- efficient concretes," Cement and Concrete Composites, vol. 34, pp. 48-54, 2012.
[4] R. Santhamarai, M. Devadas and D. Gopindh, "Concrete made from ceramic waste:Durability properties," Construction and Building Materials, vol. 25, pp. 2413-2419, 2011.
[5] A. Raval, I. Patel and J. K. Pitroda, "Re-use of ceramic industry wastes for the elaboration of eco efficient concrete," International Journal of Advanced Engineering Research and studies, vol. 2, no. 3, pp. 103-105, 2013.
[6] H. Siddes, "Experimental studies effect of fine ceramic aggregate on the strength properties of concrete," International journal of advances in Engineering, Science and Technology, vol. 1, no. 1, pp. 71-76, 2011.
[7] J. Correia, J. De Brito and A. Pereira, "Effects on concrete durability of using recycled ceramic aggregates," Materials and Structures, pp. 169-177, 2005.
[8] V. Giridhar, H. S. Rao and P. S. P. Kumar, "Influence of ceramic waste aggregate properties on strength of ceramic waste aggregate concrete," International Journal of Research in Engineering and Technology, pp. 15-24, 2015.
[9] "IS 8112 - Ordinary portland cement, 43 grade - specifications," Bureau of indian standards, New Delhi, 2013.
[10] "IS 456 - Plain and reinforced concrete - code of practice (fourth revision)," Bureau of Indian Standards, New Delhi, 2000.
[11] "IS 383 - Specification for coarse and fine aggregates from natural sources of concrete (Second revision)," Bureau of indian standards, New Delhi, 1970.
[12] "IS 10262- Concrete mix proportioning - Guideline," Bureau of indian standards, New Delhi, 2009.
[13] "IS 1199 - Methods of sampling and analysis of concrete," Bureau of indian standards, New Delhi, 1959.
[14] "IS 516 - Methods of tests for strength of concrete," Bureau of indian standards, New Delhi, 1959.
[15] "IS 5816 - Method of Test Splitting Tensile Strength of Concrete," Bureau of indian standards, New Delhi, 1999.

