SUDAN UNIVERSITY OF SCIENCE AND TECHNOLOGY

COLLEGE OF GRADUATE STUDIES

EFFECT OF CERAMIC POWDER WASTE ON THE PROPERTIES OF FRESH AND HARDENED CONCRETE

أثر مخلفات بدرة السيراميك علي خواص الخرسانة الطازجة والمتصلدة

A thesis Submitted in Partial Fulfillment of the Requirements

For the Degree of Master of Science in Civil Engineering (Structural Engineering)

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الاية

﴿الَّذِينَ يَذْكُرُونَ اللَّهَ قِيَامًا وَقُعُودًا وَعَلَىٰ جُنُوبِهِمْ وَيَتَفَكَّرُونَ فِي خَلْقِ السَّمَاوَاتِ
وَالْأَرْضِ رَبَّنَا مَا خَلَقْتَ هَٰذَا بَاطِلًا سُبْحَانَكَ فَقِنَا عَذَابَ النَّارِ ﴿١٩١﴾﴾

(آل عمران آية191)

Dedication

If someone feels that they had never made a mistake in their life, then it mean they had never tried anew thing in their life...

For anyone...

Every experience is an opportunity to learn and grow....

Dedicate this work to all people wished to me successful...

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ABSTRACT

In this study, concrete mixtures weretested to experimental the effect of ceramic powder waste and acacia tortilies gum and evaluate their efficiency on fresh and hardened concrete to achieve the design compressive strengths of concrete [20N/mm^2].By using differentceramic waste powder proportions is 5%, 10%, 20% and 30% and 0.5% of acacia tortilies gum from the weight of cement respectively. The study was carried out for 13 types of concrete mixes designed by British Standard,and compressive strength of concrete was measured in the reconstruction of maturing for 7, 28 and 56 days, One of those concrete mixes is a control mix in order to determine the optimum ratio can be added to concrete to obtain design compressive and increase with time. All the results were compared with the normal conventional control mix. The study shown the effect of ceramic waste and acacia gum on workability of fresh concrete by decreasing with the proportion of ceramic waste increase,but for the hardened concrete the specific compressive strength not less than [20N/mm^2]up to 30 % of the ceramic waste powder from cement weight at age of 28days.

مستخلص

في هذه الدراسة تم اختبار الخلطات الخرسانيةلمعرفةتأثير مخلفات بدرة السيراميك وصمغ السيال وتقييم مدى كفأتهما على الخرسانة الطازجة والمتصلدة وذلك بهدف الوصول لقوة الضغط التصميمية المستهدفة للخرسانة. [$20N/mm^2$]باستخدام نسب مختلفة من مخلفات بدرة السيراميك هي 5%,10%,20%و30% ونسبة 0.5% من صمغ السيال من وزن الاسمنت علي التوالي .أجريت الدراسة لعدد 13 خلطة خرسانية مصممة وفقا" للمدونة البريطانية وتم قياس قوة الضغط للخرسانة في اعمار انضاج 56,28,7 يوم, واحدة من تلك الخلطات الخرسانية عبارة عن خلطة مرجعية وذلك لتحديد افضل نسبة يمكن اضافتهاللخرسانة للحصول علي المقاومة المستهدفة وزيادة قوة الضغط مع الزمن . تمت مقارنة جميع النتائج المتحصل عليها مع نتائج الخلطة الخرسانية المرجعية.اظهرت الدراسة اثر مخلفات بدرة السيراميك وصمغ السيال علي خاصية قابلية التشغيل للخرسانة وذلك بانخفاضها مع زيادة نسبة مخالفات بدرة السيراميك,بالنسبة لقوة ضغط الخرسانة وجد انها لاتقل عن[$20N/mm^2$] حتي نسبة 30% من مخلفات بدرة السيراميك من وزن الاسمنت في عمر 28 يوم.

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CHAPTER ONE

INTRODUCION

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INTRODUCTION

1.1 General

Concrete is the most widely used construction material in the world. It is used in many different structures such as dam, pavement, building frame or bridge. Also, it is the most widely used material in the world, far exceeding other materials. Its worldwide production exceeds that of steel by a factor of 10 in tonnage and by more than a factor of 30 in volume. The present consumption of concrete is over 10 billion tons a year, that is, each person on earth consumes more than 1.7 ton of concrete per year. It is more than 10 times of the consumption by weight of steel.

Concrete is a composite material composed of coarse granular material (the aggregate or filler) embedded in a hard matrix of material (the cement or binder) that fills the space between the aggregate particles and glues them together. Concrete also consider composite material that consists essentially of a binding medium within which are embedded particles or fragments of aggregates. The simplest representation of concrete is filler plus binder.

According to the type of binder used, there are many different kinds of concrete. For instance, Portland cement concrete, asphalt concrete, and epoxy concrete. In concrete construction, the Portland cement concrete is utilized the most. Concrete usually refers to Portland cement concrete. For this kind of concrete, the composition can be presented as follow:

Cement
(+ **Admixture**) → Cement paste
+ Water + → mortar
Fine aggregate → concrete + → concrete
Coarse aggregate

It should be indicated that admixtures are almost always used in modern practice and thus become an essential component of modern concrete. Admixtures are defined as materials other than aggregate (fine and coarse), water, fiber and cement, which are added into concrete batch immediately before or during mixing. The widespread use of admixture is mainly due to the many benefits made possible by their application. For instance, chemical admixtures can modify the setting and hardening characteristic of cement paste by influencing the rate of cement hydration. Water-reducing admixture can plasticize fresh concrete mixtures by reducing surface tension ofwater, air-entraining admixtures can improve the durability of concreteand mineral admixtures such as pozzolans (materials containing reactive silica) can reduce thermal cracking.[7]

The most commonly used pozzolans today are industrial by-products such as fly ash, silica fume from silicon smelting and ceramic powder, highly reactive metakaolin, and burned organic matter residues rich in silica such as rice husk ash. Their use has been firmly established and regulated in many countries. However, the supply of high-quality pozzolanic by-products is limited and many local sources are already fully exploited. Alternatives to the established pozzolanic by-products are to be found on the one hand in an expansion of the range of industrial by-products or societal waste considered and on the other hand in an increased usage of naturally occurring pozzolans.[19]

The advancement of concrete technology can reduce the consumption of natural resources and reduce the burden of pollutants on the environment. The cost of natural resources is increased day by day. They have forced to focus on recovery, reuse of natural resources and find other alternatives[7]. As the world population grows, so do the amount and type of wastes being generated. Many wastes produced today will remain .The environment for hundreds and perhaps thousands of years the traditional construction materials such as concrete, ceramic waste Powder, copper slag, and silica fume are being produced.

1.2Problem Statement:

Portland cement concrete is one of the most versatile building materials on earth and has facilitated industrial growth in the last century, it is also one of the biggest in terms of environmental impact.During the production of cement, large amount of CO_2 is emitted, which affects the global environment. With increasing demand and consumption of cement, scientists and researchers are in search of developing alternate binders that are eco-friendly.

Initiatives are emerging worldwide to strike a balance between the developments in infrastructure and prevention of the environment from contamination, by using the industrial ((e.g., fly ash, ground granulated blast furnace slag, and silica fume, ceramic, glass powder.)And agricultural (Sugarcane Bagasse Ash (SBA)) wastes.

On the other hand, the boost in construction activities in the country created shortage in most of concrete making materials especially cement, resulting in an increase in price.

By the weight of cement in concrete. Based on the experimental tests, it can be concluded that, ceramic powder an industrial waste product, can be utilized effectively in partial replacement of cement, thus reducing CO_2. Emissions and disposal problems to some extent, also reduce cost of cement.

1.3 Objectives:

The key objective of this work was to develop concrete mixtures, using ceramic powder waste as a partial replacement for cement, which exhibit acceptable properties comparable to that of structural concrete.
Specific Objectives:-

- Obtaining consistent concrete.
- Enhancing the performance of concrete by improving of concrete strength.
- Studying the effect of waste ceramic powder by replacing partial cement to detect its impact on the properties of concrete mixes.
- Studying the effect of waste ceramic powder with acacia tortilies by partial replacement cement in compressive strength and workability properties of concrete.
- Find the optimum proportion of ceramic waste powder.
- Reduce the cost of cement.

1.4Methodology:

The flowing steps were adopted as a methodology of fulfill the aims of the research:

- Collection of data and information related to the research topics.
- As extensive literature review was carried out.
- Design concrete mixes by British Standard [BS] and test fresh and hardened concrete. Use different ratio of ceramic powder waste to investigate effect of the replacement on the properties of concrete.
- Design concrete mixes by ceramic powder with acacia tortilies gum to investigate effect on workability of concrete.

1.5 Hypothesis:

Ceramic powder waste may be suitably used as an alternative partial replacement to cement in structural concrete.
As Follows:

- What is the chemical composition of the ceramic powder waste?
- Can you compare ceramic powder waste with cement?
- What is the impact of using ceramic powder on the properties of the fresh and hardened concrete?
- What is the optimum ratio that can be used of ceramic powder?
- It gets possible reduction in the cost of cement?

1.6 Research Lay Out:

This study contains many of chapters are follow as:

Chapter One contains general introduction, problem statement, objective, methodology and hypothesis of research.

Chapter Two presented comprehensive literature review of related previous research

Chapter Three contains the materials use in this study such as cement, aggregate, additives, water, ceramic waste powder andConcrete mix design by British Standard.

Chapter Four presented the materials test and results.

Chapter Five design the mixes, result of experiment, discussion and analysis of the result, and draw result in charts

Chapter Six contains conclusion and recommendations.

CHAPTER TWO

LITERATURE RIVEW

CHAPTER TWO
LITERATURE REVIEW

2.1 Introduction

Today we live in the world full of development and enthusiastic for still more comfort and facilities. This leads to innovations and revolutions in each and every field, but on contrary it has negative impact on environment as resources get depleted and pollution to different natural sources are occurred.

So after studying all these research paper we concluded that if we can reduce or reuse some material in field of concrete production which is at its top now-a-days then it largely impact environment and leads to pollution free and soothing surrounding.

Thus as concluded from above literature review we can research further more in direction of partially replacing cement, sand and aggregate up to most optimum level we can by reusing or introducing waste material as its option. From studying all these research paper it is clear that positive and favorable results are obtained if further research work and study is carried out in this field.

And by using locally available wastes like glass waste, marble dust powder, ceramic waste, quarry dust, GGBS, Fly ash, etc. as partial substitution at place of concrete ingredients,so cement and coarse aggregates can replace or partially replaced by these wastes which guides sustainable development. If we replace Cement and coarse aggregates by some other materials it may also be good from economic consideration.

Over the last few years lots of research have been done by scientists conserve the cement and coarse aggregates and to minimize the disposal problems of waste materials by using these wastes as ingredients of pervious concrete. It may prove more economical than traditional concrete and question of damping of such waste produced by different industries is also get solved. Ultimate goal is to produce economical and eco-friendly concrete with all desired properties and strength which one obtains by regular concrete ingredients.

The advancement of concrete technology can reduce the consumption of natural resources. They have forced to focus on recovery, reuse of natural resources and find other alternatives. The use of the replacement materials offer cost reduction, energy savings, arguably superior products, and fewer hazards in the environment.

2.2 Previous Studies

This is chapter presented a comprehensive literature review of related previous researches:

Abdeljaleel.N.S, et al [1]"Effect of gum arabic powder and liquid on the properties of fresh and hardened concrete", they are examine of Gum Arabic, extracted from (Hashab) trees (in western Sudan), is used in concrete mixes after crushing to be in a form of powder which was dissolved in water to get the liquid

of this additive. In this study, Gum Arabic (G.A.) powder and liquid was added to concrete mixes at ratios 0.1%, 0.2%, 0.4%, 0.6%, 0.8%, 1.0 % and 1.2 % of cement content. The addition of Gum Arabic to the concrete mixes has a clear effect when equal to 0.4% of cement content. The compressive strength was measured at ages of 7, 21, and 28 days and it was found that it decreases slightly with increase in the proportion of Gum Arabic in concrete mixes.

The results of compressive strength and workability of concrete were obtained when using the Gum Arabic liquid. The compressive strength values decrease with the increase of the Gum Arabic powder and slump values remain constant in all mixes when adding different ratios of Gum Arabic powder, during all ages.

The compressive strength values decrease with the increase of the Gum Arabic liquid and slump values remain increase in all mixes when adding different ratios of Gum Arabic liquid. That mean increase in workability when adding gum Arabic liquid**.**

Abdullah. J.A., et al [2]"Partial replacement of cement with marble dust powder", they are studied the effect of Marble Dust powder in concrete on strength is presented. Five concrete mixtures containing 0%, 5%, 10%, and 20% marble dust powder as cement replacement by weight basis has been prepared. Water/cement ratio (0.43) was kept constant, in all the concrete mixes. Compressive strength, split tensile strength and flexural strength of the concrete mixtures has been obtained at 7 and 28 days. The results of the laboratory work showed that replacement of cement with marble dust powder increase, up to 10% for compressive strength, and up to 15% for split tensile strength and flexural strength of concrete.

Amit Kumar., et al [5]"Ceramic waste effective replacement of cement forestablishing sustainable concrete"**,** they studied the (OPC) cement replaced by Ceramic waste powder accordingly in the range of 0%, 10%, 20%, 30% 40%, & 50% by weight of M_{20}grade concrete. Concrete mixtures were produced, tested and compared in terms of Compressive strength to the conventional concrete. These tests were carried out to evaluate the mechanical properties for 7, 14 and 28 days. As a result, the compressive strength achieved up to 30% replacing cement with ceramic waste.This work is concerned with the experimental investigation on strength of concrete and optimum percentage of the partial replacement by replacing cement via 0%, 10%, 20%, 30%, 40% and 50% of ceramic waste. Keeping all this view, the aim of the investigation is to study the behavior of concrete while replacing the ceramic waste with different proportions in concrete. The Compressive Strength of M20gradeConcrete increases when the replacement ofCement with Ceramic Powder up to 30% replaces by weight of Cement and further replacement of Cement with Ceramic Powderdecreases the Compressive Strength. Concrete on 30% replacement of Cement with Ceramic Powder, Compressive Strength obtained is 22.98 N/mm2 and vice-versa the cost of the cement is reduced up to 12.67% in M20 grade and hence it becomes more economical without compromising concrete strength than the standard concrete. It becomes technically and economically feasible and viable.

A.J.Jeya Arthi[6]"Effective replacement of cement by ceramicwaste in concert sustainable development" In this investigation the ordinary Portland cement has been partially substituted as ceramic waste powder in the range of 0%, 15%, 30%, 35%, 40% and 45% by weight of M20 grade of concrete and tested compression strength, flexural strength and split tensile strength.Tests were carried out to evaluate the mechanical properties for 7, 14 and28 days.
Analyzing the result containing the replacement of ceramic waste powder in concrete gives when the concrete was replaced by 35% of ceramic powder the compressive strength attained was 23.43N/mm2 and the cost decreased up to 25% in M20 grade. The replacement of cement with ceramic waste up to 35% by weight of cement rises the compressive strength and further replacement of cement with ceramic waste falls the compressive strength. Therefore it suits more cost-effective without compromising the concrete strength. It becomes theoretically and economically reasonable and sustainable. It has been concluded that replacement of cement by ceramic wastes in concrete up to 35% is having good strength

E.L.Gammal.A et al [9] "Compressive Strength of Concrete UtilizingWaste Tire Rubber", they are studied replacement of the fine and coarse aggregate by weight using tire rubber. Density and compressive strength ofconcrete utilizing waster tire rubber has been investigated. Recycled waste tire rubber has been used.A total of 4 main mixtures were cast. One control mixture and three rub Crete mixtures. The control mixture was designed to have a water cement ratio of 0.35 with cement content of 350 kg/m3. To develop therubberized concrete mixtures, tire rubber was used to replace the aggregate by weight. In the first rubberized concrete mixture, the chipped rubber totally replaced the coarse aggregate in the mixture. While, in the other two rub Crete mixtures, the tire rubber replaced the fine aggregate by 100% and 50% of fine aggregate weight.

The effect of replacing tire rubber with aggregate on the concrete compressive strength was reduced significantly by 90% when using chipped rubber as a full replacement to the coarse aggregate in the concrete mix, the reduction in strength was 80% when using crumb rubber as a 100% replacement to the sand in the concrete mix.There was no significant increase in the compressive strength of concrete casted using crumb rubber replacing 50% of the sand compared to the

Compressive strength of concrete casted using crumb rubber as a 100% replacement to the sand in the control mix.

J.Swathi , Ms.V.gnanadevi,[12]"Investigation on concrete by partial replacement of copper slag for fine aggregate and ceramic waste with coarse aggregate" they were investigated of copper slag as fine aggregate replacement in range of 20%, 40%, 60% by weight of sand and the ceramic waste tiles as coarse aggregate replacement in 10%, 20%, 30% by weight of coarse aggregate. Totally 63-cubes, 35-Cylinders, 21-beams were casted and tested for compression, Split tension, Flexural strength and durability at 7, 14, 28 days curing of concrete. The obtained results are compared with M40 grade conventional concrete.

The result replacement of copper slag as sand attained high strength of at 40% replacement than conventional concrete, the replacement of ceramic tiles alone will not have sufficient strength, so it is replaced with optimum slag content as constant also have increased strength compared to control. In compression strength, then maximum strength attained is 58.54Mpa at 28days at 40% copper slag replacement, In Split tensile strength the maximum strength is attained at 28 day testing have increased strength, the flexural strength of concrete is done at 28 daysis higher than the designed mix.

that 40 wt. % of copper slag can used as replacement of sand in order to obtain concrete with good strength and durability properties.

ObiladEe.I.O. [14] "Rice Husk Ash as Partial Replacement for Cement in Concrete", He studied Ordinary Portland Cement (OPC) in concrete by replaced with Rice Husk Ash by weight at 0%, 5%, 10%, 15%, 20% and 25%.

Concrete while Compressive Strength test for cubes after 7, 14 and 28 days curing in water. The results revealed that the Compacting factor decreased as the percentage replacement of OPC with Rice Husk Ash increased.

The compressive strength of the hardened concrete also decreased with increasing OPC replacement with Rice Husk Ash. The results of the compressive strength increased as the number of days of curing increased for each percentage Rice Husk Ash replacement.

For the control cube, the compressive strength increased from 17.51 N/mm2 at 7 days to 29.15 N/mm2 at 28 days (i.e. about 66% increment). The 28 day strength was above the specified value of 25N/mm2 for grade 25.

The strength of the 5% replacement by rice husk ash showed increase in compressive strength from 16.88 N/mm2 at 7 days to 27.68 N/mm2 at 28 days (64% increment). The 28 day strength was above the specified value of 25N/mm2 for grade 25.The strength of the 10% replacement by Rice husk ash showed increase in compressive strength from 12.01 N/mm2 at 7 days to 20.88 N/mm2 at 28 days (74% increment). The 28 day strength was above the specified value of 20N/mm2 for grade 20.

The strength of the 15% replacement by rice husk ash showed increase in compressive strength from 11.24 N/mm2 at 7 days to 18.70 N/mm2 at 28 days (66% increment). The 28 day strength was above the specified value of 15N/mm2 for light weight concrete. The strength of the 20% replacement by rice husk ash showed increase in compressive strength from 10.86 N/mm2 at 7 days to 18.59 N/mm2 at 28 days (71%increment). The 28 day strength was above the specified value of 15N/mm2 for light weight concrete. The compacting factor values of the concrete reduced as the percentage of Rice husk Ash increased. The Compressive Strengths of concrete reduced as the percentage Rice Husk Ash replacement increased.

Vijayakumar.G,et al [17]"Glass Powder as Partial Replacement of Cement in Concrete Production" ,investigated the effect powder waste glasses are used as a partial replacement of cement in concrete and compared it with conventional concrete. Examines the possibility of using Glass powder as a partial replacement of cement for new concrete. Glass powder was partially replaced as 10%, 20%, 30% and 40% and tested for its compressive, Tensile and flexural strength up to 60 days of age and were compared with those of conventional concrete from the results obtained. Result of the compressive strength at the age of 28 days and 60 days. At 28 days the glass powder shows a strength of 41.96N/mm2, strength at 30% cement replacement, at 28 days but meanwhile in 60 days it shows strength at 40% 0f 3.55N/mm2. The flexural strength of glass powder added concrete at the age of 28 days and 60 days. At 28 days, in 10% replacement the strength has been increased to 6.5N/mm2, which is gained at 30% at 60 days itself and goes higher to 7.01N/mm2 in 40%.

From examine arrive to replacement of glass powder in cement by 20%, 30% and 40% increases the compressive strength by 19.6%, 25.3% and 33.7% respectively.Replacement of glass powder in cement by 40% increases the split tensile strength by 4.4% respectively.

Replacement of glass powder in cement by 20%, 30% and 40% increases the flexural strength by 83.07%, 99.07% and 100% respectively.

Glass powder concrete increases the compressive, tensile and flexural strength effectively, when compared with conventional concrete.

In this study, power max cement (42.5N/mm^2) was used assuming its properties hold for other types of cement. It will be majorly dealing with the analysis of the properties of ceramic powder waste to be used as partial replacement of cement in concrete. The ceramic waste was obtained from Salome Italy factory. Before developing mix designs, the necessary tests was done to components of the concrete i.e. cement, fine and coarse aggregates, water and additives (acacia tortilies gum).the workability andcompressive strengths at 7, 28 and 56 days of curing of concrete cubes will be analyses. 13 trial mixes by partial replacement of cement were prepared by using British standard method, namely:

- Control mix, reference mix by ratio of replacement 0%
- Four mixes, using untreated ceramic powder by replacement ratio (5%, 10%, 20%&30%) of cement.
- Four mixes, using ceramic powder treated at 550^{0}c in the same ratios above.
- Two mixes, using ceramic powder treated at 700^{0}c by replacement ratios (20% &30%).
- Finally two mixes, using ceramic powder treated at 700^{0}c by replacement ratios (20% & 30%) with addition acacia tortilies gum (0.5%).

CHAPTER THREE

THEORETICAL STUDY

CHAPTER THREE
THEORETICAL STUDY

3.1 Introduction

Concrete is the most commonly used construction material on earth. When considered over its entire life cycle - extraction, processing, construction, operation, and demolition and recycling - concrete makes a significant contribution to the triple bottom line - environmental, social and economic - of sustainable development.

Concrete is a versatile construction material: it is plastic and malleable when newly mixed, yet strong and durable when hardened. These qualities explain why concrete can be used to build skyscrapers, bridges, sidewalks, highways, houses and dams.

Concrete also enables the reduction of CO_2 emissions and other negative environmental impacts in many sectors

*Home built with insulating concert (ICF) _reduce energy usage by 40% or more. *Concrete buildings__ last longer, reduce maintenance and energy use and provide better indoor air quality

* Structures made smog-eating concert__ (TX Active) stay clean and can reduce nitric oxides in the surrounding area by as much as 60%.

* Concrete highway require less maintenance, not subject to rutting or spring thaw load restrictions, reduce fuel consumed by heavily loaded trucks.

*Agricultural waste containmentof concrete reduces odour and prevents groundwater contamination.

* Cement based solidification/stabilization in situ treatment of waste for brownfield redevelopment and remediation of contaminated sites.

3.2Concrete Material

Concrete is a very strong and versatile moldable construction material. It consists of cement, sand and aggregate (e.g., gravel or crushed rock) mixed with water. The cement and water form a paste or gel which coats the sand and aggregate. When the cement has chemically reacted with the water (hydrated), it hardens and binds the whole mix together. The initial hardening reaction usually occurs within a few hours. It takes some weeks for concrete to reach full hardness and strength. Concrete can continue to harden and gain strength over many years.

3.2.1. Cement

Is a binder, a substance used in construction that sets and hardens and can bind other materials together? The most important types of cement are used as a component in the production of mortar in masonry, and of concrete, which is a c-Combination of cement and an aggregate to form a strongbuilding material.

Making cement

Portland cement is the basic ingredient of concrete. Concrete is formed when Portland cement creates a paste with water that binds with sand and rock to harden. Construction documents often specify a cement type based on the required performance of the concrete or the placement conditions. Certain cement. Manufacturing plants only produce certain types of Portland cement. What are the differences in these cement types and how are they tested, produced, and identified in practice?

In the most general sense, Portland cement is produced by heating sources of lime, iron, silica, and alumina to clinkering temperature (2,500 to 2,800 degrees Fahrenheit) in a rotating kiln, then grinding the clinker to a fine powder. The heating that occurs in the kiln transforms the raw materials into new chemical compounds. Therefore, the chemical composition of the cement is defined by the mass percentages and composition of the raw sources of lime, iron, silica, and alumina as well as the temperature and duration of heating. It is this variation in raw materials source and the plant-specific characteristics, as well as the finishing processes (i.e. grinding and possible blending with gypsum, limestone, or supplementary cementing materials), that define the cement produce[19] .

Standards

To ensure a level of consistency between cement-producing plants, certain chemical and physical limits are placed on cements. These chemical limits are defined by a variety of standards and specifications. For instance, Portland cements and blended hydraulic cements for concrete in the U.S. conform to the American Society for Testing and Materials (ASTM) C150 (Standard Specification for Portland cement), C595 (Standard Specification for Blended Hydraulic Cement) or C1157 (Performance Specification for Hydraulic Cements).Some state agencies refer to very similar specifications: AASHTO M 85 for Portland cement and M 240 for blended cements. These specifications refer to Standard test methods to assure that the testing is performed in the same manner. For example, ASTM C109 (Standard Test Method for Compressive Strength for Hydraulic Cement Mortars using 2-inch Cube Specimens), describes in detail how to fabricate and test mortar cubes for compressive strength testing in a standardized fashion.

Nomenclature Differences

In the US, three separate standards may apply depending on the category of cement.

For Portland cement types, ASTM C150 describes in Table (3.1) below:

Table

Cement Type	Description
Type I	Normal
Type II	Moderate Sulfate Resistance
Type II (MH)	Moderate Heat of Hydration (and Moderate Sulfate Resistance)
Type III	High Early Strength
Type IV	Low Heat Hydration
Type V	High Sulfate Resistance

(3.1):Portland cement types ASTM C150

For blended hydraulic cements – specified by ASTM C595 – the following nomenclature is used:

Cement Type	**Description**
Type IL	Portland-Limestone Cement
Type IS	Portland-Slag Cement
Type IP	Portland-Pozzonlan Cement
Type IT	Ternary Blended Cement

In addition, some blended cements have special performance properties verified by additional testing. These are designated by letters in parentheses following the cement type. For example Type IP (MS) is a portland-pozzolan cement with moderate sulfate resistance properties.

Other special properties are designated by (HS), for high sulfate Resistance; (A), for air-entraining cements; (MH) for moderate heat of hydration; and (LH) for low heat of hydration. Refer to ASTM C595 for more detail.

However, with an interest in the industry for performance-based specifications, ASTM C1157 describes cements by their performance attributes in Table (3.2) below:

Cement Type	**Description**
Type GU	General Use
Type HE	High Early-Strength
Type MS	Moderate Sulfate Resistance
Type HS	High Sulfate Resistance
Type MH	Moderate Heat of Hydration
Type LH	Low Heat of Hydrate

Type	Classification	Characteristics	Applications
Type I	General purpose	Fairly high C_3S content for good early strength development	General construction (most buildings, bridges, pavements, precast units, etc.)
Type II	Moderate sulfate resistance	Low C_3A content (<8%)	Structures exposed to soil or water containing sulfate ions
Type III	High early strength	Ground more finely, may have slightly more C_3S	Rapid construction, cold weather concreting
Type IV	Low heat of hydration (slow reacting)	Low content of C_3S (<50%) and C_3A	Massive structures such as dams. Now rare.
Type V	High sulfate resistance	Very low C_3A content (<5%)	Structures exposed to high levels of sulfate ions
White	White color	No C_4AF, low Mg O	Decorative (otherwise has properties similar to Type I)

Table (3.2): General Features of the Main Types of Portland cement

Physical and Chemical Performance

Chemical tests verify the content and composition of cement, while physical testing demonstrates physical criteria. In C150/M 85 and C595/M 240, both chemical and physical properties are limited. In C1157, the limits are almost entirely physical requirements.

Chemical testing includes oxide analyses (SiO_2, CaO, Al_2O_3, Fe_2O_3, etc.) to allow the cement phase composition to be calculated. Type II cements are limited in C150/M 85 to a maximum of 8 percent by mass of tricalcium aluminate (a cement phase, often abbreviated C_3A), which impacts a cement's sulfate resistance. Certain oxides are also themselves limited by specifications:
For example, the magnesia (Mgo) content which is limited to 6 percent maximum by weight for Portland cements, because it can impact soundness at higher levels.

Typical physical requirements for cements are: air content, fineness, expansion, strength, heat of hydration, and setting time. Most of these physical tests are carried out using mortar or paste created from the cement. This testing confirms that a cement has the ability to perform well in concrete; however, the performance of concrete in the field is determined by all of the concrete Ingredients, their quantity, as well as the environment, and the handling and placing procedures used.

Although the process for cement manufacture is relatively similar across North America and much of the globe, the reference to cement specifications can be different depending on the jurisdiction. In addition, test methods can vary as well, so that compressive strength requirements (for example) in Europe don't 'translate' directly to those in North America. When ordering concrete for construction projects, work with a local concrete producer to verify that cement meeting the requirements for the project environment and application is used, and one that meets the appropriate cement specification.

3.2.2 Aggregate

Aggregates are inert granular materials such as sand, gravel, or crushed stone that, along with water and Portland cement, are an essential ingredient in concrete.

For a good concrete mix, aggregates need to be clean, hard, strong particles free of absorbed chemicals or coatings of clay and other fine materials that could cause the deterioration of concrete.

Aggregates, which account for 60 to 75 percent of the total volume of concrete, are divided into two distinct categories--fine and coarse. Fine aggregates generally consist of natural sand or crushed stone with most particles passing through a 3/8-inch sieve. Coarse aggregates are any particles greater than 0.19 inch, but generally range between 3/8 and 1.5 inches in diameter. Gravels constitute the majority of coarse aggregate used in concrete with crushed stone making up most of the remainder.

Natural gravel and sand are usually dug or dredged from a pit, river, lake, or seabed. Crushed aggregate is produced by crushing quarry rock, boulders, cobbles, or large-size gravel. Recycled concrete is a viable source of aggregate and has been satisfactorily used in granular subcases, soil-cement, and in new concrete.

After harvesting, aggregate is processed: crushed, screened, and washed to obtain proper cleanliness and gradation. If necessary, a benefaction process such as jigging or heavy media separation can be used to upgrade the quality. Once processed, the aggregates are handled and stored to minimize segregation and degradation and prevent contamination, Figure (3.1). Aggregates strongly influence concrete's freshly mixed and hardened properties, mixture proportions, and economy. Consequently, selection of aggregates is an important process. Although some variation in aggregate properties is expected, characteristics that are considered include:

- grading
- durability
- particle shape and surface texture
- abrasion and skid resistancefrom silicon, boron, carbon, and nitrogen. Some of the most advanced ceramic

unit weights and voids

- absorption and surface moisture

Grading refers to the determination of the particle-size distribution for aggregate. Grading limits and maximum aggregate size are specified because these properties affect the amount of aggregate used as well as cement and water requirements, workability, pump ability, and durability of concrete. In general, if the water-cement ratio is chosen correctly, a wide range in grading can be used without a major effect on strength. When gap-graded aggregate are specified, certain particle sizes of aggregate are omitted from the size continuum. Gap-graded aggregate are used to obtain uniform textures in exposed aggregate concrete. Close control of mix proportions is necessary to avoid segregation.

Shape and Size Matter

Particle shape and surface texture influence the properties of freshly mixed concrete more than the properties of hardened concrete. Rough-textured, angular, and elongated particles require more water to produce workable concrete than smooth, rounded compact aggregate. Consequently, the cement content must also be increased to maintain the water-cement ratio. Generally, flat and elongated particles are avoided or are limited to about 15 percent by weight of the total aggregate. Unit-weight measures the volume that graded aggregate and the voids between them will occupy in concrete the void content between particles affects the amount of cement paste required for the mix. Angular aggregates increase the Void content. Larger sizes of well-graded aggregate and improved grading decrease the void content.

Absorption and surface moisture of aggregate are measured when selecting aggregate because the internal structure of aggregate is made up of solid material and voids that may or may not contain water. The amount of water in the concrete mixture must be adjusted to include the moisture conditions of the aggregate.

Abrasion and skid resistance of an aggregate are essential when the aggregate is to be used in concrete constantly subject to abrasion as in heavy-duty floors or pavements.

Different minerals in the aggregate wear and polish at different rates. Harder aggregate can be selected in highly abrasive conditions to minimize wear.

Classify Aggregate According to Size

According to size the aggregates are classified as:

- Fine Aggregate
- Coarse Aggregate

- All in Aggregate

Fine Aggregate

It is the aggregate most of which passes 4.75 mm IS sieve show in Figure (3.3), and contains only somuch course as is permitted by specification. According to source fine aggregate may be described as:

- Natural Sand– it is the aggregate resulting from the natural disintegration rock and which has been deposited by streams or glacial agencies
- Crushed Stone Sand– it is the fine aggregate produced by crushing hard stone.
- Crushed Gravel Sand– it is the fine aggregate produced by crushing natural gravel.

According to size the fine aggregate may be described as coarse sand, medium sand and fine sand. IS specifications classify the fine aggregate into four types according to its grading as fine aggregate of grading Zone-1 to grading Zone-4. The four grading zones become progressively finer from grading Zone-1 to grading Zone-4. 90% to 100% of the fine aggregate passes 4.75 mm IS sieve and 0 to 15% passes 150 micron IS sieve depending upon its grading zone.

Coarse Aggregate

It is the aggregate most of which is retained on 4.75 mm IS sieve and contains only so much finer material as is permitted by specification. According to source, coarse aggregate may be described as:

- Uncrushed Gravel or Stone– it results from natural disintegration of rock
- Crushed Gravel or Stone– it results from crushing of gravel or hard stone.
- Partially Crushed Gravel or Stone– it is a product of the blending of the above two aggregate.

According to size coarse aggregate is described as graded aggregate of its nominal size i.e. 40 mm, 20 mm, 16 mm and 12.5 mm etc., show in Figure (3.2). for example a graded aggregate of nominal size 20 mm means an aggregate most of which passes 20 mm IS sieve. A coarse aggregate which has the sizes of particles mainly belonging to a single sieve size is known as single size aggregate. For example 20 mm single size aggregate mean an aggregate most of which passes 20 mm IS sieve and its major portion is retained on 10 mm IS sieve.

All in Aggregate

It is the aggregate composed of both fine aggregate and coarse aggregate. According to size All-in-aggregate is described as all-in-aggregates of its nominal size, i.e. 40mm, 20mm etc. For example, all in aggregate of nominal size of 20mm means an aggregate most of which passes through 20 mm IS sieve and contains fine aggregates also.

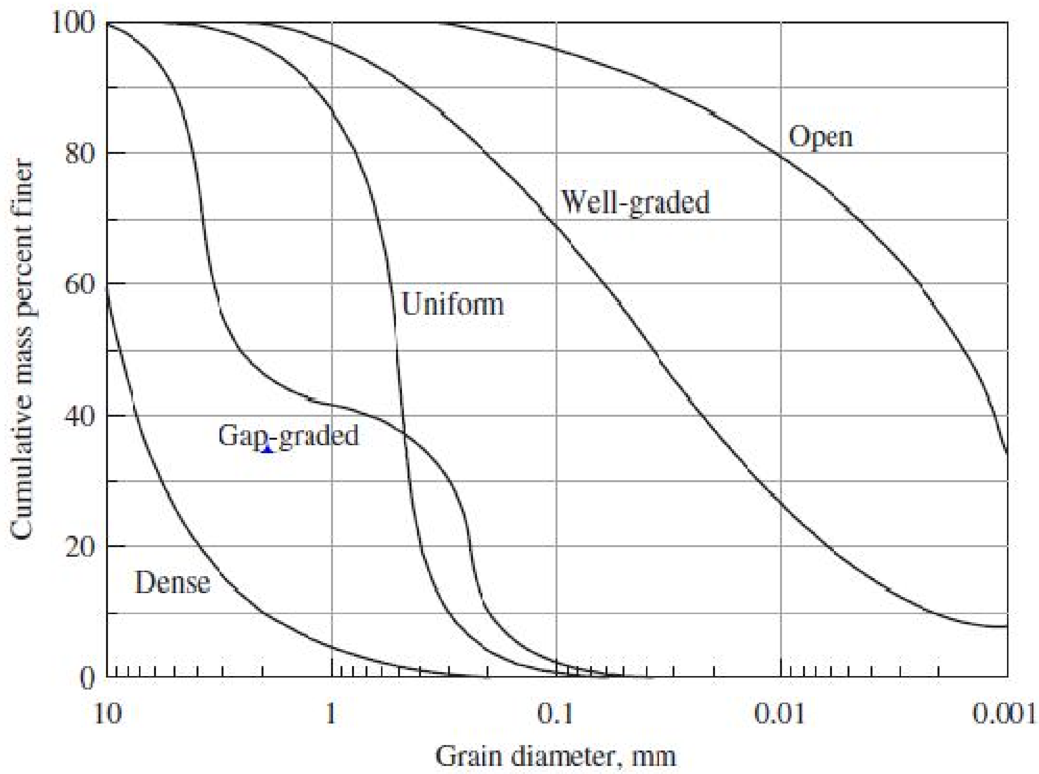


Fig (3.1): Five Type of Aggregate Gradation

5~10 mm 10~14 mm 14~20 mm 20~ mm

Figure (3.2): Different Size of Coarse Aggregate

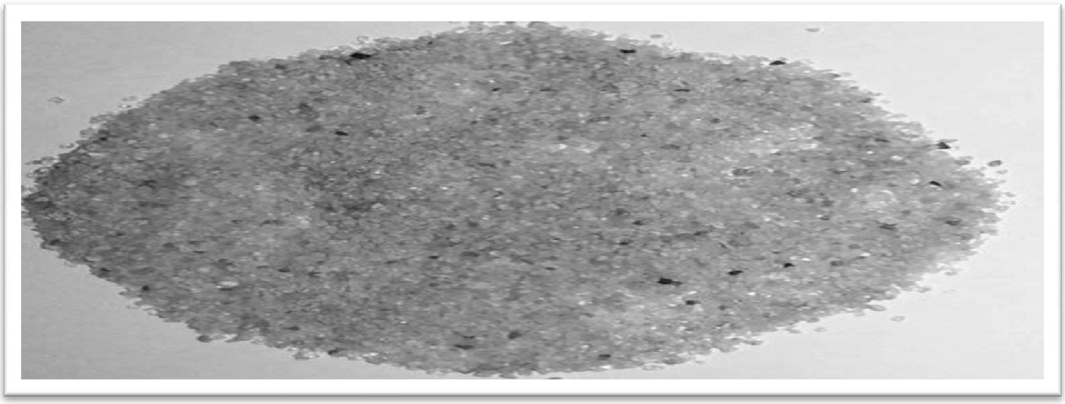


Figure (3.3):Fine Aggregate

3.2.3Water

Almost any natural water that is drinkable and has no pronounced taste or odor can be used as mixing water for making concrete. Some water which may not be suitable for drinking may still be safe for mixing concrete.

Pipe born drinking water supplies are generally safe for making concrete. Water of doubtful quality can be simply tested by making two sets of cubes or cylinders of the same mix, one with the doubtful water, and the other (used as a reference) set with distilled water, purified water, tap water, or other drinkable water of good quality. If the suspected water produces concrete of 28 day compressive strengths at least 90% of the strength of the companion (reference) set, it can be consideredeitable. Salt or brackish water can cause dampness of the concrete, efflorescence (white deposits of precipitated salts on the surface of the concrete), increased risk of corrosion (rust) damage to embedded reinforcement,and damage to paintsystems. It is therefore advisable not to use such water for durable concrete work,

and its use is generally avoided. (Concrete which has to be placed permanently under sea water would obviously not require such precautions).

Typical limits of chemicals allowed in mixing water for concrete arespecified in ASTM C94 92*: which provides a useful guide as to allowances that have worked in practice.

Some General Precautions

- Avoid using wastewater from tanneries, from industrial, chemical and metals related plants (e.g. galvanizing plants, battery making plants); as some salts of manganese, tin, zinc, copper and lead can cause significant reductions in strength and large variations in the setting time of concrete.
- Avoid waters from abattoirs, chicken processing plants, etc. impurities in such waters may have severe effects on concrete.

- Avoid waters from swamps, marshes etc., which may contain organic impurities in amounts sufficient to interfere with the setting and hardening reactions of the cement.
- Avoid water containing algae; algae can cause excessive reductions in strength by influencing cement hydration or by causing a large amount of air to be entrained in the concrete mix. Algae may also be present on aggregate surfaces, in which case they reduce the bond between the aggregate particles and the cement paste and so will reduce concrete strengths.
- Sugar. This is to be avoided at all costs

ASTM C94 92 "Standard Specification for Ready Mixed Concrete". 99 derelatively small amounts of sugar can cause problems of non-setting and non-hardening of concrete in quantities as low as 0.25% of the mass of the cement.

3.2.4 Admixtures

Using a concrete admixture to delay the setting of the concrete gives the concrete finisher longer to apply the proper finish.

Pouring fresh concrete is a time-sensitive project and unexpected delays can cause major problems. With the use of admixtures, you can have more control over yourConcrete. Admixtures can restore loads of concrete that might need to be rejected due to delays or other complications. They can improve the performance of problem concrete by modifying its characteristics and enhancing workability.

Admixtures are additions to a concrete mix that can help control the set time and other aspects of fresh concrete. Common admixtures include accelerating admix-

tures, retarding admixtures, fly ash, air entraining admixtures, and water-reducing admixtures .Table (3.3) shown types of admixture and properties.

Types of Concrete Admixtures

Concrete admixtures are used to improve the behavior of concrete under a variety

Of conditions and are of two main types: Chemical and Mineral.

Chemical Admixtures

Chemical admixtures reduce the cost of construction, modify properties of mixing/transporting/placing/curing, and overcome certain emergencies during concrete operations. Chemical admixtures are used to improve the quality of concrete during mixing, transporting, placement and curing. They fall into the

Following categories:

- air entertainers
- water reducers

- set retarders
- set accelerators
- super plasticizers
- Specialty admixtures: which include corrosion inhibitors, shrinkage control, alkali-silica reactivity inhibitors, and coloring.

Mineral Admixtures

Make mixtures more economical, reduce permeability, increase strength, and influence other concrete properties.
Mineral admixtures affect the nature of the hardened concrete through hydraulic or pozzolanic activity. Pozzolans are cementations materials and include natural pozzolans (such as the volcanic ash used in Roman concrete), fly ash and silica fume.They can be used with Portland cement, or blended cement either individually or in combinations.

ASTM Categories - Concrete Admixtures

ASTM C494 specifies the requirements for seven chemical admixture types. They are:

- Type A: Water-reducing admixtures
- Type B: Retarding admixtures
- Type C: Accelerating admixtures
- Type D: Water-reducing and retarding admixtures
- Type E: Water-reducing and accelerating admixtures
- Type F: Water-reducing, high range admixtures
- Type G: Water-reducing, high range, and retarding admixtures.

Admixtures Benefits:

The use of admixtures is increasing very rapidly, because concrete admixtures provide physical as well as economic benefits. Admixtures benefits the concrete in following possible ways:

- Admixtures reduce the required quantity of cement and make concrete economical.
- They enhance the workability of concrete
- Admixtures imparts early strength in concrete.

- Admixtures reduce the early heat of hydration and overcome thermal cracking problem in concrete. If there is a more heat of hydration then cracks can propagate in fresh concrete.
- Admixtures improve the resistance against freeze-thaw effect on concrete.

- Concrete admixtures maximize the sustainability by bringing waste products in use.
- Concrete admixtures can accelerate the setting time as well as there are admixtures that decelerate concrete setting time.
- There are some admixtures that act as anti-bacterial agents.
- There are concrete admixtures that decrease initial strength, but increase the hardened concrete strength more than the normal concrete strength.

If concrete admixtures are used properly then these are very beneficial to concrete. Otherwise there is no repair for poor quality of concrete mix ingredients.

Concrete Property	Admixture Type	Category of Admixture

Table (3.3): beneficial effects of different kinds of admixtures on concrete properties

Workability	Water reducers Air-entraining agents Inert mineral powder Pozzolans Polymer latexes	Chemical Air entraining Mineral Mineral Miscellaneous
Set control	Set accelerators Set retarders	Chemical Chemical
Strength	Pozzolans Polymer latexes	Mineral Miscellaneous
Durability	Air-entraining agents Pozzolans Water reducers Corrosion inhibitors Shrinkage reducer	Air entraining Mineral Chemical Miscellaneous Miscellaneous
Special concrete	Polymer latexes Silica fume Expansive admixtures Color pigments Gas-forming admixtures	Miscellaneous Mineral Miscellaneous Miscellaneous Miscellaneous

3.3The Ceramic:

Ceramics have been accompanying the human race since ancient times. Archaeologists have unearthed man-made ceramics that date back to at least 25,000 BC. Primitive Ceramics were made of basic earthen materials like clay and were burnt in domes. Human inventiveness gradually started with firing these articles at higher temperatures to attain harder Ceramic articles.

Ceramics once referred purely to pottery and to articles made by firing materials extracted from Earth. Today, the term has a much broader definition. Ceramics are generally thought of as inorganic and nonmetallic solids with a range of useful properties, including very high hardness and strength, extremely high melting points, and good electrical and thermal insulation.

The best-known ceramics are pottery, glass, brick, porcelain, and cement. But the general definition of a ceramic a nonmetallic and inorganic solid is so broad that it covers a much wider range of materials. At one end of the scale, ceramics include simple materials such as graphite and diamond, made up from different crystalline arrangements of the element carbon. But at the other end of the scale, complex crystals of yttrium, barium, copper, and oxygen make up the advanced ceramics used in so-called high-temperature superconductors (materials with almost no electrical resistance).

Most ceramics fall somewhere between these extremes. Many are metal oxides, crystalline compounds of a metal element andoxygen. Others are silicide, borides, carbides, and nitrides, respectively made from silicon, boron, carbon, and nitrogen. Some of the most advanced ceramic materials are combinations of ceramics and other materials known as ceramic matrix composites (CMCs).

Ceramics are best known as brittle solids particularly suited for withstanding high temperatures but, in fact, the different materials used in ceramics can give them a wide range of properties. The classic properties of ceramics include durability, strength and brittleness, high electrical and thermal resistance, and an ability to withstand the damaging effects of acids, oxygen, and other chemicals because of their inertness (chemical underactivity). But not all ceramics behave in this way. For example, graphite is a very soft ceramic and conducts electricity well, whereas diamond is a very good conductor of heat. Ceramics called ferrites are particularly good conductors of electricity and superconductors have almost no electrical material in what is known as a ceramic matrix, are not at all brittle.

The properties of a particular ceramic depend not just on the materials from which made but also on the way they are joined together—in other words, on its crystalline structure. Diamond is strong because all of its carbon atoms are bonded tightly to other carbon atoms. Graphite (such as that used in pencil "leads") shears

because it is made up from different layers. Although the carbon atoms are tightly bonded within a given layer, the different layers are held together only by much weaker bonds. China clay (also called kaolin) behaves in a similar way to graphite, with its constituent aluminum, silicon, oxygen, and hydrogen atoms tightly bonded into flat sheets. But the weak bonds between those sheets are easily broken when water surrounds them and it is this that makes wet clay so easy to mold. When china clay is fired, heat removes the water, and the chemicals inside the clay rearrange themselves into crystals of aluminum silicate tightly bonded by silicate glass, which is overall very much stronger. Firing is the process by which ceramics have traditionally been made; indeed, the word "ceramic" can be traced back to a Sanskrit word meaning "to burn." Simple ceramics such as bricks and certain types of glass are still made by processes that would be recognized by people who lived thousands of years ago. Just as in ancient times, today's pottery is made by digging clay from the ground, mixing it with water to make it flexible, shaping it on a wheel or in a mold, and then firing it in a kiln. Some of today's processes are more sophisticated than the techniques of past times. Machines have long been used in processes such as extrusion (forcing a material into shape by squeezing it like toothpaste through a shaped tool), jiggering (laying the material automatically into a rotating mold), or hot pressing (forcing a powdered form of the ceramic into a mold then simultaneously heating it and pressing it to Fuse the
material into shape). The latest industrial ceramics sometimes demand more advanced production processes. Extremely tough ceramics made of silicon nitride are made by a method called reaction bonding. This involves forming silicon powder into the desired shape then heating it with nitrogen gas. Because the silicon powder already occupies the same volume as the finished product, grains of silicon nitride can form only by fusing together tightly.

3.3.1 Ceramic Waste

Ceramic waste is one of the most active research areas that encompass a number of disciplines including civil engineering and construction materials. Ceramic waste powder is settled by sedimentation and then dumped away which results in environmental pollution, in addition to forming dust in summer and threatening both agriculture and public health. Therefore, utilization of the ceramic waste powder in various industrial sectors especially the construction, agriculture, glass and paper industries would help to protect the environmentit is most essential to develop eco-friendly.

The principle waste coming into the ceramic industry is the ceramic powder, specifically in the powder forms. Ceramic wastes are generated as a waste during the process of dressing and polishing.It is estimated that 15 to 30% waste are produced of total raw material used, and although a portion of this waste may be utilized on-site, such as for excavation pitrefill, the disposals of these waste materials acquire large. Land areas and remain scattered all around, spoiling the aesthetic of the entire region. It is very difficult to find a use of ceramic waste produced. Ceramic waste can be used in concrete to improve its strength and other durability factors. Ceramic waste can be used as a partial replacementof cement or as a partial replacement of fine aggregate sand as a supplementary addition to achieve different properties of concrete. Figure (3.4) deferent type of waste ceramic**,** Minerals present in clay become highly reactive upon incineration at temperatures between 600-900°C, afterwhich they are ground to cement fineness. They are mainly formed by siliceous and aluminous compounds. Thermal treatments causes loss of water which leads to the disruption of their crystalline structure, which consequently results in their conversion into unstable amorphous state. If at that state they are mixed with calcium hydroxide (CaOH) and water, they undergo pozzolanic reaction and consequently form compounds with better strength and durability. Therefore, they can be potentially used in mortar and concrete.

The advancement of concrete technology can reduce the consumption of natural resources. They have forced to focus on recovery, reuse of natural resources and find other alternatives.

The use of the replacement materials offer cost reduction,energy savings, arguably superior products, and fewer hazards in the environment

Figure (3.4): Different Views of Ceramic Powder

3.4 Concrete Mix Design procedure

Step-1: Determining the Water/ Cement Ratio

Set the required characteristic strength at a specified age, f_c
Calculation of the margin, M.

M = k * s ….. [1]

Here;
k = A value appropriate to the defect percentage permitted below the characteristic strength.
[k = 1.64 for 5 % defect] (obtained from Table3.4).
s = the standard deviation (obtained from Figure 3.5).

Table (3.4): K Value

Defective	Constant
1%	2.33
2.5%	1.96
5%	1.65

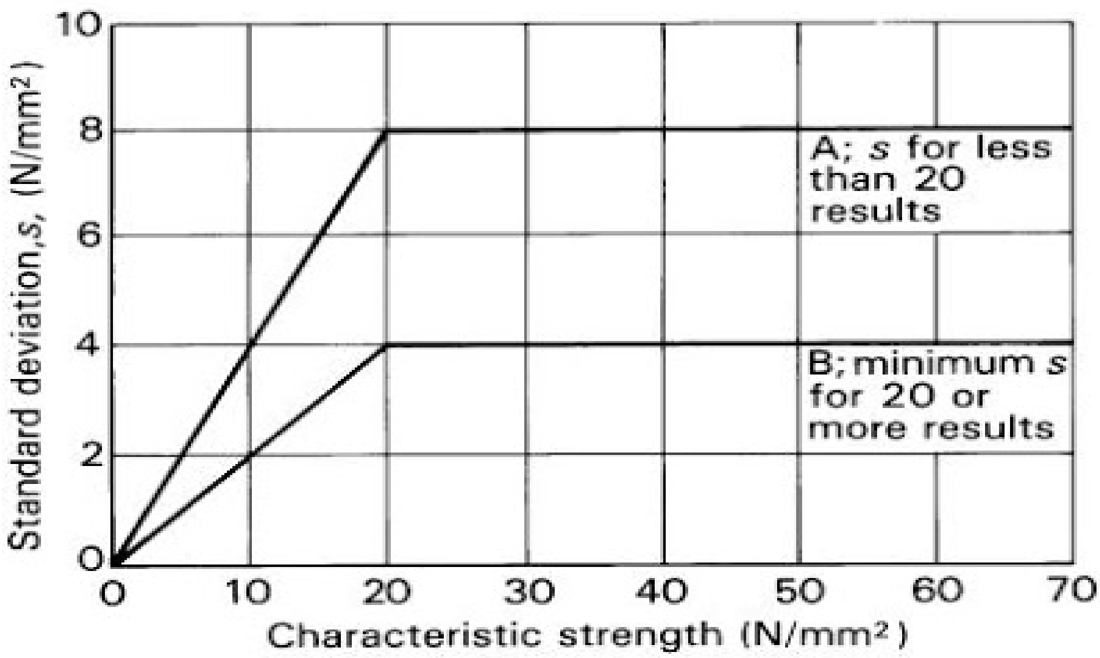


Figure (3.5): Relationship between standard deviation and characteristic strength.

Step-2: Calculation of the target mean strength, F_M

$F_M = f_c + M$ ….. [2]

Where;
F_M = Target mean strength
f_c = the specified characteristic strength

Table (3.5): Compressive Strength (N/mm2) of Concrete Mixes Made With water/cement Ratio of 0.5

Approximate compressive strength N/mm^2 of concrete mixes made with free-water/cement ratio of 0.5					
Cement strength class	Type of coarse aggregate	Compressive strength N/mm^2 Age(days)			
		3	7	28	91
42.5	un crush	22	30	42	49
	crushed	27	36	49	59
52.5	uncrushed	29	37	48	54
	crushed	34	43	55	61

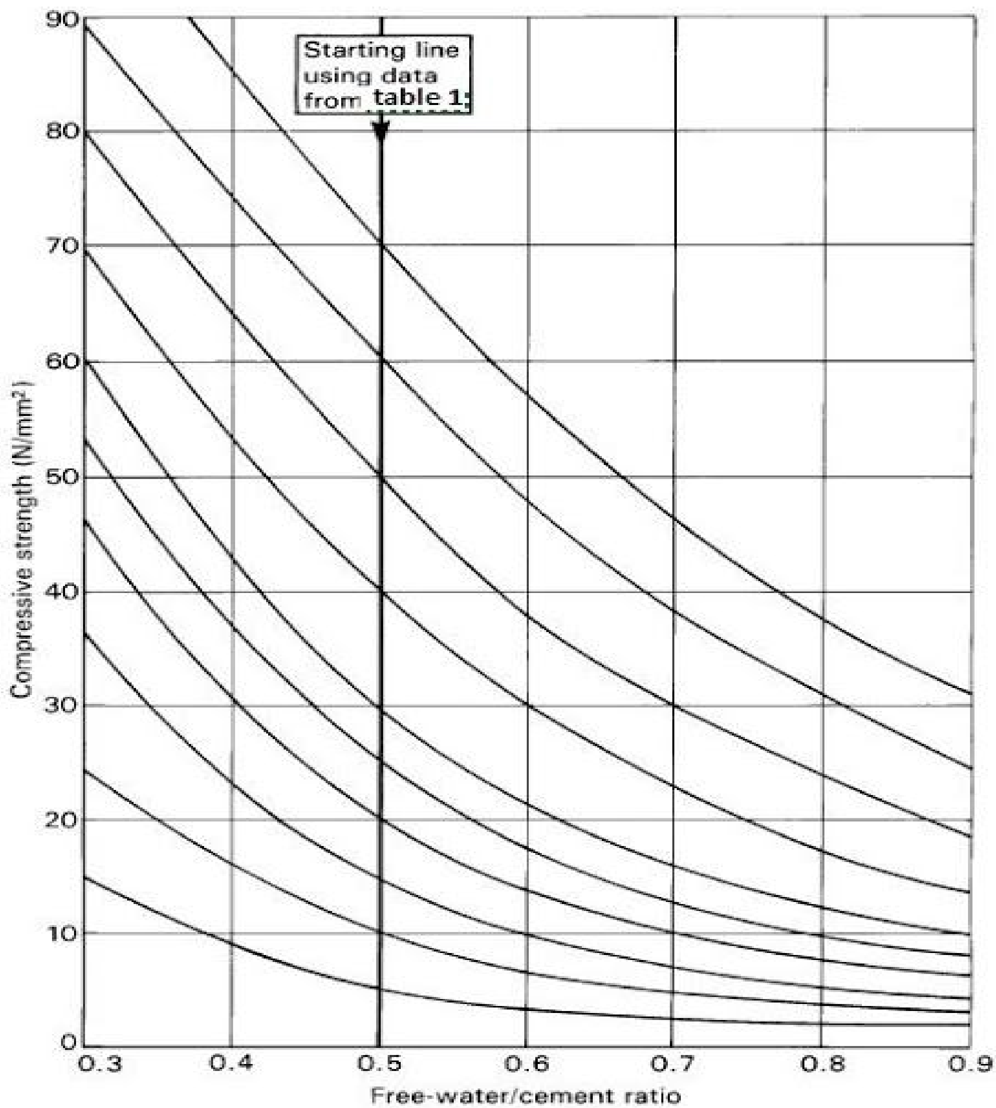


Figure (3.6): Relationship between compressive strength and water/ cement ratio.

Avalue is obtained from Table (3.5) for the strength of a mix made with a water/cement ratio of 0.5 according to the specified age, the strength class of the cement and the aggregate to be used. This strength value is then plotted on Figure (3.6) and a curve is drawn from this point and parallel to the printed curves until it intercepts a horizontal line passing through the ordinate representing the target mean strength.

Step-3: Determination of the Free-Water Content

The free-water content can be determined from Table (3.6) depending upon the type and maximum size of the aggregate to give a concrete of the specified slump or Vebe time.

Table (3.6): Approximate free-water contents (kg/m3) required to give various levels of workability

Slump(mm) **Vebe Time(s)**		**0-10** **>12**	**10-30** **6-12**	**30-60** **3-6**	**60-80** **0-3**
Max Size Of Aggregate (mm)	Type of aggregate				
10	un crush	150	180	205	225
	crushed	180	205	230	250
20	uncrushed	135	160	180	195
	crushed	170	190	210	225
40	uncrushed	115	140	160	175
	crushed	155	175	190	205

Step-4: Determination of Cement Content

The cement content can be determined from equation 3...

Cement Content = Free Water Content / water-Cement Ratio ….. [3]

The resulting value should be checked against any maximum or minimum value that may be specified. If the calculated cement content from equation 3 is below a specified minimum, this minimum value must be adopted and a modified free-water/cement ratio calculated.

If the design method indicates a cement content that is higher than a specified maximum then it is probable that the specification cannot be met simultaneously on strength and workability requirements with the selected materials. Consideration should then be given to changing the type or strength class, or both, of cement, the type and maximum size of aggregate or the level of workability of the concrete, or to the use of a water-reducing admixture.

Step 5: Determining the Total Aggregate Content

Density of fully compacted concrete can be estimated from Figure (3.7). This value depends upon the free-water content and the relative density of the combined aggregate in the saturated surface-dry condition. If no information is available regarding the relative density of the aggregate, an approximation can be made by assuming a value of 2.6 for un-crushed aggregate and 2.7 for crushed aggregate.

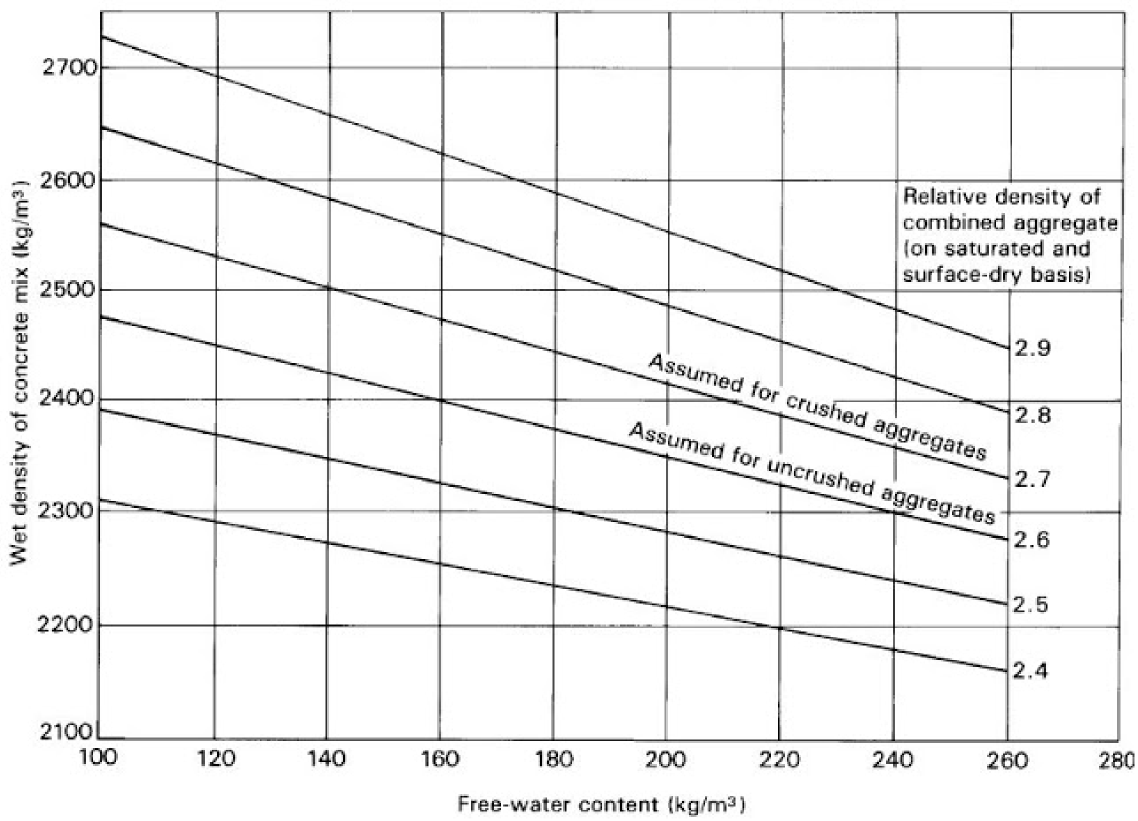


Figure (3.7): Estimated wet density of fully compacted concrete.

The total aggregate content can be calculated using equation 4:

Total Aggregate Content = D – C – W ….. [4]

Where;

D = The wet density of concrete (in kg/m^3)

C = The cement content (in kg/m^3)

W = The free-water content (in kg/m^3)

Step 6: Determining of the Fine and Coarse Aggregate Contents

Current step demonstrate how to find out total fine aggregate (materials smaller than 5 mm, i.e. the sand or fine aggregate content). The Figure (3.8) shows recommended values for the proportion of fine aggregate depending on the maximum size of aggregate, the workability level, the grading of the fine aggregate (defined by the percentage passing a 600 µm sieve) and the free-water/ cement ratio. The best proportion of fines to use in a given concrete mix design will depend on the shape of the particular aggregate, the grading and the usage of the concrete.

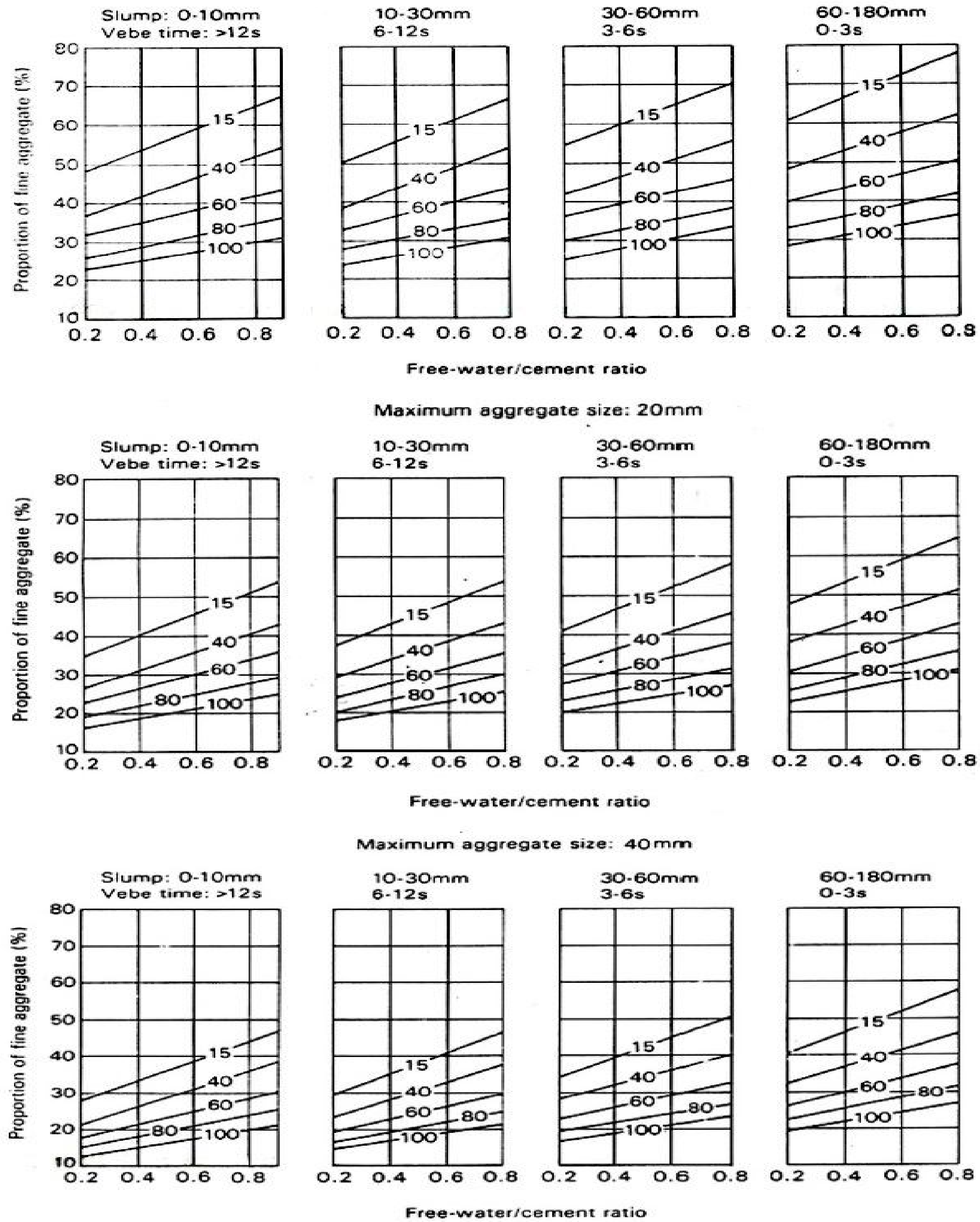


Figure (3.8): Recommended proportions of fine aggregate according to percentage passing a 600 µm sieve.

Determination of fine and coarse aggregate can be made using the proportion of fine aggregate obtained from Figure (3.8) and the total aggregate content derived from Step-5

Fine Aggregate Content = Total Aggregate Content * Proportion of Fines…. [5]

Coarse Aggregate Content = Total Aggregate Content – Fine Aggregate

CHAPTER FOUR

EXPERIMENTAL METHODOLOGY

CHAPTER FOUR

EXPERIMENTAL METHODOLOGY

4.1 Introduction

While designing a structure, engineer assumes certain value of strength for each of material being used therein. When the structure is being constructed, it is the bounden duty of the field engineers to get the same validated by regular testing of material. The quality of materials used in any infrastructure does play a vital role with regard to its ultimate strength and durability in the long run. Hence, the materials need to be tested according to certain standard procedures developed by ASTM, BIS, and RDSO to give a clear picture of material strength [11].

There are so many tests available for testing different qualities of concrete. Different tests give results for their respective quality of concrete. Thus it is no possible to conduct all the tests as it involves cost and time .thus it is very important to sure about purpose of quality tests for concrete. The most important test for quality check of concrete is to detect the variation of concrete quality with given specification and mix design during concrete mixing and place ment.it will ensure that right quality of concrete is being place at site and with check for concrete placement in place, the quality of constructed concrete members will be as desired.

4.2 Cement Tests

There are many tests which are conducted to check the quality of the cement.Various test which are done on cement are listed below.

4.2.1 Fineness

To determine the fineness of cement by dry sieving as per IS: 4031 (Part 1). 1996. Figure (4.1) shown below

Figure (4.1): Photo of Sieve No 200

The procedure is summarized as follows:

1/ Weight approximately 10g of cement to the nearest 0.01g and place it on the sieve.

2/Agitate the sieve by swirling, planetary and linear Movements, until no more fine material passes through it.

3/ Weight the residue and express its mass as a percentage R1, of the unity first placed on the sieve to the nearest 0.1 percent.

4/ gently brush all the fine material off the base of the sieve.

5/ Repeat the whole procedure using a fresh 10g sample to Obtain R2. Then calculate R as the mean of R1 and R2 as a percentage, expressed to the nearest 0.1 percent.

Finally**,** report the value of R, to the nearest 0.1 percent, as the residue on the 90μm sieve.

4.2.2 Consistency

To determine the quantity of water required to produce a cement Paste of standard consistency as per IS: 4031 (Part 4) – 1988.

The procedure is summarized as follows:

1/ Weigh approximately 400g of cement and mix it with aweighed quantity of water. The time of gauging should bebetween 3 to 5 minutes.

2/ Fill the vicat mould with paste and level it with a trowel.

3/ Lower the plunger gently till it touches the cement surface.

4/ Release the plunger allowing it to sink into the paste.

5/ Note the reading on the gauge.

6/ Repeat the above procedure taking fresh samples of cement
And different quantities of water until the reading on the
Gauge is 5 to 7mm.

Finally,express the amount of water as a percentage of the weight ofdry cement to the first place of decimal.

4.2.3 Initial and Final Setting Time

To determine the initial and the final setting time of cement As per IS: 4031 (Part 5) – 1988, Figure (4.2) shownVicat Apparatus below

The procedure is summarized as follows:

1/ Prepare a cement paste by gauging the cement with 0.85 times the water req-uired to give a paste of standard consistency.

2/ Start a stop-watch, the moment water is added to the cement.3/ Fill the vicat mould completely with the cement paste gauged as above, the mould resting on a non-porous plat and smooth off the surface of the paste making
it level with the top of the mould. The cement block thus prepared in the mould is the test block.

A.Initial Sitting Time

1/ Place the test block under the rod bearing the needle. Lower the needle gently in order to make contact with the surface of the cement paste and release quickly, allowing in to penetrate the test block.

2/ Repeat the procedure till the needle fails to pierce the test block to a point 5.0 ± 0.5mm measured from the bottom of the mould

Finally, the time period between the time, water is added to the cement and the time, the needle fails to pierce the test block by 5.0 ± 0.5mm measured from the bottom of the mould, is the initial setting time

B.Final Sitting Time

1/ Replace the above needle by the one with an annular attachment

2/ the needle makes an impression therein, while the attachment fails to do so.

Finally, the period elapsing between the time, water is added to the cement and the time, the needle makes an impression on the surface of the test block, while the attachment fails to do so, is the final setting time.

Figure (4.2):Vicat Apparatus

4.2.4 Soundness

To determine the soundness of cement by Le-Chalkier method as per IS: 4031 (Part 3– 1988).shown in Figure (4.3) below.

The procedure is summarized as follows:

1/ Place the mould on a glass sheet and fill it with the cement paste formed by gauging cement with 0.78 times the water required to give a paste of standard consistency.

2/ Cover the mould with another piece of glass sheet, and immediately submerge the whole assembly in water at a temperature of 27 ± 2oC and keep it there for 24hrs.

3/ Measure the distance separating the indicator points to the nearest 0.5mm (sayd l).

4/ Submerge the mould again in water at the temperature prescribed above.

5/ Bring the water to boiling point in 25 to 30 minutes and keep it boiling for 3hrs.

6/ Remove the mould from the water, allow it to cool and measure the distance between the indicator points (say d 2).

7/ (d 2 – d l) represents the expansion of cement.

Finally, calculate the mean of the two values to the nearest 0.5mm torepresent the expansion of cement.

Figure (4.3):Le chatelier

4.3 Test of Aggregate

There are many tests which are conducted to check the quality of aggregates. Aggregates are very important component of concrete, so the quality really matters when it comes to aggregates.

4.3.1 Sieve Analysis

To determine the particle size distribution of fine and coarse aggregates by sieving as per IS:2386 (Part I)-1963.Table(4.1)(4.2)& Figure (4.4) sieves& tool of testing.

The procedure is summarized as follows:

1/ the test sample is dried to a constant weight at a temperature of 110 + 50C and weighed.

2/ the sample is sieved by using a set of IS Sieves.

3/ on completion of sieving, the material on each sieve is weighed.

4/ Cumulative weight passing through each sieve is calculated as a percentage of the total sample weight.

5/ Fineness modulus is obtained by adding cumulative Percentage of aggregates retained on each sieve and dividing the sum by 100.

Finally,the results should be calculated and reported as:

1/ the cumulative percentage by weight of the total sample.

2/The percentage by weight of the total sample passing through one sieve and retained on the next smaller sieve, to the nearest 0.1 percent.

3/ the results of the sieve analysis may be recorded graphically on a semi-log graph with particle size as abscissa (log scale) and the percentage smaller thanthe specified diameter as ordinate.

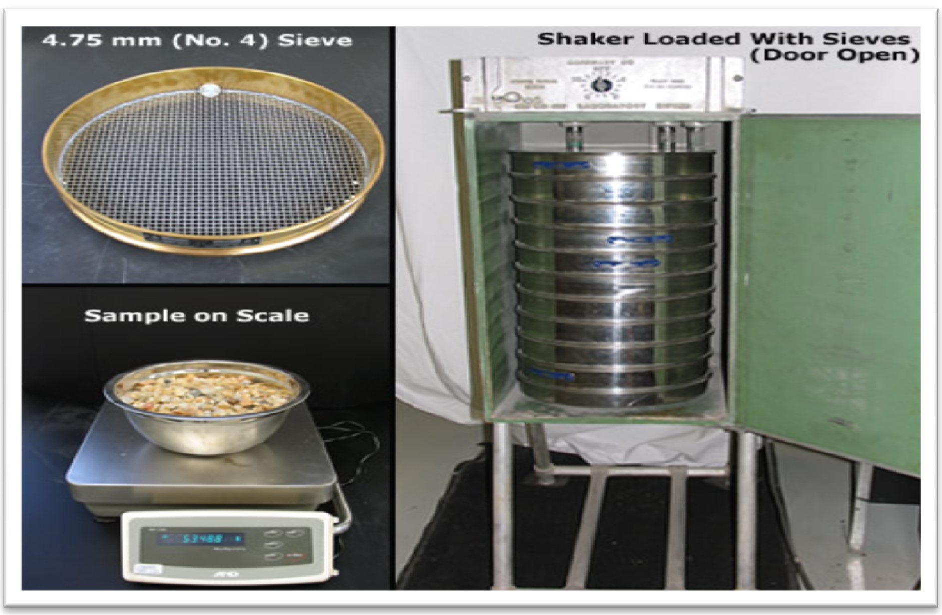


Figure (4.4): Sieves size

Table (4.1): Sieves Commonly Used For Sieve Analysis of Concrete Aggregate

Stander sieve Designation(ASTM11)		Normal Sieve Opining	
		MM	IN
Coarse Sieves			
Standard	Alternative	MM	inch
75.0mm	3in	75.0	3
63.0mm	2-1/2in	63.0	2.5
50.0mm	2in	50.0	2
37.5mm	1-1/2in	37.5	1.5
25.0mm	1in	25.0	1
19.0mm	3/4in	19.0	0.75
12.5mm	1/2in	12.5	0.50
9.5mm	3/8in	9.5	0.375
Fine sieves			
4.75mm	No.4	4.74	0.187
2.36mm	No.8	2.36	0.0937
1.38mm	No.16	1.38	0.0469
600 µm	No.30	0.60	0.0234
300 µm	No.50	0.30	0.117
150 µm	No.100	0.15	0.0059
Fine sieve normally used for aggregate			
75.5	No.200	0.075	0.0029

Table (4.2): Ranges In physical Prosperities for Normal Weight Aggregate

PROPERTY		TYPICAL RANGES
Fine Modulus of fine Aggregate		2.0-3.30
Nominal size of coarse aggregate		9.5 - 37.5 mm
Absorption		0.5 - 4%
Bulk Specific Gravity (density)		2.30 - 2.90
Bulk density coarse aggregate		1280 - 1920 kg/m3
Surface Moisture Content	Coarse	0 - 2%
	Fine	0 - 10%

4.3.2 Specific Gravity and Water Absorption

The test covers the procedures for determining the specific gravity, apparent specific gravity and water absorption of aggregates. Figure (4.5) shown tools for testing.

The procedure is summarized as follows:

1/ sample shall be screened on an IO-mm ISsieve, washed to remove fine dust.

2/ immersed the sample in distilled water in the glass vessel; it shall remain immersed at a temperature of 22 to 32°C for 24 f l/2 hours.

3/ air entrapped in or bubbles on the surface of the aggregate shall be removed by gentle agitation. This may be achieved by rapid clockwise and anti-clockwise rotation of the vessel between the operator's hands.

4/The vessel shall be overfilled by adding distilled water and the plane ground-glass disc slid over the mouth so as to ensure that no air is trapped in the vessel.

5/The vessel shall be dried on the outside and weighed (weight A).

6/ the vessel shall be emptied and the aggregate allowed to drain. Refill the vessel with distilled water.

7/ the vessel shall be dried on the outside and weighed (Weight B).

8/ The aggregate shall be placed on a dry cloth and gently surface dried with the cloth, transferring it a second dry cloth when the firstwill remove no further moisture.

9/ the aggregate shall then be weighed (weight C).

10/The aggregate shall be placed in the oven in the shallow tray, at a temperature of 100 to 110°C for 24 f l/2 hours. It shall then beCooled in airtight container and weighed (weight D).

Finally, calculations Specific gravity, apparent specific gravity and waterAbsorption shall be calculated as follows:

Specific gravity = $\left(100 * \left(\frac{D}{C-(A-B)}\right)\right)$

Apparent specific gravity = $\left(100 * \left(\frac{D}{D-(A-B)}\right)\right)$

Water absorption = $\left(100 * \left(\frac{C}{B-(A-C)}\right)\right)$

A = weight in g of vessel containing sample and filled with distilled water,

B = weight in g of vessel filled with distilled water only,

C = weight in g of saturated surface-dry sample, and

D = weight in g of oven-dry sample.

Figure (4.5): Specific Gravity Test Tool

4.3.3 Bulk Density and Voids

This method of test covers the procedure for determining unit weight or bulk density and void of aggregates.

The procedure is summarized as follows:

1. Measure the volume of the cylindrical metal measure by pouring water into the metal measure and record the volume “V” in litre.
2. Fill the cylindrical metal measure about one-third full with thoroughly mixed aggregate and tamp it 25 times using tamping bar.
3. Add another layer of one-third volume of aggregate in the metal measure and give another 25 strokes of tamping bar.
4. Finally fill aggregate in the metal measure to over-flowing and tamp it 25 times.
5. Remove the surplus aggregate using the tamping rod as a straightedge.
6. Determine the weight of the aggregate in the measure and record that weight “W” in kg.

Calculation for Compacted Bulk Density

Compacted unit weight or bulk density = w/v

W = Weight of compacted aggregate in cylindrical metal measure, kg

V = Volume of cylindrical metal measure, liter.

Calculation of Voids:

The percentage of voids is calculated as follows:

Percentage of voids = $[(G - \Upsilon)/G]*100$

G = Specific gravity of the aggregate

Υ = Bulk density in kg/liter

4.4 Test of Fresh Concrete

There are many testswhich are conducted to check the quality of fresh concrete.

4.4.1 Workability

The most important test is slump to determine workability. It can therefore use on site to check a mix of concrete has the expected fluid properties and degree of wetness. In general, wetter mixes are more workable than drier mixes, but concrete of the same consistency may vary in workability. The test is also used to determine consistency between individual batches

Slump

To determine the workability of fresh concrete by slump test asPer IS: 1199 - 1959. Figure (4.6) shown the mold for slump test

The procedure is summarized as follows:

1. The internal surface of the mold is thoroughly cleaned and Applied with a light coat of oil.
2. The mold is placed on a smooth, horizontal, rigid and non-absorbent surface.
3. The mold is then filled in four layers with freshly mixed Concrete, each approximately to one-fourth of the height of the mold.
4. Each layer is tamped 25 times by the rounded end of the tamping rod.
5. After the top layer is rotted, the concrete is struck off the Level with a trowel.
6. The mold is removed from the concrete immediately by raising it slowly in the vertical direction.
7. The difference in level between the height of the mold and that of the highest point of the subsided concrete is measured. This difference in height in mm is the slump of the concrete.

The slump measured should be recorded in mm of subsidence other specimen during the test.

Any slump specimen, which collapses or shears off laterally gives incorrect result and if this occurs, the test should be repeated with another sample.

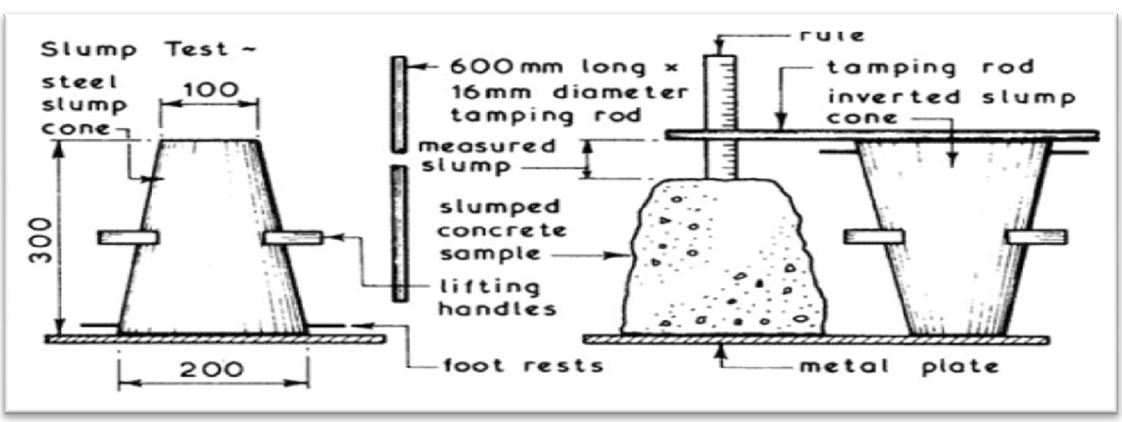


Figure (4.6): Slump Test mold

4.5 Test of Hardened Concrete:

Various tests on hardened concrete is done to ensure the design strength of concrete and quality of concrete construction is achieved.

4.5.1 Compression Test:

To determine the compressive strength of concrete specimensas per IS: 516-1-959. Figure (4.8) below shown crushing machine.

The procedure is summarized as follows:

1. The specimens, prepared according to IS: 516 - 1959 and stored in water, should be tested immediately on removal from the water and while still in wet condition. Specimen when received dry should be kept in water for 24hrs. Before they are taken for testing. The dimensions of the specimens, to the nearest 0.2mm and their weight should be noted before testing.

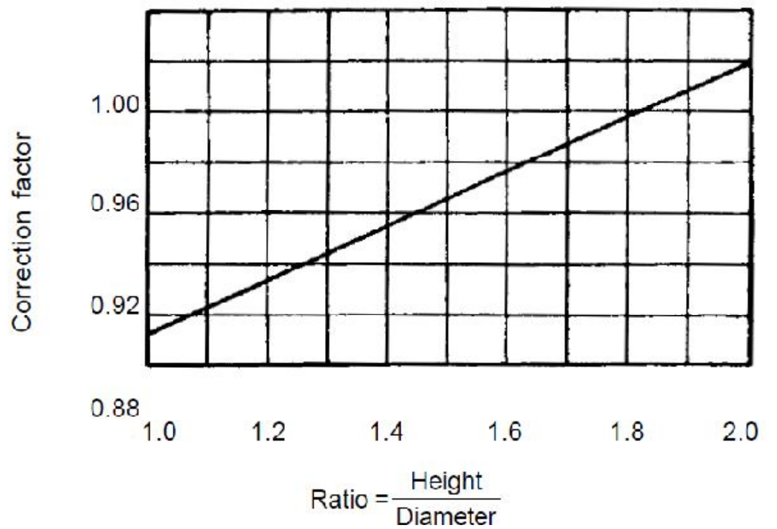
2. The bearing surfaces of the compression testing machine should be wiped clean and any loose sand or other material removed from the surfaces of the specimen, which would be in contact with the compression platens.

3. In the case of cubical specimen, the specimen should be placed in the machine in such a manner that the load could be applied to the opposite sides of the cubes, not to the top and the bottom. The axis of the specimen should be carefully aligned with the center of thrust of the spherically seated platen. No packing should be used between the faces of the test specimen and the steel platen of the testing machine. As the spherically seated block is brought to rest on thespecimen, the movable portion should be rotated gently by hand so that uniform seating is obtained.

4. The load should be applied without shock and increased continuously at a rate of approximately 140kg/sq.cm/minute until the resistance of the specimen to the increasing load breaks down and no greater load can be sustained. The maximum load applied to the specimen should then be recorded and the appearance of the

Concrete and any unusual features in the type of failure should be noted.

Finally, the measured compressive strength of the specimen should be calculated by dividing the maximum load applied to the specimen during the test by the cross - sectional area, calculated from the mean dimensions of the section and should be expressed to the nearest kg/sq.cm. An average of three values should be taken as the representative of the batch, provided the individual variation is not more than ±15% of the average. Otherwise repeat tests should be done.A correction factor according to the height/diameter ratio of the specimen after capping should be obtained from the curve given in Figure (4.7) below:



Correction factor for height-diameter ratio of a core

Figure (4.7): Correction Factor

The product of this correction factor and the measuredCompressive strength is known as the corrected compressive Strength, this being the equivalent strength of a cylinder having a Height/diameter ratio of two. The equivalent cube strength of the Concrete should be determined by multiplying the corrected Cylinder strength by 1.25.

Finally, the following information should be included in the report on each test specimen:

1. Identification mark.
2. Date of test.
3. Age of specimen.
4. Curing conditions, including date of manufacture of specimen.
5. Weight of specimen.
6. Dimensions of specimen.
7. Cross-sectional area.
8. Maximum load.
9. Compressive strength.
10. Appearance of fractured faces of concrete and type of Fracture, if unusual

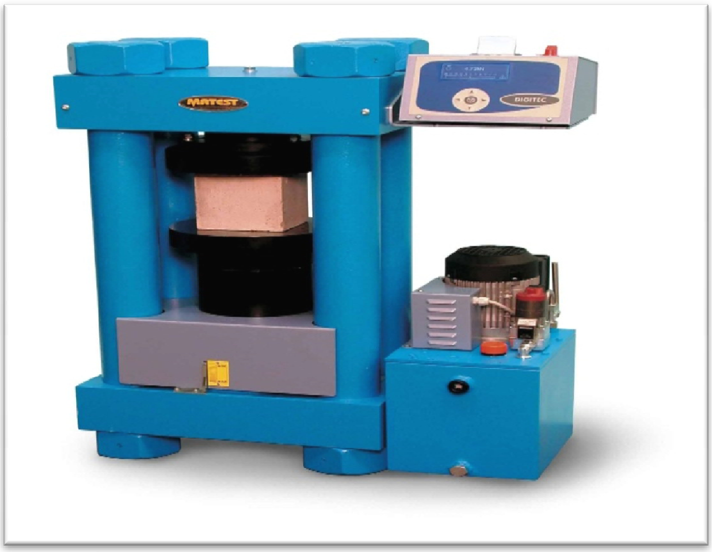


Figure (4.8): Crushing Machine

4.6 Mix of Materials

The basic material and component for design concreteadditional the chemical and physical tests.

4.6.1 Cement (OPC)

The Ordinary Sudanese Portland cement of PC 42.5 manufactured by mass was used conforming to EN 197-1 cement.

Result of Cement Test

It was conducted cement tests (fineness, consistency ,sitting time, compressive strength ,soundness and specific gravity)The results as shown in Table (4.3) below:

Table (4.3):Results of Cement tests

Test No	Name Test	Result	BS.No (12-1996)
1	Fineness	2.3%	Not more than 10%
2	Consistency	32%	26%-33%
3	Sitting Initial Time	110	Not less than 45 min
4	Sitting Final Time	338	Not more than10 hour
5	Compressive strength		
	3 days	19.8	Equal or greater than10 N/mm2
	28 days	46.5	Equal or greater than 42.5 N/mm2
6	Soundness	2mm	Not more than 10mm
7	Specific gravity	3.14	**----**

4.6.2 Ceramic Waste Powder

The principle waste coming into the ceramic industry is the ceramic powder, it c -an be used in concrete to improve its strength and other durability factors. It's used as a partial replacementof cement or as a partial replacement of fine and coarse aggregate as a supplementary addition to achieve different properties of concrete. The wastes ceramic are used in this experiment generated from Salome Italy factory in Khartoum Bahry.

4.6.3 Acacia Tortilies Gum

Generated from western of Sudan,used as additive to improve the concrete workability properties, used as liquid in the mixes.

Conducted cement, waste ceramic powder and acacia tortilies chemical test and results as shown in the Table (4.4) below:

Table (4.4): Chemical Combination Result of Cement& Waste Ceramic &Acacia Tortilies Gum

Oxide%	Cement	Ceramic No Treat	Ceramic with Treat550c	Acaica Gum
Sio2	17.703	70.373	68.612	0.066
AlO3	4.377	18.170	18.443	0.017
Fe2O3	3.440	3.735	4.409	0.003
CaO	64. 924	2.967	3.263	1.290
MgO	1.748	0.704	0.543	0.841
P2O5	0.108	0.122	0.113	0.011
K2O	0.306	1.399	1.504	0.855
Na2O	0.401	0.889	0.787	0.072
SO3	3.834	0.092	0.110	0.116

4.6.4Aggregate

Aggregates are the important constituents in concrete. They give body to the concrete, reduce shrinkage and effect economy. One of the most important factors for producing workable concrete is a good gradation of aggregates. Good grading implies that a sample fraction of aggregates in required proportion such that the sample contains minimum voids. Samples of the well graded aggregate containing minimum voids require minimum paste to fill up the voids in the aggregates. Minimum paste means less quantity of cement and less water, which are further mean increased economy, higher strength, lowershrinkage and greater durability.

All aggregate fine and coarse we are generated sample from Flatko Ready Mix.

Coarse Aggregate

The fractions from 20 mm to 4.75 mm are used as coarse aggregate.

The Coarse Aggregates from uncrushed stone. The sieves test result of coarse aggregate presented in Table (4.5) and Figure (4.2) shown below:

Table (4.5): Sieve Analysis of Coarse Aggregate &Grading According to British Standard

BS Sieve Size	Aggregate Retrain Determination No				Retrain	Cumulated Pre.Retrain	Percen Passing	BS 882:1992
	A	B	C	AVG				
40	0	0	0	0	0	0	100	-
37.5	0	0	0	0	0	0	100	-
20	493	490	495	492.70	5	5	95	90-100
10	1940	1932	1972	1948	62	67	33	30-60
5	57	53	59	56.33	18	85	15	0-20
2.5	10	12	9	10.3	15	100	0	-
1.5	0	0	0	0	0	100		
pan	0	o	0	0	0	100		
				2507.3	100			
Fine Modulus =∑ Cumulative percentage Retained/100=4.60								

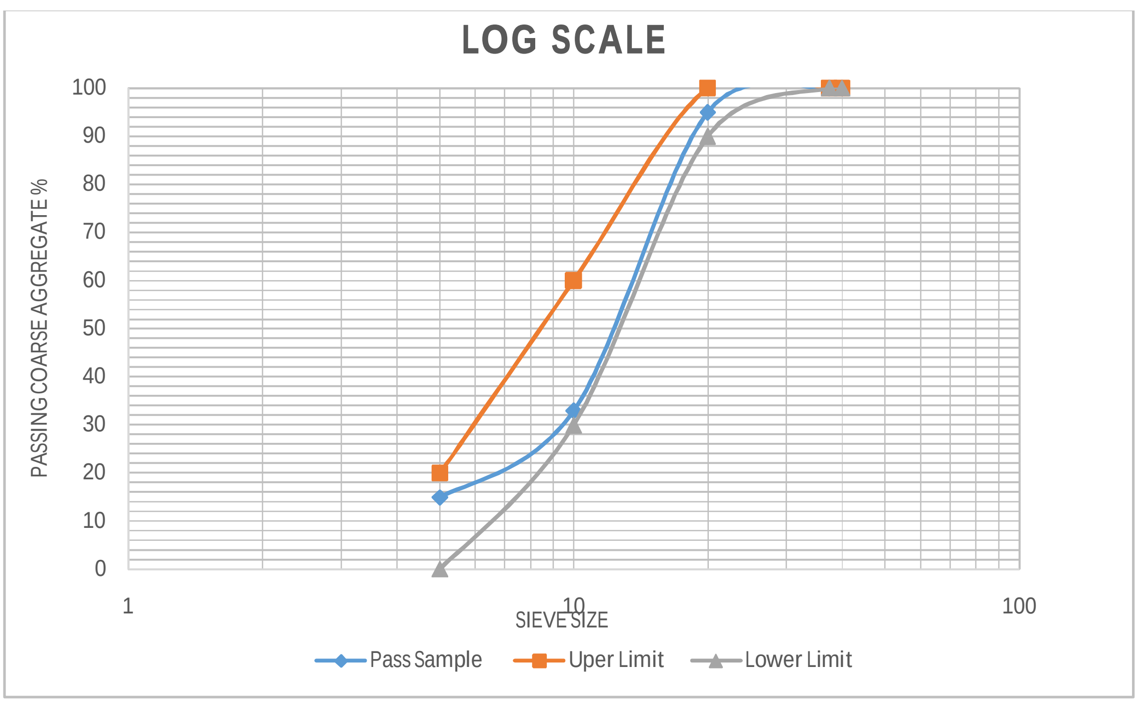


Figure (4.9): Sieves Analysis of Coarse Aggregate with upper& lower passing According to BS882:1992

Fine aggregate

The fractions from 4.75mm to75mic are used, the fine aggregate used in the experimental program was natural river sand.Impurities proportion 1% the gradient of the test, the sieves test result of fine aggregate presented in table (4.6) and figure (4.3) below:

Table (4.6): Sieves Analysis of Fine Aggregate &Grading According British Standard

BS Sieve Size	Aggregate Retrain Determination No				Retrain	Cumulative Pre.Retrain	Percentage Passing	BS 882:1992
	A	B	C	AVG				
1	2	3	4	5	6	7	8	9
10mm	15	17	14	15.33	1.53	1.53	98.47	-
4.75	37	31	33	33.7	3.37	4.90	95.10	-
2.36	29	24	20	23.33	2.33	7.41	92.59	60-100
1.18	96	197	94	129.2	12.92	20.33	79.67	30-90
600mic	444	335	468	415.7	46.85	49.18	50.82	15-54
300mic	306	310	341	319	41.99	96.07	3.93	5-40
150mic	57	50	48	51.67	5.17	98.60	2.00	-
75mic	17	10	15	14.00	1.40	100.00	00	**Class C**
pan	0	0	0	0	0	100.00	00	
				1000.7	100.29			
Fine Modulus =Cumulative percentage retain/100=2.91								

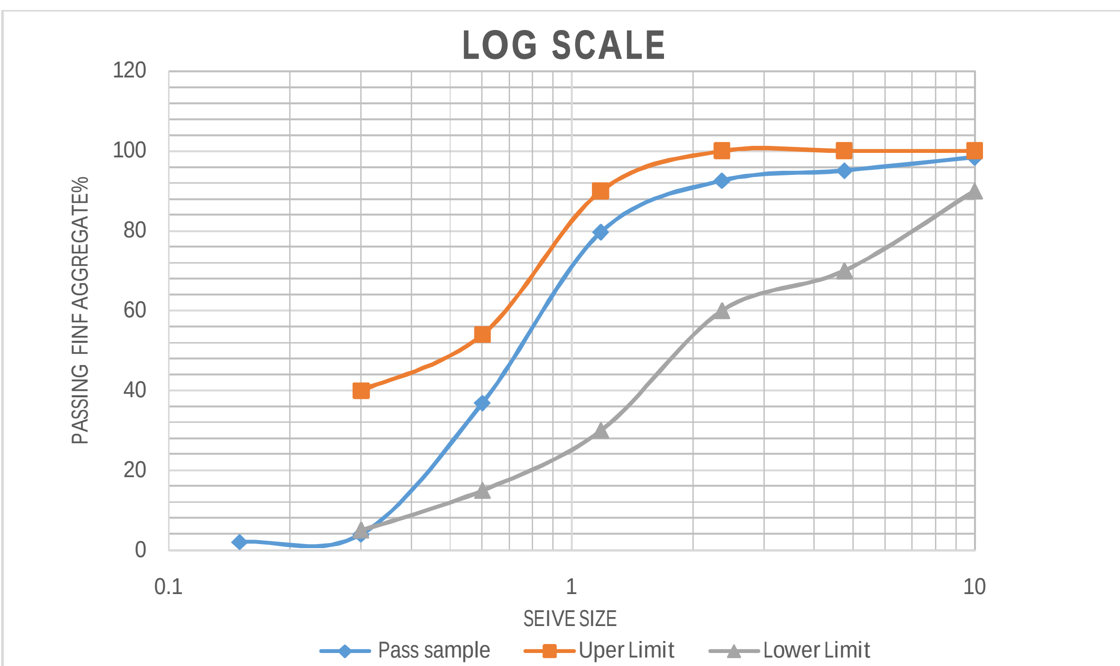


Figure (4.10):Sieves Analysis of Fine Aggregate with upper & Lower Passing According BS882:1992

Results of Fine & Coarse Aggregate Test

The most important tests of fine and coarse aggregate given in Table (4.7) below:

Table (4.7):Result of Fine & Coarse Aggregate Test

Property	Fine Aggregate	Coarse Aggregate
Fineness modulus	2.91	4.60
Specific Gravity	2.59	2.69
Bulk Density(gm/cc)	1692	1610
Absorption%	0.88	0.30

4.6.6 Water

Potable water from River Nile.Water is an important ingredient of concrete as it actually participates in the chemical reaction with cement. Since it helps to from the strength giving cement gel, the quantity and quality of water are required to be looked into very carefully. Table (4.5) shown chemical result of water with PH equal 7.

Material	Na	K	Mg	Fe	Cd	Pb	Zn	So4	Cl	PH
Pre%	31.98	5.773	19.18	0.051	0.018	0.126	0.089	0.0014	0.0716	7.0

Table (4. 8): Chemical Result of Water Test

4.7 Concrete Samples Preparation

Properties of concrete dependent on Structural configure, which in turn depends on the type component of concrete, quantity of materials ,ratios between them and also the extent of the homogeneity of these materials, distribution and how cohesion with each,also properties of concrete dependent on conditions that the hardening of concrete takes place, and concrete quality dependent some of the properties of concrete mix and that makes it workable , forming , molding and compaction with minimal effort, in general the properties of concrete in fresh and Hardened should check the specifications and conditions of each kind of concrete alone.

All components of concrete processing from cement, fine &coarse aggregate, ceramic waste powder, gum and water, and then work all thenecessary test materials to ensure the quality and suitability for use.Through the constituent material ratios of mixture were amounts materials processed according to their proportions in mix, mixed materials by the mixer for 3 minutes, the sample was taken, to test for workability of the concrete , mould in three equal layers in cube(100*100*100) each layer compacted for 35 times, then recorded all values of slump (mm), the concrete samples processed in cubes for a Compression (7,28 56 days) test and recorded all values of compressive strength (N/mm^2), Figure ((4.11)-(4.15)) show materials and tests.

Figure (4.11): Ceramic Waste Powder before & after Treated

Figure (4.12): Acacia Trotilies Gum Powder and liquid

4.8 Mix Design by British Standard Method

Step-1

*Characteristic Strength =20N/mm^2 at 28days.

*Proportion defective =5%

*From Table (3.4)K =1.64

*From Figure (3.5) standard deviation= 4N/mm^2

*Target mean strength = 20+1.64*4=26.6N/mm^2

Step-2

*Compressive strength from Table (3.5)

*Type of cement O.P.C

*type of aggregate =Uncrushed

*Approximate compressive strength at 28 days =42N/mm^2

*From Figure (3.6) we draw parallel line to the nearest carve strength 26.6N/mm2

*w/c = 0.5 w/c = 0.54 (at strength 26.6N/mm^2)

Step-3

*The water requirement from Table (3.6)

*max size aggregate 20mm - uncrushed - slump (30mm-60mm)

*water requirement=180 kg/m^3

Used=170kg/m^3

Step-4

* Max Cement content= content water/percentage w/c

=170/0.50=340kg/m^3

*Min cement content =170/0.54=314kg/m3

Used=325kg/m^3

Step-5

*Fresh density of concrete water require =170kg/m^3

*Specific gravity aggregate=2.6

*From Figure (3.7) Fresh density of concrete=2390

*Aggregate =density -cement-water

All aggregate =2390-325-170=1895kg/m^3

Step-6

*From Figure (3.8) max size=20mm, slump (30-60), fine aggregate passing from 600mm=50%, w/c = 0.52

*Property fine aggregate=36%

*Coarse aggregate=All aggregate –fine aggregate.

Coarse aggregate=1895*0.36=682kg/m^3

Used =680kg/m^3

*Fine aggregate=all aggregate-coarse aggregate =1895-680=1215kg/m^3

Used=1215kg/m^3

Figure (4.13):Slump Test **Figure(4.14):Cube Test**

Figure (4.15):Compression Test

CHAPTER FIVE

ANALYSIS AND DISCUSSION OF RESULTS

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ANALYSIS AND DISCUSSION OF RESULTS

5.1 Introduction

Laboratory tests were conducted on each of the materials Concrete (Cement - Aggregate - Ceramic waste-fresh concrete and hard concrete)has been added the ceramic powder ratio by different percentage of the weight of cement and used acacia tortilies gum as an additive to concrete mixtures in order to know the impact on the fresh and hardened concrete, and study their impacton the mix concrete. Then the obtained results in this part to fresh and hardened concrete.

5.2 Mix Proportion

The probation of mix, percentage of ceramic waste powder and acacia tortilies gum given in Table (5.1) below:

Table (5.1):Concrete Design Mix (M20) Proportion

<table>
<tr><th colspan="2" rowspan="2">Material
Kg/m^3</th><th rowspan="2">Control Mix</th><th colspan="4">Waste Ceramic powder proportion</th></tr>
<tr><th>5%</th><th>10%</th><th>20%</th><th>30%</th></tr>
<tr><td colspan="2">Cement</td><td>325</td><td>308.75</td><td>292.5</td><td>260</td><td>227.7</td></tr>
<tr><td colspan="2">Ceramic powder</td><td>0</td><td>16.25</td><td>32.5</td><td>65</td><td>97.5</td></tr>
<tr><td colspan="2">Water</td><td>170</td><td>170</td><td>170</td><td>170</td><td>170</td></tr>
<tr><td colspan="2">Fine Aggregate</td><td>680</td><td>680</td><td>680</td><td>680</td><td>680</td></tr>
<tr><td colspan="2">Coarse aggregate</td><td>1215</td><td>1215</td><td>1215</td><td>1215</td><td>1215</td></tr>
<tr><td colspan="2">Acacia Gum%</td><td>----</td><td>----</td><td>----</td><td>0.5</td><td>0.5</td></tr>
<tr><td colspan="2">Cost of cement (SD)</td><td>487.5</td><td>463.13</td><td>438.75</td><td>390.0</td><td>341.55</td></tr>
<tr><th rowspan="2">Kg/m^3</th><th rowspan="2">Cement</th><th rowspan="2">Water</th><th rowspan="2">Fine .A</th><th colspan="2">Coarse.A</th><th rowspan="2">Admixture%</th></tr>
<tr><th>10mm</th><th>20mm</th></tr>
<tr><td>weight</td><td>325</td><td>170</td><td>680</td><td>485</td><td>730</td><td>0.5</td></tr>
<tr><td>volume</td><td>1</td><td>0.52</td><td>2.09</td><td>1.5</td><td>2.25</td><td>---</td></tr>
</table>

5.3 Experimental Methodology

Concrete contains cement, water, and fine, coarse aggregate, with the control concrete, i.e. 5%, 10%, 20% and 30%, of the cement is replaced with ceramic waste,Take required quantities of material and mixed it by machine mixing. Concrete should be filled in mould in three equal layers. Each layer should be compacted for 35 times. The size of standard cubic mold used for compressive strength test (100x100x100) mm, for each mix, nine test cubes were casted in accordance with the standard (BS: part 116:1983) , most of specimen were cured After about 24 h the specimens were de-moulded and water curing was continued till the respective specimens were tested after 7, 28 and 56 days.

5.4 Result Test of fresh and Hardened Concrete

For workability, the value of slump for was taken each mixes and compressive strength performed on compression testing machine used cube samples. Three samples per batch were tested with the average strength values reported and compared with the result of control mix.

5.4.1 Results of Churching Samples

Table ((5.2) from (1-13)) all results of churching

Control Mix (0% Replacement of Cement)

Age Day	Area (mm^2)	Slump (mm)	Failure Load (kn)	Strength (N/mm^2)	Average Strength (N/mm^2)
7	10000	70	409	40.9	26.5
			258	25.8	
			265	26.5	
28			350	35	36.0
			370	37	
			360	36	
56			465	46.5	46.0
			315	31.5	
			445	45.5	

5% Replace cement by ceramic non treat

Age Day	Area ($mm^{2)}$	Slump (mm)	Failure load (kn)	Strength (N/mm^2)	Average Strength (N/mm^2)
7	10000	55	320	32.0	27.5
			270	27.0	
			280	28.0	
28			370	37.0	36.5
			320	32.0	
			360	36.0	
56			465	46.5	46.0
			315	31.5	
			445	45.5	

10% Replacement cement by ceramic powder non treat

Age Day	Area (mm^2)	Slump (mm)	Failure load (kn)	Strength (N/mm^2)	AverageStrengh (N/mm^2)
7	10000	50	320	32.0	27.0
			280	28.0	
			260	26.0	
28			360	36.0	32.5
			320	32.0	
			330	33.0	
56			360	36.0	36.5
			370	37.0	
			360	36.0	

20% Replacement cement by ceramic powder non treat

Age Day	Area (mm^2)	Slump (mm)	Failure load (kn)	Strength (N/mm^2)	Average Strength (N/mm^2)
7	10000	35	250	25.0	25.0
			240	24.0	
			260	26.0	
28			280	28.0	27.0
			250	25.0	
			280	28.0	
56			340	34.0	33.0
			280	28.0	
			320	32.0	

30% Replacement cement by ceramic powder non treat

Age Day	Area (mm^2)	Slump (mm)	Failure load (kn)	Strength (N/mm^2)	AverageStrength (N/mm^2)
7	10000	25	190	19.0	17.0
			160	16.0	
			180	18.0	
28			200	20.0	20.0
			250	25.0	
			200	20.0	
56			280	28.0	29.0
			250	25.0	
			300	30.0	

5%Replacement cement by ceramic powder treat in 550^0c

Age Day	Area (mm^2)	Slump (mm)	Failure load (kn)	Strength (N/mm^2)	Average Strength (N/mm^2)
7	10000	65	340	34.0	32.6
			330	33.0	
			310	31.0	
28			375	37.5	37 .5
			430	43.0	
			370	37.0	
56			410	41.0	42.0
			380	38.0	
			430	43.0	

10% Replacement cement by ceramic powder treat in 550^{0}c

Age Day	Area (mm^2)	Slump (mm)	Failure load (kn)	Strength (N/mm^2)	Average Strength (N/mm^2)
7	10000	60	300	30.0	30.0
			310	31.0	
			290	29.0	
28			340	34.0	35.0
			360	36.0	
			340	34.0	
56			410	41.0	40.5
			420	42.0	
			390	39.0	

20% Replacement cement by ceramic powder treat in 550^{0}c

Age Day	Area (mm^2)	Slump (mm)	Failure load (kn)	Strength (N/mm^2)	Average Strength (N/mm^2)
7	10000	50	260	26.0	26.0
			250	25.0	
			280	28.0	
28			280	28.0	29.0
			300	30.0	
			290	29.0	
56			370	37.0	37.0
			390	39.0	
			360	36.0	

30% Replacement cement by ceramic powder treat in 550^{0}c

Age Day	Area (mm^2)	Slump (mm)	Failure load (kn)	Strength (N/mm^2)	Average Strength (N/mm^2)
7	10000	35	180	18.0	20.0
			220	22.0	
			210	21.0	
28			230	23.0	24.5
			260	26.0	
			240	24.0	
56			330	33.0	32.5
			310	31.0	
			340	34.0	

20% Replacement cement by ceramic powder treat in 700^0c

Age Day	Area (mm^2)	Slump (mm)	Failure load (kn)	Strength (N/mm^2)	Average Strength (N/mm^2)
7	10000	55	280	28.0	27.5
			280	28.0	
			270	28.0	
28			320	32.0	31.5
			300	30.0	
			330	33.0	
56			370	37.0	38.5
			380	38.0	
			395	39.5	

30% Replacement cement by ceramic powder treat in 700^0c

Age Day	Area mm^2	Slump (mm	Failure load (kn)	Strength (N/mm^2)	Average Strength (N/mm^2)
7	10000	45	200	20.0	21,5
			240	24.0	
			210	21.0	
28			290	29.0	27.5
			260	26.0	
			280	28.0	
56			350	35.0	34.0
			330	33.0	
			340	34.0	

20% Replacement cement by ceramic powder treat in 700^0c+0.5%Gum

Age Day	Area (mm^2)	Slump (mm)	Failure load (kn)	Strength (N/mm^2)	Average Strength (N/mm^2)
7	10000	25	280	28.0	28.0
			270	27.0	
			290	29.0	
28			180	18.0	17.5
			170	17.0	
			150	15.0	
56			190	19.0	19.0
			180	18.0	
			200	20.0	

30% Replacement cement by ceramic powder treat in 700^0c+0.5%Gum

Age Day	Area (mm^2)	Slump (mm	Failure load (kn)	Strength (N/mm^2)	Average Strength (N/mm^2)
7	10000	20	220	22.0	23.0
			240	24.0	
			190	19.0	
28			170	17.0	19.0
			180	18.0	
			200	20.0	
56			220	22.0	21.0
			200	20.0	
			210	21.0	

Table (5.3): Compressive Strength (N/mm^2) and Slump (mm)Results for Cubes (100x100x100) mm Mix M20 and Compare with a similar study

Type of Concrete	Waste Ceramic %	Average compressive strength			Slump (mm)
		7day	28da	56day	
Control Mix (M0)	0%	26.5	36.0	46.0	70
Ceramic Wastenon Treat (M1)	5%	27.5	36.5	41.0	55
	10%	27.0	32.5	36.5	50
	20%	24.0	27.0	33.0	35
	30%	17.0	20.0	29.0	25
Ceramic Waste Treat 550^0c (M2)	5%	32.6	37.5	42.0	65
	10%	30.5	35.0	40.5	60
	20%	26.0	29.0	37.0	50
	30%	20.0	24.5	32.5	35
Ceramic Waste Treat 700^0c(M3)	20%	27.5	31.5	38.5	55
	30%	21.5	27.5	34.0	45
Ceramic700^0c+Gum (M4)	20%	28.0	17.5	19.0	25
	30%	23.0	19.0	21.0	20

Table (5.4): Compare of Compressive Strength in 7.28 Days with Similar Study

Type of Concert	Waste Ceramic %	Average compressive strength(N/mm^2)		Compration of compressive strength	
		7days	28days	7day	28day
M0	0%	26.5	36.0	23.55	30.40
M1	10%	27.0	32.5	21.98	28.14
	20%	24.0	27.0	20.38	26.46
	30%	17.0	20.0	18.60	22.98

5.5Analysis of the Results

Slump and compressive strength test results were presented in Figures blow:

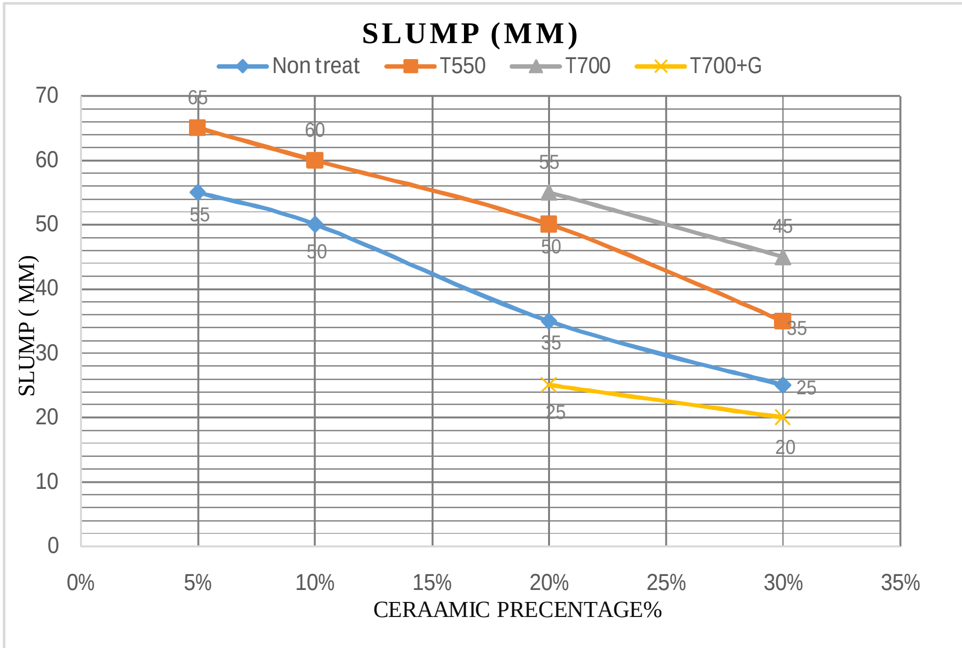

Figure (5.1) Ceramic Waste Percentage% in All Stage V/S Slump (mm)

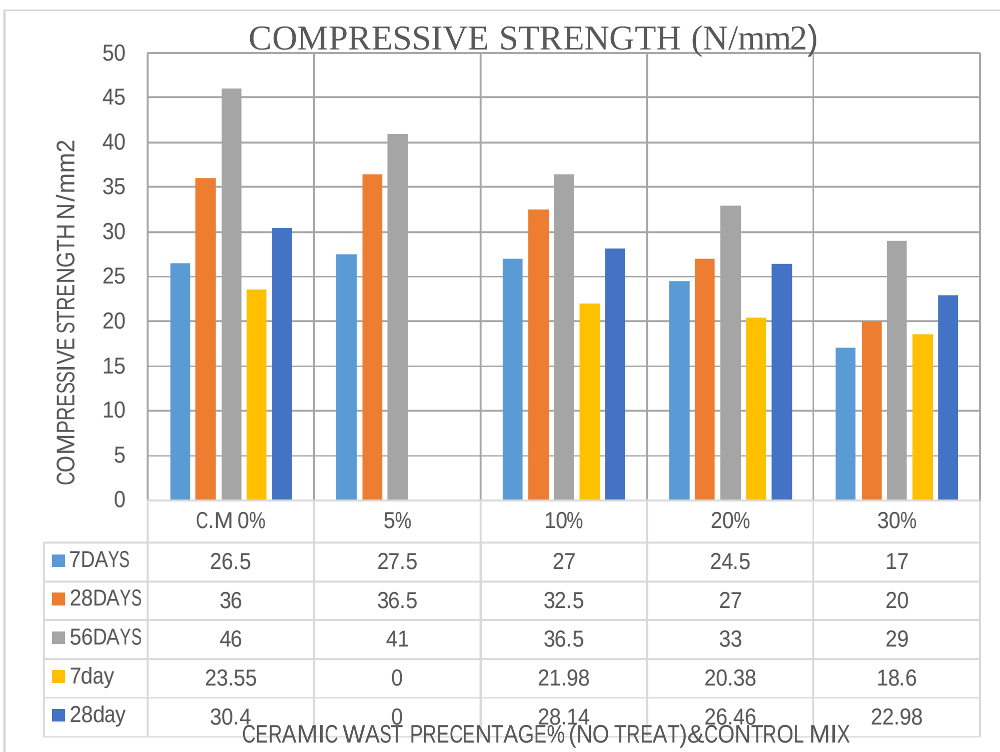

Figure (5.2): Ceramic Waste (Non Treat) &Control Mix V/S Compressive Strength (N/mm^2) of Concrete for Mix M20 at 7, 28 and 56 days and Compere with similar study

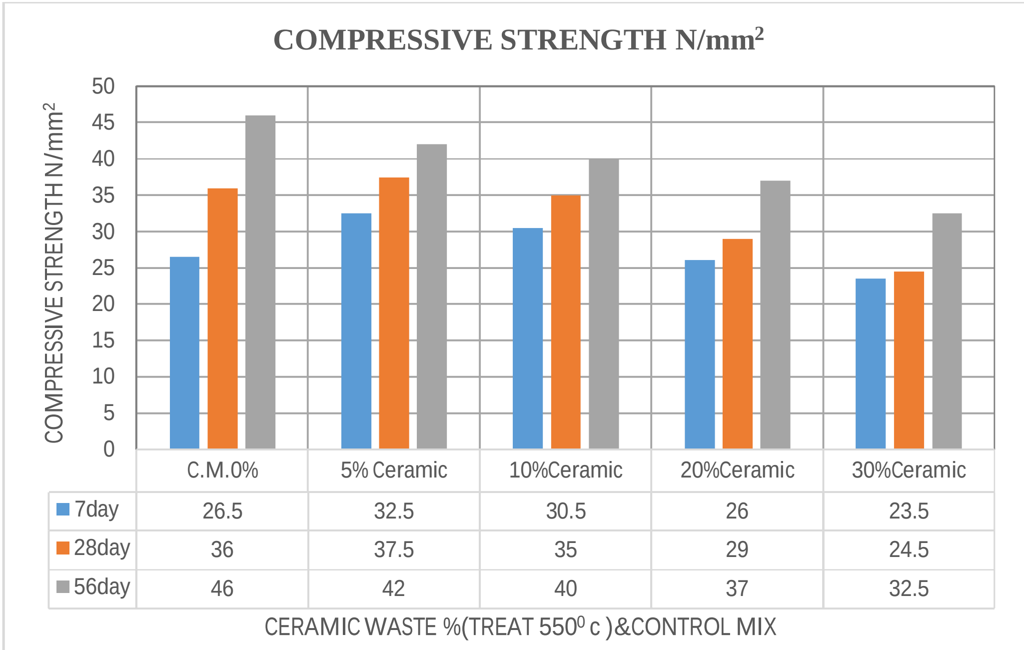

Figure (5.3): Ceramic waste (treated 550^{0}c) &Control Mix V/S Compressive Strength (N/mm^2) of Concrete for Mix M20 at 7, 28 and 56 days

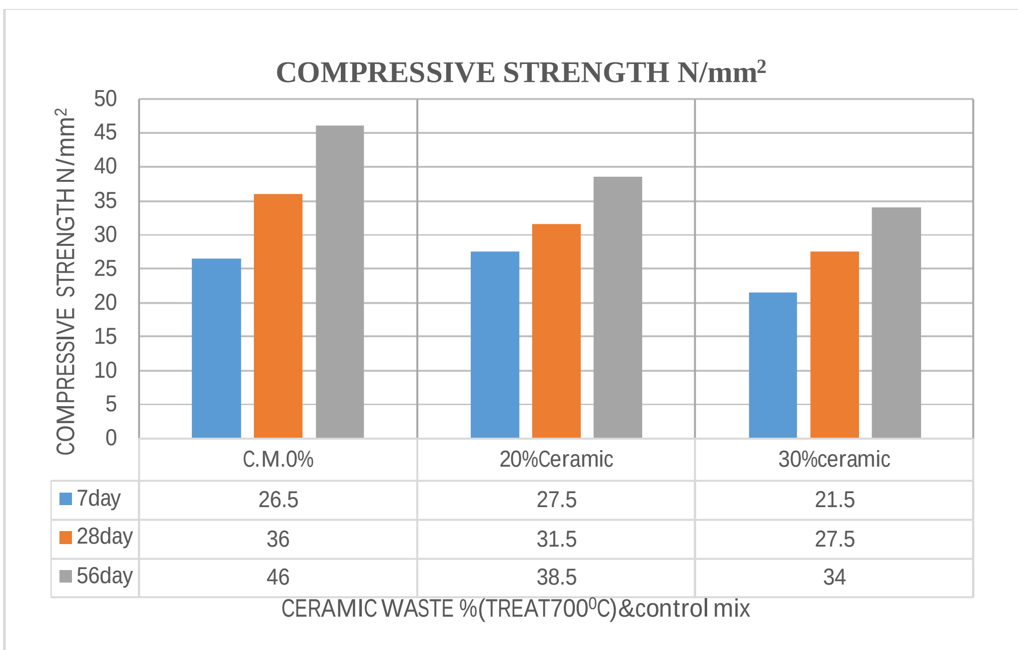

Figure (5.4): Ceramic waste (Treated770^0 c) V/S Compressive Strength (N/mm^2) of Concrete for Mix M20 at 7, 28 and 56 days

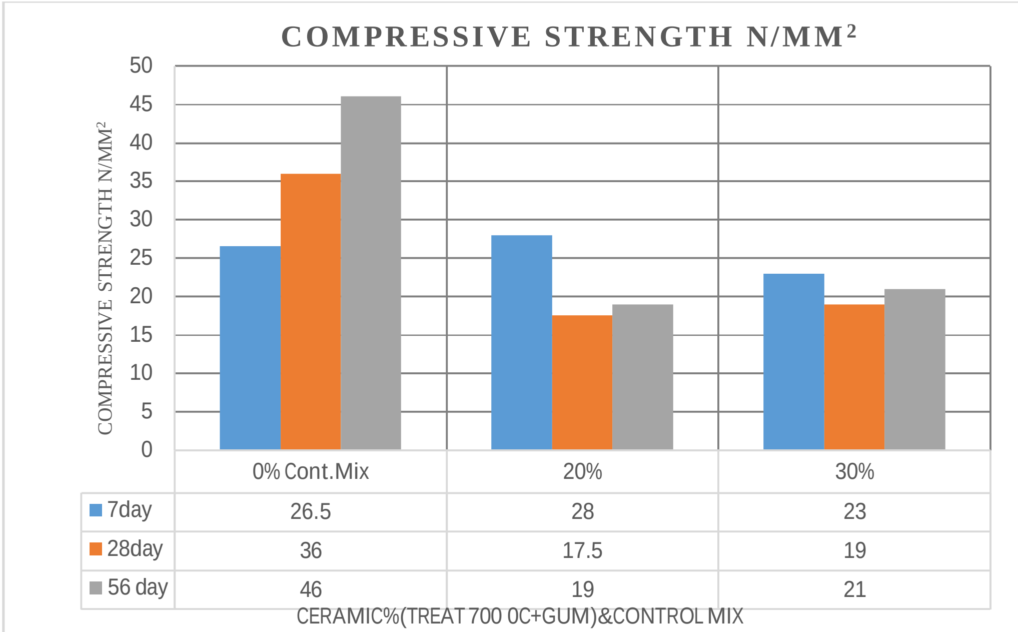

Figure (5.5): Ceramic waste (treated700^{0} c &Gum) V/S Compressive Strength (N/mm^{2}) of Concrete for Mix M20 at 7, 28 and 56 days

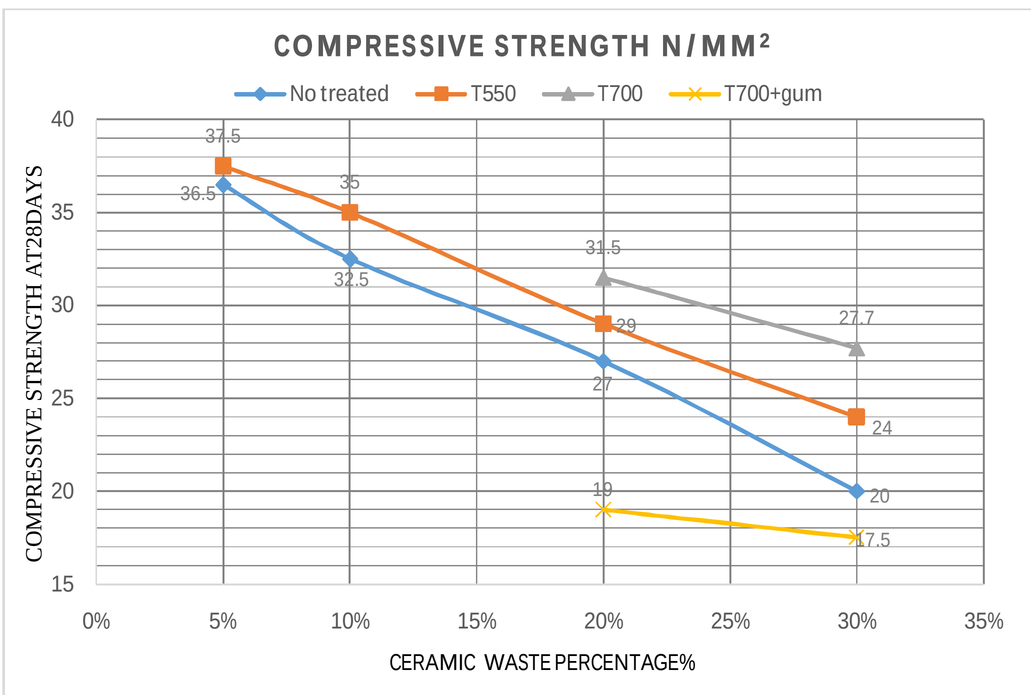

Figure (5.6): Percentage of Ceramic V/S Compressive Strength (N/mm^{2}) M20 mix at 28 days

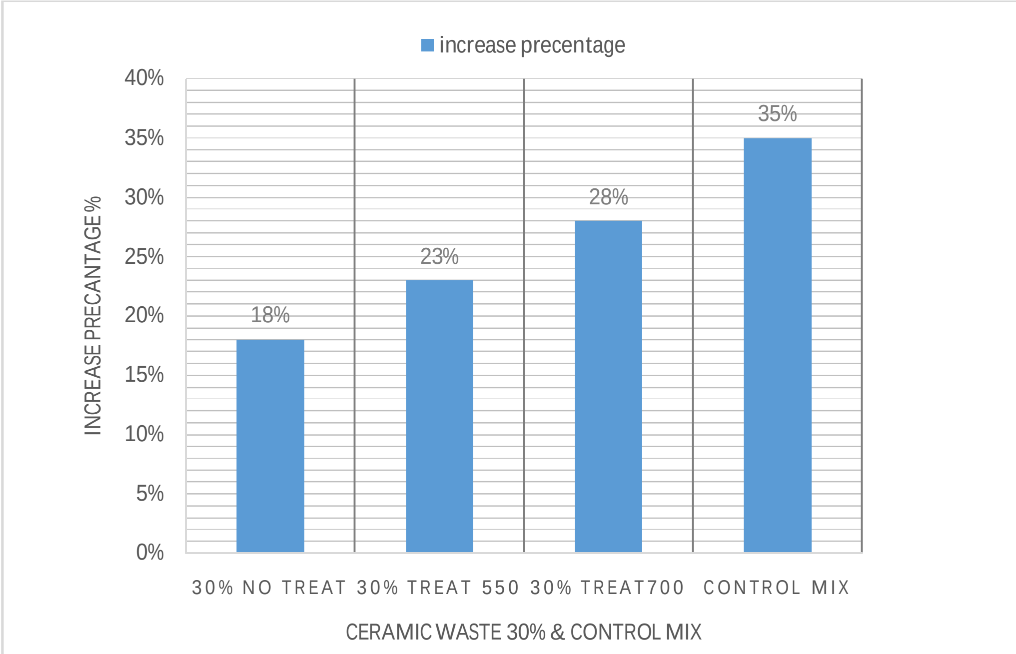

Figure (5.7): Increase Percentage for 30% Replacement And Control Mix from7 to28Day

5.5 Discussion of Results

The results of the study to determine the impact of ceramic residue on the workability of fresh concrete and compressive strength of hardened concrete analysis of the results was punched shown below:

5.5.1 Workability (Slump)

1- From Figure (5.1) and Table (5.3) the slump had been observed, that the fresh concrete slump decreased when increased the proportion of ceramic powder residues in private mix when an increase of 20% or more is due to the proportion of the clay material in the waste, which have the ability absorb water mixing ratio, which in turn affects the amount of water added thus the concrete mix

2- From Figure (5.1) after ceramic powder treated rate of slump increase gradually by increase temperature of burn (550^0 c-700^0 c).

3- Also from Figure (5.1) ,slump degreased when used ceramic powder with acacia trotilies gum by 0.5%

5.5.2 Compressive strength

Through the tests found the direct effect of Ceramics waste impact on the compressive strength, according to the proportions of replacement and the age of the samples:

1- From Table (5.1) mix proportion, Table (5.2(1-13)) all average values of compressive strength from compaction test.
2- From Figure (5.2) and Table (5.3) through laboratory tests, that the compressive strength decreased with increased ceramic powder ratio and increased over time and those of mixtures of non-treat ceramic.
3- From Figure (5.2) Table (5.4) comparison of compressive strength with a similar study [5] at 7 and 28day, when compared the results of compressive at 28day the variation observed in the values in percentages (0%&10%), in (20&30) there is no significant difference.
4- From Figure (5.3) (5.4) and Table (5.3) the compressive strength decreased with increased ratio of ceramic, but increased with over time and with temperature degree of treatment (550^0- agree with similar study of fly ash[13], noted that the addition of ceramic powder by 5% with burn 700^0) in 550^0 c degree gave a best result other than ratios.
5- From Figure (5.4), replacement of cement by 30% ceramic get compressive strength [27.5N/mm^2] greater than concrete grade M_{20} this agree with study[5], and the target strength [26.6N/mm^2], that mean this percentage is ok to replacement by weight of cement.
6- From Figure (5.5) the compressive decreased when add the acacia tortilies gum with ceramic waste to increase the compressive and workability of concrete but did not lead to the desired result. That don’t agree with study [1].
7- From Figure (5.6) the compressive increases with the age of the concrete (28 days) but at the age (7 days) had yielded the same results tend curved waste material. All values of compressive at 28day greater than design strength [20N/mm^2].
8- From Figure (5.7)the percentage of compressive strength increase with curing age of concrete by 18%, 23%& 28% for 30% replacement.
9- Increase in compressive strength of 30% ceramic with non-treat to ceramic with treated 1n 700^0 c by 38% in 28days, in other study [13] this percentage increase by 64% (with low workability).
10-From Table (5.3) reduce cost of cement by saving 30% (487.5SD to 341.55SD) in 1m3.

It is also expected to increase the compressive of concrete in cases:-

- The first increasing compressive with increasing age of curing concrete.
- Second, increase in temperature to get out of the proportion of the clay material in the ceramic waste.

- Reduce of water this lead to decrease the workability of concrete but increase the compressive strength.

Notes:

- decrease of workability may obtained by an increase level of ceramic powder and this may be due to the particles shape of ceramic or due to the degree of fineness, and this may have adverse effect in water demand **.**
- It observed a gradual increase in workability when the case ceramics burned it to reduce the proportion of the existing clay which absorb water
- When recording compressive strength and density of concrete cubes values there was a variation in the values attributed to the process of the preparation of samples of sitting and breakage, as well as the constituent materials for concrete so was taken the average of the values converged at rates ± 10%

When add the acacia tortilies gum (liquid) by percentage 0.5% with the ceramic power by replacement 20%, 30% to cement weight observed fast drying of the mixture which led to obtain a low slump (20,25mm) and varying values of compressive strength the possibility of error in the preparation of sample, or no suitable for use with ceramic powder, or properties are different when using as a liquid.

CHAPTER SIX

CONCLUSION AND RECOMMODATIONS

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CONCLUSION AND RECOMMENDATIONS

6.1 Introduction

Sustainable development is a key towards improving living conditions of the future generations. Thus recycling wastes is only rational and logical step towards conservation of natural resources. The economic aspect of recycling is motivation to proceed in this direction. From the researches discussed, it is clear that ceramic wastes are suitable to be used in the construction industry, andmore significantly on the making of concrete. Ceramic wastes are found to be suitable for usage as substitution for fine and coarse aggregates and partial substitution in cement production.

Researchers have indicated their potential for usage in both structural and non-structural concrete and even for mortars. They were found to be performing better than normal concrete, in properties such as density, durability, permeability and compressive strength. Thus to continue with further research in this area is necessary to make available the information, which will inevitably come handy in the near future.

The results of the experimental investigation were analyzed to study the requirement of the production of concrete and effect Ceramic waste powder and Acacia gum in mixes.

The aim of this work is to check whether of the waste ceramic powder has captured replace as cement in concrete without sacrificing its strength and workability properties

6.2 Conclusions

Various tests were performed in order to know the effect of ceramic waste powder and acacia tortilies gum on cement concrete. Conclusion is based on results discussed are follow as:

1- Proportions obtained of the cement concrete mix in this study are (1:0.52:680:1215) for cement, water, fine and coarse aggregate.

2- The workability and compressive strength decrease when increasing the proportion of ceramic waste but increased when used the treatment ceramic powder in high temperature (550^o-700^o).

3- The workability and compressive strength are decreased when used the ceramic powder with acacia tortilies gum 0.5%.

4- All values of compressive was greater than design compressive strength M20 ($20N/mm^2$) at age 28 days, and 30% replacement was $27.5N/mm^2$ greater than concrete design strength $20N/mm^2$ and target strength $26.6N/mm^2$.

5- 30% that is optimum proportion of replacement ceramic waste powder by weight of cement in concrete.

6- Reduce cost of cement by saving 30% (487.5SD to 341.55SD) in 1m3

6.3 Recommendations

In this research, discussion was made to ceramic waste material requirements and compressive strength was achieved according to British Standard method and Achieved to optimum proportion of ceramic waste powder.

The recommendation for the future studies can follow as:

1-Use different proportion of ceramic waste powder to achieve the better proportion than optimum proportion (30%) obtain in this research.

2-Treatment of ceramic waste powder by burning in more than 700^0c.

3-Use proportions of acacia tortilies gum other than used in this study 0.5%.

4-Use another additive with ceramic waste powder in cement concrete to improve the workability.

5-Try another concrete mixture proportion and material (Aggregate) to achieve high compressive strength with take into account the economic and availability material.

6- Recommend to use the proportion of replacement which has proved in this study (30%) in small sections, blocks, floors and for light ceilings light buildings.

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