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REUSE OF CERAMIC TILES AS COURSE AGGREGATES IN CONCRETE

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A B S T R A C T

This paper presents the results of an experimental study to investigate the potential of using recycled ceramic as aggregate in concrete. The ceramic aggregate used in this study was recycled from industrial ceramic tile waste in Egypt. The physical and mechanical characteristics of the recycled ceramic aggregate were investigated and compared to the conventional aggregates. Eleven concrete mixes with constant w/c ratio were prepared and tested. The reference concrete mix was made with conventional coarse and fine aggregates (crushed stone and natural sand). Five mixes were prepared incorporating coarse ceramic aggregate as partial substitute of coarse aggregate with replacement levels of 10%, 20%, 30%, 40%, and 50%. Besides, five mixes incorporated fine crushed ceramic as partial substitute of fine aggregate with replacement levels of 20%, 40%, 60%, 80%, and 100%. Slump test was conducted to investigate the effect of incorporating ceramic aggregates on the workability of fresh concrete. Compressive strength, splitting tensile strength, flexural strength, density, water absorption and sorptivity tests were accomplished to investigate the properties of hardened concrete. The experimental results revealed that the use of recycled ceramic tile aggregates is promising in structural concrete applications

Keywords*: Fine ceramic aggregate, Coarse ceramic aggregate, Sorptivity*

1. INTRODUCTION

Rapid industrial development causes serious problems all over the world such as depletion of natural aggregates and creates enormous amount of waste material from construction and demolition activities. One of the ways to reduce this problem is to utilize the waste. A large quantity of wastages produced annually in all countries, in particular construction and demolition waste contribute the highest percentage of wastes worldwide about 75%. Furthermore, ceramic materials contribute the highest percentage of wastes within the construction and demolition wastes about 54%. Ceramic waste is durable, hard and highly resistant to Biological, Chemical and Physical degradation forces. Ceramic tile aggregate are hard having considered value of specific gravity, rough surface on one side and smooth on other side, are lighter in weight than normal stone aggregates. Using ceramic tiles as aggregate in concrete not only will be cost effective but also will be good from environmental point of view. Aggregate and cement which are most important constitution used in concrete production are essential material needs for construction industry. This certainly led to a continuous and increasing demand of natural material used for this production. Parallel to the need for utilization of natural resource. The huge amount of natural aggregate, sand and water are being consumption in concrete production consequences to minimize these research have concentrated on the use of waste material as potential alternatives in construction industry, especially in concrete construction. In fact utilization of waste material (ex- slag, Flyash, plastic etc)in concrete construction is one of the prime research interests to reach the goal of achieved sustainable construction. Aggregate impact about 70% to 75% of volume to concrete. In this aspect consumption of waste tiles or broken tiles as course aggregate in concrete manufacturing can be get new scientific sobriety in the field of sustainable concrete. A large amount of tiles get waste in industry and mega construction projects.

2. MATERIALS

- **Cement:**

Cement is a fine powder, which when mixed with water and allowed to set and harden, is capable of uniting fragments or masses of solid matter together to produce a mechanically strong material. The most commonly used cement is ordinary Portland cement of 53 grade confirming to IS: 12269. The tests conducted on cement are Standard Consistency, Specific Gravity and Setting time.

- **Fine Aggregate:**

Locally available free of debris and nearly riverbed sand is used as fine aggregate. The fractions ranges from 4.75 mm to 150 micron are termed as fine aggregate. The sand particles should also pack to give minimum void ratio, higher voids content leads to requirement of more mixing water. In the present study the sand conforms to zone I as per the Indian standards. The tests conducted on fine aggregates are Fineness, Specific Gravity and Water absorption.

- **Coarse Aggregates:**

The fractions above 4.75mm are termed as coarse aggregate. The crushed aggregates used were 20mm nominal maximum size and are tested as per Indian standard sand results are within the permissible limit.

- **Ceramic tile Aggregate:**

CTA are crushed uniformly to about 20mm size manually using hammer and sieved through 20mm IS: Sieve. The various test were conducted on the ceramic tiles are specific gravity, water absorption and impact test.

- **Water:**

Water available from the local sources conforming to the requirements of water for concreting and curing as per IS: 456-2000.

Fig. 1 -Composition of materials

3. EXPERIMENTAL WORK

The experimental work aimed to investigate the potential of using ceramic tile waste as aggregate in concrete. The experimental program was designed to achieve the following objectives:

1) Determining the physical and mechanical characterization of recycled ceramic tile waste aggregate.

2) Studying the effect of using recycled ceramic tile waste as partial replacement of fine and coarse aggregates on the properties of both fresh and hardened concrete.

3.1 Materials

The concrete mix constituent materials were: ordinary Portland cement (CEM I 42.5R) complying with EN 197- 1[8]provided by the Arabian Cement Company, natural siliceous sand with fineness modulus 2.68, and crushed stone with particle size of 5- 20 mm and a nominal maximum size of 20 mm. A high range water reducing and set retarding concrete admixture “Sikament R 2004” complying with ASTM C 494 Type G [9] was used as a super plasticizer with a constant content(1.5% by weight of cement).

3.2. Recycled Ceramic Aggregate

Ceramic tile wastes were crushed into small pieces using a crusher and then sieved to get the required coarse ceramic aggregate particles with sizes ranging from 5 to 20 mm. The fine ceramic aggregate was obtained by sieving the fine crushed ceramic to get particles with sizes ranging from 2.36 mm to 150 μm. Fig. 1 shows the coarse and fine recycled ceramic aggregates used in this study. The characteristics of both conventional and ceramic aggregates were determined according to EN 933[10]

Fig. 2 - : Recycled ceramic tile waste aggregates

4. RESULTS AND DISCUSSION

Compressive strength test was performed on concrete cube specimen of size 15cm*15cm*15cm to check strength by obtaining the 7 days 14 days and 28 days compressive strength. The compressive strength of cube is calculated by dividing the maximum compressive force by the cross-sectional area of the cube specimen

1) 7 DAYS COMPRESSIVE STRENGTH:

Table 1 - Compressive strength results table about 7 day.

CONCRETE GRADE	TILE AGGREGATE REPLACED WITH NORMAL	NO OF DAY	TARGETMAIN STRENGTH N/mm2	COMPRESSIVE STRENGTH ACHIVED N/mm2
M20	0%	7	18.6	20.72
M20	5%	7	18.6	20.10
M20	10%	7	18.6	18.48
M20	20%	7	18.6	18.21

2) 28 DAYS COMPRESSIVE STRENGTH:

Table 2 - Compressive strength results table about 28 day.

CONCRETE GRADE	TILE AGGREGATE REPLACED WITH NORMAL	NO OF DAY	TARGET MAIN STRENGTH N/mm2	COMPRESSIVE STRENGTH ACHIVED N/mm2
M20	0%	28	26.6	29.03
M20	5%	28	26.6	28.21
M20	10%	28	26.6	27.95
M20	20%	28	26.6	27.04

3) COMPRESSIVE STRENGTH:

The compressive strength values varied from 18.6 MPa to 20.72 MPa for 7 days strength. Also, it varied from 26.6 MPa to 29.3 MPa for 28 days. It was found that, there was not much variation in the compressive strength of conventional concrete and crushed stone aggregate concrete. The strength of the concrete with different coarse aggregates is given in Table 3. The compressive strength of concrete cubes made with ceramic insulator and glass concrete were found to be 16% and 26.34 % lesser respectively than that of conventional concrete. The reasons may be due to smooth surface texture of these aggregates and poor bonding properties of the matrix with aggregates

Fig. 3 - : Breaking of blocks

5. CONCLUSION

Research on the usage of waste construction materials is very important due to the material waste is gradually increasing with the increase in population and increasing of urban development. The reasons that many investigations and analysis had been made on ceramic tile aggregate are because tile aggregates are easy to obtain and their cost is cheaper than the natural aggregates. For natural aggregates mining is needed but tile aggregate can ignore this process.

Ceramic tile aggregate is an appreciated and appropriate concrete material for substitution into concrete composition based on its properties. Mechanical properties of ceramic aggregate are similar to the natural aggregate and its behavior is similar but not same. Water absorption, crushing value and impact value, are higher than natural coarse aggregate and lower by specific gravity i.e. 2.61g/cm3.

It is possible in M 20 grade concrete to substitute 20% of normal 20 mm aggregates with ceramic tile aggregates without compromising its required compressive strength. For all concrete mixes (M 20, M25, M30) compression strength of concrete decreases with increase in the proportion of replacement of natural aggregates with tile aggregates which is due to low specific gravity higher porosity of tile aggregates as compare to natural

aggregates. In M30 grade concrete with 5% substitution of tiles aggregate it's strength decreases from 38.73 to 36.73 n/mm2, which is less than target mean strength. So, as per results substitution should be avoided for this grade of concrete. M 20 and M 25 concretes are suitable for the replacement of aggregates. Finally, using waste ceramic tiles in concrete is an effective measure with regard to reducing the costs of concrete and keeping the environment clean along with wastage management and decreasing the use of natural raw materials.

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