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DEPARTMENT OF CIVIL ENGINEERING

OPTION: CONSTRUCTION TECHNOLOGY

STUDY ON USE OF CERAMIC WASTE AS PARTIAL REPLACEMENT OF FINE AGGREGATE IN CONCRETE

Submitted in partial fulfillment of the requirement of the award of Advanced Diploma in Construction Technology

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Kigali,October 2024

DECLARATION

I the undersigned, hereby declare that this project is our original work and it has never been presented elsewhere as a report or in any other format. All sources of information used in this report have been duly acknowledged.

Students' Name, Signature(s) and Date

NAME: Emmanuel NZEYIMANA………………………..**DATE**:……………………..

.

CERTIFICATE

This is to certify the project work known as **“STUDY ON USE OF CERAMIC WASTE AS PARTIAL REPLACEMENT OF FINE AGGREGATE IN CONCRETE** is a recorded of the original work done by Emmanuel NZEYIMANA . In partial fulfillment of the requirement for the award of advanced diploma in civil engineering department, option of construction technology in ULK POLYTECHNIC during academic year 2023-2024

SUPERVISOR	SIGNATURE
Eng………………………..	…………………………

DATE………/ ..../2024

DEDICATION

We dedicate this dissertation to:

The Almighty God, for making dreams possible, our entire family and to all our friends and loved ones.

ACKNOWLEDGEMENT

First,I would like to thank Almighty God for his unfailing love and guidance throughout my entire life and for taking us through our Degree A1 of POLY ULK successfully.

I would like to express our sincerest gratitude to our supervisor, **………………………** for the guidance during the entire project. His work in this research is commendable.

I would also like to thank our parents for all the encouragement and support they gave us during the entire project.

I would also like to thank our lectures for taking more effort in guiding us during the entire project.

I would like to thank the entire families, friends and colleagues for all the love and support they have given us throughout our life.

Finally, to all who through one way or the other contributed immensely to the realization of this project.

ABSTRACT

The main objective of this final year research project about "***Study on use of ceramic waste as partial replacement of fine aggregate in concrete***" was to study and evaluate the possibility for replacement of fine aggregates by ceramic wastes in concrete.Following the fixed methodology and with set specific objectives, the study identified the current problems related to the use of fine ordinary aggregates, on one side and to the future disposal of ceramic wastes due to manufacturing industries, on the other side. Through testing, it was first established that the properties of ceramic wastes were adequates for replacement of fine aggregates. This research presents strength parameters and behavior of concrete where natural sand has been replaced partially by ceramic waste.This research is done to enhance the strength and durability of concrete. in addition to the strength, the continuous extraction of natural sand is a big challenge to the future of well-being because it will not only make the aggregate expensive but also degrade the environment. In the project, laboratory test was done to check the strength of different concrete components such as sand, ceramic tile waste, coarse aggregate and also resulting cubes to test their compressive strength. The designed concrete with ceramic wastes tested using The specimen for prepared cube were tested for compressive strength at 7,14 and 28 days with different replacement of sand by ceramic wastes for 0,5,10 and 15% of ceramic tile waste showed good results with 5% of replacement. The test result of compressive strength during 28 days of curing for the successful waste replacement of 5% were 22.88MPa compared to 22 MPa for convention concrete. The split tensile test results during 28 days of curing for the successful waste replacement of 5% were 3.18MPa compared to 2.82 MPa for convention concrete. The test result of flexural strength test result during 28 days of curing for the successful waste replacement of 5% were 5.97 MPa compared to 5.67 MPa for convention concrete.Regarding the cost the study showed that as the cost of one block for both concrte differe only at 1.6% the clear benefit would depend on the importance of the relevant construction.The analysis of test results shows that the practical percent where the sand has been replaced partially by ceramic tile waste is 5% which may be recommended for structural concrete works.

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LISTS OF ABBREVIATIONS

OBB: The over burnt brick bat

REMA: Rwanda Environmental Management Authority

ISO: International Standard Organization

IS: Indian Standard

GLA: Glazed

OPC: Ordinary Portland Cement

CTA: Crushed Tile Aggregate

RPM: Revolution per minutes

CHAPTERONE:GENERALINTRODUCTION

1.1. Introduction of the Study

This chapter presented the background to the study, statement of the problem, objectives of the study, reach of question, the scope of study, significance of the study, profile of study and the organization of study.

1.2 Background of the Study

Aggregates play a crucial role in construction, particularly in the formulation of concrete. Approximately 75% of concrete's volume consists of aggregates, and their increasing cost over time poses a significant challenge. Additionally, the demand for large quantities of concrete often leads to environmental degradation for financial gain. Meanwhile, the growing construction industry has resulted in a rise in ceramic waste, which is non-biodegradable and accumulates at various sites. An increase in the production of ceramic materials could also exacerbate environmental issues. Ceramic waste, being a completely residual material, can be repurposed as aggregate in sustainable concrete. Utilizing ceramic waste in concrete production can help protect the environment and reduce the consumption of natural resources. The incorporation of industrial waste as aggregates in concrete represents a viable strategy for managing substantial waste volumes and curbing the depletion of natural resources.

This situation inspired the selection of this research topic, with the goal of making a meaningful contribution to engineering.

1.3ProblemStatement

Rwanda is currently experiencing significant development across multiple sectors, particularly in construction. The demand for building materials is substantial, with their performance and availability being essential for sustainable construction. Aggregates are routinely employed in concrete production and are recognized as vital materials. Unfortunately, their rising costs and the environmental impacts of extraction are concerning. Additionally, the presence of ceramic waste poses disposal challenges due to its non-biodegradable nature, which negatively affects soil fertility and agricultural productivity. This creates an urgent environmental concern. If researchers can propose a solution to address these interconnected issues, it could have a profound impact on the local construction industry. This study aims to present a method for converting ceramic waste into components for concrete, rather than disposing of them.

The study is intended to work out and assesses the ceramic wastes properties and establishes their potentiality as partial replacement of final aggregates in concrete

1.4 Research objectives

1.4.1 General objectives

The general objective of this project is to study and evaluate ceramic wastes properties as a potential partial replacement of fine aggregates in concrete.

1.4.2 Specific objectives

The achievement of the above main objective was eased by implementing the following specific objectives:

- To identify key problems related to the use of fine ordinary aggregates and to the future disposal of ceramic wastes due to manufacturing industries.
- To Analyze the properties of ceramic wastes before using them in concrete mixture.
- To establish the performance characteristics of the new concrete compared to the ordinary one's.
- To establish the practical percentage of replacement of sand by ceramic waste for the new concrete in Rwanda.
- To estimate the cost of block where the new concrete has been used and compare with ordinary concrete.

1.5 Significance of research

"All sectors of the Rwandan Society value and undertake sound environmental management and rational use of natural resources in order to contribute to the national aspirations for sustainable development." (REMA, 2013).

It is intended to find ways to improve ways of making new innovation from waste materials which are disposed and has no use. The faculty encourages students to research deeply in improving the strength of already used materials and reuse of waste in order to reduce the extraction of natural resources which has become scarce throughout time.

As students in research it is needed to find solution for society which is sustainable such as proper use of natural resources and exploitation of new materials which is normally taken as waste, and find its use in construction industry.

Based on above views, it is necessary to find ways to reduce adverse impact on environment by using waste materials in construction which is disposed in environment and damage it heavily.

1.6Scope of research

This project focuses on the investigation of the strength of the concrete which have the cement adding aggregates (which will contain some percentage of ceramic wastes) and water to form the concrete. This will mainly consist of observation and sampling of ceramic and grinding of ceramic waste (mainly sanitary ware and floor tiles) at desirable sizes, after grinding we will mix it with other aggregates and the cement in specified proportions to make concrete cubes then, Tests will be conducted to check their strength.

The ceramic waste (tiles) to be used is collected from a construction sites near SONARWA of ROKO construction, where during construction they often are broken and are unfit for use. Other site of collection is from public waste management sites where sanitary ware and ceramics used in kitchen are obtained for they have been broken and are unfit for use.

1.7 Research methodology

This part of research includes an overview of methodology and procedures that the researcher will use during the research. Basically this point will describe in details the techniques and methodology that the researcher will use and how data will be collected and analyzed during the research. Below are Methods to be used:

1: Documentation using articles, books, international journals and other relevant sources on what has been done related to this research.

2: Site visits at ceramic waste disposal sites and construction site where ceramic waste are available.

3: Sample preparation of different ingredients of concrete and grinding of ceramic wastes and considering different waste replacement percentages.

4: Mixing of cement, aggregates and ceramic wastes.

5: Laboratory tests including concrete compressive strength test, slump test.

6: Cost estimation for evaluation of new concrete cost

Conclusion on obtained strength and cost estimated on newly done concrete.

CHAPTER TWO. LITERATURE REVIEW

2.1 Introduction

The construction industry is one of the largest consumers of natural resources and a significant contributor to environmental degradation. As urbanization accelerates globally, the demand for conventional building materials continues to rise, leading to the depletion of natural aggregates and an increase in construction waste. Among the various types of waste generated, ceramic waste—derived from discarded tiles, pottery, and sanitary ware—represents a substantial portion. This waste is often sent to landfills, creating environmental challenges and waste management issues.

In response to these challenges, researchers have increasingly focused on recycling waste materials for use in concrete production. The incorporation of ceramic waste as a partial replacement for fine aggregates offers a dual advantage: it helps reduce landfill waste and can enhance certain properties of concrete. Previous studies have shown that ceramic materials can improve the mechanical strength, durability, and overall performance of concrete mixtures, while also contributing to sustainability goals.

This literature review aims to explore existing research on the use of ceramic waste in concrete, highlighting its properties, benefits, and challenges. By synthesizing findings from various studies, this review will provide a comprehensive understanding of how ceramic waste can be effectively utilized in concrete production, ultimately supporting the shift towards more sustainable construction practices.

2.1.1 Ceramics

Ceramic products are made from natural materials which contain a high proportion of clay minerals. These, through a process of dehydration followed by controlled firing at temperatures of between 700ºC and 1000ºC, acquire the characteristic properties of "fired clay". Thus, the manufacturing process involved in ceramic materials requires high firing temperatures which may activate the clay minerals, endowing them with pozzolanic properties and forming hydrated products similar to those obtained with other active materials.

The unique combinations of properties offered by ceramics make them attractive for many specialized structural applications where metals are inadequate. On the other hand, the inherent brittleness of most ceramics makes the design and development of reliable ceramic structural members exceedingly difficult.

The current option for disposal of ceramic wastes is landfill. This is due to unavailability of standards, avoidance of risk, lack of knowledge and experience in using ceramic wastes in construction. (O. Zimbili, A Review on the Usage of Ceramic Wastes in concrete production, 2014)

PHYSICAL PROPERTIES OF THE CERAMIC TILES

The ceramic tiles are subjected to tests according to European standards, as results of which, the manufacturer declared specific technical parameters. These parameters are placed on the ceramic tile packing and constitute an important role of information to the buyer. The discussion of the most important criteria, which should be taken into account while taking a decision on buying tiles, is presented below.

FREEZE RESISTANCE

The ceramic tiles, which are to be laid out at the places exposed to the impact of negative temperatures, should have the declared freeze resistance confirmed by the test according to

PN-EN ISO 10545-12.

THERMAL SHOCK RESISTANCE

The ceramic tiles which can be subjected to the local sudden temperature change should have the declared thermal shock resistance confirmed by test according PN-EN ISO 10545-9.

BENDING STRENGTH AND BREAKING FORCE

To put it simply, these parameters specify at which stress, the tile is subjected to breaking. it is a particularly important parameter in case of floor tiles, which are subjected to significant mechanical loads, and abrasive tiles layout in places, where stresses caused by the movements of building walls can occur. These tests determining the bending strength and the breaking force are performed according to test method specified in PN-EN ISO 10545-9.

CHEMICAL RESISTANCE

Specifies the resistance of the tile to the impacts of testing solutions: daily use agents, salts for swimming pool as well as acids and alkalis. The tiles resistant to the chemical factors cannot be subject to changes under the influences of these substances, e.g. a change in gloss or color. The chemical resistance test is performed in accordance with the test method specified in PN-EN ISO 10545-13. Grade GA (for daily use agents and salts for swimming pools) means the lack of visible changes after the test; GLA (for weak acids and alkalis i.e. with concentration up to 3%) signifies the lack of visible changes after the test.

STAIN RESISTANCE

Specified according to the test method described in PN-EN ISO 10545-14. By grades from 1 to 5, determines the easiness of the removal of the visible colors from the tile surface. The tiles from the surface of which, the colors can be removed in the easiest way (with the use of hot water and a fabric) correspond to grade 5.

2.1.2 PORTLAND CEMENT

Pozzolana Portland cement is produced by either intergrading of ordinary Portland cement clinker along with gypsum and pozzolana materials in certain proportions on grinding the OPC clinker, gypsum, and pozzolanic materials separately or thoroughly blending them in certain proportions.

2.1.3 AGGREGATES

Aggregates are the materials basically used as filler with binding material in the production of mortar and concrete. They are derived from igneous, sedimentary and metamorphic rocks or manufactured from blast furnace slag, etc. Aggregates form the body of the concrete, reduce the shrinkage and effect economy. (Duggal, 2003).

The most obvious environmental impact of aggregate mining is the conversion of land use, most likely from undeveloped or agricultural land use, to a (temporary) hole in the ground. This major impact is accompanied by loss of habitat, noise, dust, blasting effects, erosion, sedimentation, and changes to the visual scene. Mining aggregate can lead to serious environmental impacts. Societal pressures can exacerbate the environmental impacts of aggregate development. In areas of high population density, resource availability, combined with conflicting land use, severely limits areas where aggregate can be developed, which can force large numbers of aggregate operations to be concentrated into small areas.

Doing so can compound impacts, thus transforming what might be an innocuous nuisance under other circumstances into severe consequences.

Environmental Impacts Of Mining Natural Aggregate. Available from: https://www.researchgate.net/publication/225864061_Environmental_Impacts_Of_Mining_Natural_Aggregate.

Water

The purpose of using water with cement is to cause hydration of the cement. Water in excess of that required for hydration acts as a lubricant between coarse and fine aggregates and produces a workable and economical concrete. (Duggal, 2003).

2.2 NECESSITY OF USING WASTE IN CONSTRUCTION

Concrete is the base material for construction industries. It is strong in compression and weak in tension, the main constituent of the concrete in cement, sand, coarse aggregate and water, replacing some of these material makes significant changes in cost as well as performance. Coarse aggregate filled almost 70% of volume in concrete, the cost of coarse aggregate rapidly increasing also the availability of the aggregate is getting reduced. The major cost of the concrete is belonged to the aggregate. The over burnt brick bat (OBB) wastes 20-30mm size having available in the brick manufacturing industries. In recent research, the OBB wastes were replaced with concrete. This OBB maintains strength and performance to the concrete also reduce the weight of the concrete. Strongly OBB replaced with concrete can be performed in the mass concrete filling area. In environmental aspects replacement of OBB in concrete is reduce the conservation in the natural resources. Raw material utilization can be diminished which at last spare time and vitality. These will diminish the measure of ozone-harming substance era. The blocks which are close to the fire in the oven subjected to high warmth more than 1000 degree centigrade it will shrink and changes in shape, the shading ends up noticeably ruddy and its appearance like rosy to blackish inclination stone.

This over consumed block fills in as waste in the development business and needs to amass some place during the time spent reusing. (S Kanchidurai*, 2018).

2.3 AVAILABILITY OF CERAMIC WASTE IN RWANDA

Among the industries that manufacture construction materials and equipment, it has been identified that there is an industry called Nyanza Ceramics CPC company which is currently working and umubano tile which is planning to start this year.

“His remarks come amidst Umubano Tiles’ plans to construct a $2m (Rwf1.2 billion) ceramic tile-making plant in Rwanda. The plant will be the first of its kind in East Africa and would cater for Rwanda’s booming construction sector and also reduce the importation of ceramic tiles in the region.’’(New times,2016)

The consultant shall determine technology, designs, skills and equipment requirement on the basis of products. Besides the usual cups, plate. the consultant shall be required to identify technology and specification for production of sanitary ware and tiles. The consultant shall be expected to be considerate of the availability and supply of raw materials. (New times,2017).

2.4 COMPRESSIVE STRENGTH OF CONCRETE WHERE CERAMIC WASTE ARE USED

(O. Zimbili, 2014) Said that “Research on the use of wastes from *sanitary ware* as partial substitute for coarse aggregates in concrete (15 to 25%), and produced positive results. The increase in partial substitution resulted in lower density in concrete, and higher compressive and tensile strength. The concrete produced was suitable for structural use”.

Andrés Juan, César Medina (2010) “Both the compressive and tensile strengths obtained at different ages are higher for recycled concrete than the reference concrete. In addition, as the percentage of conventional coarse aggregate substituted by ceramic coarse aggregate rose, so too did the strength when compared with the reference concrete”.

The concrete is cast by partially replacing fine aggregate and coarse aggregate with egg shell and ceramic waste in various proportions such as 5%,7.5%,10%,12.5% and 15%. The compressive strength and split tensile strength reveals high strength of 12.5% replacement of egg shell and ceramic waste. At an age of 28 days curing, the compressive strength of 12.5%

replacement is 3.8% higher than the conventional concrete. At an age of 28 days curing, the split tensile strength of 12.5% replacement is 23.7% higher than the conventional concrete. Thus egg shell and ceramic waste can be utilized in the manufacture of concrete at replacement rate of 12.5%. (Nirmala, 2016).

Tile powder behaves like admixtures, which can be used to produce Ready Mix Concrete. When crushed tiles replace coarse aggregate, compressive strength increases up to 10%, but after that it decreases. The authors further confirm that ceramic waste can be used as coarse aggregate as the properties of ceramic waste coarse aggregate are within the range of the values of concrete making aggregate according to Indian Standards. The use of Crushed Tile Aggregate (CTA) caused a 40% loss in compressive and splitting tensile strengths. CTA has negatively affected abrasion and freeze thaw durability. According to these results, 100% replacement of CTA as a coarse aggregate is not appropriate. (Adebola A. Adekunle, 2017).

2.5 SPLIT TENSILE STRENGTH OF CONCRETE WHERE CERAMIC WASTE ARE USED

The compressive strength and split tensile strength reveals high strength of 12.5% replacement of egg shell and ceramic waste. At an age of 28 days curing, the compressive strength of 12.5% replacement is 3.8% higher than the conventional concrete. At an age of 28 days curing, the split tensile strength of 12.5% replacement is 23.7% higher than the conventional concrete (Nirmala, 2016)

OBB replaced 25 and 50% of coarse aggregate, conventional beam casted for comparison. The specimen size was maintained 100 x 150 x 100 as specified in Indian standard [13] [14]. The beams are designed as the singly reinforced beam with 2 numbers of 10mm diameter bar in tension zone and two numbers of 10mm diameter bar at compression zone. For shear reinforcement, 8mm diameter bars were used at 100mm spacing. The beams are identified as (CB) conventional beam and for beams with brick bats as (BBB) Brick bat beam. The specimens are tested using two-point loading by 100T loading frame. shows the flexural beam mold placed by different percentage. (S Kanchidurai*, 2018)

CHAPTER THREE. RESEARCH METHODOLOGY

3.1. Description of the case study or the site

This chapter elaborates and explain the methodology used including different laboratory tests done on different ingredients of concrete and ceramic waste which helped to know the behavior of this newly done concrete versus the old known one.

The site where the collection of materials which are used to carry out different tests done on concrete must be having aggregates which has good strength so that this will result in good quality concrete which will be helpful in different construction activities, the sand should be free from impurities and soil materials, the water should.

The site where the ceramic waste were collected is located at ROKO construction site near Sonarwa will has been obtained from the site of construction because they have been broken during the construction process of floor paving using ceramic materials.

Figure.3. 1.broken tiles available on site

3. 2. Detailed description of Methods and Materials

3.2.1 Cement

Cement is the binder material in concrete and in this laboratory test, the ordinary Portland cement of grade 32.5 is used.

Figure.3. 2.sample of cement ready to be mixed with in other ingredients

3.2.2 Coarse aggregates

Coarse aggregates that are used are obtained from the site of hostel construction (of real contractors), which normally of size of 25 to 16mm and are crushed stone type from their crushing site.

Figure.3. 3.Shows the crushed stone aggregates which will be used in the concrete cubes

3.2.3 Fine aggregates

The natural sand that is used in the laboratory test is a river sand (from cst site) free from impurities and soils or organic materials.

Figure.3. 4.shows the type of sand used in the mix

3.2.4 Ceramic wastes

Ceramic wastes that are used are broken ceramic tiles from the Sonarwa site (of ROKO contractors) which are obtained during the floor paving process and toilet flooring and kitchen.

Figure.3. 5.shows the ceramic tile waste before and after grinding into fine aggregates

3.2.5 Water

Water which is used is normally the water from water taps which is clean with no color or odor to ensure that they will easily allow the hydration process of cement.

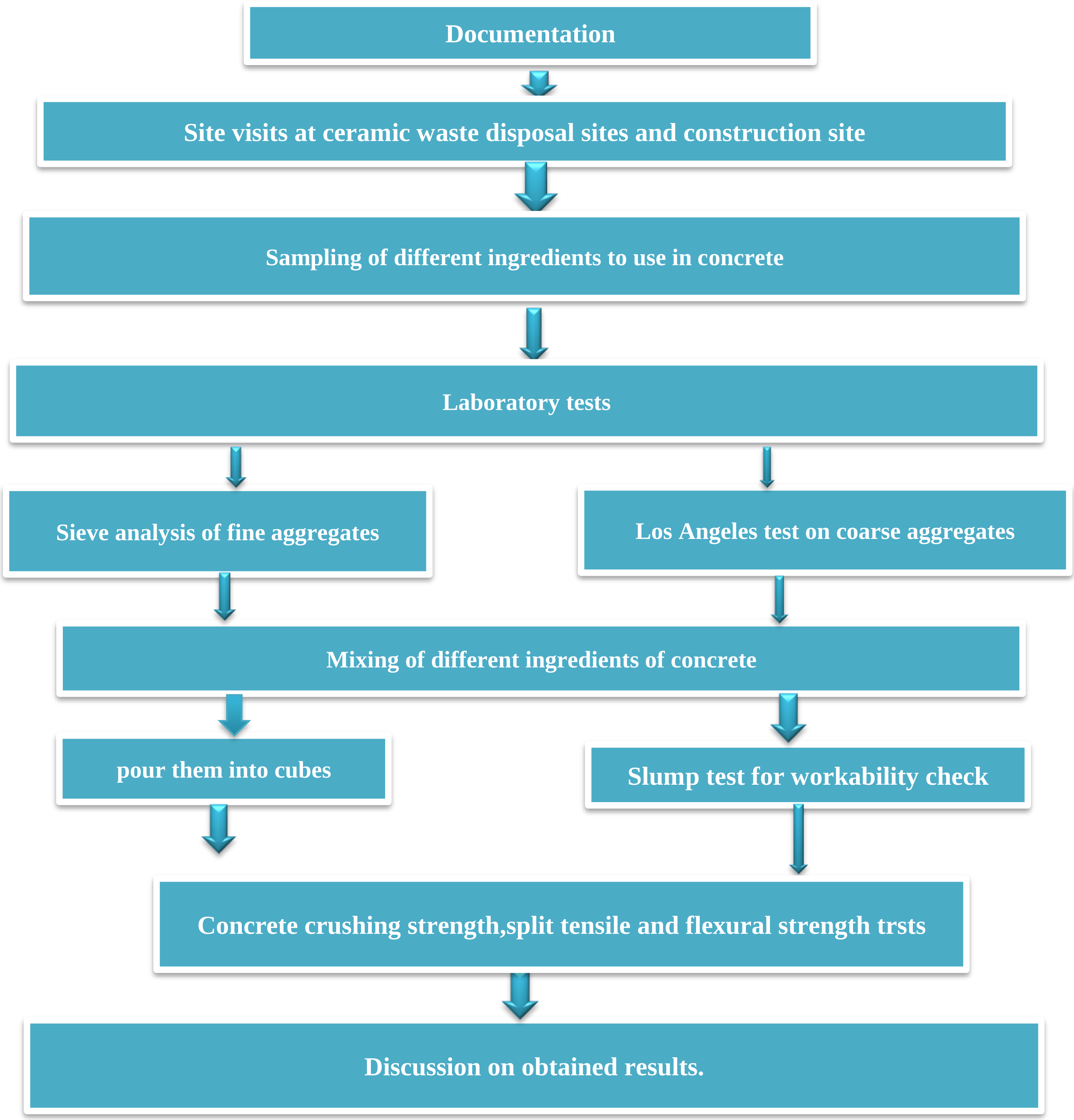

Figure.3. 6.Flowchart which shows the methods to be used in undertaking the research.

3.3. LABORATORY TESTS WITH DIFFERENT CONCRETE COMPONENTS

3.3.1. grain size distribution test

The aim of this test is to determine the size of aggregates used in the test, obviously which will be used during the strength tests.

In this project the grain size distribution test will be done on natural sand, coarse aggregates.

3.3.2. Natural sand apparatus used

A set of sieves of different sizes, balance, oven, sieve shaker machine.

Figure.3. 7.shows the sieve sizes successively rest on the electrical shaker machine, balance and oven

➢ Procedure

1. dry the sample of 1kg in the oven for 24 hours
2. organize the sieves from the bigger to the smaller one, pour the sample
3. crump the cover on the top of the machine
4. run the sieve shaker machine for 10 minutes
5. weight each fraction retained on each sieve

3.3.3.Los Angeles abrasion test

Abrasion value is the percentage of aggregate weight that passing sieve (No. 12 = 1.7mm) after application of standard abrasion by mechanical rotation parallel with standard iron balls for a dry aggregate. Its aim is to choose the best type of aggregate due to abrasion value and to calculate the hardness of aggregates.

➢ **APPARATUS**

1. Los Angeles equipment consisting a cylindrical barrel diameter is (70) cm and height is (50) cm, handled on a horizontal axis can be rotate around this axes with a speed of (30-33) rpm.

2. Balance.

3. Sieves of No. 37.5,25 ,19,12.5 and 10mm.

4. Iron or metallic balls (12) numbers, diameter is (4.8) mm and weight of each is (445) gm. 5. Oven



Figure.3. 8.different equipment used in los Angeles abrasion test such as steel balls, balance and abrasion machine.

- **PROCEDURES**

1. Put about 5kg is (W1) of the aggregate in the oven for drying.

2. Open the los Angeles equipment and put the dried aggregate sample with the (12) balls in it and close it again.

3. Rotate the barrel for (500) times.

3.3.4 SLUMP TEST FOR FRESH CONCRETE

The slump test is the simplest workability test for concrete, involves low cost and provides immediate results. Due to this fact, it has been widely used for workability tests since 1922. The slump is carried out as per procedures mentioned in **IS: 1199 – 1959.**

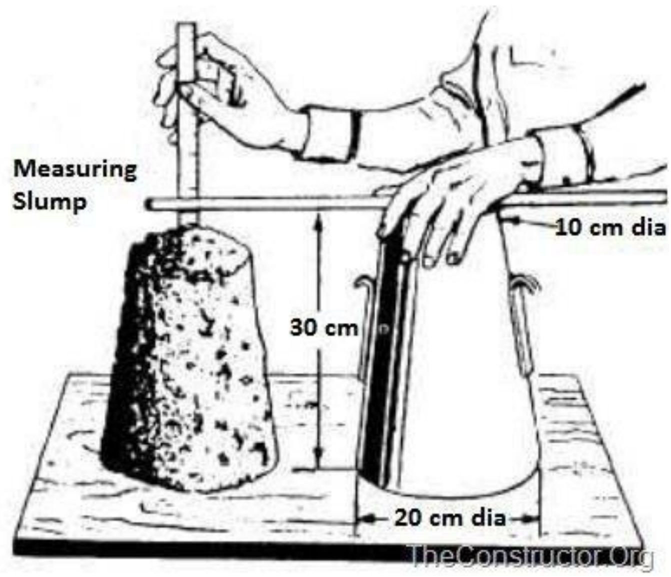

Figure.3. 9.shows the measurement of slump

Procedure for Concrete Slump Test:

The concrete slump test is a simple and effective method to measure the consistency and workability of fresh concrete. Here's a step-by-step procedure for conducting the test:

Materials Needed:

- Slump cone (Abrams cone)

- Base plate
- Tamping rod (600 mm long, 16 mm diameter)
- Measuring tape or ruler
- Water and concrete sample

Procedure:

1. **Prepare the Equipment:**
    - Place the slump cone on a stable, level surface. Ensure the base plate is clean and free from debris.
2. **Fill the Cone:**
    - Begin filling the cone with fresh concrete in three layers.
    - Each layer should be approximately one-third of the cone's height (about 4 inches or 10 cm).
3. **Compact Each Layer:**
    - Use the tamping rod to tamp each layer 25 times, making sure to distribute the tamping evenly. Push the rod down to the bottom of the cone for effective compaction.
4. **Level the Top:**
    - After tamping the final layer, use the tamping rod to strike off the excess concrete at the top of the cone, ensuring it's level with the top edge.
5. **Remove the Cone:**
    - Carefully lift the slump cone vertically upwards without disturbing the concrete. This should be done slowly to avoid any movement.
6. **Measure the Slump:**
    - After removing the cone, measure the vertical distance from the top of the cone to the highest point of the concrete that has settled. This measurement is the slump value, typically recorded in millimeters or inches.
7. **Record the Results:**
    - Document the slump measurement, and note any observations about the concrete's appearance and consistency.

Tips:

- Ensure the concrete sample is representative of the batch.

- Perform the test within 15 minutes of mixing the concrete for accurate results.
- Clean the equipment thoroughly after use to prevent contamination.

Interpretation:

- A higher slump indicates a more workable mix, while a lower slump suggests a stiffer mix. Typical slump values range from 25 mm to 150 mm, depending on the intended application of the concrete.

This method provides valuable information about the workability of concrete, helping ensure quality in construction practices.

4o mini

Figure.3. 10.shows the slump of the fresh concrete

3.4.PRESENTATION OF TEST RESULTS FOR CONCRETE COMPONENTS

3.4.1 Sieve analysis for fine (natural sand) aggregates

Sample mass =1000g

Sieve size(mm)	Mass retained in each sieve(g)
4.75	11.45
2.36	14.57
1.18	11.07
0.6	137.89
0.3	214.65
0.15	110.3
0.075	14.63
Pan	5.34

Table.3. 1.data on sieve analysis of natural sand

3.4.2 Sieve analysis for ceramic waste

Sieve size(mm)	Mass retained in each sieve(g)
4.75	5.45
2.36	44.57
1.18	211.07
0.6	237.89
0.3	314.65
0.15	124.93
Pan	11.34
Total	$\sum$ =1000

Table.3. 2.Sieve analysis for ceramic waste

3.4.3 Sieve analysis for coarse aggregates

Sample mass =1500g

Sieve size(mm)	Mass retained (g)
40	0
37.5	61.31
25	730.46
16	330.06
12.5	237.93
11.2	117.15
10	12.32
6.3	10.97
4.75	0
2.36	0
2	0
Pan	0
Total	1500

Table.3. 3.data on sieve analysis of course aggregates

3.4.4 Los Angeles abrasion test for coarse aggregates

The sample used to undertake this test is those passing in the sieve below and it is called Los Angeles class A, sample mass is 5000g.

The table below shows the mass retained in sieves of class A

Sieve sizes(mm)	Mass retained(g)
37.5	0
25	1249.11
19	1250.36
12.5	1249.73
10	1250.8
Total	5000

Table.3. 4.data on sieve analysis of course aggregates used in los Angeles test

3.5 PROPERTIES OF RAW MATERIALS

5.5.1 GRADING OF SAND

Sieve analysis was done to determine particle size distribution of fine aggregate, it is a useful test because it helped to know the estimation of how much coarse particles contained in sand.

It is expressed in numerical index termed fineness modulus. The test is specified in IS 383-1970.

Table.3. 5.Computation about sieve analysis of sand

Sieve size(mm)	Mass retained in each sieve(g)	PERCENTAGE weight retained (g)	Cumulative percentage weight retained (%)	Percentage of mass passing(%)
4.75	11.45	1.14	1.14	98.86
2.36	44.57	4.4	5.54	94.46
1.18	411.07	41.10	46.64	53.36
0.6	137.89	13.78	65.42	34.58
0.3	214.65	21.46	86.88	13.12
0.15	124.93	12.49	99.37	0.63

Pan	5.34	0.5	100	0
Total	∑ =1000		304.99	

Fineness modulus of fine aggregates = (cumulative% retained /100) =304.99/100=3.05

This shows that the sand used here lies in the category of Coarse sand in zone II.

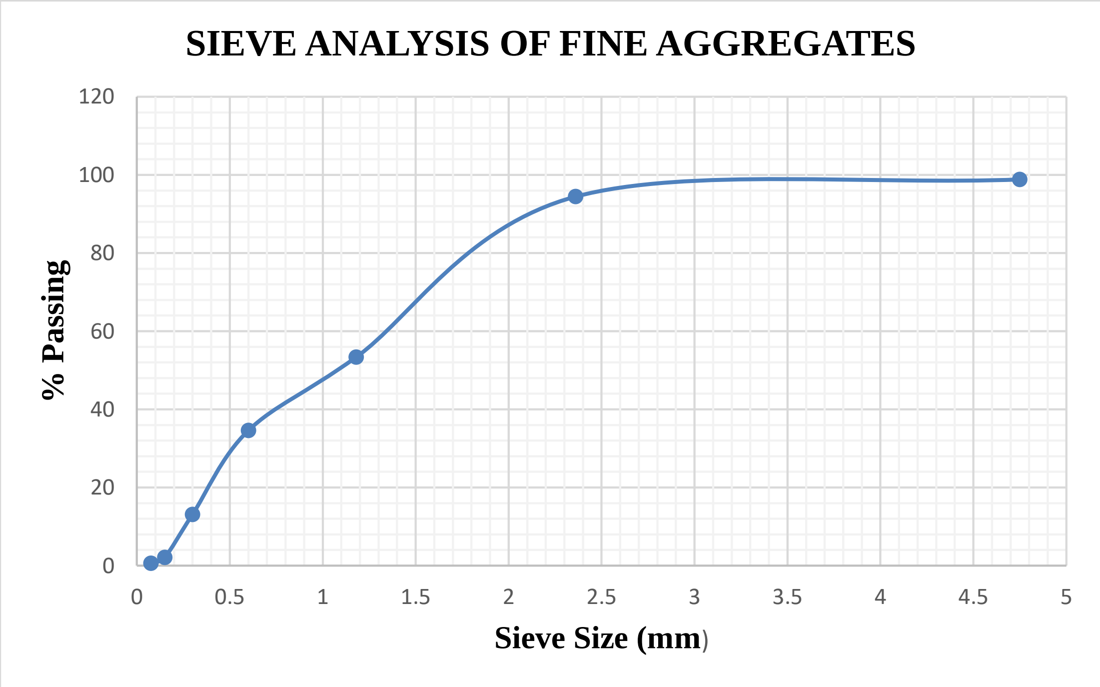

Table.3. 6.Show the graph of grain size distribution of fine aggregate

3.5.2 GRADING OF COARSE AGGREGATE

The sieve analysis of coarse aggregate will help to identify the dominant diameter of aggregate we have in the sample and is critical in determining the strength that the resulting concrete will have. this will also help in increase of abrasion characteristics of coarse aggregates.

Table.3. 7.Computation about sieve analysis of coarse aggregate

Sieve size(mm)	Mass retained in each sieve(g)	percentage weight retained (g)	Cumulative percentage weight retained (%)	Percentage of mass passing(%)
40	0	0	0	100
37.5	61.31	4.08	4.08	95.92
25	730.46	48.69	52.77	47.23
16	330.06	22.00	74.77	25.23
12.5	237.93	15.86	90.63	9.37
11.2	117.15	7.81	98.44	1.56
10	12.32	0.82	99.26	0.74
6.3	10.97	0.73	99.99	0.01
4.75	0	0	99.99	0.01
2.36	0	0	99.99	0.01
2	0	0	99.99	0.01
Total	1500			

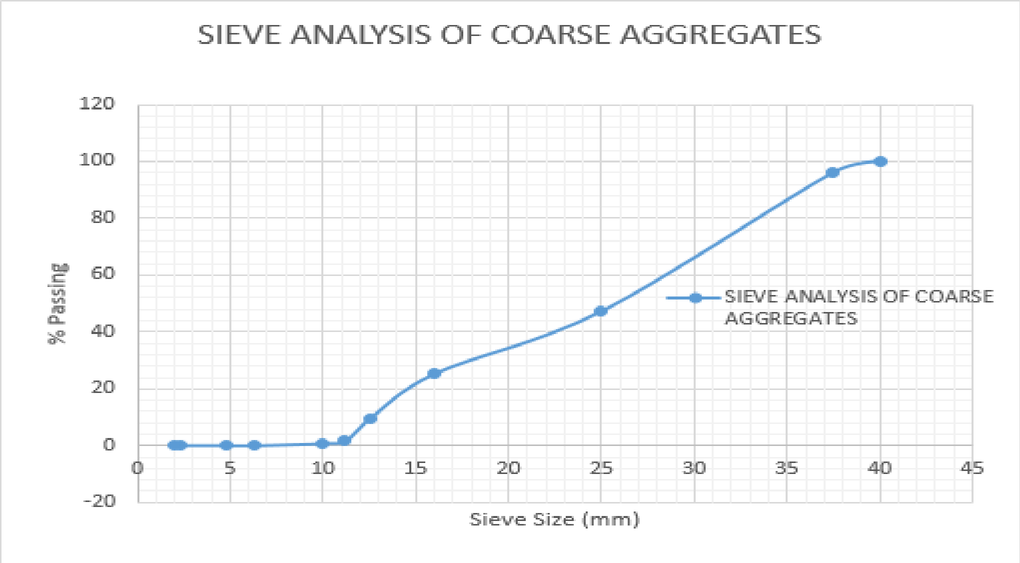

Table.3. 8.graph showing the sieve analysis of coarse aggregates

Sieve having the diameter of 10-15mm have 20% of the coarse aggregates, 15-25mm have 22% of the whole sample while from 25-40mm have 50% of the sample. The most dominant diameter is 25mm aggregates.

4.2.4 Grading of Ceramic Tile Waste

Sieve analysis was done to determine particle size distribution of fine aggregate; it is a useful test because it helped to know the estimation of grain size distribution in ceramic tile waste.

Table.3. 9.Shows the grain size of ceramic tile waste

Sieve size(mm)	Mass retained in each sieve(g)	PERCENTAGE weight retained (g)	Cumulative percentage weight retained (%)	Percentage of mass passing(%)
4.75	5.45	0.545	0.545	99.45
2.36	44.57	4.45	4.995	95.01
1.18	211.07	21.11	26.105	73.89
0.6	237.89	23.79	49.895	50.11
0.3	314.65	31.46	81.355	16.645
0.15	124.93	12.49	93.845	6.155
Pan	11.34	1.13	100	0
Total	$\sum$ =1000		256.74	

Fineness modulus of fine aggregates = (cumulative% retained /100) =256.74/100=2.58

This shows that the ceramic tile waste used here lies in the category of Fine sand in zone III.

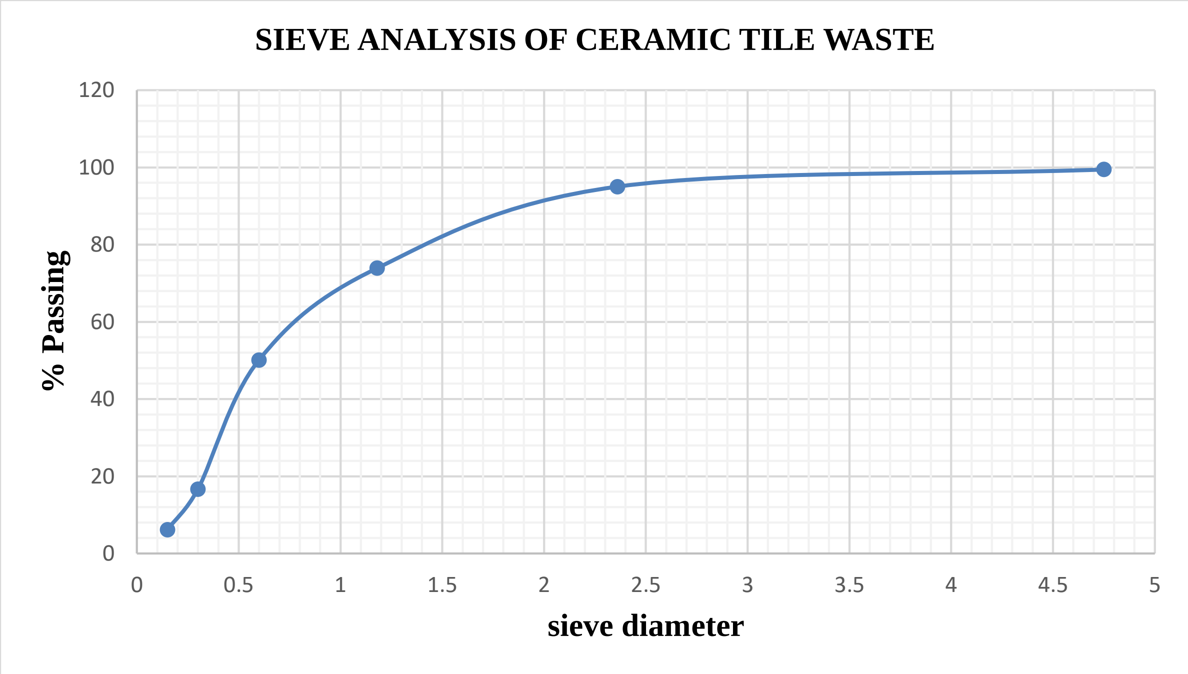

Figure.3. 11.sieve analysis of ceramic tile waste

4.2.5 LOS ANGELES TEST OF COARSE AGGREGATE

For class A

Sieve sizes(mm)	Mass retained(g)
37.5	0
25	1249.11
19	1250.36
12.5	1249.73
10	1250.8
Total	5000

Table 3.8 sampling for class A for Los angeles test

M: Initial mass used in the machine =5000 g

m: mass retained in sieve 1.75mm=3376.3 g

m1: mass passing =5000-3376.3=1623.7 g

% of fine= $\frac{(m1*100)}{M} = \frac{(1623.7*100)}{5000}$=32.474%

Since the percentage obtained is <35% the aggregate used are good for use in structural concrete.

3.4. Preparation of Concrete Cubes For Harderned Concrete

After mixing the cement, fine aggregates (natural sand and ceramic tile waste), coarse aggregates and water with the mix ratio of 1:1.5:3 of M20, the cube size is 150mm*150mm*150mm, this homogenous mix is poured in standard steel cubes used to make samples which will be tested for concrete crushing strength test.

The target strength is = minimum strength +1.65*standard deviation

Per IS 383:1970 specify standard deviation of 4 for M20, M25

The target strength is = 20+1.65*4=26.6 Mpa

3 Cubes are done for each waste replacement percentage and for 7,14 and 28 days which makes them 36 cubes and the average is made to simplify the calculation.

Cubes are formed with different percentage of ceramic tile waste:

1. Concrete cubes where there is partial replacement of fine aggregates by 5% of ceramic tile waste.
2. Concrete cubes where there is partial replacement of fine aggregates by 10% of ceramic tile waste.
3. Concrete cubes where there is partial replacement of fine aggregates by 15% of ceramic tile waste.

Figure.3. 12.show the cubes ready to be used in the compressive machine for 7 days test

These cubes formed and put in water bath where they spend different days which are 7,14 and 28 days. After 7 ,14 and 28 days the cubes were transferred Saint Joseph technical school for concrete crushing test to check their compressive strength variation on the 7^{th} to the 28^{th} day respectively.

3.4.1.Crushing strength test

This is used to determine the stress at which the concrete cube will fail, this value is the most important strength factor which can characterize the concrete.

Apparatus

1. Steel plates where the cubes will rest.
2. Concrete crushing strength machine.
3. balance

Figure.3. 13.Shows the concrete compressive machine and the cube rest on steel plates holding it ready to be crushed

- **Procedure**

1.take the cubes from the water bath and place them in the machine

2.start the machine

3.when the cubes start to crack the machine stops to increase the stress applied stop the machine

4.read the stress at which the machine stopped when the cube has crushed.

3.4.2.Split Tensile Test

The tensile strength of concrete is one of the basic and important properties. Splitting tensile strength test on concrete cylinder is a method to determine the tensile strength of concrete.

The concrete is very weak in tension due to its brittle nature and is not expected to resist the direct tension. The concrete develops cracks when subjected to tensile forces. Thus, it is necessary to determine the tensile strength of concrete to determine the load at which the concrete members may crack.

Split tensile strength is done by putting a concrete cylinder horizontally in a compressive machine from SJTEC laboratory; we have used 2 cylinder specimens of 150mm diameter, the specimens were loaded uniformly, the load at which the cylinder fail was recorded, the specimen was also tested immediately after taking the cylinder from water on 7th, 14th and 28th day.

The following formula was used to obtain the tensile strength:

Tensile strength: $\frac{2P}{\pi DL}$ where p: maximum load N applied to the specimen

D: diameter of the specimen in mm

L: length of specimen in mm

3.4.3.Flexural Test

It is the ability of a beam or slab to resist failure in bending. It is measured by loading unreinforced 150x150 mm concrete beams with a span three times the depth (usually 450mm). The flexural strength is expressed as "Modulus of Rupture"(MR) in MPa.

It is calculated as follows:

Flexural strength = $\frac{PL}{BH^2}$

Where:

P: Load applied

L: length of the beam

B: breadth of the beam

H: Height of the beam

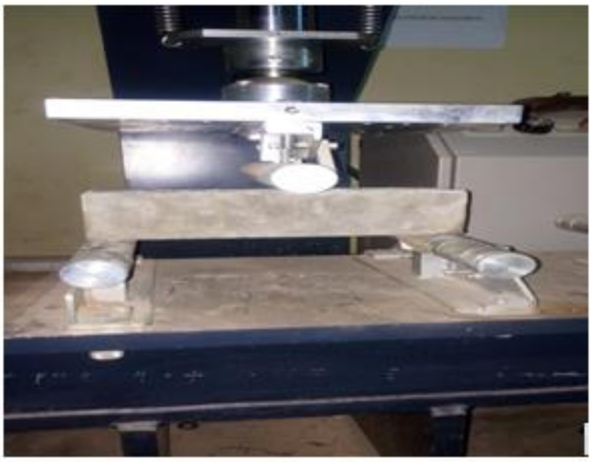

Figure.3. 14.show the beam being loaded in flexural strength testing machine

3.6 SLUMP TEST FOR FRESH CONCRETE

After measuring the steel cone and find it to be 30 cm, the concrete cone was measured and found to be 22.8cm, the resulting slump is 7.2cm which is 72 mm.

3.7 COMPRESSIVE STRENGTH OF CONCRETE CUBES

After testing the cubes for 7,14 and 28 days respectively the following results were obtained.

The Table below shows the compressive strength results for 7-day test

COMPRESSIVE TEST AFTER 7 DAYS PERIOD				
Mass (g)	Waste replacement percentages (%)	Area (mm^2)	Load (KN)	Samples
8035	0	22500	410	3
7980	5	22500	400	3
8060	10	22500	325	3
8370	15	22500	320	3
			Total	12

Table.3. 10.data from the lab of concrete crushing test for 7 days

COMPRESSIVE TEST AFTER 14 DAYS PERIOD				
Mass (g)	Waste replacement percentages (%)	Area (mm^2)	Load (KN)	Sample
8203.5	0	22500	455	3
7969.5	5	22500	475	3
8035	10	22500	420	3
8106.5	15	22500	395	3
			Total	12

Table.3. 11.data from the lab of concrete crushing test for 14 day

COMPRESSIVE TEST AFTER 28 DAYS PERIOD				Sample
Mass (g)	Waste replacement percentages (%)	Area (mm^2)	Load (KN)	3
8119.25	0	22500	495	3
7974.75	5	22500	515	3
8047.5	10	22500	430	3
8238.25	15	22500	425	12

Table.3. 12.data from the lab of concrete crushing test for 28 days

3.8 Tensile Strength of Concrete

Days	Waste replacement(%)	Length(cm)	Diameter(cm)	Load(KN)	Strength(Mpa)
7	0	30	15	175	2.47
	5			150	2.12
	10			125	1.76
	15			110	1.55
14	0	30	15	165	2.33
	5			175	2.47
	10			140	1.98
	15			120	1.68
28	0	30	15	200	2.82
	5			225	3.18
	10			180	2.54
	15			165	2.33

Table.3. 13.tensile strength of concrete

3.4.3 Flexural Strength of Concrete

Days	Waste replacement (%)	Length(Cm)	Width(Cm)	Depth(Cm)	Load(KN)	Strength(Mpa)
14	0	28	7	7	5.31	4.6
	5				5.64	4.9
	10				4.98	4.33
	15				4.74	4.07
28	0	28	7	7	5.88	5.67
	5				7.28	5.97
	10				6.95	5.47
	15				6.7	4.82

Table.3. 14.shows flexural strength of concrete

CHAPTER FOUR. CONCRETE TEST, RESULTS AND COST ESTIMATION

4.1 INTRODUCTION

This section includes data analysis and interpretation. It presents the findings of the study and checks that the specific objectives have been achieved, in addition it also discusses the outcome obtained. Data was collected using laboratory test where tabulation, charts and existing literature were used for analysis.

4.2 Result Analysis

4.3 Analysis of Obtained Slump For Fresh Concrete

From figure 3.9 it is shown that the measured slump was a true slump having the slump of 72mm which shows that it is recommended for use.

4.4 Analysis of Mechanical Property of Concrete

Table.4. 1.data analysis of compressive strength for 7 days

Mass (g)	Area	Volume(m^3)	Density(kg/m^3)	Waste %	Load(KN)	compressive strength(Mpa)
8035	22500	0.003375	2380.74	0	410	18.44
7980	22500	0.003375	2364.44	5	400	17.77
8060	22500	0.003375	2388.14	10	325	14.44
8370	22500	0.003375	2480	15	320	14.22

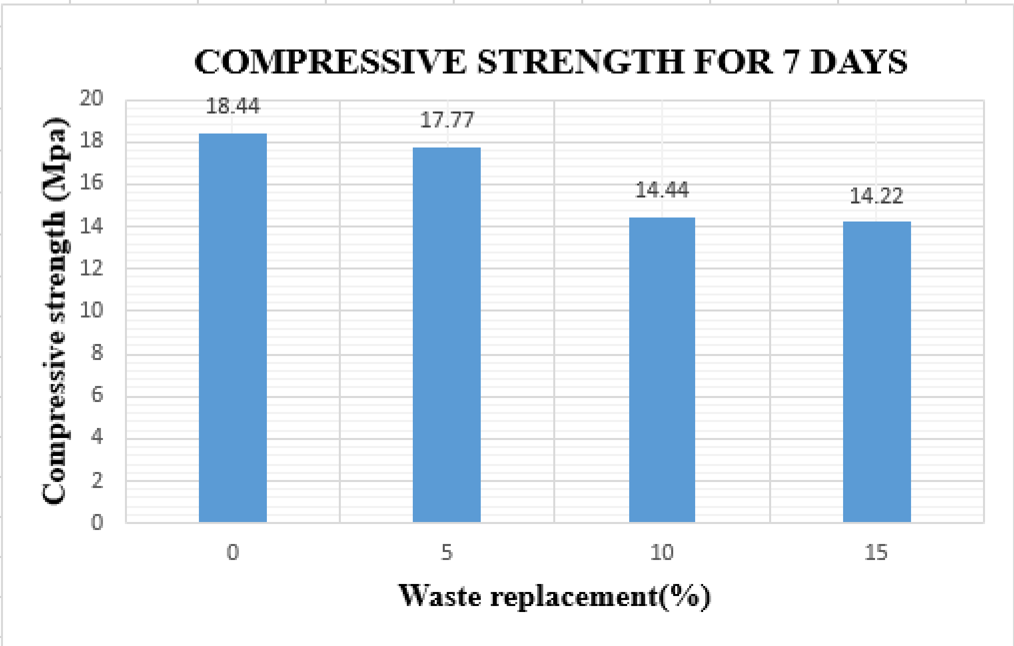

figure.4. 1.data analysis of compressive strength for 14 days

The conventional concrete has the strength of 18.44 Mpa, while when the 5% of ceramic waste replace the fine aggregate partially the strength drops by 3.6 % which is considerably equal to the conventional concrete and can be recommended for use in structural concrete, while when 10% of ceramic waste replace the fine aggregate partially the strength drops by 21.7 % which is high and cannot be recommended for structural concrete can be used whether on damp proof coarse and other minor works. when 15% of ceramic waste replace the fine aggregate partially, the strength drops by 22.89% which is high and cannot be recommended for structural concrete.

Mass (g)	Area	Volume(m^3)	% of waste	Density(kg/m^3)	Load(KN)	compressive strength(MPA)
8203.5	22500	0.003375	0	2430.66	455	20.22
7969.5	22500	0.003375	5	2361.33	475	21.11
8035	22500	0.003375	10	2380.74	400	17.77
8106.5	22500	0.003375	15	2401.92	395	17.55

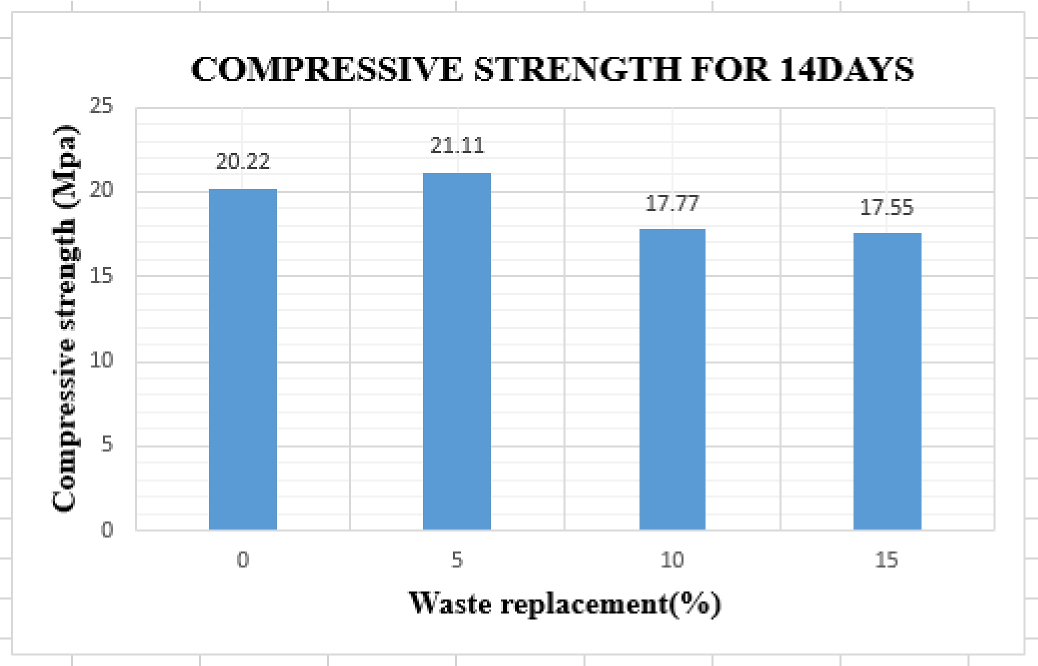

figure.4. 2.show the variation of compressive strength vs waste replacement at 14 days

The conventional concrete has the strength of 20.22 Mpa, while when the 5% of ceramic waste replace the fine aggregate partially the strength increases by 4.2% which slightly increased compared to the conventional concrete and can be recommended for use in structural concrete, while when 10% of ceramic waste replace the fine aggregate partially the strength drops by 12.1% which is high and cannot be recommended for structural concrete except for minor works. when 15% of ceramic waste replace the fine aggregate partially, the strength drops by 13.3% which is high and cannot be recommended for structural concrete.

Table.4. 2.data analysis of compressive strength for 28 days

Mass (g)	Area(mm^2)	Volume(m^3)	%of waste	Density(kg/m^3)	Load(KN)	compressive strength(MPA)
8119.25	22500	0.003375	0	2405.70	495	22
7974.75	22500	0.003375	5	2362.88	515	22.88
8047.5	22500	0.003375	10	2384.44	430	19.11
8238.25	22500	0.003375	15	2440.96	425	18.88

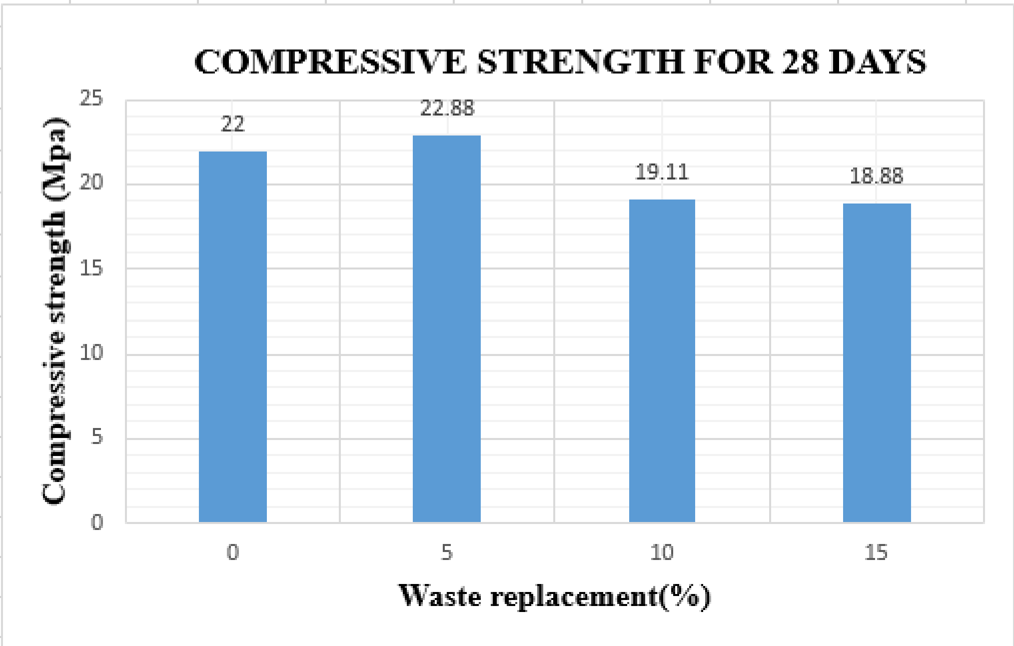

figure.4. 3.show the variation of compressive strength vs waste replacement at 28 days

The conventional concrete has the strength of 22 Mpa, while when the 5% of ceramic waste replace the fine aggregate partially the strength increases by 3.5 % which slightly increased compared to the conventional concrete and can be recommended for use in structural concrete, while when 10% of ceramic waste replace the fine aggregate partially the strength drops by 13.14% which is high and cannot be recommended for structural concrete except for minor works. when 15% of ceramic waste replace the fine aggregate partially, the strength drops by 14.2% which is high and cannot be recommended for structural concrete.

To sum up it is seen that 5% partial replacement of fine aggregate by ceramic tile waste is the most practical and will yield slightly the same strength for 7 days, and slightly increase in strength for 14 and 28 days which means the strength increases after a long period of time.

4.5.Split Tensile Strength

4.5.1.Split Tensile Strength For 7 Days

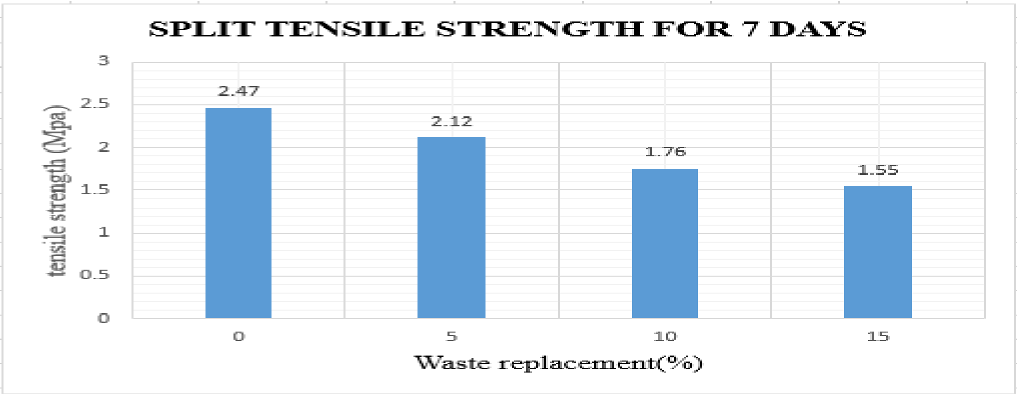

figure.4. 4.show the split tensile strength for 7 days

The conventional concrete has the strength of 2.47 Mpa, while when the 5% of ceramic waste replace the fine aggregate partially the strength drops by 14.18 % which has decreased compared to the conventional concrete and cannot be recommended for use in structural concrete, while when 10% of ceramic waste replace the fine aggregate partially the strength drops by 28.75% which is high and cannot be recommended for structural concrete except for minor works. when 15% of ceramic waste replace the fine aggregate partially, the strength drops by 37.25% which is high and cannot be recommended for structural concrete

4.5.1.Split Tensile For 14 Days

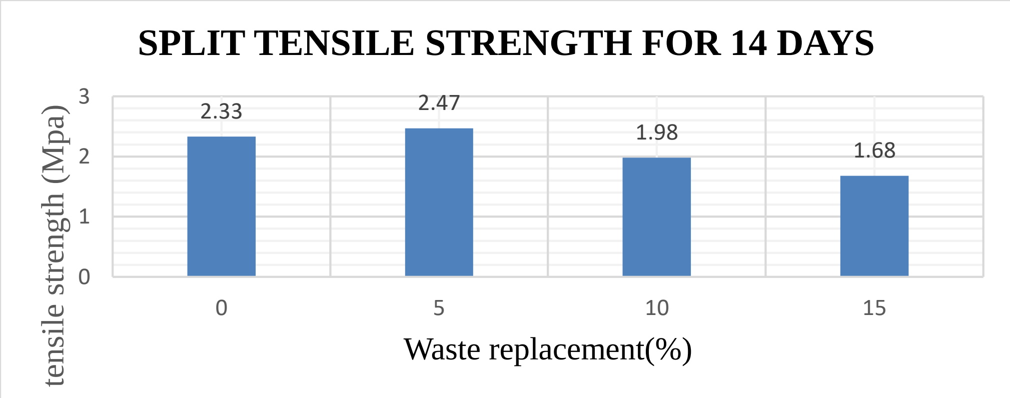

figure.4. 5. show the split tensile strength for 14 days

The conventional concrete has the strength of 2.33 Mpa, while when the 5% of ceramic waste replace the fine aggregate partially the strength increases by 5.67 % which slightly increased compared to the conventional concrete and can be recommended for use in structural concrete, while when 10% of ceramic waste replace the fine aggregate partially the strength drops by 15.03% which is high and cannot be recommended for structural concrete except for minor works. when 15% of ceramic waste replace the fine aggregate partially, the strength drops by 27.9% which is high and cannot be recommended for structural concrete.

4.5.2.Split Tensile For 28 Days

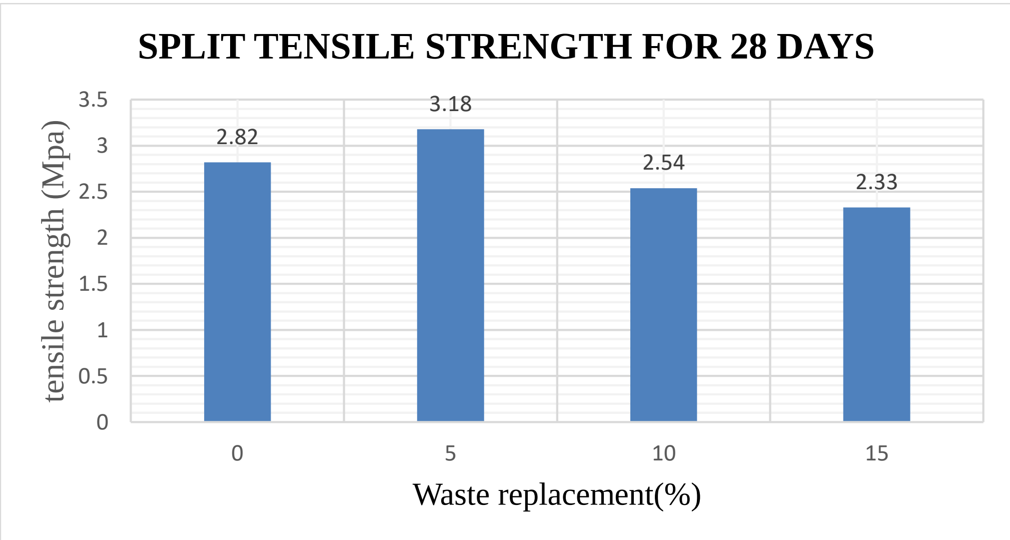

figure.4. 6.show the split tensile strength for 28 days.

The conventional concrete has the strength of 2.82 Mpa, while when the 5% of ceramic waste replace the fine aggregate partially the strength increases by 11.33 % which slightly increased compared to the conventional concrete and can be recommended for use in structural concrete, while when 10% of ceramic waste replace the fine aggregate partially the strength drops by 9.9% which is high and cannot be recommended for structural concrete except for minor works. when 15% of ceramic waste replace the fine aggregate partially, the strength drops by 17.38% which is high and cannot be recommended for structural concrete.

4.5.Flexural Strength of Concrete

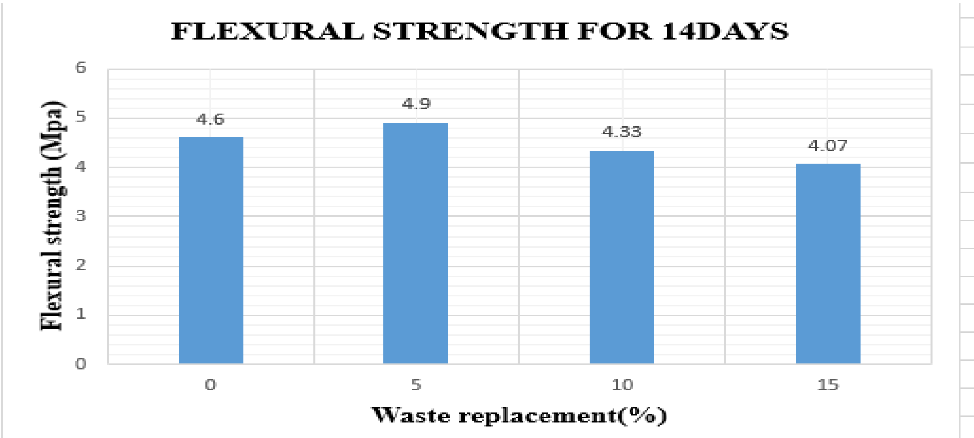

figure.4. 7. Shows the flexural strength of concrete for 14 days

The conventional concrete has the strength of 4.6 Mpa, while when the 5% of ceramic waste replace the fine aggregate partially the strength increases by 6.13 % which slightly increased compared to the conventional concrete and can be recommended for use in structural concrete, while when 10% of ceramic waste replace the fine aggregate partially the strength drops by 6.23% which is low and can be recommended for structural concrete. when 15% of ceramic waste replace the fine aggregate partially, the strength drops by 13% which is high and cannot be recommended for structural concrete.

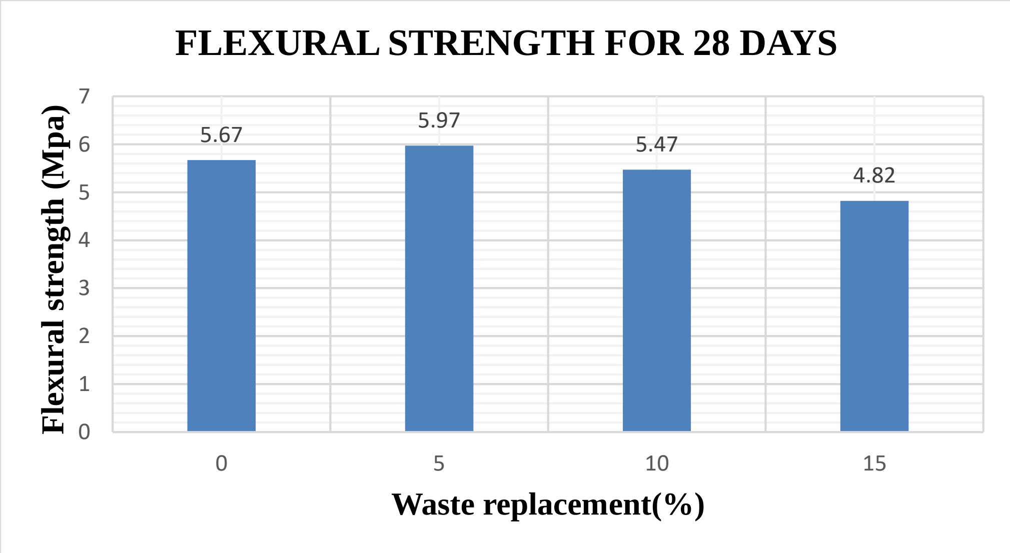

figure.4. 8.the flexural strength of concrete for 28 days

The conventional concrete has the strength of 5.67 Mpa, while when the 5% of ceramic waste replace the fine aggregate partially the strength increases by 5.03 % which slightly increased compared to the conventional concrete and can be recommended for use in structural concrete, while when 10% of ceramic waste replace the fine aggregate partially the strength drops by 3.65% which is low and can be recommended for structural concrete. when 15% of ceramic waste replace the fine aggregate partially, the strength drops by 17.63% which is high and cannot be recommended for structural concrete.

4.7 Cost Estimation of the Newly Designed Concrete

Based on the partial replacement of fine aggregate is of low percentage which is 5%, the cost estimation on the designed product such as block is estimated below.

4.7.1 Estimation of Block Made With Cement and Natural Sand

Having the mix ratio of 1:6

We have the volume of block=40*15*20=12000cm^3

2*hollows=(16*11*16)*2=5632cm^3

Total volume of hollow block=12000-5632=6368cm^3 which is equal to 0.00637m^3

Specific density of cement =1440kg/m^3

1 m^3 of wet concrete=1.52 m^3 of dry concrete

1 bag of cement =50kg

Sum=1+6=7

Quantity of cement required =$\frac{1}{7*50} * 0.00637 * (1440 * 1.52)$=0.039 bags

Quantity of sand required= $\frac{6}{7} * 1.52 * 0.00637$=0.0083 m^3

Table.4. 3.shows the cost estimation of block made with cement and natural sand

Items	Quantity	Rates(RWF)	Total(RWF)
1.Cement	0.039 bags	9000	351
2.Sand	0.0083 m^3	20000	166
Total			517

4.7.2 Estimation of Block Made With Cement and Natural Sand and Ceramic Waste

For the partial replacement of 5% ceramic waste of fine aggregate we have

= (5*166)/100=8.3 Rwf

Total cost of sand=166-8.3=157.7 Rwf

Total cost of the block made in cement and natural sand with 5% of ceramic waste =351+157.7= 508.7 Rwf.

From above findings it is seen that the replacement will not have a huge effect on cost as the cost decreases by only 1.6% , but this will have an effect on the cost of blocks which builds a multistorey building. On the contrary the replacement will help us to avoid waste disposal which will cost more money in future treatment, it will be used as a tool of waste management.

4.3 Results Discusion and Conclusion

The compressive strength and split tensile strength reveals high strength at 5% in this study which shows that the replacement should be limited to lower percentage otherwise it wil yield in lower strength.

Based on standard density of Plain cement concrete which is 2400kg/m^3 (M. S. Shetty,1987). the concrete designed in this project has the density of 2382.35kg/m^3 which shows that the concrete where ceramic waste has been used result in reduction of density.

figure.4. 9.Shows the broken ceramic tiles disposed on site which is harmful to the environment

CHAPTER FIVE. CONCLUSION AND RECOMMENDATIONS

5.1. Conclusion

The main objective of this research project "Study on use of ceramic waste as partial replacement of fine aggregate in concrete" was to study and evaluate ceramic wastes properties as a potential partial replacement of fine aggregates in concrete.

Following the fixed methodology and with set specific objectives, the study identified the current problems related to the use of fine ordinary aggregates, on one side and to the future disposal of ceramic wastes due to manufacturing industries, on the other side.

The study established that the properties of ceramic wastes are adequates and lies in the category of fine aggregates. The show that the partial replacement of fine aggregate by ceramic waste in the concrete was possible as test results showed the acceptable strength.

The compressive strength results at 28 days of curing showed that the concrete in which ceramic tile waste were used as partial replacement of fine aggregate is the one which have a high compressive strength followed by the normal concrete The compressive strength increased by 4.7%. the recommended waste replacement of fine aggregate is limited to 5% otherwise the strength will decrease.

The split tensile strength and flexural results at 28 days of curing showed that the concrete in which ceramic tile waste were used as partial replacement of fine aggregate is the one which have a high split tensile strength followed by the normal concrete. The split tensile strength increased by11.33 % and 5.03% respectively. The recommended ceramic waste replacement of fine aggregate is limited to 5% otherwise the strength will decrease.

Regarding the cost reduction, this study showed that even if the cost of one block for both concrte does not differ substantially (with only 1% of decrease), this would make an impact as the importance of the relevant construction increase.

Regarding the environment, the partial replacement of fine aggregate will help to decrease the mining of sand which might be scarce in the future.

Therefore, it can be concluded that the project objectives have been achieved.

5.2 Recommendation

At the end of this study, following recommendations are made to both users and researchers:

5.2.1 Recommendation to the use of ceramic tile waste as partial replacement of fine aggregate

- During the mixing process, water cement ratio should be carefully taken so that the concrete will not take long time to harden because the dominant composition in ceramics is clay.
- The concrete made where with partial replacement of fine aggregate by ceramic waste beyond 5% should be used on only minor works because it has shown a decrease in strength.
- The grinding of ceramic waste should be controlled so that it will not result in very fine particles of size of clays and silts.

5.2.2 Recommendation to the future research

- Care should be taken in grinding the ceramics used if possible appropriate mechanical machine should be used.

- ❖ Hand mixing and compaction were used in this research, thus machine mixing and compaction should be employed and considered.

- ❖ Should think of extending the research in using sanitary ware and other ceramic materials.

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THANK YOU VERY MUCH!!!