An Investigation Study on Partial Replacement of Coarse Aggregates by using Ceramic Tiles

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Abstract:
The major part of the construction industry is based on concrete. In concrete the vital and costly material after the cement is aggregated. The use of ceramic waste originating from the construction sites and industries, as coarse aggregates in concrete presents an effective and sustainable endeavour to environment problems through the reduction in the degradation of natural resources caused by the extraction of natural aggregates and decrease in dumping volume as well.Utilizing ceramic tile waste, this research will focus on ceramic wastes obtain from the construction industry in India The strength of concrete increases with ceramic coarse tile aggregate by up to 40%. This indicates that the recycled ceramic waste has a potentially to be used a coarse aggregate partial replacement for concrete.

Keywords: Recycled ceramic tiles, coarse aggregate, compressive strength, split tensile strength.

1. INTRODUCTION

Concrete is a composite material consisting of mainly water, aggregate, and cement. The physical properties desired for the finished material can be attained by adding additives and reinforcements to the concrete mixture. A solid mass that can be easily molded into the desired shape can be formed by mixing these ingredients in certain proportions. Ceramic tiles are made of a mixture of clay and other minerals, which are fired at high temperatures
to create a dense, hard material that is resistant to wear and moisture. Compared to conventional coarse aggregates like gravel or crushed stone, ceramic tiles are relatively lightweight and have a smooth surface texture hen using ceramic tiles as a partial replacement for coarse aggregates in concrete, the first consideration is the size of the tiles. The tiles should be broken into small pieces that are roughly the same size as the coarse aggregate particles they are replacing. This can be done by crushing the tiles using a hammer or other mechanical device.

The next consideration is the compatibility of the ceramic tiles with the other components of the concrete mix, such as the cement, water, and any additives like plasticizers or air entraining agents. Ceramic tiles are generally inert and do not react chemically with these other components, but their smooth surface texture can make it difficult for them to bond with the cement paste. To improve the bonding between the tiles and the cement paste, a bonding agent or a fine aggregate can be added to the mix. Ceramic tiles are relatively lightweight and have a low density compared to conventional coarse aggregates, which can affect the strength and durability of the concrete. The tiles are also more brittle than conventional coarse aggregates, which can make the concrete more susceptible to cracking and other forms of damage.

Finally we can say, partial replacement of coarse aggregates with ceramic tiles is possible, but it requires careful consideration of the size and properties of the tiles, as well as their compatibility with the other components of the concrete mix.

1.2 IMPORTANCE OF THE STUDY

The objective of our project to find a substitute for coarse aggregate which is more economical and durable without reducing the strength of the concrete. Such a substitute should comply with the existing standards stipulated for coarse aggregate. It also should be available at cheaper rates in abundant quantities.

However, though the inclusion of ceramic in concrete gives many benefits, such inclusion causes a significant increase in early strength due to the durability of ceramic tiles. Nevertheless, ceramic tiles causes an workabilility increase .

When examining the above qualities of ceramic and quarry dust it becomes apparent that if both are used together, the loss in early strength due to one may be alleviated by the gain in strength due to the other, and the loss of workability due to the one may be partially negated by the improvement in workability caused by the inclusion of the other.When examining the above qualities of fly ash and quarry dust it becomes apparent that if both are used together, the loss in early strength due to one may be alleviated by the gain in strength due to the other, and the loss of workability due to the one may be partially negated by the improvement in workability caused by the inclusion of the other.

1.3 SCOPE OF THE STUDY

Ceramic tile industry produces large amount of waste during mining and processing stages. Ceramic tiles are also wasted during construction stage of new building. This waste is dumped on open land which creates lot of environmental as well as health problems. Therefore, it is necessary to utilize this waste material as a construction material in concrete production. Ceramic wastes have special properties, which can contribute positively in other areas of recycling.

The study identifies physical properties of CTA as a partial or full replacement for natural coarse aggregate. Also, this study will help designers and planners to seek CTA as a good alternative to natural coarse aggregate. So, they can manage the ceramic tile waste by product. Aggregate occupies between 70 % and 80 % of the total concrete volume, and because of that the strength of aggregate is very important for the final strength of the concrete . Thus the study on concrete aggregates is the important issues for the area of civil engineering.

Thus, the use of tile wastes has two main benefits for society, one is it helps on improving the quality of concrete and another is it helps on maintaining the environment.

1.4 NEED

Ceramic tiles are also wasted during construction stage of new building. This waste is dumped on open land which creates lot of environmental as well as health problems.

The need for the use of ceramic tile is because of its:

- Durability

- Aesthetics
- Easy maintenance
- Slip resistance
- Cost effect

Therefore, it is necessary to utilize this waste material as a construction material in concrete production. Ceramic wastes have special properties, which can contribute positively in other areas of recycling.

Overall, the use of ceramic tiles in concrete provides a number of benefits, including durability, aesthetics, easy maintenance, slip resistance, and cost-effectiveness.

2. CERAMIC TILES

A ceramic is any of the various hard, brittle, heat-resistant and corrosion-resistant materials made by shaping and then firing an inorganic, nonmetallic material, such as clay, at a high temperature.
Examples: Earthenware, porcelain, and bricks.

2.1 MATERIALS USED IN CERAMIC TILES

Ceramic tiles are made from a variety of natural and synthetic materials that are molded and fired at high temperatures to create a hard, durable surface.

- Clay
- Feldspar
- Kaolin
- Quartz
- Pigment
- Glasses

2.2 Waste created by ceramic tiles

Ceramic tiles are commonly used in homes, offices, and public spaces.

- Production waste
- Installation waste
- Disposal waste

To minimize the wastage created by ceramic tiles, it is important to choose high-quality, durable tiles that are suitable for the intended use and are installed by trained professionals.Recycling and repurposing ceramic tiles can also help reduce waste and minimize the environmental impact of this popular building material.

2.3 APPLICATIONS OF CERAMIC TILES

Ceramic tiles are versatile and durable building materials that can be used for a variety of applications, both indoors and outdoors.

- Flooring
- Walls
- Countertops
- Outdoor areas
- Fire places

Overall, ceramic tiles offer a wide range of design options and practical benefits, making them a popular choice for many applications.

3. MATERIALS AND PROPERTIES

In this investigation, the following materials were used:

- Ordinary Portland Cement of 53 Grade cement conforming to IS:169-1989
- Fine aggregate and coarse aggregate conforming to IS: 2386-1963.
- Water.

3.1 CEMENT:

Ordinary Portland Cement of 53 Grade of brand name Parasakthi, available in the local market was used for the investigation. Care has been taken to see that the procurement was made from single batching in air tight containers to prevent itfrom being effected by atmospheric conditions.

For 53 Grade OPC Cement, the minimum compressive strength achieved by the

cement at the end of the 28th day shouldn't be less than 53MPa or 530 kg/cm^2. The colour of OPC is grey colour and we will get white cement also.

Table-1: Properties of cement

S.No	Properties	Results	Standards
1	Normal consistancy	0.28	
2	Initial setting time	30 min	Min.30min
3	Final setting time	174min	Max.600min
4	Specific gravity	2.9	
5	fineness	5%	Max.10%
6	Compressive strength		
6a	3 days strength	36.3Mpa	Min.27Mpa
6b	7 days strength	44.5Mpa	Min.40Mpa
6c	28 days strength	56.6Mpa	Min.53Mpa

Fig:1 Collection of Cement

3.2 FINE AGGREGATE

Sand is a natural granular material which is mainly composed of finely divided rocky material and mineral particles. The most common constituent of sand is silica(silicon dioxide, or SiO_2), usually in the form of quartz, because of its chemical inertness and considerable hardness, is the most common weathering resistant mineral. Hence, it is used as fine aggregate in concrete.

Table-2: Properties of fine aggregates

S.No	Description	Result	Standards
1	Sand zone	Zone- IV	
2	Specific gravity	2.5	2.5 – 2.7
3	Free Moisture	1%	0% - 5%
4	Bulking of fine aggregates	35%	Maximum of 40%

Fig:2 Collection of Fine aggregates

3.3 COARSE AGGREGATES:

Crushed aggregates of less than 12.5mm size produced from local crushing plants were used.The aggregate exclusively passing through a 20mm sieve size is selected.

Fig:3 Collection of coarse aggregates

Table-3: Properties of Coarse Aggregate

S.NO	Description	Results
1	Nominal size used	20mm
2	Specific gravity	2.89
3	Impact value	14.57
4	Water absorption	0.2%
5	Sieve analysis	20mm

3.4 WATER

Water plays a vital role in achieving the strength of concrete. For complete hydration it requires about 3/10th of its weight of water.

Water participates in chemical reaction with cement and cement paste is formed and binds with coarse aggregate and fine aggregates.

Table-4: Properties Of Water

S.N0	DESCRIPTION	RESULTS
1.	Molecular formula	H_20
2.	ph	7
3.	appearance	Clear colourless,odourless, tasteless
4.	denstity	100kg/m^3

3.5 CERAMIC TILE AGGREGATE:

Broken tiles were collected from the solid waste of ceramic manufacturing unit and from demolished building. The waste tiles were crushed into small pieces by manually and by using crusher.

- The required size of crushed tile aggregate was separated to use them as partial replacement to the natural coarse aggregate.
- The tile waste which is lesser than 4.75 mm size was neglected.
- The crushed tile aggregate passing through 20mm sieve are used.
- Crushed tiles were partially replaced in place of coarse aggregate by the percentages of 10%, 20% and 30%,40% and 50% individually.

Fig:4 Collection Of Ceramic Tile Aggregate

Table-5:Properties of Crushed Tiles Aggregates

S.no	Description	Test results
1	Specific gravity	2.6
2	Fineness modulus	5.91mm
3	Impact value	20.1%
4	Water absorption	5%

4. CONCRETE MIX DESIGN
(AS PER IS:10262-2009)

TEST DATA REQUIRED FOR CALCULATION

Specific gravity of cement=2.76
Specific gravity of fine aggregate=2.50
Specific gravity of coarse aggregate=2.89
Specific gravity of water =1
Water absorption of fine aggregates =1.21%
Water absorption of coarse aggregates =0.21%

4.1 MIX DESIGN FOR M_{25} GRADE CONCRETE:

After the calculation as per code values
Quantities required for cubes
Cement =125 kg/m^3
Fine aggregates = 182 kg/m^3
Coarse aggregates = 332 kg/m^3
Water = 186 kg/m
Crushed coarse aggregate =180 kg/m^3
Total quantities required for 2 cylinders for each mix
Cement = 5.2 kg
Fine aggregate = 8.09 kg

Coarse aggregate = 18.15 kg
Water required = 2.74 L
final mix proportion = 8.9: 13.8 : 13.1: 196
= **1 : 1.5: 3.4 : 0.5**

A total 36 cubes with the same dimensions (150mmX150mmX150mm) and 12 cylinders of dimensions (300mmX150mm) were cast with six different proportions six cubes and two cylinders as one type of control proportion that is 0% of ceramic waste as partial replacement of coarse aggregates and the remaining 30 cubes and 10 cylinders as 10%, 20%,30%,40% and 50% of ceramic as partial replacement of coarse aggregates.

5.EXPERIMENTAL DETAILS

This chapter deals with the various mix proportions adopted in carrying out the experiments and experimental results obtained with respect to their workability, compressive strength,and split tensile test.

Table -6 :Details of aggregate replacement for mix codes

S. No	Mix code	Cement (%)	Coarse aggregate (%)		Fine aggregate (%)
			NCA	CCA	
1	M0	100	100	0	100
2	M1	100	90	10	100
3	M2	100	80	20	100
4	M3	100	70	30	100
5	M4	100	60	40	100
6	M5	100	50	50	100

5.1 WORKABILITY:

The property of fresh concrete which is indicated by the amount of useful internal work required to fully compact the concrete without bleeding or segregation in the finished product

DIFFERENT TEST METHODS FOR WORKABILITY MEASUREMENT:

Depending upon the water cement ratio in the concrete mix, the workability may be determined by the following two methods:

1.Slump Test
2.Compaction Factor Test

- **SLUMPCONE TEST**

The slump obtained for the mix =50mm

Table-7 :Test results from slump cone test for workability in mm

S.No	Mix code	Aggregate replacement(%)	Workability (mm) M_{25}
1	M0	0	50
2	M1	10	54
3	M2	20	58
4	M3	30	63
5	M4	40	67
6	M5	50	70

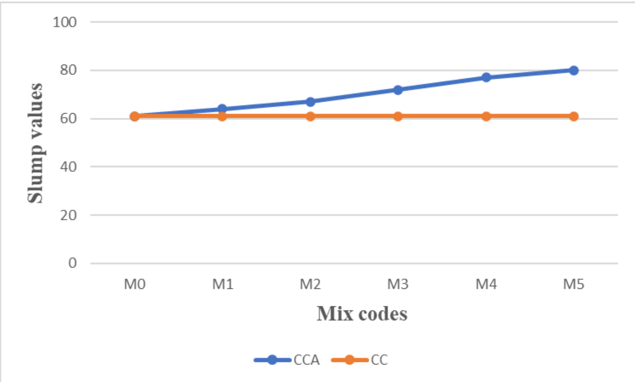

Fig:5 Graph sheet showing slump values for different combination of mixes

➢ COMPACTION FACTOR TEST

The results obtained from the compaction factor test for the workability of various mixes of replacements of M25 grade of concrete are tabulated as follows:

Table-8: Test results of compaction factor test for workability

S.No	Mix code	Aggregate replacement(%)	Compaction factor (M_{25})
1	M0	0	0.83
2	M1	10	0.85
3	M2	20	0.86
4	M3	30	0.88
5	M4	40	0.90
6	M5	50	0.92

Fig:6 Graph sheet showing compaction factor values for different combination of mixes

COMPRESSIVE STRENGTH

- COMPRESSIVE STRENGTH $= \frac{LOAD}{AREA}$

Table-9: Compressive strength results of M25 grade of concrete for 7 and 28 days

S.No	Mix code	Compressive strength	
		7 days	28 days
1	M0	26.67	39.50
2	M1	27.85	42.35
3	M2	28.66	45.63
4	M3	30.23	48.92
5	M4	32.56	51.50
6	M5	30.21	48.30

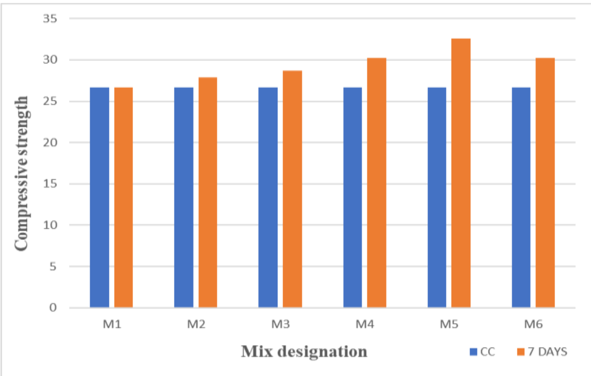

Fig:7 Bar chart showing compressive strength test result for 7 days

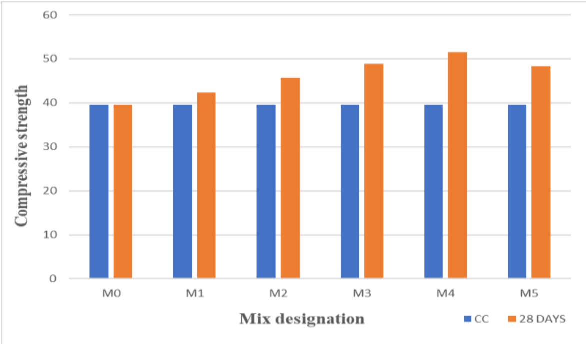

Fig:8 Bar chart showing compressive strength test result for 28 days

SPLIT TENSILE STRENGTH TEST

- The split tensile strength is calculated
- using the formula = $\frac{2P}{\pi LD}$

Where, P = applied load
D = diameter of the specimen
L = length of the specimen

Table-10:Split tensile strength results of M25 concrete for 7 and 28 days

S. NO	Mix code	Aggregate Replacements % (CCA)	Split tensile strengh	
			7days	28 days
1	M0	0	1.67	2.56
2	M1	10	1.68	2.58
3	M2	20	1.70	2.61
4	M3	30	1.73	2.63
5	M4	40	1.75	2.65
6	M5	50	1.63	2.59

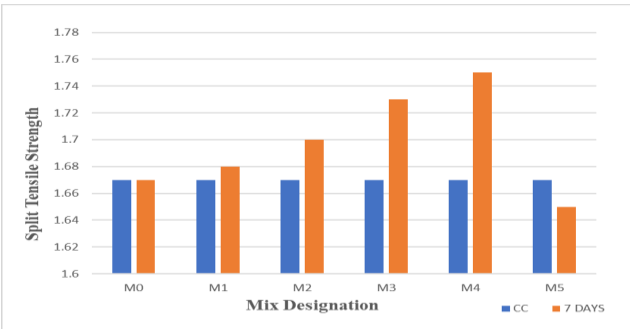

Fig:9 Bar chart showing split tensile strength test result for 7 days

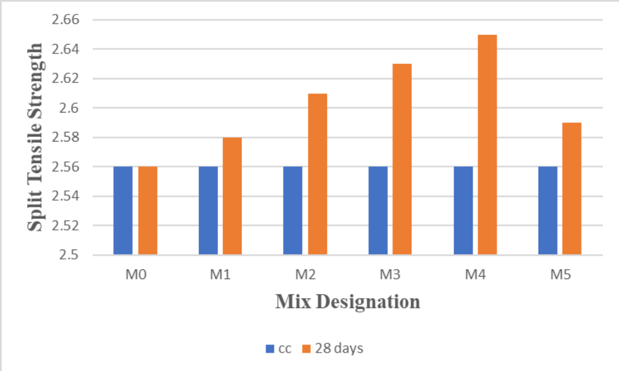

Fig:10 Bar chart showing split tensile strength test result for 28 days

6.CONCLUSION

The following conclusions are made based on experimental investigations on compressive strength and split tensile strength considering the environmental aspects also.

- The workability of concrete increases with the increase in the ceramic tile aggregate replacement up to limited addition
- The properties of concrete increased linearly with the increase in ceramic aggregate up to 40% replacement later it is decreased linearly.
- M4 mix of concrete produced a better concrete in terms of compressive strength and split tensile strength than the other mixes. But the mixes up to 40% of ceramic coarse aggregate can beused.
- The usage of ceramic coarse aggregate has an effect on the properties of concrete in increment manner.
- The ceramic coarse aggregate improves the mechanical properties of concrete.
- The concrete which is much more stable and durable than the conventional concrete by replacing the coarse aggregate can be made.
- The concrete with upto 40% replacement satisfies the compressive strength of M_{25} grade concrete however higher the percentage addition of ceramic waste reduces the strength of normal concrete.
- The split tensile strength of ceramic tile aggregate is very much in a straighter path compared to the conventional grades of concrete.
- The split tensile strength of 10%, 20%, 30% and 40% replacements at 7 days and 28 days shows the consistency in attaining the required range.
- Hence the replacement of waste ceramic tile aggregate by 40% gives the required strength and can be considered as optimum percentage.
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