International Journal of Engineering Research-Online
A Peer Reviewed International Journal
Email:editorijoer@gmail.com http://www.ijoer.in

Vol.4., Issue.4., 2016
(July-August)

REVIEW ARTICLE

ISSN: 2321-7758

A REVIEW ON THE OPTIMUM MIX PROPORTIONING OF CERAMIC WASTE CONCRETE USING TAGUCHI METHOD

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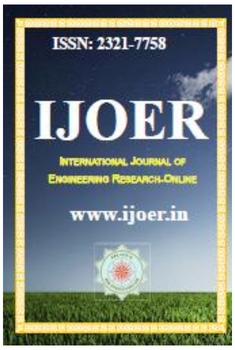

ABSTRACT

In the world there are different nature of construction has been taken into consideration. The construction field may be in the form of residential, commercial or many more monuments where ceramic tiles are used in huge amount. From that places where the alternatives of fine aggregate and coarse aggregate as ceramic waste material plays a vital role to preserve the natural resources and overcome in expenditure while project. Establishment for a pollution free environment there must be one of the most important factor is using of ceramic waste material which helps to mitigate production of cement where large number of contaminants are originate. The use of ceramic waste gave an alternative to natural coarse and fine aggregate. During the experimental work the ceramic waste has been tried as replacement of aggregates and substitute to natural fine aggregate and coarse aggregate in concrete making of cubes. After getting all response from experimental study the results indicate effectiveness of ceramic waste as partial replacement of fine aggregate in the range of (30%, 40% and 50%) and natural coarse aggregate in the range of (20%, 30% and 40%) by weight of concrete without affecting the design strength.

Keywords – Ceramic waste, compressive strength, pollution, environment, contaminants, coarse aggregate, fine aggregate, monuments

INTRODUCTION

Ceramic tiles today have become an integral part of construction. In the world during 2014-15 the production at global level of ceramic tiles is about 11913 million square meters in which Indian ceramic tiles production is 750 million square meters. In the ceramic industry, about 15 – 30% waste material generated from the total production. The recycling of these wastes is not likely in any from at present. However, the ceramic waste is hard, durable and highly resistant to biological, chemical and physical degradation forces. The ceramic industries are dumping the crust and 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 after and occupation of a vast area of land, especially after the powder dries up so it is essential to dispose the ceramic wastes quickly and use in the construction industry. As the ceramic waste piling up every day, there is a pressure on ceramic industries to find a solution for its disposal. With the utilization of ceramic waste it helps to improve economical condition of developing countries and focus on to regulate the environmental pollution for developed countries.

For the purpose of the saving natural resources there is best opportunity for civil engineers is the exploitation of ceramic waste in construction industry. The depletion of natural aggregates is a very steady problem hence partial replacement of such ceramic waste materials offer energy savings, time savings, fewer hazards in the environment and cost reduction for any construction project where ceramic waste is being used.

Objective

There are different kinds of objectives of this research which are following as –

- To use of the ceramic waste for the making of concrete as the partial replacement of fine aggregate and coarse aggregate which helps to make the pollution free environment as well as providing an economic value of the waste material.
- To safety the nature of concrete after replacement of such materials which are by conducting experimental works.
- To forming robust design with the application of Taguchi's Method.
- To minimize the time duration while making a successful project using "Design of experiment" from Taguchi's Method.
- To check the characteristics strength of concrete as compare to conventional concrete.

Materials

Cement

For making of concrete, cement is a prime ingredient which is usually applied in experimental works was commercially available. Portland-Pozzolana Cement part I based on fly ash which is manufactured by Prism cement company also known as Prism champion confirming to IS 1489:1991 was used in this study. The compressive strength of cement was 33 Mpa. The initial and final setting time was found as 30 minutes and 600 minutes respectively.

Aggregate

Aggregates are the important materials in the concrete. They give body to the concrete, reduce shrinkage and effect economy. One of the most important factors for producing workable concrete the aggregates should be of good gradation. Good grading implies that a sample fraction 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 means less quantity of cement and less water, which are further mean increased economy, higher strength, lower shrinkage and greater durability.

I. Coarse Aggregate

The fractions from (20 - 4.75 mm) are used as coarse aggregate. The coarse aggregate from crushed basalt rock, confirming to IS 383:1970 is being use. The flakiness and elongation index were maintained well below 15%.

II. Fine Aggregate

The fractions which are come in category 4.75 mm to 150 micron are termed as fine aggregate. The river sand is used in combination as fine aggregate confirming to the requirements of IS 383:1970. The river sand is washed and screens to eliminate deleterious materials and oversize particles.

Water

Water is an important ingredient of concrete as it actually participates in the chemical reaction with cement. Since it helps to form the strength giving cement gel, the quantity and quality of water are required to be looked into very carefully.

Ceramic Waste

The ceramic wastes are obtained from the place of construction of local buildings where flooring work is going on. The ceramic waste is taken out in the form of crust and which are not desirable for the making of concrete. Before start out on the experiment, for getting the desired shape and size the crust of ceramic waste is properly change through mechanical process.

Ceramic waste Aggregate

The coarse aggregate is obtained from crust which is mechanically formed from the ceramic waste. The aggregate most of which is retained on 4.75 mm IS sieve and containing only so much finer material as is permitted which is shown in fig. (a) The specific gravity of tile aggregate is 2.63 and fineness modulus of 7.358.

Fig. - (a)

Ceramic waste Powder

Also fine aggregate is comes from crust in the form of powder with the help of mechanical process. The fine aggregate most of which passes 4.75 mm IS sieve and contains only so much coarser material which is shown in fig. (b).

Fig. - (b)

Taguchi Method

Taguchi has envisaged a new method of conducting the design of experiments which are based on well defined guidelines. This method uses a special set of arrays called orthogonal arrays. These standard arrays stipulates the way of conducting the minimal number of experiments which could give the full information of all the factors that affect the performance parameter. The crux of the orthogonal arrays method lies in choosing the level combinations of the input design variables for each experiment.

While there are many standard orthogonal arrays available, each of the arrays is meant for a specific number of independent design variable and levels.

Table -1(a)

L_9 (3^4) Orthogonal array					
	Independent Variables				Performance Parameter Value
Experiment #	Variable 1	Variable 2	Variable 3	Variable 4	
1	1	1	1	1	P1
2	1	2	2	2	P2
3	1	3	3	3	P3
4	2	1	2	3	P4
5	2	2	3	1	P5
6	2	3	1	2	P6
7	3	1	3	2	P7
8	3	2	1	3	P8
9	3	3	2	1	P9

The table - 1(a) shows an L_9 orthogonal array. There are totally 9 experiments to be conducted and each experiment is based on the combination of level values as shown in the table. For example, the third experiment is conducted by keeping the independent design variable 1 at level 1, variable 2 at level 3, variable 3 at level 3, and variable 4 at level 3.

Designing an experiment

The design of an experiment involves the following steps

- Selection of independent variables
- Selection of number of level settings for each independent variable
- Selection of orthogonal array
- Assigning the independent variables to each column
- Conducting the experiments
- Analyzing the data
- Inference

Design Mix

As per Indian Standard method (IS 10262:2009) a mix M20 grade was designed and the same was used to prepare the test samples. The design mix proportion is done in following table.

Design Mix Proportion for Various Concrete Mix

Table-1(b)

Experiment #	Concrete Designation	Concrete design Mix Proportion
1	A1	1 : 1.46 : 3.00
2	A2	1 : 1.48 : 2.90
3	A3	1 : 1.45 : 2.95
4	A4	1 : 1.46 : 3.00
5	A5	1 : 1.48 : 2.90
6	A6	1 : 1.45 : 2.95
7	A7	1 : 1.46 : 3.00
8	A8	1 : 1.48 : 2.90
9	A9	1 : 1.45 : 2.95

Experimental Methodology

The evolution of ceramic waste for use as a replacement of fine aggregate and coarse aggregate begins with the testing of concrete. Cement, fine aggregate, coarse aggregate and water was prime material for making the concrete. With control of the concrete, i.e. 30%, 40% and 50% of the fine aggregate is replaced with ceramic waste and again 20%, 30% and 40% of the coarse aggregate is replaced with ceramic waste, the data from the ceramic waste is compared with data from a standard concrete without ceramic waste. Using Taguchi Method there are nine experiments were done and from each experiment six cube samples were cast on the mold of size (100×100×100) mm with various proportions with partial replacement of coarse aggregate and fine aggregate also with different w/c ratios which are already shown in Table- 1(a) & (b). After about 24 hrs. the specimens were de-molded and water curing was continued till the respective specimens were tested after 14 and 28 days for testing of compressive strength.

Compressive Strength

Compressive strength tests were performed on compression testing machine using cube samples. Three samples per batch were tested on 7 days and 28 days respectively with the average strength values reported in this paper. The comparative studies were made on their characteristics for concrete mix with the partial of fine aggregate with ceramic waste as 30%, 40% & 50% and coarse aggregate with ceramic waste as 20%, 30% & 40%.

Table -1(c) : *(FA – fine aggregate, CA – coarse aggregate, w/c – water cement ratio)*

$L_9(3^4)$ Orthogonal array						
	Independent Variables				Compressive Strength	
Experiment	Cement (kg/m^3)	FA (%)	CA (%)	w/c Ratio	7 Days (N/mm^2)	28 Days (N/mm^2)
1	370	30	20	0.48	22.53	25.87
2	370	40	30	0.49	16.20	25.86
3	370	50	40	0.50	15.93	24.47
4	380	30	30	0.50	17.40	26.87
5	380	40	40	0.48	16.80	24.73
6	380	50	20	0.49	15.80	24.67
7	390	30	40	0.49	20.60	30.67
8	390	40	20	0.50	16.66	26.46
9	390	50	30	0.48	21.00	32.27

Conclusion

On the basis of experimental investigations concerning the compressive strength of concrete, are several conclusions are made such as –

a) The compressive strength of M20 grade concrete increase when the replacement of fine aggregate with ceramic waste (powder) up to 50% by weight of fine aggregate and also the replacement of coarse aggregate with ceramic waste up to 40% by weight of coarse aggregate.

b) Concrete on 50% replacement of fine aggregate with ceramic waste (powder) and 30% replacement of coarse aggregate with ceramic waste, compressive strength obtained is 32.27 N/mm^2 and vice-versa the weight of concrete is reduced up to 11.8% by weight of conventional concrete in M20 grade and therefore it becomes more decrement in dead load without compromising concrete strength than the standard concrete. It becomes technically and economically feasible and viable.

c) Utilization of ceramic waste and its application are used for the development of the construction industry and material sciences.

d) Usage of ceramic waste can not only preserve the finite raw materials, but also reduce energy consumption.

e) It is the possible alternative solution of safe disposal of ceramic waste.

References

[1]. Abdullah Mohd. Mustafa Al Bakri, Hussin Kamarudin, RuzaidiCheMohd, BharinShamsul, RamlyRozaimah and NisaNurKhairatun, (2006),"Concrete Ceramic waste slab", Journal of engineering research and education, Volume 3 139-145.

[2]. Brito J. de, Pereira A. S. and Correria J. R., (2004), "Mechanical Behavior of non-structural concrete made with recycled ceramic aggregates". Elsevier Ltd., cement and concrete composites 27 (2005) 429-433.

[3]. C. Medina Martínez, M.I.GuerraRomero,J. M. Morán del Pozo and A. Juan Valdés, "USE OF CERAMIC WASTES IN STRUCTURALS ONCRETES", 1st Spanish National Conference on Advances in Materials Recycling and Eco – Energy Madrid, 12-13 November 2009.

[4]. Correia J. R., Brito J. de and Pereira A. S., (2005), "Effects on concrete durability of using recycled ceramic aggregates". International union of laboratories and experts in construction materials, systems and structures, RILEM publications, materials and structures 38.

[5]. Daniyal Md. and Ahmad Shakeel (2015), "Application of Waste Ceramic Tile Aggregates in Concrete", International Journal of Innovative Research in Science, Engineering and Technology (An ISO 3297: 2007 Certified Organization) Vol. 4, Issue 12, December 2015, ISSN(Online): 2319-8753, ISSN (Print): 2347-6710.

[6]. Fernando and Said "Compressive strength and durability properties of ceramic wastes based concrete" Materials and Structures, 2009, vol. 44, page no: 155–167.

[7]. İ.B.TOPÇU And M.CANBAZ, "Utilization of crushed tile as aggregate in concrete", Iranian Journal of Science & Technology, Transaction B, Engineering, Vol. 31, No. B5, pp. 561-565, 2007.

[8]. Juan Andres, Medina Cesar, Guerra M. Ignacio, Moran Julia M, Aguado Pedro J., Rojas M Isabel Sanchez de, Frias Moises and Rodríguez Olga (2010)."Re-Use of Ceramic Wastes in Construction", Ceramic Materials, WilfriedWunderlich (Ed.), ISBN: 978-953-307-145-9, InTech, Available from: Pacheco-Torgal F. andJalali S. (2010), "Reusing ceramic wastes in concrete". Elsevier Ltd., construction and building materials 24 (2010) 832-838.

[9]. Raval Amit kumar D., Patel Indrajit N., PitrodaJayeshkumar (2013),"Eco-Efficient Concretes: Use Of Ceramic Powder As A Partial Replacement Of Cement", International Journal of Innovative Technology and Exploring Engineering (IJITEE) ISSN: 2278-3075, Volume-3, Issue-2, July 2013.

[10]. Raval Amit kumar D., Patel Indrajit N., PitrodaJayeshkumar (2013), "Ceramic waste: Effective Replacement of cement for establishing sustainable concrete" International Journal of Engineering Trends and Technology (IJETT) ISSN: 2231-5381, Volume-4, Issue-6, June 2013.

[11]. Senthamarai R. M. and DevadasManoharan P., (2005), "Concrete with ceramic aggregates".Elsevier Ltd., cement and concrete composites 27 (2005) 910-913.

[12]. Zimbili O., Salim W., Ndambuki M. (2014), "A Review on the Usage of Ceramic Wastes in Concrete Production", World Academy of Science, Engineering and Technology International Journal of Civil, Environmental, Structural, Construction and Architectural Engineering Vol: 8, No:1, 2014.