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Experimental Study on Partial Replacement of Fine Aggregate by Ceramic Waste in Concrete

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Abstract - *Waste and find the solution of resulting it the most serious problem of the word today. Waste utilization has become an attractive alternative to disposal now days. There are number of researches, for use of waste in industry most of them related to use these waste in construction are or use of waste in concrete to develop new type of concrete. Use of waste producing is not only makes it economical but also a very good and attractive solution of disposal problem. Ceramic waste from ceramic industry is used to produce a new type of concrete by replacing the cement. According a report in India 30% of the daily production goes on waste during the manufacturing, usages and transportation. Ceramic waste increases day by day because of its usages in construction, so it is necessary for ceramic industry for diminishing the waste dump at ceramic industries is recycling, reusing and substitution of concrete ingredients. Ceramic waste produce from industry is durable, hard, and highly resistant to biological, chemical and physical degradation forces. Ceramic waste powder can be used to produce lightweight concrete, without affecting. The compressive strength of the concrete is improved by the use of optimal dosage of ceramic tile powder. Utilization of Ceramic waste is one of the active research area that encompass the effectiveness of replacement in all the aspects of construction materials. It is very essential to develop eco-friendly concrete from ceramic waste. This paper deals with the experimental study on the mechanical strength properties of M25 grade concrete with the partial replacement of sand by using ceramic waste. In order to analyze the mechanical properties such as compressive, split tensile, flexural strength, the samples were casted with 10%, 20%, 30%, 40%, replacement of sand using ceramic waste and tested for different periods of curing like 7 days, 14 days and 28 days. The optimum of percentage addition of Ceramic waste is analyzed considering the requirements of mechanical properties of concrete.*

Key Words: Ceramic wastes, Partial replacement, Eco-friendly, Behavioural study.

1. INTRODUCTION

T he ceramic waste and will help to increase the high compressive strength of the concrete when compared to the other materials. Considering the environmental factors we can recycle the Construction and debris waste used in the concrete. Concrete is an essential construction material which is usually associated with Fine aggregate henceforth fine aggregate acts as an essential element in the construction field. In the present condition the demand of sand is going increased, and it leads to the gradual cost increment of river sand. Thus the M-sand have being implementing in present situation. But, some of the criteria regarding the manufacturing of M-sand are limited in a particular amount. So, still the demand of sand is there, so introducing the new fine aggregate from waste ceramic tiles, by crushing it to get the required size. The 30% of ceramic products are being waste daily, so there is a small cost for this waste or sometimes it has no cost because the ceramic products can't be recycled and re-used. The utilization of concrete in Indian construction industries is at the rate of about 400 million tons per year and if this continues it may reach a billion tons in less than a decade. Concrete is made of various aggregates present in the earth's crust, in this manner its assets are consistently drained causing ecological strain. Environment is also been affected by various human actions which deliver solid waste in significant amounts i.e., more than 2500 million tons per year, inclusive of all the industrial, medical, agricultural and other forms of waste from the rural and urban areas. Clearance of all these solid wastes causes various issues and complication thereby affecting the ecology. Presently large amounts of ceramic wastes are generated in ceramic industries which would have an important impact on environment and humans. But now a days the awareness regarding the use of these ceramic waste in construction field has increased. Even this type of usage produce solid waste but the disposal of them is not much complicated compared to the waste and pollution by the source industries. The non-biodegradable ceramic materials used for Floor tiles, wall tiles, and weather course tiles, sanitary ceramic products, electrical ceramic insulators and ceramic utensils etc. can be conveniently recycled into concrete elements for various service and locations. This replacement has numerous ad-vantages such as the economy, using as sustainable material and reduction solid waste disposal and minimize the environmental hazards. Ceramic tiles possess a broad range of properties, and certain tiles are better suited for some installations than others. Few tiles are fitted for all types of installations; consequently, good knowledge of the properties is essential for the consumer to achieve the desired and look forward value of the tile. Because so many tile installations are built around or near water, and because due to porous materials it can soak up the moisture and dock unwanted organisms,

absorption is one of the most important properties, that is because, in wet-area applications, it can involve health and safety issues, and in exterior applications, it can initiate important freeze/thaw damage. Ceramic waste can be separated in two categories in compliance with the origin of raw materials. The first one are all fired waste generated by the ceramic factories that use only red paste to manufacture their products, such as brick, blocks and roof tiles. The second one is all ignited waste manufactured in stoneware ceramic such as wall, floor tiles and sanitary ware. The ceramic industry is comprised of the following sub-sectors like wall and floor tiles, sanitary ware, bricks and roof tiles, stubborn materials and ceramic materials for domestic and ornamental.

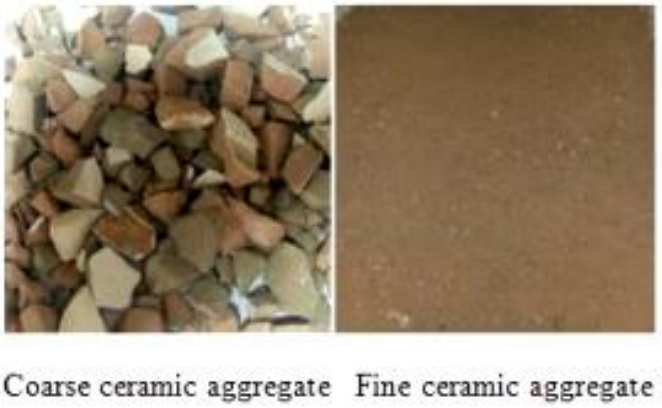

Fig -1: Sample Ceramic aggregates

2. LITERATURE REVIEW

- G. Sivaprakas, v. Saravana kumar and lakhi jyoti saikia, "Experimental Study on Partial Replacement of Sand by Ceramic Waste in Concrete"(2016) says clearly that the ceramic waste can be used as replacement materials for river sand in concrete. The concrete with 10 and 20% replacement satisfies the compressive strength of M25 grade however higher the percentage addition of ceramic waste reduces the strength of normal concrete. The tensile strength of 10, 20, 30% replacements at 14 days shows the consistency in attaining the required range. Hence the replacement of river sand using 30% ceramic waste in concrete gives the required strength and can be considered as optimum percentage

- C.Karthik and S.Ramesh Kumar, "Experimental Investigation on Concrete with Ceramic Waste as A Partial Replacement of Fine Aggregate"(2016) Ceramic wastes are the main problem of tile industries and from demolition buildings. The aim of this investigation was the utilization of ceramic waste collected from dressing and polishing of metal or non-metal compounds in concrete as fine aggregate. The use of ceramic waste in concrete as positive effects on the environment and obtaining lower costs. In this experimental investigation, concrete mix M25 has been used. The concrete with ceramic waste as a partial replacement of fine aggregate are used and the results have been evaluated. The properties of ceramic waste fine aggregate concrete are not significantly different from those of conventional concrete. The compressive strength and split tensile strength of concrete made using ceramic waste up to 30% replacement of fine aggregate, the strength increases.

- Dr. M.Swaroopa Rani, "A Study on Ceramic Waste Powder"(2016)The study shows that the addition of the industrial wastes improves the physical and mechanical properties..The Compressive Strength of M40 grade concrete increases when the replacement of cement with ceramic waste is up to 10% by weight of cement, and further replacement of cement with ceramic powder decreases the compressive strength.

- Aruna D : For tile waste based concrete, coarse aggregates were replaced by 20mm down size, tile wastes by 0% , 5%, 10%, 15%, 20% and 25% and also the cement is partially replaced by fly-ash. The average maximum compressive strength of roof tile aggregate concrete is obtained at a replacement of 25%. A reduction of 10-15% of strength is observed compared to conventional concrete at 25% of roof tile aggregate replacement. The workability of roof tile waste concrete is in the range of medium. Overall, the replacement of tiles in concrete is satisfactory for small constructions.

- Batriti Monhun R. Marwein : The ceramic waste adopted is broken tiles. Ceramic waste concrete (CWC)made with these tiles at 0%, 15%, 20%, 25% and 30%. M20 grade concrete is adopted; a constant water cement ratio of 0.48 is maintained for all the concrete mixes. The characteristics properties of concrete such as workability for fresh concrete, also Compressive Strength, Split Tensile Strength are found at 3, 7 and 28 days. The paper suggests that the replacement of waste tile aggregate should be in the range of 5-30% and also it is suitable to ordinary mixes like M15 and M20.

- Parminder Singh and Dr. Rakesh Kumar Singla : A research paper on utilization of ceramic waste tiles from industries. A partial replacement to coarse aggregate has been studied. Three different grades of concrete has been prepared and tested. The results are not appropriate with the conventional but considering the strength properties, it is advisable to use ceramic tile aggregate in concrete. It is finally concluded that, about 20% of ceramic tile usage in M20 grade of concrete is preferable.

- Paul O. Awoyera : The usage of ceramic tiles in concrete was observed in this paper. In this, both the coarse and fine aggregates are replaced with ceramic fine and ceramic coarse aggregates obtained from construction

sites of Ota, Lagos and Nigeria in various percentages. The ceramic fine and coarse aggregates are replaced in conventional concrete individually and the strength parameters are studied. Finally, it states that usage of ceramic waste in concrete gives considerable increase in strength compared to conventional concrete.

- P. Rajalakshmi: Use of ceramic waste will ensure an effective measure in maintaining environment and improving properties of concrete. The replacement of aggregates in concrete by ceramic wastes will have major environmental benefits. In ceramic industry about 30% production goes as waste. The ceramic waste aggregate is hard and durable material than the conventional coarse aggregate. It has good thermal resistance. The durability properties of ceramic waste aggregate are also good. This research studied the fine aggregate replacement by ceramic tiles fine aggregate accordingly in the range of 10% and coarse aggregate accordingly in the range of 30%, 60%, and 100% by weight of M-30 grade concrete. This paper recommends that waste ceramic tiles can be used as an alternate construction material to coarse and fine aggregate in concrete irrespective of the conventional concrete; it has good strength properties i.e., 10% CFA and 60% CCA being the maximum strength.

- Prof. Shruthi H. G.: Ceramic tiles were obtained from manufacturing industries, from construction and demolition sites, this cause's environmental pollution. The utilization of crushed tile as a coarse aggregate in concrete would also have a positive effect on the economy. study, Ceramic tile waste were used in concrete as a replacement for natural coarse aggregate with 0%, 10%, 20% and 30% of the substitution and M20 grade concrete were used. The concrete moulds were casted and tested for Compressive Strength and Split Tensile Strength after a curing period of 3, 7 & 28 days. The results indicate that, the maximum compressive strength is obtained for the 30% replacement of ceramic tile aggregate with natural coarse aggregate.

- Wadhah M.Tawfeeq : This study investigated the effects of using crushed tiles (CT) as coarse aggregates in the concrete mix. The technology of concrete recycling is well established in the U.S. Recycling of Portland cement concrete, as well as asphaltic concrete, has been shown to be a cost-effective alternative for road, street and highway construction. It includes not only the water content and tiles but also the gravel/sand ratio. They concluded that as the water cement ratio decrease, the compressive strength increases. The paper consists of replacement of crushed tiles to 50% and 100% only. The results show that replacement of crushed tiles as coarse aggregate below 50% will have considerable properties.

3. PROPERTIES OF MATERIALS AND METHODOLOGY

Ceramic Waste:
Tiles Ceramic waste is accessible from vast ceramic industrial facilities, ceramic item producing units and from regular development exercises. Customary ceramics, for example, blocks, rooftop and floor tiles, other development materials, and specialized ceramics, for example, porcelain are normally very heterogeneous because of the wide compositional scope of the common mud utilized as crude materials. Around 300 kg of wastes from an Indian ceramic organization (RAK Ceramics Pvt. Ltd., Chennai) was smashed with an altering pole physically to make the ceramic aggregate. In this manner, by utilizing this framework to pound a ceramic waste is conceivable to acquire coarse aggregates, fine aggregates. And ceramic powder that subsequent to sieving (IS 4.75 mm strainer) can be utilized without extra work and with insignificant cost suggestions.

Cement
Ordinary Portland cement of 53 grade conforming to IS 8112-1989 was used. The initial setting time of cement is 30 minutes and the specific gravity of cement is 3.15.

S. No	Material Properties	Cement Test Results
1.	Initial Setting Time	30 minutes
2.	Final Setting Time	600 minutes
3.	Standard Consistency Test	40%
4.	Specific Gravity	2.69
5.	Fineness	5%

Table-1 Properties of cement

Fine aggregate
Natural river sand which is locally available obtained from the Godavari river is used as fine aggregates. Manufactured sand with fraction passing the 4.75mm sieve and retained on the 600micron sieve was used and fineness modulus of 4.04 with the specific gravity of 2.64 was used. The grading zone of aggregate was zone 2.

Coarse aggregate
Aggregates greater than 4.75mm are considered as aCoarse aggregate. Crusted granite coarse aggregate of 20mm downsize were used and the fineness modulus of 4.32 with a specific gravity of 2.63 was used.

Water
Water to be used for the Mixing and Curing purpose of cement concrete should be free of dirt and pollution. As per the IS: 456-2000 specifications.

Methodology
Collection of material: for ceramic waste for concrete and materials are collected like normal grade of cement, aggregates, water.

Weighing and mixing process: material are weighed in proper ratio as per design and after then mixed in proper way. Moulding process: concrete mixer is molded in cube

sized 150*150*150 mm^3 and beam size of 500*100*100 mm^3. Removing of mould After 24 hours the moulds are removed. Curing process: concrete cubes and beams are cured in fresh water for 7 days to 28 days. Testing process: after removing the moulds, concrete cubes and beams are tested in campus concrete laboratory. Analysis and test result: after various test on cube and beams, result are calculated.

In this research paper, M25, mix proportion is designed as per guidelines of Indian Standard recommended method IS 10262:2009. We used 53-grade cement; also zone 2 is taken into consideration from IS 383(1970) for fine aggregate. The coarse aggregate is selected passing through 20mm and retained on 10mm Sieve.

Quantities of the ingredients required for 1 cum cement concrete (M25)

Materials	Quantity
Cement	384 kg/cum
Sand	658 kg/cum
Coarse Aggregate	1142kg/cum
Water	192 ltr/cum

Table-2 Material Quantity

Mix Designation	Cement	FA	CA	Ceramic waste as FA
M-0	100%	100%	100%	0%
M-10	100%	90%	100%	10%
M-20	100%	80%	100%	20%
M-30	100%	70%	100%	30%
M-40	100%	60%	100%	40%

Table-3 Details of Replacement by sand

4. RESULTS AND DISCUSSIONS

All the tests have been performed in standard procedures and the results and load values obtained were tabulated and calculated in following sections.

Workability

Slump of Concrete Mixes

The use of fine ceramic aggregate as replacement of sand in concrete mixes resulted in a decrease in the slump as the percentage of the replacement ratio increases as shown in Fig... When replacement of coarse aggregates reached 40%, the loss in slump was 61.1%, while loss in slump reached 100% when replacement level of fine aggregate was 60%. This expected reduction of slump is due to the high water absorption of ceramic aggregates.

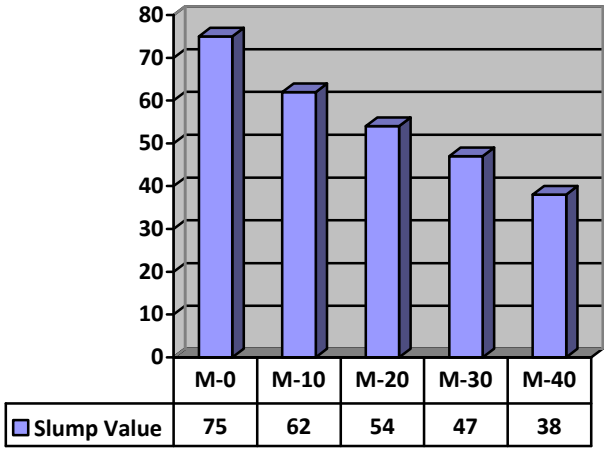

Table -4 Slump values

Compressive Strength

Compressive strength tests were conducted on cured cube specimen at 7 days and 28 days age using a compression testing machine of 200 kN capacity. The cubes were fitted at center in compression testing machine and fixed to keep the cube in position. The load was then slowly applied to the tested cube until failure.

Concrete cubes of size 150mm x150mm x 150mm were casted for 0%, 10%, 20%, 30%, 40%, ceramic aggregate replacement. The compressive strength for M25 grade of concrete is tested for 7, 28 days of curing and the results are tabulated and plotted.

Sl.no	Mix (days)	Ceramic waste as FA replacement%	Cube Compressive strength (N/mm^2)
1	7	0%	17.14
		10%	18.6
		20%	18.86
		30%	25.23
		40%	22.9
2	28	0%	26.37
		10%	28.60
		20%	29.03
		30%	38.83
		40%	35.30

Table-5 Compressive Strength values

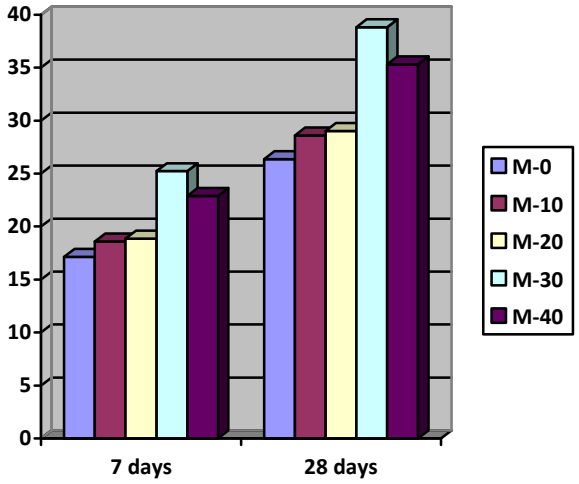

Chart -1 Compressive Strength

Split Tensile Strength

The split tensile test were conducted as per IS 5816:1999. Concrete cylinders of size 150mmx300mm were casted for 0%, 10%, 20%, 30%, 40% replacement of ceramic aggregate. The split tensile strength for M25 grade of concrete is tested for 28 days of curing and the results are tabulated and plotted below

Sl.no	Mix (days)	Ceramic waste as FA replacement%	Cylinder
			Split Tensile strength (N/mm²)
1	28	0%	3.09
		10%	3.23
		20%	3.96
		30%	4.41
		40%	4.34

Table -6 Split Tensile Strength values

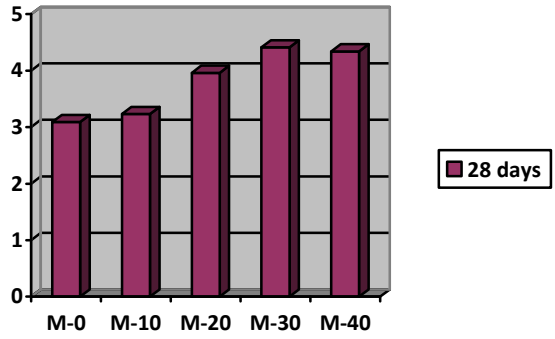

Chart -2 Split Tensile Strength

5. SUMMARY AND CONCLUSIONS

The present research focused on investigating the mechanical and physical properties of the recycled ceramic tile aggregate and the different characteristics of concrete incorporating this type of aggregate compared with concrete made of natural aggregate.

Based on the results of the experimental work carried out in this research, the following conclusions could be drawn.

The test results show clearly that the ceramic waste can be used as replacement materials for river sand in concrete.

The use of ceramic aggregates enhances some of the concrete properties such as compressive strength due to decrease in free-water. On the other hand, a decrease in workability was detected as the percentage of replacement increases since ceramic has high water absorption. Therefore, slump decreases as percentage of ceramic waste replacement increases for all cases. The decrease was remarkable in case of fine ceramic aggregate

The concrete with 10%, 20%, 30% & 40% replacement satisfies the compressive strength of M25.

The tensile strength of 10, 20, 30% replacements at 28 days shows the consistency in attaining the required range.

Hence the replacement of river sand using 30% ceramic waste in concrete gives the required strength and can be considered as optimum percentage.

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