

Experimental Study On Using Tiles Waste As Replacement Of Coarse And Fine Aggregate In Concrete

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Abstract

Ceramic wastes have been discovered to be acceptable for use as fine and coarse aggregate substitutes in concrete manufacturing. According to studies, approximately 20-30% of the material produced in tile production facilities ends up as trash. The purpose of this research is to see whether discarded tiles can be used as a partial substitute for coarse and fine aggregates in concrete. Because of these factors, the reuse of demolished building wastes such as ceramic tile has emerged as a viable option for reducing solid waste and addressing the shortage of natural aggregates for concrete production. Ceramic tile trash is generated not only during the destruction of buildings, but also in the production process.

Crushed waste ceramic tiles, as well as crushed waste ceramic tile powder, are used to substitute coarse and fine aggregates. 10 percent, 20 percent, 30 percent, 40 percent, and 50 percent of the coarse aggregates were substituted with ceramic waste broken tiles. Along with the ceramic coarse tile, 10% of the fine aggregate was substituted with ceramic tile powder. The M20 concrete grade was developed and tested. Crushed tiles and tile powder were used to replace coarse and fine aggregates in various percentages in the mix design for various kinds of mixes. Workability tests, compressive strength tests, and split tensile strength tests were conducted for various concrete mixes with varying percentages after 7, 14, and 28 days of curing.

Keywords: Crushed tiles, Compressive strength, Split tensile strength

I.INTRODUCTION

Cement, fine aggregates, and coarse aggregates have long been used in the design of concrete mixes, and they play an important role in the planning of a particular grade of concrete. However, resources have become more expensive in recent years. To achieve the same strength as these fundamental materials, a few additional materials that are locally available at cheap cost must be introduced to replace fine aggregates, coarse aggregates, and cement. Natural resources needed for different structures are rapidly depleting, resulting in a constant increase in their price. This helps engineers and researchers discover alternative replacements for the manufacture of building materials while keeping quality, strength, and stability in mind. One of the most important components of concrete is coarse aggregate, which makes up 70-80 percent of the volume of the concrete and has a significant impact on its physical look and characteristics.

However, with increasing urbanisation and population growth, particularly in countries like India, the demand for this specific building material cannot be fulfilled easily. As a result, waste goods such as waste ceramics may be used to solve this issue. The estimated cost of manufacturing ceramic tiles in India is Rs.21,000 Core. According to reports, the Indian Ceramic Tiles sector increased by approximately 11% in 2013-14 and is projected to reach a value of Rs.301 billion by 2016. According to a February 2016 study from the Worldwide Ceramic Tiles Material on the Market, the worldwide ceramic waste materials market would expand at a Compound Annual Growth Rate of 9.57 percent from 2016 to 2020.

Ceramic goods are made at very high temperatures, between 1000°C and 1250°C, resulting in exceptionally hard materials that are impervious to chemical, freezing, and thermal stress. Considering the characteristics of ceramic waste, such as shattered tiles, concrete should be used as a replacement for traditional building materials. This aids in the resolution of issues such as cost, scarcity, and other environmental issues that may emerge as a result of incorrect garbage disposal.

1.1 CONCRETE

Concrete is a composite material that primarily consists of water, aggregate, and cement. By adding additives and reinforcements to the concrete mixture, the required physical characteristics for the final material may be achieved. By combining these materials in certain quantities, a solid mass that can be readily shaped into the required shape may be created. Over time, a hard matrix produced by cement binds the other components together to form a single hard (rigid) durable material with a wide range of applications, including buildings, pavements, and so on. The ancient Romans were among the first to use concrete technology on a wide scale, and the Roman Empire made extensive use of concrete technology. The colosseum in Rome was mainly constructed of concrete, and the pantheon's dome is the world's biggest unreinforced concrete building. The technique was re-pioneered after the fall of the Roman Empire in the mid-eighteenth century, since the use of concrete had become more uncommon. In terms of tonnage, concrete is the most extensively utilised man-made material today.

1.2 CONCRETE PROPERTIES

Concrete is, in general, a material with a higher compressive strength than tensile strength. Because the tensile stress is smaller, it is usually reinforced using materials that are strong in tension, such as steel. Concrete's elastic behaviour is generally stable at low stress levels, but when matrix cracking occurs, it begins to decrease. Concrete has a low coefficient of thermal expansion, which causes shrinkage as it ages.

All concrete constructions fracture to some degree as a result of shrinkage and stress. When concrete is exposed to long-duration stresses, it is prone to creep. Various tests will be carried out for the applications to verify that the concrete characteristics match the requirements. Various combinations of concrete components produce different concrete strengths, which are measured in psi or Mpa. Concrete of various strengths is utilised for various building applications. A extremely low-strength concrete may be utilised if the concrete must be light. The addition of lightweight particles, air, or foam to concrete achieves lightweight concrete; nevertheless, the strength of the concrete is decreased as a result. For regular operations, concrete with a compressive strength of 3000-psi to 4000-psi is often utilised. Although 5000-psi concrete is more costly, it is commercially accessible as a more

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durable alternative. Concrete with a 5000-psi strength is often utilised in major civil projects. Concrete with a strength more than 5000 psi was often utilised for certain construction components. To keep the column diameters modest, high-rise concrete structures comprised of lower level columns may utilise 12,000 psi or higher strength concrete.

To reduce the number of spans needed, bridges may utilise concrete with a strength of 10,000 psi in long beams. Other structural requirements may necessitate the use of high-strength concrete on occasion. If the structure must be extremely stiff, even stronger than needed to withstand the service loads, high-strength concrete may be selected. Concrete with a strength of 19000-psi was utilised for these business reasons.

1.3 CONCRETE OF LIGHT WEIGHT

Concrete's significant self-weight is one of its drawbacks. The density of typical concrete will be in the 2200 to 2600 kg/m³ range. Concrete will become an uneconomical structural material as a result of its high self-weight. Attempts have been made in the past to decrease the self-weight of concrete in order to improve its structural efficiency. The density of light weight concrete ranges from 300 to 1850 kg/m³ depending on the materials used.

There is just one technique for creating lightweight concrete, which is to include air into the mix. In practise, there are three methods to do this.

I By substituting cellular porous or lightweight aggregate for traditional mineral aggregate.

Aerated concrete is made by introducing gas or air bubbles into mortar.

(iii) No-fines concrete, which is made without sand in the aggregates.

Lightweight concrete has grown in popularity in recent years, and it offers a number of benefits over traditional concrete.

1.4.CONSTRUCTION WASTE IN INDIA:

The solid trash generated by demolitions of structures is growing day by day in today's building industry. Ceramic tiles are widely used in today's structures, and their use is growing on a daily basis in the building industry. Most structures utilise ceramic goods as part of the basic construction components. Wall tiles, floor tiles, sanitary ware, domestic ceramics, and technical ceramics are all examples of produced ceramics. They're usually made out of natural materials with a lot of clay minerals in them. Despite the aesthetic advantages of ceramics, their wastes, among other things, create a slew of environmental problems. On the other hand, waste tile is being produced from destroyed building debris. The ceramic sector in India produces 100 million tonnes of tiles each year, with approximately 15% to 30% waste material produced from the entire output. This waste is not currently recycled in any form; however, because ceramic waste is durable, hard, and highly resistant to biological, chemical, and physical degradation forces, we chose these waste tiles as a replacement material for the basic natural aggregate in order to reuse them and reduce the solid waste generated during construction demolitions. Tile powder and waste tiles were gathered from the nearby area. Some academics are also looking at repurposing building debris in order to minimise solid waste and conserve natural basic aggregates. These studies advocate for the use of recycled aggregates in

concrete mixes, and they found that using recycled aggregates in lieu of natural coarse aggregate had positive results.

1.5. TILE AGGREGATE CONCRETE

Crushed tiles are used in lieu of coarse aggregate, and tile powder is used in place of fine aggregate in this. Crushed tiles were used to replace fine and coarse aggregates separately, as well as in combinations (replacing coarse and fine aggregates at the same time in a single mix).

A workability test was carried out to determine the acceptability of these crushed waste tiles and tile powder in concrete mixes with varying percentages of these components. The slump cone test is used to assess the workability of new concrete. Casting cubes are also used to perform compressive strength tests for 3, 7, and 28 days to evaluate the strength change by various percentages of waste components. The goal of this research is to better understand how ceramic solid waste behaves and performs in concrete. The leftover crushed tiles are utilised to substitute coarse aggregate to some extent 10%, 20%, 30%, 40% and 50%.

II.METHODOLOGY

2.1. MATERIALS:

The following materials were utilised in this investigation:

- Ordinary Portland Cement of Grade 53, in accordance with IS169-1989
- Coarse and Fine aggregates that meet IS: 2386-1963 specifications.
- Water.

2.2 CEMENT:

Ordinary Portland cement is the most popular kind of cement used as a basic component in concrete, mortar, stucco, and most specialised grouts throughout the globe. In the mid-nineteenth century, it evolved from other kinds of hydraulic lime in England, and it typically comes from limestone. It's a fine powder made from clinker, which is formed by heating materials. We'll add tiny quantities of the other components after grinding the clinker. There are many different kinds of cements on the market. When comparing various grades of cement, the 53 Grade OPC Cement regularly outperforms the competition. The grade number of a cement, according to the Bureau of Indian Standards (BIS), indicates the minimum compressive strength that the cement is anticipated to achieve within 28 days. The minimum compressive strength obtained by the cement at the conclusion of the 28th day for 53 Grade OPC Cement shall not be less than 53MPa or 430 kg/cm². OPC is grey in colour, and we may obtain white cement by removing ferrous oxide during the cement production process.

The investigation was carried out using standard Portland Cement of Grade 53 from the Ultra Tech Company brand, which is widely accessible in the local market. To avoid being affected by atmospheric conditions, care was taken to ensure that the purchase was done from single batching in airtight containers. Physical criteria were met by testing the cement in accordance with IS: 169-1989, and chemical requirements were met by testing it in accordance with IS: 4032-1988. Table - 1 lists the cement's physical characteristics.

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SL.NO	Properties	Test results	IS: 169-1989
1.	Normal consistency	0.32	
2.	Initial setting time	50min	Minimum of 30min
3.	Final setting time	320min	Maximum of 600min
4.	Specific gravity	3.14	
5.	Compressive strength		
	3days strength	23.2 Mpa	Minimum of 23Mpa
	7days strength	33.6 Mpa	Minimum of 33Mpa
	28days strength	43.6 Mpa	Minimum of 43Mpa

Table-2.1 Properties of cement

2.3 FINE AGGREGATES:

Sand is a finely split rocky material and mineral particles that make up a natural granular substance. The most frequent component of sand is silica (silicon dioxide, or SiO₂), which is typically in the form of quartz and is the most common weathering resistant mineral due to its chemical inertness and significant hardness.

As a result, it's often utilised as a fine aggregate in concrete.

In the study, river sand that was readily accessible on the market was utilised. In compliance with IS: 2386-1963, the aggregate was evaluated for physical criteria such as gradation, fineness modulus, and specific gravity. Before usage, the sand was surface dried.

S.No	Description Test	Result
1	Sand zone	Zone- III
2	Specific gravity	2.59
3	Free Moisture	1%
4	Bulk density of fine aggregate (poured density)	1385.16 kg/m ³
	Bulk density of fine aggregate (tapped density)	1606.23 kg/m ³

Table 2: Properties of Fine Aggregate

2.4. COARSE AGGREGATES:

Crushed aggregates with a size of less than 12.5mm were obtained from local crushing facilities. The aggregate that only passes through a 12.5mm filter and is kept on a 10mm sieve is chosen. In line with IS: 2386-1963, the aggregates were evaluated for physical criteria such as gradation, fineness modulus, specific gravity, and bulk density. To achieve the necessary combined grade, the separate aggregates were blended. The mixture's specific gravity and water absorption are listed in the table.

S.No	Description	Test Results
1	Nominal size used	20mm
2	Specific gravity	2.9
3	Impact value	10.5
4	Water absorption	0.15%
5	Sieve analysis	20mm
6	Aggregate crushing value	20.19%
7	Coarse aggregate Bulk density (Poured density)	1687.31kg/m ³

Table 2.3: Coarse Aggregate Properties

2.5 WATER:

Concrete's strength is dependent on the presence of water. It needs approximately 3/10th of its weight in water to be completely hydrated. For ordinary concrete, a minimum water-cement ratio of 0.35 has been shown. Water contributes in a chemical reaction with cement, resulting in cement paste that binds coarse and fine particles. If additional water is used, segregation and bleeding occur, causing the concrete to weaken, although the fibres absorb the majority of the water. As a result, it may help to prevent bleeding. It is possible that if the water content exceeds the permitted limits, bleeding will occur. The necessary workability is not obtained if less water is utilised. Water that is suitable for drinking must be used in the concrete, and the pH value should be between 6 and 9.

2.6. AGGREGATE OF CERAMIC TILE:

Broken tiles were gathered from a ceramic manufacturing unit's solid refuse and a destroyed structure. The discarded tiles were manually and with the use of a crusher broken into tiny bits. Crushed tile aggregate of the appropriate size was separated and used as a partial substitute for natural coarse aggregate. The tile waste with a dimension of less than 4.75 mm was overlooked. Crushed tile aggregate that has passed through a 16.5mm sieve but has been kept on a 12mm screen is utilised. Crushed tiles were used in lieu of coarse aggregate in percentages of ten percent, twenty percent, thirty percent, forty percent, and fifty percent, respectively, coupled with fine aggregate replacement.



Figure 2.1: Ceramic Tile Aggregate Sample

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2.7. CERAMIC TILE-FINE AGGREGATE:

After crushing the tile aggregate, part of the material is finer in size. Because it is also a waste and comparable to sand, this material is used in concrete as a fine aggregate substitute. In conjunction with the coarse aggregate replacement, the aggregate that passes through the 4.75mm sieve is utilised as a partial replacement for fine aggregate of 10%.



Figure 2.2: Ceramic Fine Aggregate Sample

S. No	Description	Test Results
1	Origin Rock	Feldspar
2	Impact value of crushed tiles	12.5%
3	Specific gravity of crushed tiles	2.6
4	Specific gravity of tile powder (C.F.A)	2.5
5	Water absorption of crushed tiles	0.19%

Table4: Properties of Ceramic tile aggregate

2.8. MIXING

Mixing should take place on a non-porous surface. In alternating layers, spread out the specified amounts of coarse and fine aggregate. Pour the cement on top of it and mix it dry with a shovel, stirring the mixture many times until the colour is consistent. This homogeneous mixture is applied in a 20cm thick layer. The mixture is sprinkled with water and flipped over at the same time. This process is repeated until a nice uniform, homogenous concrete is achieved. It's also important to note that the water is sprinkled rather than poured. To get the desired consistency, a little amount of water should be added towards the conclusion of the mixing process. Even a little amount would suffice at that point.



Figure 2.3: Mixing of concrete

2.9. CASTING OF CUBES:

The concrete cubes were made to test the concrete's compressive strength. Metal moulds made of steel or cast iron were used to make the cubes. To avoid deformation, these moulds should be thick enough. These moulds are designed to make it easy to remove the moulded item without damaging it. A plane-surfaced base plate is included with each mould. The base plate should be large enough to hold the mould during filling without leaking, and it should be screwed to the mould. To prevent concrete adherence, the inner surface of the mould is lightly coated with oil.

Following these steps, the concrete components, which include cement, fine aggregate, coarse aggregate, tiles waste, and water, are completely mixed in a dry environment until a uniform colour is obtained. The water is then added in the proper amounts and properly mixed again. The concrete is then poured into the mould.



Figure 2.4: Casting of concrete cubes

2.10. COMPACTION:

Ensure that the concrete is sufficiently compacted by tamping it with a tamping rod. Insufficient compaction may result in poor workability, which makes the concrete harsh. Due to incorrect compaction, cavities may be present, allowing water to percolate through the concrete and compromising its durability. Proper compaction and mechanical compaction should be accomplished via hand compaction and mechanical compaction. The use of a table vibrator for mechanical compaction is possible. Remove the extra concrete using a trowel after the compaction is complete. Make a reference mark on the concrete cubes. Allow these cubes to sit for 24 hours without losing moisture. Then soak these cubes in water to cure them.



Figure 2.5: Compacting concrete cube

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2.11. Curing of Cubes:

The hydration of cement particles gives concrete its strength. The hydration of cement is a long-term process rather than a masonry activity. Of course, the rate of hydration is rapid at first, but it slows down with time. The amount of hydration product produced, and therefore the amount of gel created, is determined by the degree of hydration. For filling the spaces in the gel pores, the cement needs a W/C ratio of 0.15. To put it another way, a water/cement ratio of approximately 0.38 would be needed to hydrate all of the cement particles as well as fill the gel pores. A W/C concentration of 0.38 might theoretically fulfil the need for water for hydration in a concrete produced and contained in a sealed container while leaving no capillary cavities.

However, it is clear that a water content of 0.5 is needed for full hydration in a sealed container in order to maintain the desired relative humidity level.

Curing is becoming more important as the demand for concrete rises. Curing may also be defined as keeping the concrete wet and warm enough to allow the cement to continue to hydrate. It may be defined more precisely as a method of maintaining a suitable moisture content and a favourable temperature in concrete during the time immediately after installation, so that hydration cement can continue until the desired characteristics for high-quality concrete are formed. It has long been known that efficient and intermittent curing improves the overall quality of concrete. If curing is ignored during the early stages of hydration, the quality of the concrete will deteriorate irreversibly. A healthy and nutritious feeding provided to a freshly born infant may be likened to a successful curing in the early stages of hydration.



Figure 2.6: Curing of Concrete Cubes

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

3.1 MIX DESIGN FOR M20 GRADE CONCRETE:

At 28 days, a certain compressive strength is needed in the field : 20 Mpa

a) The mean strength, $f_{ck}^l = f_{ck} + k_s$

$$= 20 + (1.65 \times 5)$$

$$= 28.25 \text{ Mpa}$$

b) For OPC, adopting a water-cement ratio of 0.55

c) From table 2 of IS: 10262-2009, the maximum amount of water in 20 mm aggregates is 186 litres.

Adopting a water content of 180 liters

d) Water-cement ratio=0.55

$$\text{Cement Content, } C = \frac{180}{0.55} = 328 \text{ kg/m}^3$$

From IS: 456-2000, For extreme exposure, the minimum cement content is 300 kg/m³.

Hence O.K.

e) From table 3 of IS:10262-2009, coarse aggregate volume equivalent to 20 mm aggregate size and fine aggregate volume (Zone II) for water-cement ratio of 0.55 =0.62 %

The water-to-cement ratio in this instance is 0.55. As a result, the amount of coarse aggregate must be increased in order to reduce the fine aggregate content. As a result, with a water-cement ratio of 0.44 = 0.62, the adjusted percentage of coarse aggregate volume is 0.62.

Volume of Fine Aggregates = 1- volume of C.A.

$$= 1 - 0.62 = 0.38\%$$

$$\text{f) Volume of cement} = \frac{328}{3.14} * \frac{1}{1000} = 0.104\%$$

$$\text{Volume of water} = \frac{180}{1} * \frac{1}{10000} = 0.18\%$$

Volume of all in aggregates = 1- volume of (cement + water)

$$= 1 - (0.104 + 0.18)$$

$$= 0.71 \%$$

$$\text{Mass of Coarse aggregate (C.A.)} = e \times \text{Vol. of C.A.} \times \text{Sp. gravity of C.A.} \times 1000$$

$$= 0.71 * 0.62 * 2.9 * 1000$$

$$= 1276.58 \text{ kg/m}^3$$

$$\text{Mass of Fine aggregate (F.A.)} = e \times \text{Vol. of F.A.} \times \text{Sp. gravity of F.A.} \times 1000$$

$$= 0.71 * 0.38 * 2.59 * 1000 = 598 \text{ kg/m}^3$$

g) Mix proportions:

C	:	FA	:	CA	:	WATER
328	:	598	:	1276.58:	:	180

h) Site Corrections:

$$\text{Water Absorption of C.A.} = 1276.58 * \frac{0.15}{100}$$

$$= 1.9 \text{ kg/m}^3$$

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$$\text{Moisture content of F.A.} = 598 * \frac{1}{100}$$

$$= 5.98 \text{ kg}$$

$$\text{Weight of C.A.} = 1276.58 - 1.9$$

$$= 1274.68 \text{ kg/m}^3$$

$$\text{Weight of F.A.} = 598 + 5.98$$

$$= 603.98 \text{ kg/m}^3$$

$$\text{Adjusted water content} = 180 - 2 + 6.98$$

$$= 184.98 \text{ liters}$$

i) Volume of coarse aggregate equivalent to 20 mm size aggregate and fine aggregate:

$$\text{Cement} = 330 \text{ kg/m}^3$$

$$\text{Fine aggregates} = 705 \text{ kg/m}^3$$

$$\text{Coarse aggregates} = 1275 \text{ kg/m}^3$$

$$\text{Water Final Mix Proportions:} = 185 \text{ kg/m}^3$$

CEMENT	NFA	NCA	WATER
330	605	1275	185
1	1.52	3.18	0.55

For 10% CCA Aggregates:

Mix Proportions:

CEMENT	NFA	NCA	CCA	WATER
330	605	1175	100	185
1	1.52	2.85	0.33	0.55

For 20% CCA Aggregates:

Mix Proportions:

CEMENT	NFA	NCA	CCA	WATER
330	605	1030	240	185
1	1.52	2.53	0.65	0.55

For 30% CCA Aggregates:

Mix Proportions:

CEMENT	NFA	NCA	CCA	WATER
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330	605	925	350	185
1	1.52	2.28	0.90	0.55

For 40% CCA Aggregates:

Mix Proportions:

CEMENT	NFA	NCA	CCA	WATER
330	605	795	480	185
1	1.52	1.93	1.25	0.55

For 50% CCA Aggregates:

Mix Proportions:

CEMENT	NFA	NCA	CCA	WATER
330	605	675	600	185
1	1.52	1.61	1.57	0.55

For 10% CCA+10%CFA Aggregates:

Mix Proportions:

CEMENT	NFA	CFA	NCA	CCA	WATER
330	545	60	1175	100	185
1.1	1.37	0.15	2.85	0.33	0.55

For 20% CCA+10%CFA Aggregates:

Mix Proportions:

CEMENT	NFA	CFA	NCA	CCA	WATER
330	545	60	1030	240	185
1.1	1.37	0.15	2.53	0.65	0.55

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In this project, concrete grades M20 are developed with an appropriate water cement ratio to provide the required concrete strength, as well as for different fine and coarse aggregate mix replacements.

IV. EXPERIMENTAL STUDY

It is discussed in this chapter what the various mix proportions are used in the tests, as well as the experimental findings achieved in terms of Workability, The Compressive Strength, Split tensile strength, Flexural strength, and Durability.

4.1 INTRODUCTION:

By varying the proportion of coarse and fine aggregates replaced by crushed tiles, crushed tile powder, several kinds of mixtures were created. Along with traditional mixes, all kinds of mixes are produced. The coarse aggregates are replaced with 10%, 20%, 30%, 40%, and 50% crushed tiles, respectively, while the fine aggregate is replaced with 10% of both crushed tile powder separately and in combination with the coarse aggregate. The following are the mix designations in detail:

S.no	Mix Code	Cement (%)	Coarse Aggregate (%)		Fine Aggregate (%)	
			Natural Coarse Aggregate	Crushed Tiles	Sand	Crushed tile powder
1	Mix 1	100	100	0	100	0
2	Mix 2	100	90	10	100	0
3	Mix 3	100	80	20	100	0
4	Mix 4	100	70	30	100	0
5	Mix 5	100	60	40	100	0
6	Mix 6	100	50	50	100	0
7	Mix 7	100	90	10	90	10
8	Mix 8	100	80	20	90	10
9	Mix 9	100	70	30	90	10
10	Mix10	100	60	40	90	10

Table 4.1: Specifications on aggregate replacement for mix codes are provided.

4.2.WORKABILITY:

The amount of usable internal effort needed to completely compact the concrete without bleeding or segregation in the finished product, as noted by the amount of valuable internal work necessary to completely compact. Workability is one of the physical properties of concrete that influences its strength and durability, as well as the labour cost and final look. When concrete is readily poured and compacted uniformly, without bleeding or segregation, it is considered to be workable. Unworkable concrete requires more effort to compress in place, and honeycombs and/or pockets may be evident in the final product.

DIFFERENT TEST METHODS FOR MEASUREMENT OF WORKABILITY:

The workability of concrete may be assessed using one of three techniques, depending on the water cement ratio in the mix.

Test for Slump

Test for Compaction Factor

The slump-cone test and compaction factor tests were used to evaluate the workability of concrete in this research. Below are the test protocols.:

4.2.1 WORKABILITY IS DETERMINED BY THE SLUMP-CONE TEST:

To determine the workability of concrete, fully combine cement, sand, and coarse aggregate in the proportions specified in the mix design to produce a homogeneous concrete mix.

It is necessary to have the following things on hand for the concrete slump test:

Slump test mould, non-porous base plate, measurement scale, and temperature rod The test mould is in the shape of a frustum of a cone with a height of 30 cm, a bottom diameter of 20 cm, and a top diameter of 10 cm. The tamping rod is made of steel with a diameter of 16 mm and a length of 60 cm, with one end rounded.

- Clean the inside of the mould and coat it with oil.
- Place the mould on a flat, non-porous horizontal base plate.
- Fill the mould in three about equal levels with the prepared concrete mix.
- Using the rounded end of the brush, tame each layer 25 times of the tamping rod over the cross section of the mould in a consistent way. Tamping should permeate the underlying layer for the following layers.
- Remove any extra concrete and use a trowel to smooth the surface.
- Remove any mortar or water that has seeped between the mould and the base plate, then quickly and gently raise the mould from the concrete in a vertical orientation.
- The droop is defined as the discrepancy between the mold's height and the height point of the specimen being examined.



Figure-4.1.: Concrete Slump cone test

The form of the concrete slump that may be seen during the slump test is as follows:

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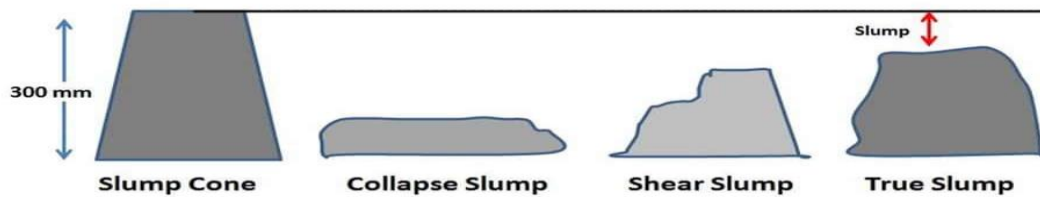


Figure-4.2: Results of Different Types of Concrete Slump Tests

True Slump – The True slump is the only kind of slump that can be assessed in the experiment. According to the illustration in figure-1, After the cone has been removed, the measurement is measured within a cone's peak and the peak of the concrete's peak.

It is possible to have zero slump in a mix if the water-cement ratio is very low, resulting in dry mixtures. This kind of concrete is most often utilised in the building of roads.

This is an indicator that the water-to-cement ratio is too high, i.e. that the concrete mix is too wet; or that the concrete mix has a high workability, in which case the slump test is not suitable.

When there is shear slump, it is an indication that the result is insufficient and that the concrete should be retested..

4.2.2 THE COMPACION FACTOR TEST IS USED TO DETERMINE WORKABILITY:

APPARATUS

A set of trowels, a hand scoop (15.2 cm long), a rod of steel or other appropriate material (1.6 cm diameter, 61 cm length, rounded at one end), and a balance are included in the compaction factor equipment.

Procedure:

- To determine the workability of concrete, thoroughly mix the cement, sand, and coarse aggregate according to the mix proportions specified in the design to produce a homogeneous concrete mix.
- Calculate the weight of an empty cylinder (W1).
- Fill the top hopper with the newly prepared concrete and, after 2 minutes, open the trap door of the hopper to discharge the concrete. The lower hopper's trap door should be opened immediately after the concrete has reached a condition of equilibrium, allowing the concrete to descend into the cylinder, where it will be partly compressed before being removed from the hopper.
- The excess concrete over the top of the cylinder should be removed using a trowel.
- Thoroughly clean the cylinder and weigh it in conjunction with the partly compacted concrete (W2).
- To compaction each layer, give 25 blows with the tamping rod to the cylinder after it has been emptied and filled with the same sample of concrete in four layers.

- Level the mi and weigh the cylinder with the completely compacted concrete to ensure that it is level (W3).

$$\text{COMPACTION FACTOR} = (W_2 - W_1) / (W_3 - W_1)$$

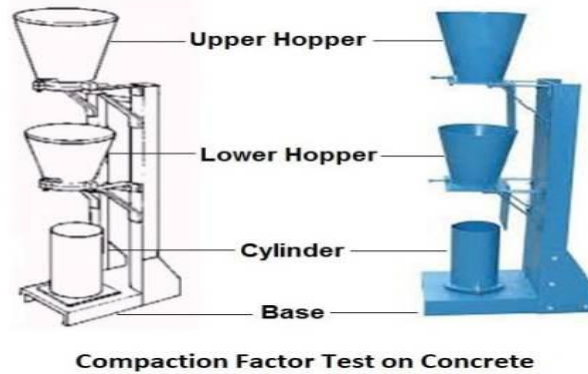


Figure 4.3.: Compaction factor Assembly

V. TEST RESULTS

5.1 WORKABILTY:

Concrete that is workable in all circumstances, that is, that can be prepared quickly, put, compacted, and moulded, is considered to be perfect. In this chapter, the workability is evaluated using two different techniques, which are as follows:

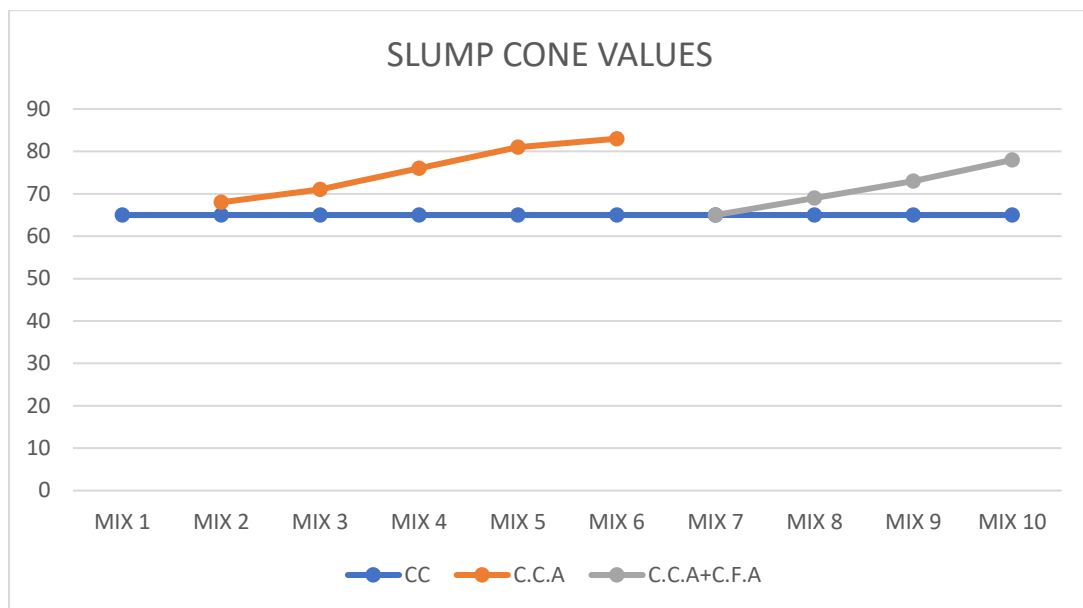
5.1.1 Slump Cone Test: The test was carried out on freshly prepared concrete that had been placed before to the moulding process. A total of 14 concrete mixes are produced at various periods throughout the day. Workability Table 6 displays the results of a slump cone test performed on concrete of grade M20.

S. No	Mix Designation	Aggregate Replacements % (CCA+CFA)	Workability (mm)
			M20
1	Mix 1	0+0	65
2	Mix 2	10+0	68
3	Mix 3	20+0	71
4	Mix 4	30+0	76
5	Mix 5	40+0	81
6	Mix 6	50+0	83
7	Mix 7	10+10	65
8	Mix 8	20+10	69
9	Mix 9	30+10	73
10	Mix 10	40+10	78

Table 5.1: The findings of the slump cone test for workability were measured in millimetres.

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The workability determined by the slump cone test increases in a proportional way to the increase in mix percentage replacement. As previously stated, the workability range of concrete is expanding while remaining in the medium range overall.



Graph 5.1: Comparison of workability for various mixes with conventional concrete

In accordance with the results, it is observed that the workability of the Mix1, Mix2, Mix3, Mix4, Mix5, Mix6, Mix7, Mix8, Mix9, and Mix10 mixes is increased by 4.8 percent, 9.6 percent, 17.7 percent, 25.8 percent, 30.6 percent, 1.6 percent, 8 percent, 14.5 percent, 22.5 percent, and 16.1 percent when compared to the conventional M20 concrete grade (M0).

5.1.2. Compaction Factor Test:

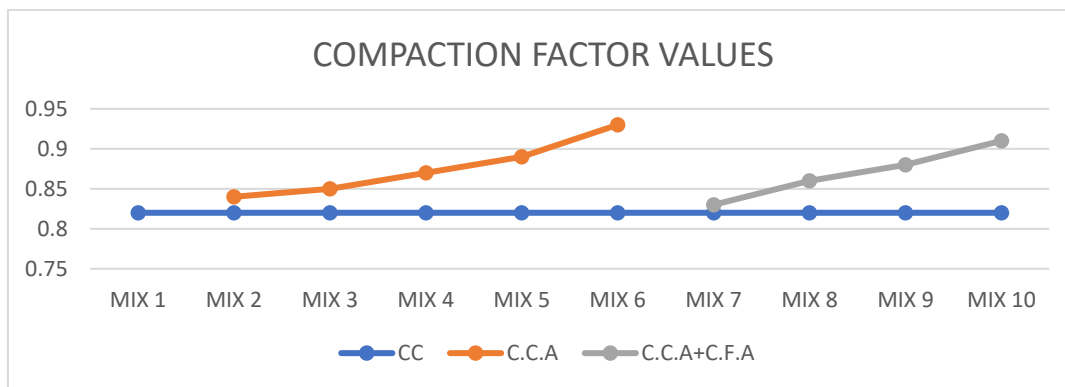
Using the same mix that had been evaluated for workability by slump cone, the compaction factor test was carried out. Following table summarizes the findings of the compaction factor test for the workability of different mixtures of substitutes for M20 grade concrete acquired from the compaction factor test:

S.No	Mix Designation	Aggregate Replacements % (CCA+CFA)	Compaction Factor
			M20
1	Mix 1	0+0	0.82
2	Mix 2	10+0	0.84
3	Mix 3	20+0	0.85
4	Mix 4	30+0	0.87
5	Mix 5	40+0	0.89
6	Mix 6	50+0	0.93

7	Mix 7	10+10	0.83
8	Mix 8	20+10	0.86
9	Mix 9	30+10	0.88
10	Mix10	40+10	0.91

Table 5.2: Compaction factor test results for workability

The compaction factor test, which measures the workability of M20 grade concrete, is similar to the slump cone test in that it measures the consistency of the concrete. The pattern of increment for the mixtures is almost same, and this will be explored in more detail later.



Graph 5.2: Compaction factor for different mixtures compared to traditional concrete

According to the results, the workability of Mix1, Mix2, Mix3, Mix4, Mix5, Mix6, Mix7, Mix8, Mix9, and Mix10 mixes is increased by an amount of 2.4 percent, 4.3 percent, 6.1 percent, 8.5 percent, 13.4 percent, 1.2 percent, 4.9 percent, 7.3 percent, 10.9 percent, 3.6 percent, and 9.7 percent when compared to conventional M20 concrete grade.

The workability obtained from both the slump cone and the compaction factor tests increases in a comparable way. The workability improves as the amount of ceramic coarse tile aggregate rises, but there is a little divergence when the amount of ceramic fine tile aggregate is increased.

5.2 Compressive strength:

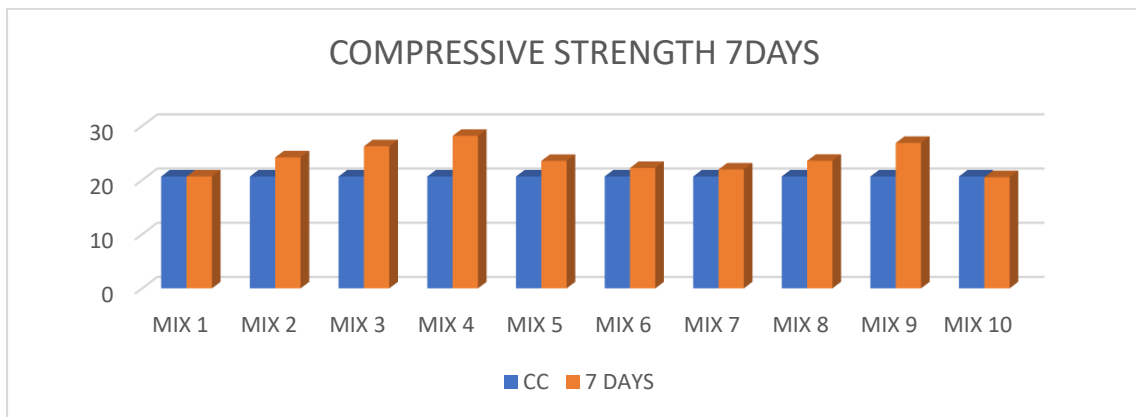
After performing the workability tests, a total of 30 cubes with dimensions of 150 x 150 x 150mm were cast and tested for 7 days, 14 days, and 28 days on each of 13 specimens after being casted and tested. The outcomes are summarised in the table below:

S.No	Mix Designation	Aggregate Replacements % (CCA+CFA)	Compressive strength of M20 grade in N/mm ²		
			7 days	14 days	28 days
1	Mix 1	0+0	20.67	28.56	33.45
2	Mix 2	10+0	24.19	31.26	36.7
3	Mix 3	20+0	26.23	32.96	39.4

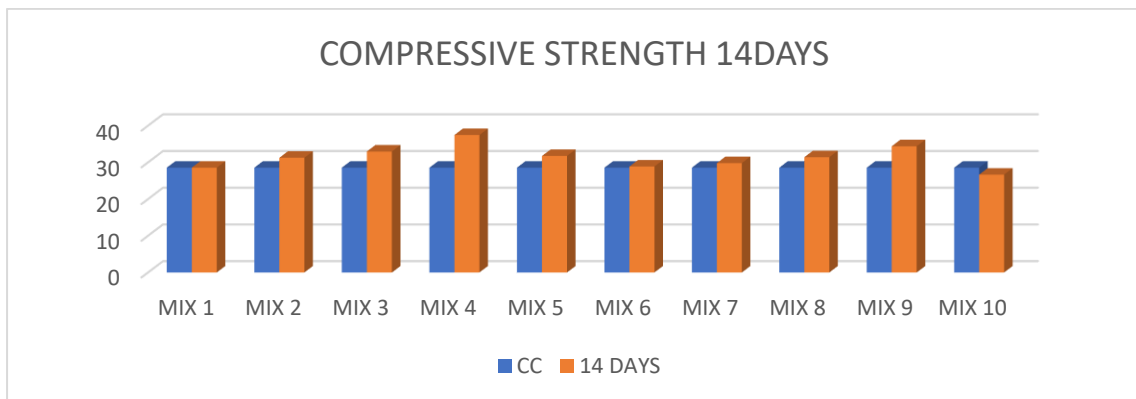
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4	Mix 4	30+0	28.15	37.45	43.14
5	Mix 5	40+0	23.53	31.75	37.15
6	Mix 6	50+0	22.23	28.87	33.4
7	Mix 7	10+10	21.95	29.8	34.18
8	Mix 8	20+10	23.54	31.4	36.14
9	Mix 9	30+10	26.85	34.4	38.55
10	Mix10	40+10	20.52	26.65	32.5

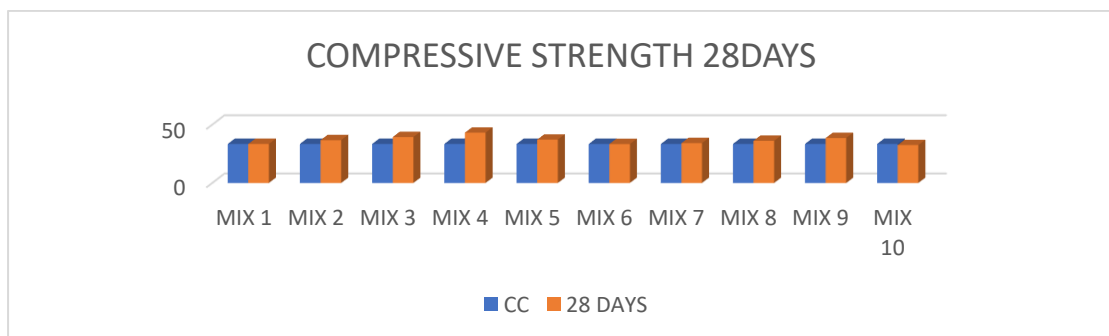
Table: 5.3: Compressive strength results of concrete for 7, 24 and 28 days



graph 5.3: Compressive strength of concrete at 7 days

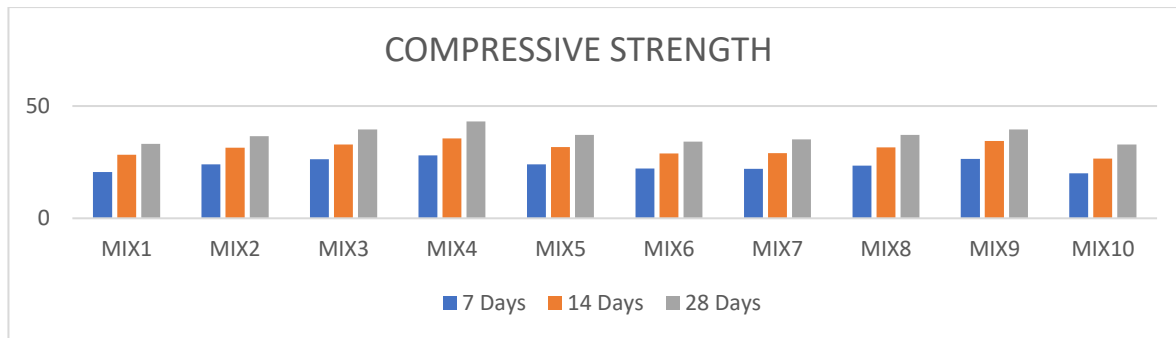


graph 5.4: Compressive strength of concrete at 14 days



Graph 5.5: Compressive strength of concrete at 28 days

The findings of the compression tests provide a complete picture of the project's conclusion, since the substitution of tile aggregates resulted in a concrete with characteristics that are comparable to those of ordinary concrete.



Graph 5.6: Compressive Strength comparison at 7, 14 and 28 days

After 7 days of curing, the compressive strength of concrete varies as follows: 20.67, 24.19, 26.23, 28.15, 23.53, 22.23, 21.95, 23.54, 26.85, and 20.52 for Mix1, Mix2, Mix3, Mix4, Mix5, Mix6, Mix7, Mix8, Mix9, Mix10, when compared to conventional concrete. After 7 days of curing, the compressive strength of concrete varies as follows: 20.67, 24.

In comparison to ordinary concrete, the compressive strength of mixes 1, 2, 3, 4, 5, 6, 7, 8, 9, and 10 differs as follows: 28.56, 31.26, 32.99, 37.45, 31.75, 29.8, 31.4, 34.4, and 26.65 for mix 1, mix 2, mix 3, mix 4, mix 5, mix 6, mix 7, mix 8, mix 9, and mix 10 after 14 days of curing

Comparing the compressive strengths of Mix1, Mix2, Mix3, Mix4, Mix5, Mix6, Mix7, Mix8, Mix9, and Mix10 to conventional concrete after 28 days of curing shows that the compressive strength varies as follows: 33.45, 36.7, 39.4, 43.14, 37.15, 33.4, 34.18, 36.14, 38.55, and 32.5 compared to conventional concrete after 28 days of curing. **5.3 Split Tensile strength:**

In the following table, the split tensile strength achieved by testing the cylindrical specimen for M20 grade of concrete to all of the mixes intended for different replacements is

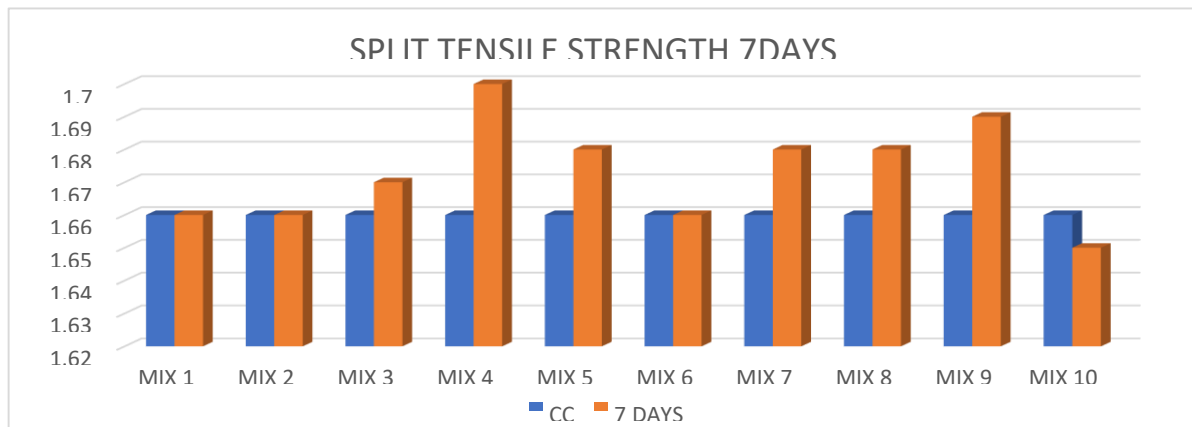
S.No	Mix Designation	Aggregate Replacements % (CCA+CFA)	Split Tensile Strength of M20 grade in N/mm ²		
			7 days	14 days	28 days
1	Mix 1	0+0	1.66	2.15	2.58
2	Mix 2	10+0	1.66	2.21	2.68
3	Mix 3	20+0	1.67	2.26	2.61
4	Mix 4	30+0	1.70	2.25	2.67
5	Mix 5	40+0	1.68	2.21	2.57
6	Mix 6	50+0	1.66	2.15	2.56
7	Mix 7	10+10	1.68	2.16	2.58
8	Mix 8	20+10	1.68	2.2	2.62

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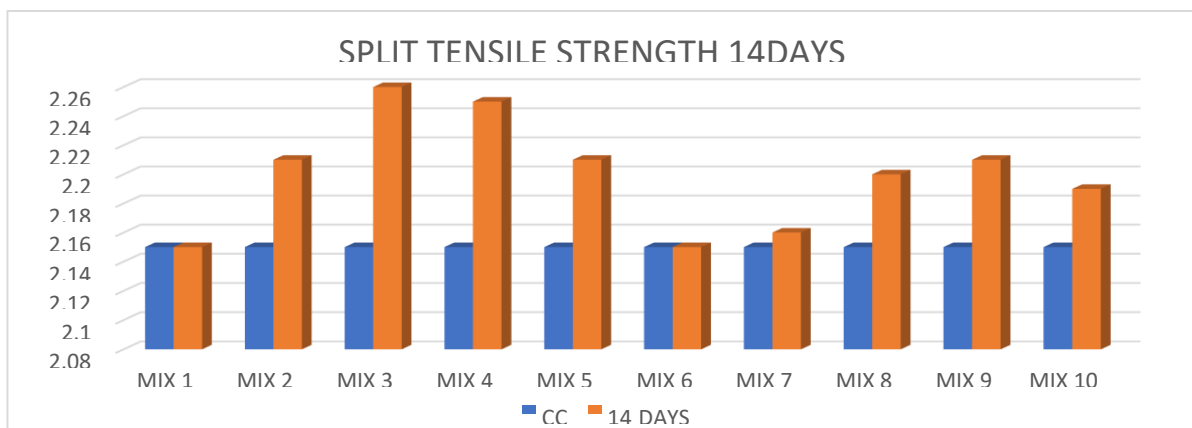
9	Mix 9	30+10	1.69	2.21	2.67
10	Mix10	40+10	1.65	2.19	2.50

shown for each mix.:

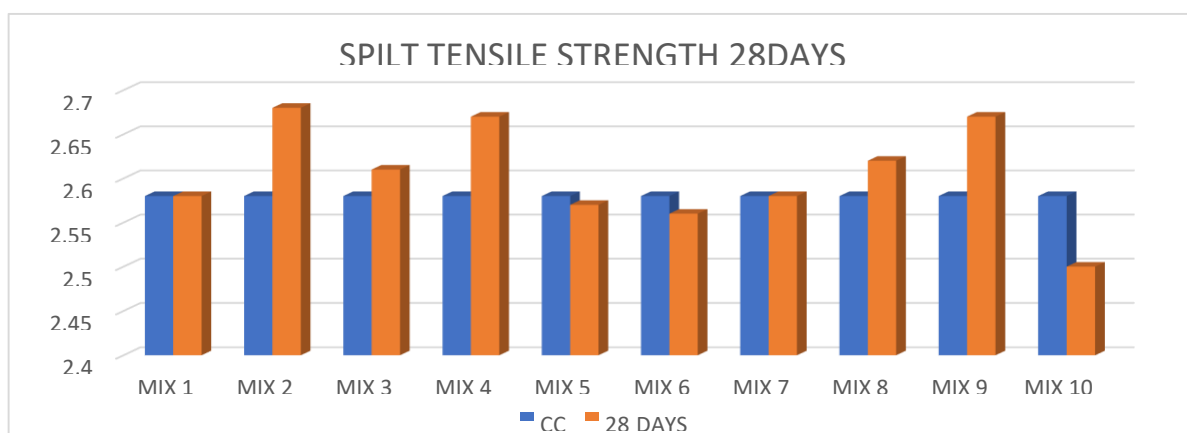
Table 9: Split tensile strength results for M20 grade of concrete



Graph 7: Split tensile strength of concrete at 7days

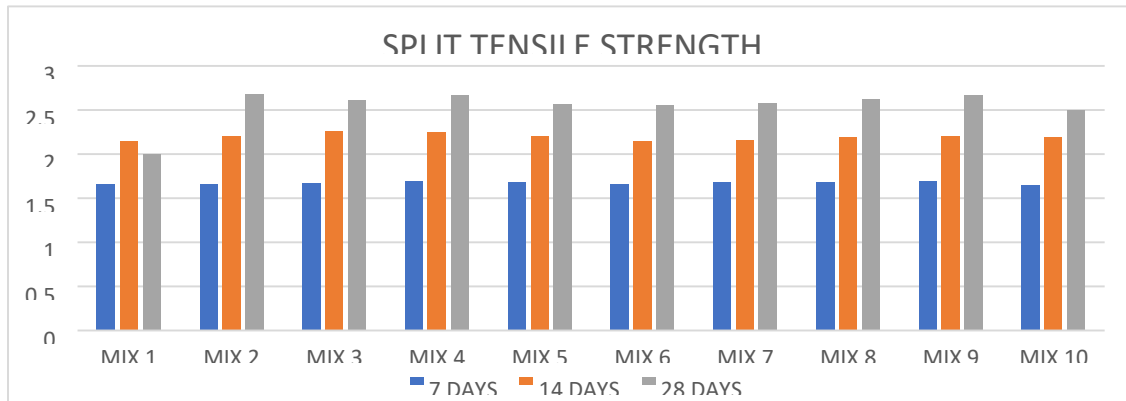


Graph 8: Split tensile strength of concrete at 14days



Graph 9: Split tensile strength of concrete at 28days

The findings show that the strength, or tensile strength, of the hybrid concrete is much higher than that of conventional concrete at all curing ages tested (7 days, 14 days, and 28 days), compared to conventional concrete. When different amounts of aggregates are substituted for cement, the strength of the concrete increases.



Graph 10: Split tensile comparison at 7, 14 and 28 days

After 7 days of curing, the split tensile strength of concrete varies as follows: 1.66 1.66 1.67 1.70 1.68 1.66 1.68 1.69 and 1.65 for Mix1, Mix2, Mix3, Mix4, Mix5, Mix6, Mix7, Mix8,

Mix9, and Mix10 when compared to conventional concrete: 1.66 1.66 1.67 1.70 1.68 1.66 1.68 1.69 and 1.65 for Mix1, Mix2, Mix3, Mix4, Mix5, Mix6, Mix7, Mix8, Mix9, and Mix

Compared to conventional concrete, the split tensile strength of Mix1, Mix2, Mix3, Mix4, Mix5, Mix6, Mix7, Mix8, Mix9, and Mix10 changes as follows: 2.15 2.21 2.26 2.25 2.21 2.15 2.16 2.2 2.21 2.19 2.19 2.19 2.19 2.19 2.19 for Mix10 compared to conventional concrete after 14 days of curing

After 28 days of curing, the split tensile strength of concrete varies as follows: 2.58 2.68

2.61 2.67 2.57 2.56 2.58 2.62 2.67 and 2.50 for Mix1, Mix2, Mix3, Mix4, Mix5, Mix6, Mix7, Mix8, Mix9, and Mix10 when compared to conventional concrete: 2.58 2.68 2.61 2.67 2.57 2.56

2.58 2.62 2.67 and 2.50 for Mix1.

VI.CONCLUSION

6.1 General:

The primary goal of the research is to create a concrete that is much more stable and durable than ordinary concrete by substituting coarse and fine particles with finer aggregates. Designing mix designs for all of the material replacements has been completed, and a total of 90 specimens (42 cubes, 42 cylinders, and 6 beams) have been produced and tested in the areas of strength calculation as well as comparisons have been completed.

6.2 Conclusions:

- Using experimental studies on compressive strength, split tensile strength, and flexural strength, as well as consideration of environmental factors, the following findings may be drawn:

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- The workability of concrete improves as the percentage of tile aggregate replacement rises in the mix. The workability is further improved by the use of tile powder, which, owing to its chemical characteristics, serves as an admixture.
- The characteristics of concrete improved linearly with the increase of ceramic aggregate up to a point of 30 percent replacement, after which they began to decline linearly again.
- The M3 concrete mix generated a stronger concrete in terms of compressive strength, split tensile strength, and flexural strength than the other concrete mixes tested in this study. However, ceramic coarse aggregate mixtures containing up to 50% ceramic coarse aggregate may be utilised.
- In certain cases, the use of ceramic fine aggregate has a negative impact on the characteristics of concrete in a gradual way.
- The use of tile powder in conjunction with ceramic coarse aggregate results in a modest improvement in the mechanical characteristics of concrete.
- Comparing the split tensile strength of ceramic tile aggregate to the usual grades of concrete, the ceramic tile aggregate follows a significantly more direct route.

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