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Study of Characteristic Strength of Concrete by Partial Replacing Cement with Ceramic Waste Powder

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ABSTRACT

In the construction industry, ceramic wall tiles are utilized as building materials. Due to this manufacturing variation, the temperature in the kiln fluctuates from 200°C to 1200°C, and the material possesses pozzolanic reactivity. During various manufacturing processes, 5–10% of the production in the ceramics industry is lost.The waste from the ceramic factory was dumped nearby, resulting in environmental pollution that harmed the nearby fields and residences. Therefore, incorporating ceramic waste powder in concrete would help save energy and safeguard the environment in a variety of ways. This research is based on secondary as well as primary data. This investigation highlighted nature of concrete strength variation with increasing the ceramic waste. The maximum strength gain when 30% of cement is replacing by ceramic waste.

I. INTRODUCTION

Each year thousands tones of wastes are disposed of in landfills which effects occupation and degradation of valuable land. Due to fast industrialization, urbanization, and infrastructure expansion in developing nations like India, the depletion of natural resources is a typical occurrence. India produces 100 million tons of ceramics annually. In the ceramics sector, waste material makes up 15% to 30% of overall production. Currently, there is no recycling of this garbage in any way. Even though designated sites have been marked for dumping, the Ceramic Industries continue to dump the powder near their unit in any neighboring pit or empty spaces. This causes significant environmental and dust pollution, especially after the powder dries up, and occupies a significant amount of land, thus it is imperative to swiftly dispose of ceramic waste and use it in the building business. Ce Modern concrete technology has the potential to use fewer natural resources. They are being compelled to concentrate on resource recovery, repurposing, and other alternatives. The use of replacement materials results in lower costs, less energy use, possibly superior goods, and less environmental dangers.

II. LITERATURE REVIEW

AD Raval et al.(2013)

One of the most active study fields in a variety of fields, including civil engineering and building materials, is ceramic waste. Ceramic waste powder is settled by sedimentation and then discarded, endangering both human health and agriculture in addition to causing environmental damage. Use of the ceramic waste powder in many industrial fields, particularly in the building, farming, glass, and paper industries, will thereby contribute to environmental protection. It is crucial to create environmentally friendly concrete from ceramic waste. In this research project, ceramic waste powder has been used in place of (OPC) cement in the following proportions: 0%, 10%, 20%, 30%, 40%, and 50% by weight of M-25 grade concrete. Concrete mixtures were created, evaluated, and compared to traditional concrete in terms of compressive strength. These tests were run to assess the mechanical qualities throughout the course of 7, 14, and 28 days. As a result, replacing cement with ceramic waste increased compressive strength by up to 30%. This study focuses on the experimental analysis of concrete strength and the best replacement percentage for cement using ceramic waste at 0%, 10%, 20%, 30%, 40%, and 50%.

Amr S EI-Dieb et al. (2018)

Over 22 billion tonnes of ceramic waste powder (CWP), which is created during the final polishing of ceramic tiles, are generated globally each year. Environmental issues from the disposal of CWP in landfills will be severe. (i.e, soil, air, and groundwater pollution). Chemically, CWP is distinguished by being primarily made of silica (SiO2) and alumina. (Al2O3). More than 80% of the CWP is made up of these two minerals. To create environmentally friendly concretes, CWP has the potential to be employed as an element that replaces Portland cement either totally or in part. The purpose of this chapter is to provide an overview of the effects of employing CWP in the creation of eco-friendly concretes, with an emphasis on the development of zero-cement alkali-activated concret.

Pincha Torkittikul et al. (2010)

The purpose of this research was to determine whether it was feasible to make mortar and concrete from of ceramic waste and fly ash. To create fine aggregates, ceramic waste fragments from a nearby industry were crushed and sieved. The measured concrete properties show that while the workability of fly ash concrete with 100% ceramic waste as fine aggregate decreased with increasing ceramic waste content for Portland cement concrete and fly ash concrete, it remained adequate, in contrast to the Portland cement control concrete with 100% ceramic waste where close to zero slump was observed The compressive strength of the concrete made from ceramic waste was observed to decrease as the ceramic waste percentage was raised above 50%, peaking at 50% for the control concrete. This was a direct result of the concrete being less usable. However, as the percentage of ceramic waste was increased up to 100%, the compressive strength of the fly ash concrete also rose. As a result, the advantages of employing ceramic waste as fine aggregate in concrete that contains fly ash were confirmed.

Said Jalali et al.(2010)

In this article, an experimental investigation of the characteristics and toughness of concrete including ceramic wastes is presented. A number of concrete mixtures with a goal mean compressive strength of 30 MPa were created using ceramic powder to substitute 20% of the cement (W/B = 0.6). Both a concrete mix with natural sand and coarse ceramic aggregates

(W/B = 0.5) and a concrete mix with ceramic sand and granite aggregates were made. Mechanical tests, water performance, permeability, chloride diffusion, and accelerated ageing tests are used to evaluate the mechanical and durability performance of concrete made from ceramic waste. Results show that concrete with some of the cement substituted with ceramic powder performs more durably, although having a minor drop in strength. In terms of compressive strength, capillarity water absorption, oxygen permeability, and chloride diffusion, results also reveal that concrete mixtures with ceramic particles outperform control concrete mixtures.

O.Zimbili et al.(2014)

The key to bettering the living conditions of future generations is sustainable development. Recycling garbage is therefore the only sensible and reasonable move in the direction of protecting natural resources. Recycling's economic benefits provide encouragement to move in this way.It is evident from the studies described that ceramic wastes are ideal for use in the building industry, and particularly on the production of concrete. Ceramic wastes have been discovered to be appropriate for use as a partial replacement in the manufacturing of cement. Researchers have suggested that they may be used in mortars as well as structural and non-structural concrete. They were discovered to be outperforming regular concrete in regards to qualities including density, toughness, permeability, and compressive strength. Thus to continue with further research in this area is necessary to make availablethe information, which will inevitably come handy in the near future.

Liles Gautam et al.(2020)

Due to the high alumina and silica content, ceramic waste can be used in place of cement as a substitute in concrete. When this high alumina and silica react with the calcium that is already present in cement, C-S-H and C-(A)-S-H gel are created. It can also be utilised as an additional cementing material. Numerous writers discovered that young people have low compressive strength. However, higher strength was seen as ages increased. The majority of authors substituted 10–40% and even 100% of ceramic waste for cement and fine aggregate, respectively. Lower pozzolanic activity at the beginning stages may be the source of the strength decline at earlier stages. Numerous researchers have noted an increase in the percentage of water absorption as the level of ceramic waste replacement has increased. However, the values were less than 10%, therefore, it can be used as a good construction material. Increase in durability properties were observed with the inclusion of ceramic waste in concrete by several researchers. The finer size of particles is the most suitable reason for increasing the durability performance.

III. METHODS AND MATERIAL

2.1. Cement

Cement used for this experimental study is Ordinary Portland Cement 53. The chemical and physical property of the cement which analysed in Indian Standard code:-12269 and laboratory eklavya university damoh.

2.2. Ceramics Waste Powder (CWP)

The sample of Ceramics Waste Powder (CWP) used in this experimental study is taken from Ceramics wall and Floor Tiles factory which is located in Asansol, West Bangal. The Factory collected the Ceramics Waste Powder at the time of Each Process of Production of Ceramics Floor and wall tiles, and dumped around the factory very close to the storage of Raw materials.

2.3. Aggregate

Aggregates play a major role in concrete production since they make up for around 60% to 80 % of the volume of concrete. Aggregates have a strong influence on the properties of freshly mixed and hardened concrete, thus making it more compact, decreasing its permeability (which makes it more water-resistant) and modifying its heat retention values. The relevant tests were made to identify the properties of the aggregates which are used for this research. After that, corrective measures were taken in advance before proceeding to the mix proportioning, like blending the aggregates in order to meet the grading requirement, washing the aggregates in order to remove impurities.

2.4. Fine Aggregate

Fine aggregates generally consist of natural sand or crushed stone with most particles smaller than 4.75 mm. The sand used for this research is a natural sand sourced from "EKLAVYA UNIVERSITY DAMOH " Necessary laboratory investigations were carried out to this sand in order to ensure compliance of property of the sand with the required standards and specifications. These are Gradation, specific gravity and absorption capacity, bulk density, moisture content and silt content were the tested parameters in order to assess thephysical properties of the sand.

2.5. Casting

All of the cube moulds were professionally cleaned and oiled to prior to casting Compressive strength tests were conducted using a cube shaped steel mould with dimension of 150 * 150 * 150. To guarantee that there were no gaps remaining that wouldresult in a slurry leak, the moulds were firmly screwed together. Concrete was poured into the prepared greased mould for each category and cement slurry was compacted using a vibrating table. The specimens were then placed in the mould then p laced in the mould and covered with a moist sack for 24 hours.

2.6. Curing

After 24hrs of open air curing the specimens were taken out the moulds and put in a curing tank with clean before being tested for mechanical and other qualities after 7day sand 28 days.

2.7. Workability

Slump is the most commonly used test for measuring workability of concrete at site as well as in the laboratory. The apparatus for slump test consists of a metallic mould in the form of a frustum of a cone with internal dimension as follows, Bottom dia. = 20cm, Top dia. = 10cm, Height = 30cm. Internal surface of mould is thoroughly cleaned and kept it on horizontal surface. Filled the concrete in four layer and tapper it with 16mm diameter rod, the mould is removed by lifting it slowly and carefully in a vertical direction. This allows the concrete is measured. This difference in height in mm is taken as slump of concrete.

IV. COMPRESSIVE STRENGTH OF CONCRETE

Compressive strength is the most common test conducted on hardened concrete. It is very easy and simple to perform and partly because many of the desirable properties of concrete are qualitatively related to its compressive strength. Compression test specimens are used cubes, cylinder and prisms. Take required quantities of material and mixed it by hand or by machine mixing. Concrete should be filled in mould in three equal layers. Each layer should be compacted for 25 times with a 16mm dia. rod. After hardened the specimens are taken out and cured in clean, fresh water. Curing is done until the required days of testing. The test should be carried out immediately upon the removal of specimen from water curing and after that finding out the compressive strength by compressive machine.

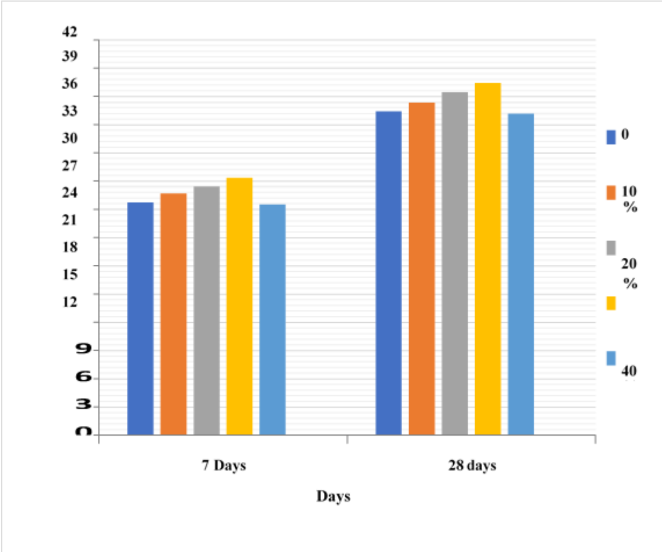

Fig- compressive strength with variation of CWC

Fig:- Compression Testing machine

Compressive Strength of Cubes (150 ×150 ×150 mm) for M25 mix at 7 &28 days

SR.NO.	Replacement %	7days(N/mm2)	28 days(N/mm2)
1	A0-M25	24.72	34.42
2	A1-M25	25.72	35.37
3	A2-M25	26.42	36.42
4	A3-M25	27.33	37.44
5	A4-M25	24.52	34.15

3.1. Split Tensile Strength

Tensile stress is likely to develop in concrete due to drying, shrinkage, corrosion of steel reinforcement or due to temperature gradients. The determination of flexural tensile strength is essential to estimate the load at which the concrete members may cracks. It is of a great importance while designing liquid retaining structures and pre-stress concrete structures. The cylinder is placed with its axis horizontal between the platens of a testing machine, and the load is increased until failure by splitting along the vertical diameter takes plac. If such strips are not provided then the observed stress will be reduced for up to 8%. Horizontal Tensile Stress $=2P/\pi D$ Where, P = Compressive load on cylinder

Fig:- Split Tensile Strength Test

5	40	4.12	5.86

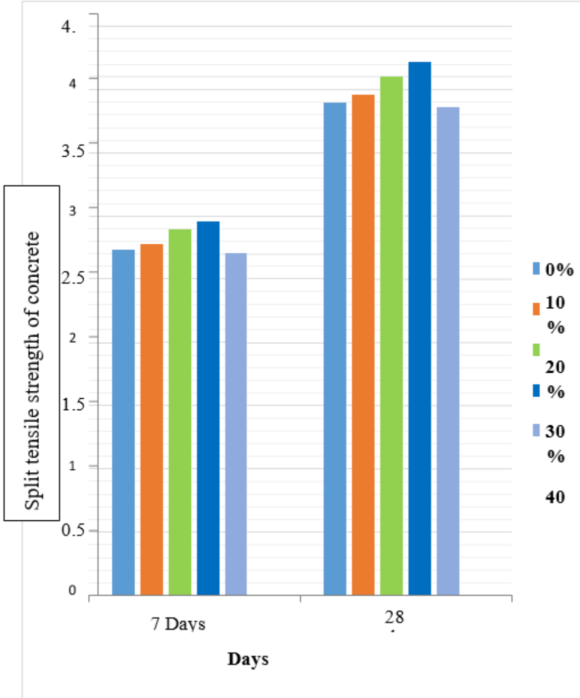

Fig variation of split tensile strength with time

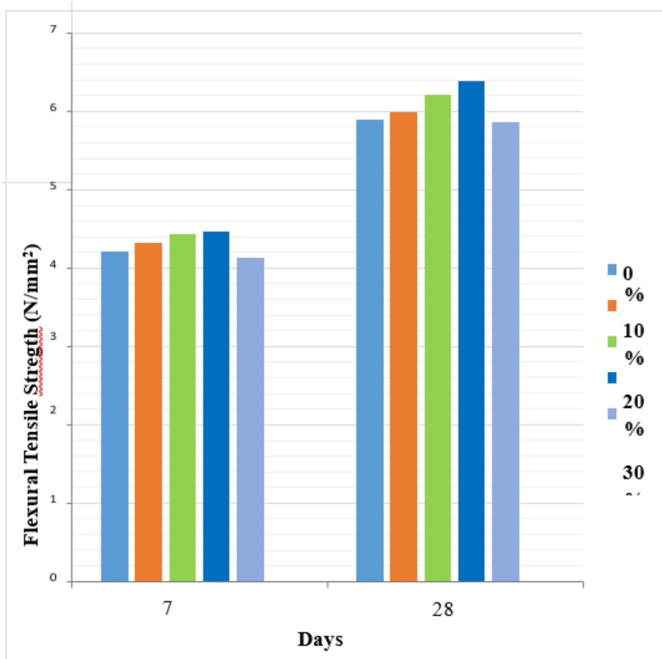

Fig variation of flexural strength with time

Flexural Tensile Strength (N/mm²)

The normal tensile stress in concrete, when cracking occurs in a flexure test is known as modulus of ruptures, i.e. flexural strength. The standard test specimen is a beam of size 150mm × 150 mm × 700mm size. The specimen should be should be cast and cured in the same manner as for casting of cubes. The specimens should be immediately tested on removal from the water. The flexural strength can be finding out by universal testing machine. The flexural strength can be found out by central loading as well as the load is applied through two similar rollers mounted at the third point of the supporting span. The flexural strength can be found out by formula as follow

$$F_{cr} = P.L/bd^2$$

Flexural Strength for M25 mix at 7 & 28 days

SL. NO.	Replacement %	7 days	28 days
1	0	4.21	5.88
2	10	4.32	5.97
3	20	4.43	6.21
4	30	4.46	6.37

V. CONCLUSION

This study was carried to obtain the results, test conducted on the tile powder modified cement concrete mix, in order to ascertain the influence of tile powder on the characteristic strength of concrete.

- The most optimal dosage for the partial alternative of cement by ceramic tile powder is 30 %.
- The compressive strength of concrete decreases, when the addition of dosage is morethan 30%. The results show if 30% replacement of cement by ceramic tile powder willaffect the strength of concrete.
- By doing this project we could gave a contribution to the society by making the environment more eco-friendly by utilizing the ceramic waste scientifically. Thus by adopting replacement method we can overcome problems such as waste disposal crisis.
- Utilization of tile powder and its application for the sustainable development of the construction

industry is the most efficient solution and also address the high value application of such waste.

- By using the replacement materials offers cost reduction and can overcome few environmental hazards.

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