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A REVIEW PAPER ON UTILISATION OF CERAMIC WASTE IN CONCRETE

Batriti Monhun R. Marwein [1], M. Sneha [2], I. Bharathidasan [3]

[1]PG Student, M.E Structural Engineering, Arunai Engineering College, Tiruvannamalai-606 603, India, bmonhun@gmail.com

[2]Assistant Professor, Civil Engineering Department, Arunai Engineering College, Tiruvannamalai - 606603, India, snehaphd.civil@gmail.com

[3]PG Student, M.E Structural Engineering, Arunai Engineering College, Tiruvannamalai-606 603, India, dasan1992@yahoo.in

Abstract: **This study aims in achieving an acceptable ordinary strength concrete with ceramic waste as substitute of conventional coarse aggregates. The ceramic waste to be adopted is broken tiles from local shops. Ceramic waste concrete (CWC) will be made with these tiles at 0%, 15%, 20%, 25% and 30%. M_{20} grade concrete will be adopted; a constant water cement ratio of 0.48 will be maintained for all the concrete mixes. The characteristics properties of concrete such as workability for fresh concrete, also Compressive Strength, Split Tensile Strength and Modulus of Elasticity for hardened concrete will be found out in this study at 3, 7 and 28 days for each percentage of replacement. 3 numbers of specimens for each percentage replacement will be casted and tested with the corresponding tests and finally compared with regular M_{20} grade concrete.**

Keywords: Ceramic waste, broken tiles, Compressive strength, Split Tensile Strength and Modulus of Elasticity.

1. INTRODUCTION

Natural sources required for various constructions are getting depleted at a rapid rate, due to which there is always a rise in their price. This led the engineers and researchers in finding other substitutes for the production of construction materials keeping in mind of maintaining the quality, strength and durability. One of the most important constituents of concrete being coarse aggregate the fact being that it occupies 70-80% of the volume of concrete; thus making a big impact on the characteristics and properties of concrete. However, with the urbanization and rapid rise in the population especially in a country like India the demands for this particular construction material cannot be met easily. Hence, to overcome this problem is by using waste products such as waste ceramics.

In India the Ceramic Tile Industry approximate worth is Rs.21,000 Crore and was reported, the Indian Ceramic Tiles industry grew by around 11% in 2013-14 and expected to reach a size of Rs.301 billion by 2016. As in a present report of *Global Ceramic Tiles Market* of February 2016, the global ceramic tiles market will grow at a CAGR(Compound Annual Growth Rate) of 9.59% during the period of 2016-2020. Globally India is ranked 3rd and accounted for over 6% of total global production. Even with a tremendous growth in the ceramic production there is an inappropriate consumption. Thus resulting to a huge wastage which is reported to be around 15%-30% annually, generated from the total production.

Snapshot of natural coarse aggregate and ceramic waste aggregate.

. Ceramic products are manufactured at extremely high temperatures between 1000°C-1250°C which results in very hard, highly resistant to chemical, freezing and thermal shock. Considering the properties of ceramics their waste such as broken tiles should be included in concrete as a substitute to conventional construction material. This will help to solve problems like cost, scarcity as well as other environmental issues that may arise due to improper dumping of such waste.

II. REVIEW OF LITERATURE WORKS

The following suggestions can be drawn from the various consolidated literature review:

R.M. Senthamarai et al. (2005) substituted conventional crushed stone aggregate with ceramic electrical insulator. Different water cement ratio of 0.35, 0.40, 0.45, 0.50, 0.55 and 0.60 were adopted. Compressive strength, split

tensile strength, flexural strength and Modulus of elasticity were found out. It is found that the compressive, split tensile and flexure strength of ceramic coarse aggregate are lower by 3.8%, 18.2% and 6% respectively when compared to conventional concrete.
A.Mohd Mustafa et al. (2008) studied on various types of ceramic waste like flower pots, tiles and clay bricks. Different water cement ratios were adopted such as 0.4, 0.5 and 0.7 with concrete of characteristics strength of 20 MPa. Flower pots gave the best results for compressive strength of about 2.50% lesser than that of conventional concrete.

C. Medina et al. (2012) investigated on the reuse of waste as recycled coarse aggregate in partial substitution of 15%, 20% and 25% in the manufacture of structural concrete. Compressive strength is found out t 7, 28 and 90 days. There is an increase in strength with increase of percentage replacement, the best results shown is at 25% with increase of 21.12%, 11.04% and 6.70% at 7, 28 and 90 days respectively.

R.M.Senthamarai et al. (2011) studied the durability properties of ceramic industry waste as coarse aggregate in concrete. Water cement ratios from 0.35- 0.60 were used and properties such as volume of voids, water absorption, chloride penetration and sorption were studied. Water absorption ranges from 3.74-7.21% whereas that of conventional concrete from 3.1 – 6.52%. Concrete with Ceramic shows higher results in all tests.

T. Sekar (2011) studied on strength characteristics of concrete utilizing waste materials viz: ceramic tiles, ceramic insulator waste and broken glass pieces. Ceramic tiles gave the best results when compared to the other two type of waste. The concrete produced by ceramic tile aggregate produced similar strength in compression, split tensile and flexure as conventional concrete.

Y. Tabak et al. (2012) studied on the mechanical and physical properties of concrete produced form Floor Tiles Waste Aggregate (FTWA). Two samples were made, the first one substitution by Floor Tile Waste Dust (FTDA) and the other a combination of Floor Tile Waste Dust (FTDA) and Floor Tile Waste Aggregate (FTWA).Best result is shown b FTWA substitution. Increase in compression strength is 13.53%, 16.70% and 2.91% for 2, 7 and 28 days. Similarly there is an increase of 23.21%, 0.1% and 19.47% respectively for flexure strength. There is a reduction of specific density and water absorption of 0.284Kg/m^3 and 0.158% respectively when compared to conventional concrete.

D. Tavakoli et al. (2013) investigated on the possibility of using ceramic tile in concrete. Coarse aggregate is replaced in the range of 0-40%. There is an increase in compressive strength by 5.13% whereas there is a decrease in slump, water absorption and unit weight by 10%, 0.1% and 2.29% respectively with 10% substitution.

Sudarsana et al. (2013) investigated on the influence of water absorption of ceramic waste aggregate on strength properties of ceramic aggregate concrete. M_{20} concrete is used with 0.48 water cement ratio. Ceramic waste water absorption is 0.08% more than conventional aggregate. Compressive strength is best at 20% replacement reaching 93.45%, 98.84% to that of conventional concrete at 7 and 28 days. There is decrease in density with increase of percentage replacement; at 100% replacement density is 4.43% less when compared to conventional concrete.

Maya et al. (2014) studied the mechanical properties of roof tiles as coarse aggregate with different ratios of 0.40, 0.45 and 0.50, subjected to elevated temperature. There is a decrease in compressive strength and Split Tensile with increase in water cement ratio and temperature.

Umapathy et al. (2014) studied on Rice Husk Ash(RHA) as cement at 10%, 15% and 20% and waste tiles as coarse aggregate at 20%, 30% and 50%. Compression strength is found out and the best results is with 20% tiles and 10%RHA of 80.60% to that of conventional concrete.

Amir Javed et al. (2015) analysed the compressive and flexural strength of concrete with stone dust as natural sand at 20%, 40%, 60%, 80% and 100% along with ceramic waste as stone aggregate at 20% replacement. It is found that at 40% stone dust and 20% ceramic waste compressive strength reaches upto 77.32% of that of conventional concrete whereas there is an increased in flexure strength by 25.62%.

Aruna et al. (2015) experimented on clay roof tile in concrete, pervious concrete and another combination of fly ash as cement and tile as coarse aggregate. Tile is replaced at 0%, 5%, 10%, 15%, 20% and 25% as T0, T5, T10, T15, T20 and T25. In pervious concrete, as 0%, 10%, 20% and 30% as P0, P10, P20 and P30. Similarly T0F0, T5F10, T10F20, T15F30, T20F40 and T25F50 for fly ash and tile combination. Water cement ratio adopted is 0.41. Density and slump is least at T25 as 4.59% and 75mm respectively. In pervious concrete at P30 density is less by 8.68% than conventional concrete. And also at T25F50 by 6.27% and slump as 75mm. Maximum compression is attained at T15F30 as 81.26% to that of conventional concrete.

Hemanth Kumar et al. (2015) replaced both coarse aggregate and fine aggregate partially with tiles waste at 10% and 20% for both. Workability and compressive strength were studied at 7 and 28 days. The optimum results obtained is at 20% as fine aggregate and 10% as coarse aggregate.

J.Swathi et al. (2015) partially replaced fine aggregate with copper slag as 20%, 40% and 60% and coarse aggregate with waste ceramic tiles as 10%, 20% and 30%.M40 grade of concrete was used. Compressive strength increased by 7.59N/mm^2 at a combination of

40% copper slag with 10% waste ceramic tiles and also Flexure increased by 4.07%.

Kotresh et al. (2015) investigated on ferrous slag as fine aggregate at 0%, 20%, 40%, 60%, 80% and 100% and Mangalore tiles as coarse aggregate. Water cement ratio of 0.52 and 0.58 is adopted. Compressive strength is $15.33N/mm^2$ and $18.495N/mm^2$ with 0.52 water cement ratio at 7 and 28 days. Similarly it is $10.573N/mm^2$ and $13.995N/mm^2$ for 0.58 water cement ratio.

M.Roobini et al. (2015) determined the development strength of concrete with ceramic tiles as coarse aggregate. 20MPa characteristic strength concrete is used with water cement ratio of 0.5. The compressive strength and split tensile strength improved by 4.84% and 13.30% respectively at 20% replacement. Whereas, flexure strength is best at 10% replacement which is 4.84% more than that of conventional concrete.

R. Janarthanan et al. (2015) experimented on ceramic waste as a construction material by replacing it as coarse aggregate for 25%, 50% and 100%. M_{30} concrete mix is chosen. Best results were found out at 25% replacement with $34.63N/mm^2$ Compression strength which is close to conventional concrete being $34.23\ N/mm^2$.

Shler Saeed Qadir (2015) studied on ceramic waste of 0%, 15%, 25% and 35% substitution as coarse aggregate. M_{30} grade concrete is used with water cement ratio of 0.33. Best compressive strength reaches upto 91.58%, indirect tensile upto 98.20% and flexure strength upto 98.12% to that of conventional concrete.

T.Subramani et al. (2015) focused on the production of light weight concrete by replacing conventional coarse aggregate with waste ceramic tiles at 20%, 25% and 30%. M_{30} grade concrete is adopted with water-cement ratio of 0.43. There is increase of 16.33%, 76.76% and 37.07% in Compressive strength, Split tensile strength and Flexure strength at 30% replacement.

V. Giridhar et al.(2015) experimented on concrete with ceramic waste as natural coarse aggreagate at 0%, 20%, 40%, 60%, 80% and 100%. M_{20} concrete is adopted. Maximum compression attained at 20% replacement reached 93.45% and 98.84% to that of conventional concrete. Similarly split tensile strength reaches 97.38% and 93.78% to that of conventional concrete at 7 and 28 days respectively.

III. DISCUSSION

Based on various studies, it is observed that with the inclusion of ceramic waste in concrete the properties of concrete improves and even far better than conventional coarse aggregate itself. It is observed that in most of the papers the mechanical properties such as compressive, split tensile and flexure have improved. In addition there is a decrease in density thus resulting in a light weight concrete. There is also promising results regarding the durability properties.

IV. CONCLUSIONS FROM THE REVIEW

- The optimum level of ceramic waste replacement should be between 5 to 30% in order to obtain maximum strength of the concrete.
- The best possible ceramic waste must be found out which will be suitable to be used as a substitute for conventional coarse aggregate.
- Research should be made with ordinary concrete like M_{15} and M_{20} as this type of concrete only is commonly adopted, after which research can be carried with high strength concrete.
- The ceramic waste to be used should be deglazed and a lower cement ratio should be adopted so as to achieve the desired targeted strength.

V. REFERENCES

[1] R.M.Senthamarai and P. Devadas Manoharan, “Concrete With Ceramic Waste Aggregate”, Elsevier, Cement and Concrete Composites, No. 27, Pp. 910-913, 2005.

[2] A. Mohd Mustafa Al Bakri, M.N. Norazian, H.Kamarudin and G.Che Mohd Ruzaidi, “The Potential of Recycled Ceramic Waste as Coarse Aggregates For Concrete”, Malaysian Universities Conferences on Engineering and Technology, Pp.1-3, 2008.

[3] C.Medina, M.I.Sanchez de Rojas and M.Frias, “Reuse of Sanitary Ceramic Wastes as a Coarse Aggregate in Eco-Efficient Concrete”, Elsevier, Cement and Concrete Composites, No.34, Pp. 48-54, 2012.

[4] R.M.Senthamarai, P.Devadas Manoharan and D.Gobinath, “Concrete Made From Ceramic Industry Waste: Durability Properties”, Elsevier, Construction and Building Materials, No. 25, Pp. 2413-2419, 2011.

[5] T.Sekar, “Study on Strength Characteristics on Utilisation of Waste Materials As Coarse Aggregate in Concrete”, International Journal of Engineering Science and Technology, Vol. 3, No.7, Pp. 5436-5440, 2011.

[6] Y.Tabak, M.Kara, E.Gunay, S.t.Yildirimand and S.Yilmaz. "Ceramic Tile Waste As a Waste Management Solution For Concrete", CRETE 2012.

[7] D.Tavakoli, A.Heidari and M.Karimian "Properties of Concrete Produced with Waste Ceramic Tile Aggregate", Asian Journal Of Civil Engineering, Vol. 14 No.3, Pp. 369-382, 2013.

[8] Sudarsana Roa hunchate, Giridhar Valikala and Vaishali.G.Ghorpade, "Influence Of Water Absorption of the Ceramic Aggregate on Strength Properties Of Ceramic Aggregate Concrete", International Journal of Innovative Research in Science, Engineering and Technology, Vol. 2, No. 11, Pp. 6329-6335, 2013.

[9] T.M.Maya and Nivin Philip "Mechanical Prroperties of Concrete Containing Roof Tile Aggregate Subjected To elevated Temperature", International Journal of Innovative Research in Advanced Engineering, Vol. 1, No.8, Pp. 255-261, 2014.

[10] U.Umapathy, C.Mala and K.Siva"Assesment of Concrete Strength Using Partial Replacemnt of Coarse Aggregate for Waste Tiles and Cement For Rice Husk Ash in Concrete", International Journal of Engineering Research and Applications, Vol. 4, No. 5, Pp. 72-76, 2014.

[11] Amir Javed, Salman Siddique and V.S.Ram Prasad, "Investigation On Ceramic Waste and Stone Dust as Aggregate Replacement in Concrete", International Journal of Engineering Technology, Management and Applied Sciences, Vol. 3, ISSN. 2349-4476, Pp. 127-130, 2015.

[12] D.Aruna, Rajendra Prabhu, Subhash C Yaragal, Katta Venkataramana, "Studies On Usage Potential Of Broken Tiles As Part Replacement To Coarse Aggregates In Concrete", International Journal of Research In Engineering and Technology, Vol. 4, No.7, Pp.110-114, 2015.

[13] Hemanth Kumar Ch, Ananda Ramakrishna K, Sateesh Babu K, Guruvaiah T, Naveen N and Jani Sk, "Effect of Waste Ceramic Tiles in Partial Replacement of Coarse and Fine Aggregate of Concrete", International Advanced Research Journal in Science, Engineering and Technology, Vol. 2,No.6,Pp. 13-16, 2015.

[14] J.Swathi and V.Gnanadevi, "An Experimental Investigation On Concrete By Partial Replacement Of Copper Slag For Fine Aggregate And Ceramic Waste With Coarse Aggregate", International Journal of Emerging Technology in Computer Science And Electronics, Vol.13, No. 4, ISSN.0976-133, 2015.

[15] K.M. Kotresh, D.P.Anup, Mesfin Cetahun Belachew and H.P. Vageesh , "Cost Effective Concrete by Using Mangalore Tile Wastages and Iron Ore Slag", International Journal of Innovative Research in Science, Engineering and Technology, Vol. 4, No.4, Pp. 2451-2459, 2015.

[16] M.Roobini and R.Loganathan,"Study On Concrete Strength By Utilisation of Waste Ceramic Tiles As Aggregate In Concrete", Integrated Journal Of Engineering Research and Technology, ISSN N0. 2348 - 6821, Pp. 227-232, 2015

[17] Janarathanan R, Radha Srinivasan and Muthu Mariappan P, "Effective Utilisation Of Ceramic Waste as a Raw Material in Concrete," International Journal for Scientific Research and Development, Vol. 3, No. 1, Pp. 904–906, 2015.

[18] Shler Saeed Qadir, "Strength and Behavior of Self Compacting Concrete with Crushed Ceramic Tiles as Partial Replacement for Coarse Aggregate and Subjected To Elevated Temperature", International Journal of Engineering Technology, Management and Applied Sciences, Vol. 3, No. 4, ISSN.2349-4476, 2015.

[19] T.Subramani and B.Suresh, " Experimental Investigation Of Using Ceramic Waste As A Coarse Aggregate Making A Light Weight Concrete", International Journal of Application or Innovation in Engineering and Management, Vol. 4, No. 5, Pp. 153-162, 2015.

[20] V.Giridhar, H.Sudarsana Rao and G.Ghorpade "Development of Regression Models For Stregth Of Ceramic Waste Aggregate Concrete", International Journal Of Emerging Trends In Engineering and Development, Vol. 1, N0.5, ISSN. 2249-6149, 2015.