Sudan university of Science and Technology

College of Graduate Studies

Effect of Using Basalt and Limestone as Coarse Aggregate in Concrete Mixtures

تأثير استخدام البازلت والحجر الجيري كركام خشن في الخلطات الخرسانية

A Thesis Submitted in Partial Fulfillment of The Requirements for The Degree of Master of Science (M.Sc) in Civil Engineering

(Construction Engineering)

by :

Montaser Hatim AL ameen Ahmed

Supervisor:

Dr. Mona Adam Gumma

January 2020

الآية

قال تعالي :

(وَجَعَلْنَا فِي الْأَرْضِ رَوَاسِيَ أَنْ تَمِيدَ بِهِمْ وَجَعَلْنَا فِيهَا فِجَاجًا سُبُلًا لَعَلَّهُمْ يَهْتَدُونَ**)**

{ الأنبياء 31 }

DEDICATION

Mixed my joy with my graduation and sadness for losing you my Mother, I wish you here with me existed to see that I fulfilled your desire .

My father, Thank you for your unconditional support with my studies. I am honored to be my father. Thank you for giving me a chance to prove and improve myself through all my walks of life.

I would like also to express my gratitude to my beloved family: for their endless love.

Also ,Teachers who paved our way of science and knowledge.

My friends, who stood by me in every moment of my life and taste with me most beautiful moments.

ACKNOWLEDGMENT

All praise and gratitude is due to Allah for all his blessings helping and giving me health, strength and ability to complete this work.

I wish to acknowledge all the support, encouragement and assistance given throughout this research by **Dr. MONA ADAM GOMAA** for being a supervisor and friend , This work would not have been possible without the support from her, sincere thanks

Special thanks to **Eng .Salah Aldeen Ahmed Yousif** general manager of laboratory Material Test and all his team I am very grateful for their helps.

I would like to extend my heart thanks to all those helped me with their invaluable suggestions and advice to complete my research.

ABSTRACT

In this study, concrete mixtures were tested to effect of basalt and limestone as coarse aggregate and evaluate their efficiency on fresh and hardened concrete to achieve the design compressive strengths of [25N/mm2]. By using different proportions is 25%, 50%, 75% and100 %from the weight of coarse aggregate. The study was carried out for 6 types of concrete mixes designed by British Standard, compressive strength of concrete and workability were measured in the reconstruction of maturing for (7, 28 and 56) days. One of those concrete mixes is a design 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 Design Mix.

The study shown the effect of basalt and limestone on workability of fresh concrete by decreasing with the proportion of basalt and limestone ,also for the hardened concrete the specific compressive strength not less than[25N/mm2] at 28 days of curing , It was also found that the ideal ratio for high compressive strength is the use of basalt (100%) , this ratio over the mix design about (27% in 7days & 11% in 28 days and 11.5% in 56 days of curing) and the second ratio is the use of basalt (75%) with limestone (25%) , these ratio decreases with increasing limestone, this is due to the fact that basalt is denser and more durable and less water absorbing than limestone.

المستخلص

في هذه الدراسة , تم اختبار الخلطات الخرسانية لتأثير البازلت والحجر الجيري كركام خشن وتقييم كفاءتها علي الخرسانة الطازجة والمتصلدة لتحقيق قوة ضغط تصميمية (25نيوتن / ملم 2) .

باستخدام نسب مختلفة هي (25 ,50, 75, 100) من وزن الركام الخشن . أجريت الدراسة علي 6 أنواع من الخلطات الخرسانية المصممة وفقا للمعايير البريطانية , وتم قياس قوة الضغط للخرسانة وقابلية التشغيل في فترة معالجة (7 ,28 , 56) يوما. احد هذه الخلطات الخرسانية هو خلطة تصميمية من اجل تحديد النسبة المثلي التي يمكن إضافتها للخرسانة للحصول علي زيادة في قوة الضغط التصميمية مع الوقت . تمت مقارنة هذه النتائج مع الخلطة التصميمية .

أوضحت الدراسة تأثير البازلت والحجر الجيري علي قابلية تشغيل الخرسانة الطازجة من خلال التناقص مع نسبة الحجر الجيري , أما بالنسبة للخرسانة المتصلدة لا تقل قوة الضغط المحددة عن (25 نيوتن / ملم 2) في 28 يوم من المعالجة ووجد أيضا أن النسبة المثلي لإعطاء قوة ضغط تصميمية عالية هي استخدام البازلت (100%) ,وهذه النسبة اكبر من الخلطة التصميمية حوالي (27% في 7يوم , 11% في 28 يوم , 11.5% في 56 يوم للمعالجة) والنسبة الثانية باستخدام بازلت (75%) مع حجر جيري (25%) وتقل هذه النسبة مع زيادة الحجر الجيري ,ويرجع ذلك الي حقيقة ان البازلت اكثر كثافة واقل قدرة علي امتصاص المياه مقارنة بالحجر الجيري .

Contents

List of Tables

List of Figures

Table of symbols

NO	Code	Definition
1	°c	Unit for measuring heat (Celsius scale)
2	°F	Unit for measuring heat (Fahrenheit scale)
3	Ib	Unit for measuring weight (pound)
4	C	Carbon
5	O	Oxygen
6	In	Unit for measuring length (Inches)
7	ASTM	American Society for Testing and Materials
10	Mg	Magnesium
11	S	Sulfur
12	H	Hydrogen
13	CaO	Calcium sulfur
14	Si	Silicon
16	BS	British standard
17	Ft	Unit for measuring length (Feet)
18	PPm	Unit for measuring *parts per million*
19	K	Potassium
21	IS	Indian Code
22	Mm	Unit for measuring length(Millimeter)
23	G	Specific gravity of the aggregate
24	W	Weight of compacted aggregate in cylindrical metal
25	V	Volume of cylindrical metal measure
26	ɣ	Bulk density of the aggregate in Kg/liter
27	AL	Aluminum
28	MNO	Magnesium Oxide
29	Zno	Zinc oxide
30	Cuo	Calcium oxide
31	KN	Kilonewton
32	N/mm2	Newton / Millimeter square
33	Mm2	Millimeter square
34	Mix 1	Mix design contain natural aggregate
35	Mix 2	Mix contain 100% basalt
36	Mix 3	Mix contain 100% limestone
37	Mix 4	Mix contain 50% basalt & 50% limestone
38	Mix 5	Mix contain 75% basalt & 25% limestone
38	Mix 6	Mix contain 25% basalt & 75% limestone

CHAPTER ONE

INTRODUCTION

CHAPTER ONE
INTRODUCTION

1-1 General :

Construction engineering is a professional discipline that deals with the planning, construction and management of infrastructures such as highways, bridges, airports, rail roads, buildings, dams, and reservoirs. Construction of such projects requires knowledge of engineering and management principles and business procedures, economics, and human behavior. Construction engineers engage in the design of structures temporary, cost estimating, planning and scheduling, materials procurement, selection of equipment, and cost control.

Civil engineering is a related field that deals more with the practical aspects of projects. Construction engineers learn some of the design aspects similar to civil engineers as well as project site management aspects.

Education for construction engineers is primarily focused on construction procedures, methods, costs, schedules and personnel management. Their primary concern is to deliver a project on time within budget and of the desired quality.

In large construction projects, such as skyscrapers, cranes are essential Construction engineering is differentiated from Construction management from the standpoint of the use of mathematics, science and engineering to analyze problems and design a construction process. A good familiarity with reading blueprints is necessary because Construction engineers build many of the things that people use every day. Construction engineering involves many aspects of construction including: commercial, residential, bridges, airports, tunnels, and dams. It is an extremely large industry that provides jobs to many and continues to grow.

1-2 Research Problem :

Since approximately three-quarters of the volume of concrete is occupied by aggregate, it is not surprising that its quality is of considerable importance. Not only may the aggregate limit the strength of concrete but the aggregate properties greatly affect the durability and structural performance of concrete.

Related to important role of aggregate in concrete mix to improvement of properties by use other aggregate without natural aggregate . In this research used basalt and limestone considered the benefits and weaknesses of in concrete have been broadly studied .

1-3 Questions of the Research:

Basalt and limestone may be suitably used as an alternative partial replacement to aggregate in structural concrete.

As Follows:

1-What is the impact of using basalt and limestone on the properties of the fresh and hardened concrete (compressive strength and workability)?

2- What is the optimum ratio that can be used of basalt and limestone?

3- Can you compare basalt and limestone with aggregate?

1-4 Objectives of the research:

The main Objectives of the research including:-

1- studying the impact of using basalt & limestone as aggregate on the properties of the fresh and hardened concrete .

2-To carry out different tests on basalt and limestone and compare their result.

3- Use different ratio of basalt & limestone to investigate effect of the replacement on the properties of concrete.

4- Compare and discuss the result of workability and compressive strength between basalt & limestone and natural aggregate.

1-5 Methodology of study :

In this study, It will be analysis of the chemical and physical properties of natural aggregate and basalt & limestone to be used as partial replacement of natural aggregate in concrete. Also The necessary tests was done to components of the concrete i.e. cement, fine and coarse aggregates, water and (natural aggregate and basalt & limestone) depending on references and previous studies.

The workability and compressive strengths at 7, 28 and 56 days of curing of concrete cubes will be analysis. 6 trial mixes by partial replacement of aggregate by weight were prepared by using British standard method , namely:

- Mix design , using normal aggregate by ratio of replacement 0%
- Five mixes, using basalt & limestone by replacement ratio (25%,50% , 75% & 100%) of coarse aggregate.

1-6 Research lay out :

This study contains many of chapters are follow as:

- Chapter One contains general introduction, Research Problem, Questions of Research, Objectives of the research and methodology of study.
- Chapter Two presented comprehensive literature review, Also the materials & tests use in this study such as cement , aggregate, water , basalt ,limestone , Concrete mix design by British Standard and previous research.
- Chapter Three presented the materials test and results.
- Chapter Four design the mixes, result of experiment, result and discussion, and draw result in charts
- Chapter Five contains conclusion and recommendations.

CHAPTER TWO

LITERATURE REVIEW AND THEORETICAL STUDY

CHAPTER TWO
LITERATURE RIVEW AND THEORETICAL STUDY

2-1 Introduction:

Concrete, in the broadest sense, is any product or mass made by the use of a cementing medium. Generally, this medium is the product of reaction between hydraulic cement and water. But, these days, even such a definition would cover a wide range of products: concrete is made with several types of cement and also containing pozzolan, fly ash, blast-furnace slag, micro- silica, additives, recycled concrete aggregate, admixtures, polymers, fibres, and so on; and these concretes can be heated, steam-cured, autoclaved, vacuum-treated, hydraulically pressured, shock-vibrated, extruded, and sprayed.

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 .Also the recycle aggregate has long been recognized to have the potential to conserve natural resources and decrease energy used in production .using of recycle aggregate after treatment and combined with natural aggregate by replacement proportion as a coarse or fine aggregate .Also we can use partial replacement marble or granite stone recycle or natural combined in concrete mixtures and soon.(Neville A.M, 2003)

2-2 Concrete Material :

A composite material is made up of various constituents. The properties and characteristics of the composite are functions of the constituent materials' properties as well as the various mix proportions .

Before discussing the properties of the composite, it is necessary to discuss those of the individual constituents as well as the effects of the mix proportions and methods of production .(Bang seng.C,John.N ,2003)

2-2-1 Cement :

Ancient Romans were probably the first to use concrete a word of Latin origin based on hydraulic cement, that is a material which hardens under water. This property and the related property of not undergoing chemical change by water in later life are most important and have contributed to the widespread use of concrete as a building material. Roman cement fell into disuse, and it was only in 1824 that the modern cement, known as Portland cement, was patented by Joseph Aspdin, a Leeds builder.(Neville A.M. , 2003)

Portland cement is the name given to a cement obtained by intimately mixing together calcareous and argillaceous, or other silica, alumina, and iron oxide-bearing materials, burning them at a clinkering temperature, and grinding the resulting clinker. The definitions of the original British and new European Standards and of the American Standards are on those lines; no material, other than gypsum, water, and grinding aids may be added after burning.

A. Manufacture of Portland cement :

From the definition of Portland cement given above, it can be seen that it is made primarily from a combination of a calcareous material, such as limestone or chalk, and of silica and alumina found as clay or shale. The process of manufacture consists essentially of grinding the raw materials into a very fine powder, mixing them intimately in predetermined proportions and burning in a large rotary kiln at a temperature of about 1400 °C (2550 °F) when the material sinters and partially fuses into clinker. The clinker is cooled and ground to a fine powder, with some gypsum added, and the resulting product is the commercial Portland cement used through-out the world.

The mixing and grinding of the raw materials can be done either in water or in a dry condition; hence, the names wet and dry process. The mixture is fed into a rotary kiln, sometimes (in the wet process) as large as 7 m (23 ft) in diameter and 230 m (750 ft) long. The kiln is slightly inclined. The mixture is fed at the upper end while pulverized coal (or other source of heat) is blown in by an air blast at the lower end of the kiln, where the temperature may reach about 1500°C (2750 °F). The amount of coal required to manufacture one tone (2200 lb) of cement is between 100 kg (220 lb) and about 350 kg (770 lb), depending on the process used. Nowadays, gas and various combustible materials are also used.

As the mixture of raw materials moves down the kiln, it encounters a progressively higher temperature so that various chemical changes take place along the kiln: First, any water is driven off and CO_2 is liberated from the calcium carbonate. Further on, the dry material undergoes a series of chemical reactions until, finally, in the hottest part of the kiln, some 20 to 30 per cent of the material becomes liquid, and lime, silica and alumina recombine. The mass then fuses into balls, 3 to 25 mm (½ to 1 in.) in diameter, known as clinker.

Afterwards, the clinker drops into coolers, which provide means for an exchange of heat with the air subsequently used for the combustion of the pulverized coal. The cool clinker, which is very hard, is underground with gypsum in order to prevent flash-setting of the cement. The ground material, that is cement, has as many as 1.1 x 10^{12} particles per kilogramme (0.5 x 10^{12} per lb).

B- Types of Portland cement :

The American Society for Testing and Materials (ASTM) defines five types of cement, specifying for each the mineral composition and chemical and physical characteristics such as fineness. The most common cement is Type I . Type III cement is used if more rapid strength development is required. The other types are characterized by either lower heat of hydration or better sulfate resistance than that of Type I cement.

C- 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(2.1) below:

Table (2.1): Portland cement types ASTM C150

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

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

Table (2.2): General Features of the Main Types of Portland cement according to British standard

Type	Classification	Characteristics	Applications
Type I	General purpose	Fairly high C_3S content for good early strength development	General construction (mostbuildings, ridges ,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 C3S	Rapid construction, cold weather concreting
Type IV	Low heat of hydration (slow reacting)	Low content of C3S (<50%) and C_3A	Massive structures such as dams.
Type V	High sulfate resistance	Very low C_3A content (<5%)	Structures exposed to high levels of sulfateions
White	White color	No C_4AF, low Mg O	Decorative (otherwise has properties similar to Type I)

D- Basic chemistry of cement:

We have seen that the raw materials used in the manufacture of Portland cement consist mainly of lime, silica, alumina and iron oxide. These compounds interact with one another in the kiln to form a series of more complex products, and, apart from a small residue of uncombined lime which has not had sufficient time to react, a state of chemical equilibrium is reached. However, equilibrium is not maintained during cooling, and the rate of cooling will affect the degree of crystallization and the amount of amorphous material present in the cooled clinker. The properties of this amorphous material, known as glass, differ considerably from those of crystalline compounds of a nominally similar chemical composition. Another complication arises from the interaction of the liquid part of the clinker with the crystalline compounds already present.

Nevertheless, cement can be considered as being in frozen equilibrium, i.e. the cooled products are assumed to reproduce the equilibrium existing at the clinkering temperature. This assumption is, in fact, made in the calculation of the compound compos1t10n of commercial cements: the 'potential' composition is calculated from the measured quantities of oxides present in the clinker as if full crystallization of equilibrium products had taken place.

Four compounds are regarded as the major constituents of cement: they are listed in Table 2.1 together with their abbreviated symbols. This shortened notation, used by cement chemists, describes each oxide by one letter, viz.: CaO = C; SiO_2 = S; $Alz0_3$ = A; and Fe_2O_3 = F. Likewise, H_2O in hydrated cement is denoted by **H.**

Table 2.3: Main compounds in Portland cement

Name of compound	Oxide composition	Abbreviation
Tricalcium silicate	$3CaO.SiO_2$	C_3S
Dicalcium silicate	2CaO.SiO2	C_2S
Tricalcium aluminate	$3CaO.Al_2O_3$	C_3A
Tetracalcium aluminoferrite	$4CaO.Al_2O_3.Fe\ _2O_3$	C4AF

The silicates, C_3S and **C_2S,** are the most important compounds ,which are responsible for the strength of hydrated cement paste. In reality, the silicates in cement are not pure compounds, but contain minor oxides in solid solution. These oxides have significant effects on the atomic arrangements, crystal form, and hydraulic properties of the silicates.

The presence of C_3A in cement is undesirable: it contributes little or nothing to the strength of cement except at early ages, and when hardened cement paste is attacked by sulfates, the formation of calcium sulfo-aluminate (ettringite) may cause disruption. However, C_3A is beneficial in the manufacture of cement in that it facilitates the combination of lime and silica.

C_4AF is also present in cement in small quantities, and, compared with the other three compounds, it does not affect the behaviour significantly; however, it reacts with gypsum to form calcium sulfoferrite and its presence may accelerate the hydration of the silicates.

The amount of gypsum added to the clinker is crucial, and depends upon the C_3A content and the alkali content of cement. Increasing the fineness of cement has the effect of increasing the quantity of C_3A available at early ages, and this raises the gypsum requirement. An excess of gypsum leads to expansion and consequent disruption of the set cement paste. The optimum gypsum content is determined on the basis of the generation of the heat of hydration so that a desirable rate of early reaction occurs, which ensures that there is little C_3A available for reaction after all the gypsum has combined. ASTM C 150-05 and BS EN 197-1 specify the amount of gypsum as the mass of sulfur trioxide (SO_3) present.

In addition to the main compounds listed in Table 2.1, there exist minor compounds, such as MgO, TiO_2, Mn_2O_3, KP, and Na_2O; they usually amount to not more than a few per cent of the mass of cement. Two of

the minor compounds are of interest: the oxides of sodium and potassium, Na_2O and K_20, known as the alkalis (although other alkalis also exist in cement). They have been found to react with some aggregates, the pro- ducts of the alkali-aggregate reaction causing disintegration of the concrete, and have also been observed to affect the rate of the gain of strength of cement. It should, therefore, be pointed out that the term 'minor compounds' refers primarily to their quantity and not necessarily to their importance.

E- Hydration of cement :

• Heat of hydration and strength :

In common with many chemical reactions, the hydration of cement compounds is exothermic, and the quantity of heat (in joules) per gram of un hydrated cement, evolved upon complete hydration at a given temperature, is defined as the heat of hydration. Methods of determining its value are described in **BS** 4550: Part 3: Section 3.8: 1978, and in **ASTM** C 186-05.

The temperature at which hydration occurs greatly affects the rate of heat development, which for practical purposes is more important than the total heat of hydration; the same total heat produced over a longer period can be dissipated to a greater degree with a consequent smaller rise in temperature.

For the usual range of Portland cements, about one-half of the total heat is liberated between 1 and 3 days, about three-quarters in 7 days, and nearly 90 per cent in 6 months. In fact, the heat of hydration depends on the chemical composition of the cement, and is approximately equal to the sum of the heats of hydration of the individual pure compounds when their respective proportions by mass are hydrated separately.

2-2-2 AGGREGATES:

A- Introduction :

Aggregate is a broad encompassing boulders, cobbles, crushed stone, gravel, air-cooled blast furnace slag, native and manufactured sands, and manufactured and natural lightweight aggregates. Aggregates may be further described by their respective sizes.

Aggregate was originally viewed as an inert, inexpensive material dispersed throughout the cement paste so as to produce a large volume of concrete. In fact, aggregate is not truly inert because its physical, thermal and, sometimes, chemical properties influence the performance of concrete, for example, by improving its volume stability and durability over that of the cement paste. From the economic viewpoint, it is advantageous to use a mix with as much aggregate and as little cement as possible, but the cost benefit has to be balanced against the desired properties of concrete in its fresh and hardened state.

Aggregates comprise the greatest volume percentage in Portland cement concrete, mortar, or asphaltic concrete. In a Portland cement concrete mix, the coarse and fine aggregates occupy about 60 to 75% of the total mix volume. For asphaltic concrete, the aggregates represent 75 to 85% of the mix volume. Consequentially, the aggregates are not inert filler materials. The individual aggregate properties have demonstrable effects on the service life and durability of the material system in which the aggregate is used, such as Portland cement concrete, asphaltic concrete, mortar, or aggregate base.

Natural aggregates are formed by the process of weathering and abrasion, or by artificially crushing a larger parent mass. Thus, many properties of the aggregate depend on the properties of the parent rock, e.g. chemical and mineral composition, petrographic classification, specific gravity, hardness, strength, physical and chemical stability, pore structure, colour, etc. In addition, there are other properties of the aggregate which are absent in the parent rock: particle shape and size, surface texture and absorption. All these properties may have a considerable influence on the quality of fresh or hardened concrete.

The acceptability of a coarse or fine aggregate for use in concrete or mortar is judged by many properties including gradation, amount of fine material passing the No. 200 sieve, hardness, soundness, particle shape, volume stability, potential alkali reactivity, resistance to freezing and thawing, and organic impurities.

B- Classification of aggregates :

The principal requirements for an aggregate to be suitable for concrete are that it will be strong, durable and inert. The individual particles ideally must be of equant shape and be evenly graded from coarse to fine within their particular grading size fraction. Classification of aggregates beyond the broad categories of crushed rock, sand and gravel must be appropriate to its use in the construction industry and have both a scientific and a commercial viability. A petrographic description can be of considerable value in any assessment of the likely performance of a particular rock type, but the geological name is only of importance in that it implies that there will be a set of physical and mechanical properties which are very broadly typical of that particular material. In an early consideration of the practical classification of aggregates the British Standards Institution in 1973 recognized eleven ‘Trade Groups’ of rocks (BS 812, 1975), each group containing a number of individual rock types classified into their particular group on the basis of the assumed similarities of the physical and mechanical properties they shared.

In general terms the accepted recommended approach to the description and classification of any aggregate requires a three-stage description:

a. A description of the aggregate type (sand, gravel, crushed rock)
b. A description of the physical characteristics (particle shape, size, grading)
c. A petrographic description and classification (mineralogy, geological name)

C- Shape and texture classification :

The external characteristics of the aggregate, in particular the particle shape and surface texture, are of importance with regard to the properties of fresh and hardened concrete. The shape of three-dimensional bodies is difficult to describe, and it is convenient to define certain geometrical characteristics of such bodies.

Roundness measures the relative sharpness or angularity of the edges and corners of a particle. The actual roundness is the consequence of the strength and abrasion resistance of the parent rock and of the amount of wear to which the particle has been subjected. In the case of crushed aggregate, the shape depends on the nature of the parent material and on the type of crusher and its reduction ratio, i.e. the ratio of initial size to that of the crushed product. A convenient broad classification of particle shape is given in Table 2-4.

Table 2.4: Particle shape classification of aggregates with example

Classification	Description	Examples
Rounded	Fully water-worn or completely shaped by attrition	River or seashore gravel; desert, seashore and wind-blown sand
Irregular	Naturally irregular, or partly shaped by attrition and having rounded edges	Other gravels; land or dug flint
Flaky	Material of which the thickness is small relative to the other two dimensions	Laminated rock
Angular	Possessing well-defined edges formed at the intersection of roughly planar faces	Crushed rocks of all types; talus; crushed slag
Elongated	Material, usually angular, in which the length is considerably larger than the other two dimensions	
Flaky and Elongated	Material having the length considerably larger than the width, and the width considerably larger than the thickness	

D- Mechanical properties :

1- Bond :

Both the shape and the surface texture of aggregate influence considerably the strength of concrete, especially so for high strength concretes; flexural strength is more affected than compressive strength. A rougher texture results in a greater adhesion or bond between the particles and the cement matrix. Likewise, the larger surface area of a more angular aggregate provides a greater bond.(Neville A.M. , 2003)

2- Strength :

Clearly, the compressive strength of concrete cannot significantly exceed that of the major part of the aggregate contained therein, although it is not easy to determine the crushing strength of the aggregate itself. A few weak particles can certainly be tolerated; after all, air voids can be viewed as aggregate particles of zero strength.

3- Hardness :

Hardness, or resistance to wear, is an important property of concrete used in roads and in floor surfaces subjected to heavy traffic. The aggregate abrasion value (AAV) is assessed using BS 812-113: 1990.

E- Physical properties :

Several common physical properties of aggregate, of the kind familiar from the study of elementary physics, are relevant to the behavior of aggregate in concrete and to the properties of concrete made with the given aggregate. These physical properties of aggregate and their measurement will now be considered.

1- Specific gravity :

Since aggregate generally contains .pores, both permeable and impermeable, the meaning of the term specific gravity (or relative density) has to be carefully defined, and there are indeed several types of this measure. According to ASTM C 127-04, specific gravity is defined as the ratio of the density of a material to the density of distilled water at a stated temperature; hence, specific gravity is dimensionless. BS 812-2: 1995 and **BS** EN 1097-3: 1998 use the term particle density, expressed in kg/m^3 Thus particle density is numerically 1000 times greater than specific gravity.

2- Bulk density :

It is well known that in the metric system the density (or unit weight in air, or unit mass) of a material is numerically equal to the specific gravity although, of course, the latter is a ratio while density is expressed in kilogrammes per litre, e.g. for water, 1.00 kg per litre. However, in concrete practice, expressing the density in kilogrammes per cubic metre is more common. In the American system, the absolute specific gravity has to be multiplied by the unit mass of water (62.4 lb/ft^3) in order to be converted into absolute density expressed in pounds per cubic foot.

3- Porosity and absorption :

The porosity, permeability and absorption of aggregate influence the bond between it and the cement paste, the resistance of concrete to freezing and thawing, as well as chemical stability, resistance to abrasion, and specific gravity.

The pores in aggregate vary in size over a wide range, but even the smallest pores are larger than the gel pores in the cement paste. Some of the aggregate pores are wholly within the solid whilst others open onto the surface of the particle so that water can penetrate the pores, the amount and rate of penetration depending on their size, continuity and total volume. The range of porosity of common rocks varies from 0 to 50 per cent.

4- Moisture content :

Since absorption represents the water contained in the aggregate in a saturated, surface-dry condition, we can define the moisture content as the water in excess of the saturated and surface-dry condition. Thus, the total water content of a moist aggregate is equal to the sum of absorption and moisture content.

F-Thermal properties :

There are three thermal properties that may be significant in the performance of concrete: coefficient of thermal expansion, specific heat, and conductivity. The last two are of interest in mass concrete to which insulation is applied, but usually not in ordinary structural work. The coefficient of thermal expansion of aggregate determines the corresponding value for concrete, but its influence depends on the aggregate content of the mix and on the mix proportions in general .

G- Deleterious substances :

There are three broad categories of deleterious substances that may be found in aggregate: impurities which interfere with the processes of hydration of cement, coatings preventing the development of good bond between aggregate and cement paste, and certain individual particles which are weak or unsound in themselves. These harmful effects are distinct from those due to the development of chemical reactions between the aggregate and the cement paste, such as alkali-silica and alkali-carbonate reactions. The aggregate may also contain chloride or sulfate salts; methods of determining their contents are prescribed by BS 812-117 and 812-118: 1988, respectively, and by **BS** EN 1744-1: 1998.

2-2-3 Water :

A- Quality of water :

The quality of the water is important because impurities in it may interfere with the setting of the cement, may adversely affect the strength of the concrete or cause staining of its surface, and may also lead to corrosion of the reinforcement. For these reasons, the suitability of water for mixing and curing purposes should be considered. Clear distinction must be made between the effects of mixing water and the attack on hardened concrete by aggressive waters because some of the latter type may be harmless or even beneficial when used in mixing.

B- Mixing water:

In many specifications, the quality of water is covered by a clause saying that water should be fit for drinking.

Such water very rarely contains dissolved solids in excess of 2000 parts per million (ppm), and as a rule less than 1000 ppm. For a water/cement ratio of 0.5 by mass, the latter content corresponds to a quantity of solids equal to 0.05 per cent of the mass of cement, and thus any effect of the common solids (considered as aggregate) would be small. If the silt content is higher than 2000 ppm, it is possible to reduce it by allowing the water to stand in a settling basin before use. However, water used to wash out truck mixers is satisfactory as mixing water (because the solids in it are proper concrete ingredients), provided of course that it was satisfactory to begin with. **ASTM** C 94-05 allows the use of wash water, but, obviously, different cements and different admixtures should not be involved.

The criterion of potability of water is not absolute: drinking water may be unsuitable as mixing water when the water has a high concentration of sodium or potassium and there is a danger of alkali-aggregate reaction.

2-2-4 Basalt :

Basalt is an a phanitic (fine grained) igneous rock with generally 45–53% silica (SiO_2) and less than 10% feldspathoid by volume, and where at least 65% of the rock is feldspar in the form of plagioclase. This is as per definition of the International Union of Geological Sciences (IUGS) classification scheme. It is the most common volcanic rock type on Earth, being a key component of oceanic crust as well as the principal volcanic rock in many mid-oceanic islands. Basalt is a volcanic equivalent of gabbro. The difference between basalt and gabbro is that basalt is a fine-grained rock while gabbro is a coarse-grained rock.

Basalt is defined by its mineral content and texture, and physical descriptions without mineralogical context may be unreliable in some circumstances. Basalt is usually grey to black in colour , but rapidly weathers to brown or rusted due to oxidation of its mafic (iron-rich) minerals into hematite and other iron oxides and hydroxides.

A- Basalt-Forming Environments :

Most of the basalt found on Earth was produced in just three rock-forming environments:

1) Oceanic divergent boundaries.

2) Oceanic hotspots.

3) Hotspots beneath continents.

B- Uses of Basalt :

Basalt is used for a wide variety of purposes. It is most commonly crushed for use as an aggregate in construction projects. Crushed basalt is used for road base, concrete aggregate, asphalt pavement aggregate, railroad ballast, filter stone in drain fields, and may other purposes. Basalt is also cut into dimension stone. Thin slabs of basalt are cut and sometimes polished for use as floor tiles, building veneer, monuments, and other stone objects.

C- Metamorphism and weathering :

Basalt is largely composed of minerals with little resistance to weathering. Hence, basalt as a whole also tends to disintegrate faster than granite and other felsic rock types. Magnetite is one of the most resistant common minerals in basalt and forms the bulk of heavy mineral sands. Other minerals disintegrate and release their components to water as ions or form clay minerals. Iron and aluminum are among the least mobile ions and therefore tend to form laterite deposits enriched in these elements.

Basalt metamorphoses to a number of different rock types, depending on pressure, temperature, and the nature of volatile compounds that react with minerals in basalt. Most common metamorphic rocks with basaltic protolith are chlorite schist, amphibolites, blueschist, and eclogite.

2-2-5 Limestone :

Limestone is one of the most common types of rock found on the surface of the Earth. About 10% of the land surface of our planet is made of limestone or similar types of rock; while around 25% of the world's population either live on or take their water from limestone. It is thought that 50% of all our oil and gas reserves are trapped in limestone buried beneath the surface.

The rock limestone is mostly made up of one of two types of mineral either calcite or aragonite. Both of these are different crystal arrangements of the same chemical compound calcium carbonate ($CaCO_3$).

A- Limestone is a special type of rock for several reasons :-

- It is most commonly made by microscopic organisms living in the sea
- It can be dissolved in natural waters – allowing caves, shafts, natural bridges and sculptured rock outcrops to form (like those found in the Waitomo area).
- It is the essential ingredient in making agriculture lime and cement.
- Limestone was also used to build the Egyptian pyramids, the Taj Mahal and the Greek Parthenon (all of these are now being slowly dissolved by acids in the atmosphere).

B- Examples of Limestone :

Marble :

Buried limestone that has been caught in an active part of the Earth's crust can suffer huge increases in temperature and pressure. These can compress, melt, and then re crystallize the original limestone further to form a very beautiful and hard rock – the famous marble. New Zealand's deepest caves are found in the marble mountains of the northwest South Island.

Dolomite :

Magnesium (Mg) is an element similar to Ca that also forms a carbonate. While limestone is mostly $CaCO_3$, if it has high levels of magnesium then it is known as a dolomite as found in the Dolomite Mountains of Italy.

Chalk :

This variety of limestone is entirely made up of small "coccoliths" - shells from a form of algae. It is un compacted and little cemented compared to other limestone it is found today almost as it was when laid down on the seabed.

2-2-6 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.

(obtained from Table 2.5). s = the standard deviation [k = 1.64 for 5 % defect]

(obtained from Figure 2.1).

Table (2.5): K Value

Defective	Constant
1%	2.33
2.5%	1.96
5%	1.65

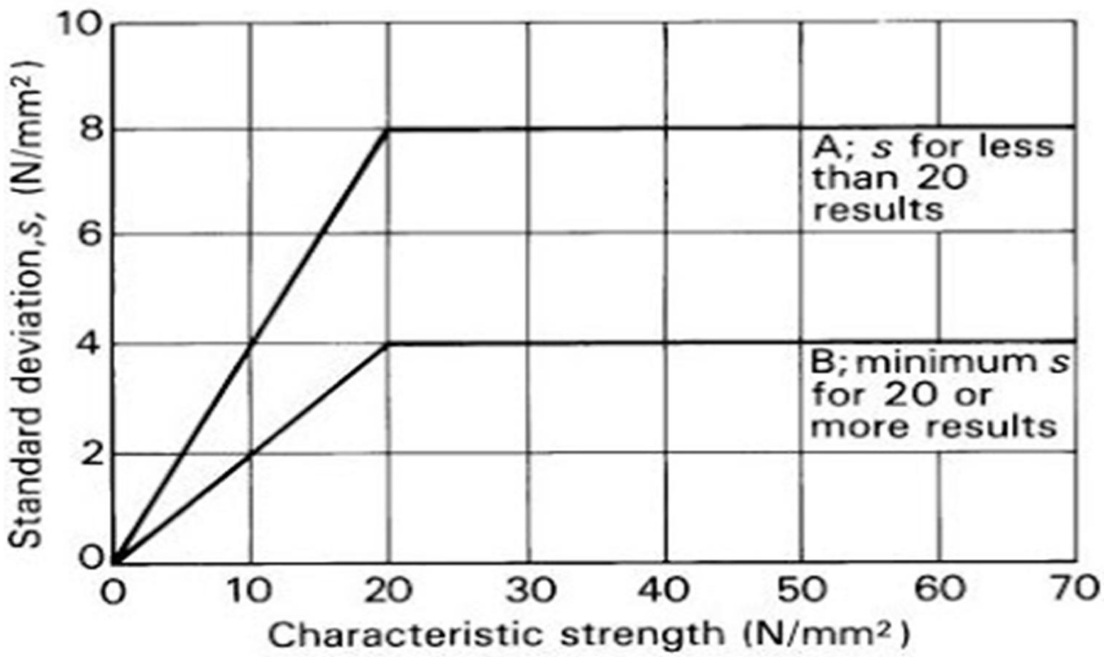


Figure (2.1): Relationship between standard deviation and characteristic strength.

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 (2.6): 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	Uncrushe d	29	37	48	54
	Crushed	34	43	55	61

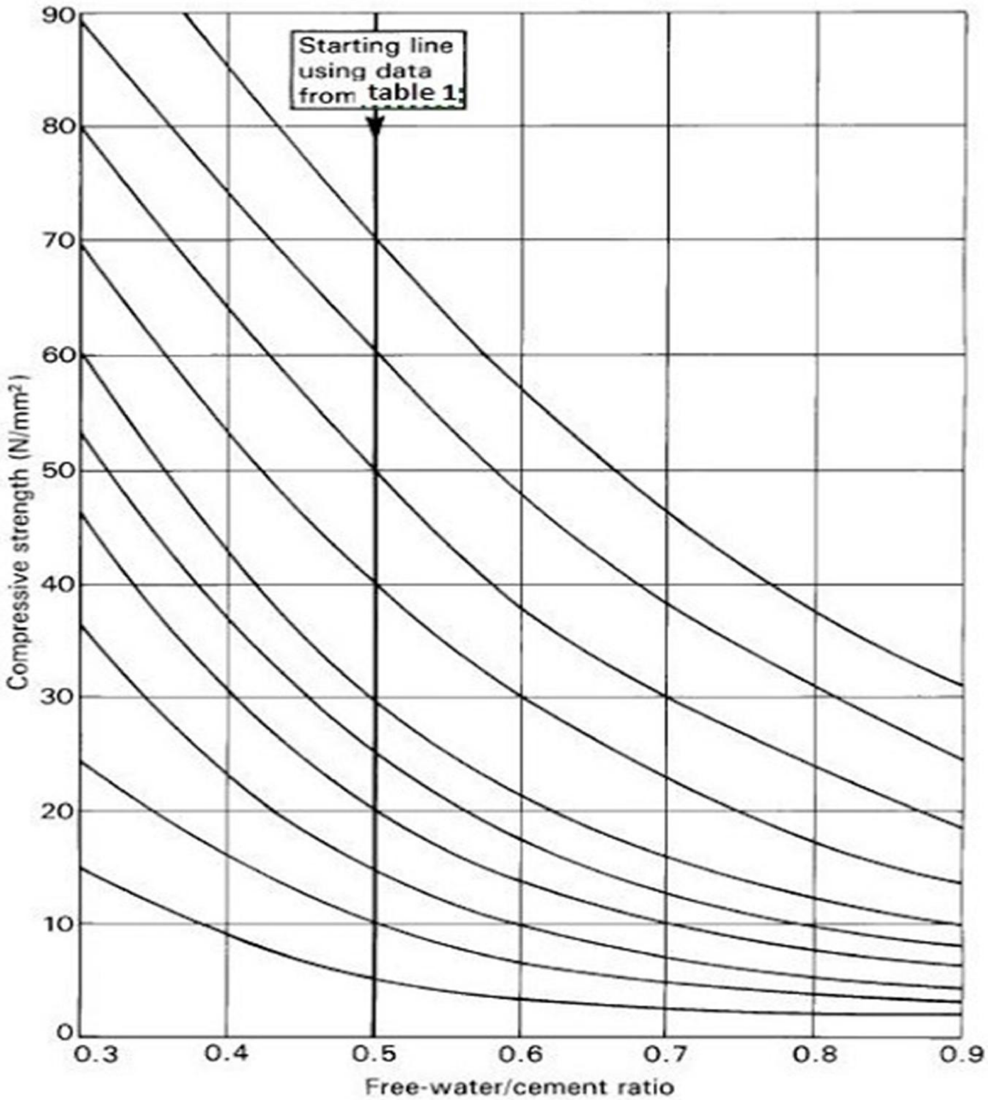


Figure (2.2): Relationship between compressive strength and water/ cement ratio.

A value is obtained from Table (2.6) 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 (2.2) 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 (2.7) depending upon the type and maximum size of the aggregate to give a concrete of the specified slump or Vebe time.

Table (2.7): 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

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 (2.3). 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.

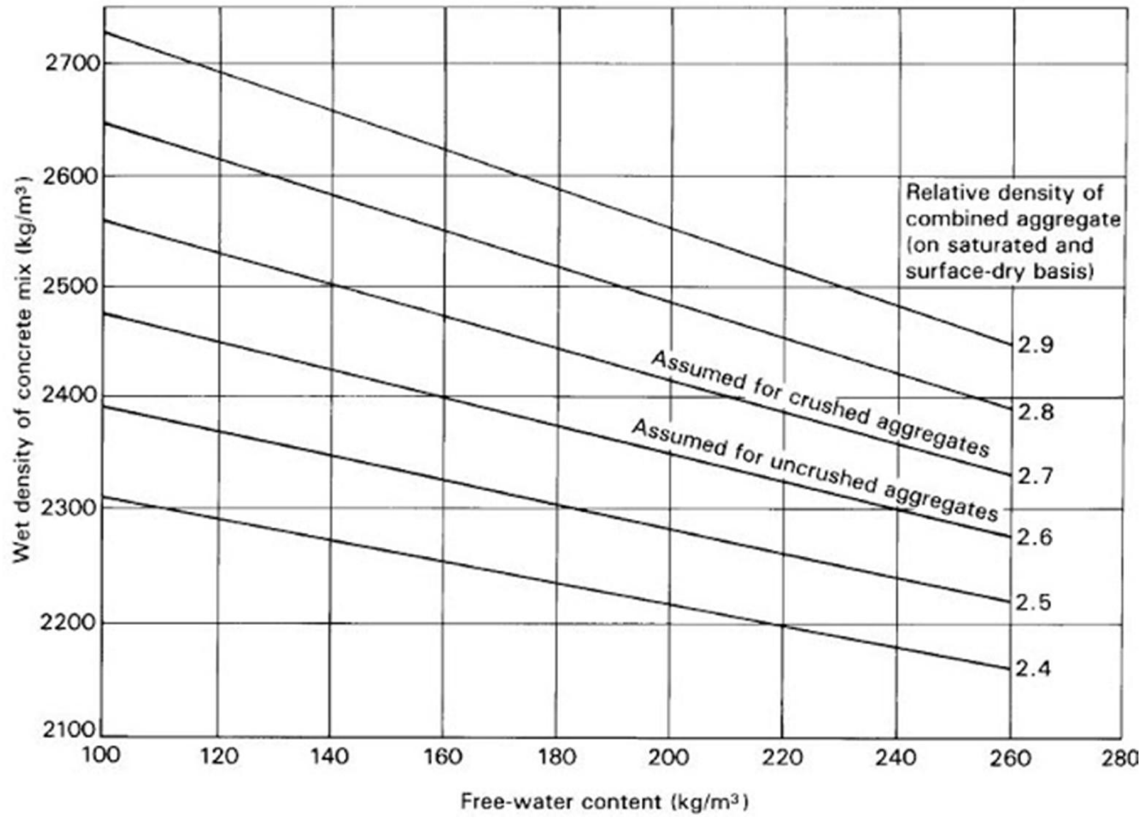


Figure (2.3): Estimated wet density of fully compacted concrete.

The total aggregate content can be calculated using equation 4: Total Aggregate
….. [4]   Content = D – C – W
Where;
D = The wet density of concrete (in kg/m3) C = The cement content (in kg/m3)
W = The free-water content (in kg/m3)

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 (2.4) 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.

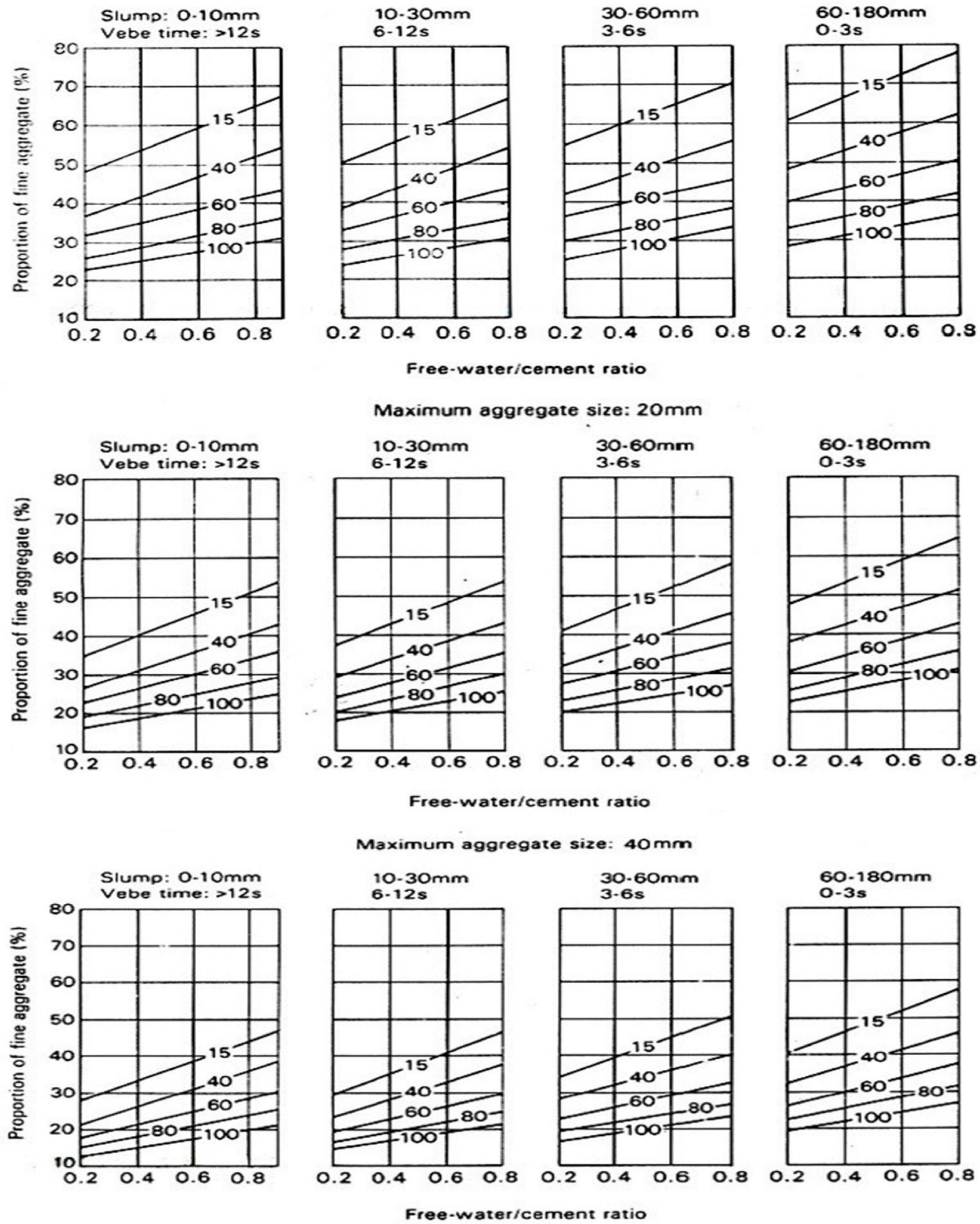


Figure (2.4): Recommended proportions of fine aggregate according to percentage passing a 600 µm sieve.

Determination of fine and coarse aggregate can be made using the proportion of fine aggregate obtained from Figure (2.4) 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 (Neville, A.M , 2003)

2-3 Tests of materials:

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 placement .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 .

2-3-1 Tests of cement:

Because the quality of cement is vital for the production of good concrete, the manufacture of cement requires stringent control. A number of tests are performed in the cement plant laboratory to ensure that the cement is of the desired quality and that it conforms to the requirements of the relevant national standards. It is also desirable for the purchaser, or for an independent laboratory, to make periodic acceptance tests or to examine the properties of a cement to be used for some special purpose.

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.

A- Fineness :

To determine the fineness of cement by dry sieving as per IS:4031(Part1) 1996. Figure (2.5) shown below

Figure (2.5): 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.

B- 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 a weighed quantity of water. The time of gauging should be between 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 of dry cement to the first place of decimal.

C- Initial and Final Setting Time :

To determine the initial and the final setting time of cement As per IS: 4031 (Part5) – 1988, Figure (3.2) shown Vicat Apparatus below The procedure is **summarized as follows:**

1- Prepare a cement paste by gauging the cement with 0.85 times water required 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 anon-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 moulds 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 (2.6): Vicat Apparatus

D- Soundness :

To determine the soundness of cement by Le-Chalkier method as per IS: 4031 (Part 3 – 1988).shown in Figure (2.7) 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 nearest0.5mm (say 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 d2).

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

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

Figure (2.7): Le chatelier

2-3-2 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.(IS Code ,1963)

A- Sieve Analysis :

To determine the particle size distribution of fine and coarse aggregates by sieving as perIS:2386 (Part I)-1963.Table (2-8)(2-9)& Figure (2-8) 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 than the specified diameter as ordinate.

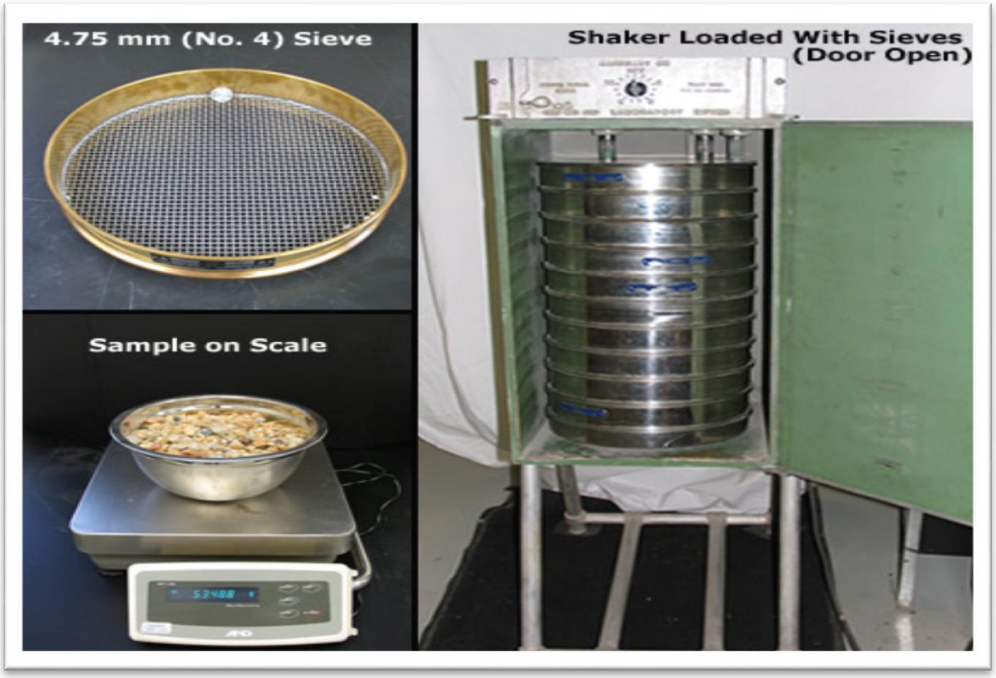


Figure (2.8): Sieves size

Table (2.8): 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%

Table (2-9): **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	0.07 5	0.0029

B- Specific Gravity and Water Absorption :

The test covers the procedures for determining the specific gravity, apparent specific gravity and water absorption of aggregates. Figure (3.5) shown tools for testing.

The procedure is summarized as follows:

1- sample shall be screened on an IO-mm IS sieve, 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 first will 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 temperate of 100 to110°C for24 fl/ 2hours.It shall then be Cooled in airtight container and weighed (weight D).

Finally, calculations Specific gravity, apparent specific gravity and

water Absorption shall be calculated as follows:

$$\text{Specific gravity} = 100 * \frac{D}{C-(A-B)}) \quad (1)$$

$$\text{Apparent specific gravity} = 100 * \frac{D}{D-(A-B)}) \quad (2)$$

$$\text{Water absorption} = 100 * \frac{C}{B-(A-C)}) \quad (3)$$

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 (2.9): Specific Gravity Test Tool

C- 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-ϒ)/G]*100

G = Specific gravity of the aggregate

ϒ=Bulk density in kg/liter

2-3-3 Test of Fresh Concrete:

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

A- 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 l batches.

a- Slump:

To determine the workability of fresh concrete by slump test as Per IS: 1199 - 1959. Figure (2-10) 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 of flat early gives in correct result and if this occurs, the test should be repeated with another sample.

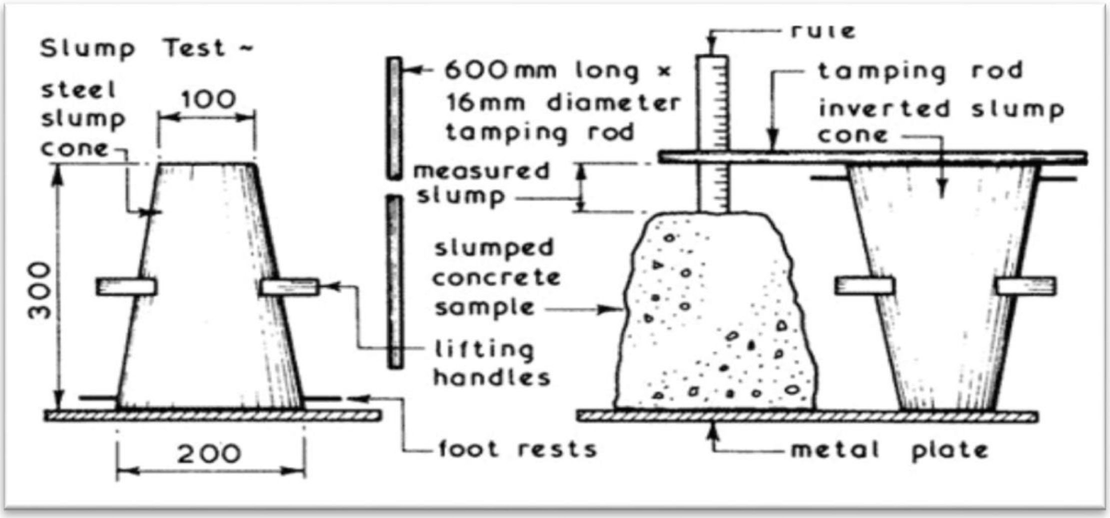


Figure (2.10): Slump Test mold

2-3-4 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.

A- Compression Test:

To determine the compressive strength of concrete specimens as per IS: 516-1-959. Figure (2-11) below shown crushing machine.

Figure (2.11) crushing machine

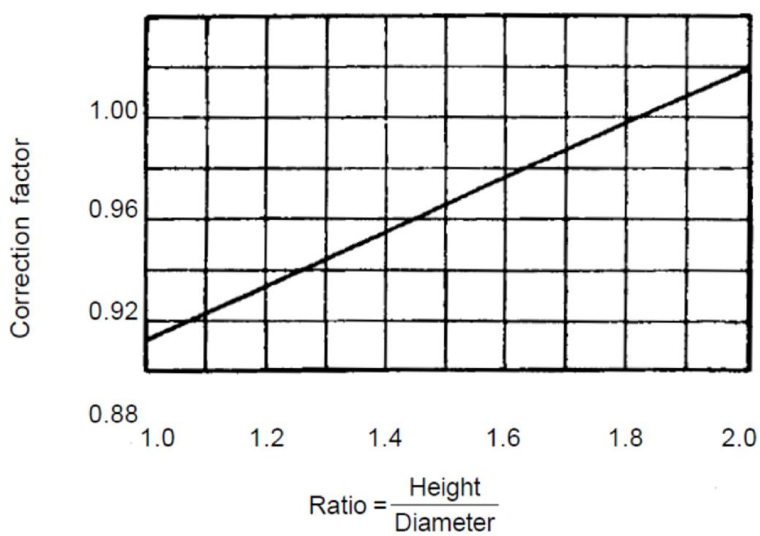
The procedure is summarized as follows:

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 the specimen, 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 (2-12)below:



Correction factor for height-diameter ratio of a core

Figure (2.12): Correction Factor

The product of this correction factor and the measured Compressive 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 by1.25.

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-section a l area.
8. Maximum load.
9. Compressive strength.
10. Appearance of fractured faces of concrete and type of Fracture, if unusual

2-4 Previous Studies :

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

1- Pankaj Swarnakar , R S Pandy : M. Tech Scholar BTIRT , Sagar , M.P.India Asst . prof. of hod , ctmbtirt .

This study aims at environmentally assessing the most significant input and output flows related to the production of concrete using basalt aggregates. An experimental program is set up to test the effect of basalt aggregate content and its combinations with granite stone with variation of percentages in concrete mixes. Different aggregate percentage combinations were used in this study for basalt and granite (0%,100%),(30%,70%),(50%,50%),(75%,30%),(90 %,10%) respectively.

The laboratory investigation included measurement of compressive strength and workability.

The result of this tests indicate a general improvement in mix properties with the introduction of basalt aggregates in the mix.'

Emphasizing on the M-20 & M-25 grades are being considered in this study. Furthermore, the alternative use of granite aggregates was assessed from both technical and environmental perspectives.

Laboratory tests will be done to find out the key properties of an aggregate such as specific gravity, absorption and abrasion are determined for both granite stone and basalt aggregates ,Also to find out workability & performance of slump cone test for every mix.

Compressive strength is determined by breaking cube samples(15x15x15) cm. Three cubes for each mix were tested.

Five mixes were prepared; namely 0% basalt (as a reference mix), 25% basalt, 50% basalt, 75% basalt and 100% basalt. The composition of each mix was 60% coarse aggregate of 20 mm size and 40% coarse aggregate of 10mm size.
The series of laboratory tests will be conducted to find out various parameters discussed in this paper such as compressive strength, basalt mix strength over the granite stone mix. This is due to the fact that granite is denser and more durable and less water absorbing than basalt. Also higher workability can be obtained for more granite aggregate content mix which will reduce the cost of labor. As granite aggregate is a natural aggregate also available in plenty, through this relatively high strength concrete can be obtained by using granite aggregate as coarse aggregate in concrete.

2- Siva Kishore1, L.Mounika2, C.Maruti Prasad3 and B.Hari Krishna: Assistant Professor, Department of Civil Engineering, KL University, Vaddeswaram, Guntur Dist., Andhra Pradesh. India.

The purpose of this paper is to investigate the feasibility of using basalt aggregates in concrete mixes. Concrete is the most important engineering material and the addition or replacement of some of the materials may change the properties of the concrete. In recent years a lot of research work has been carried out in order to obtain more durable and long term performance of concrete structures in the dynamic environment. An experimental program is set up to test the effect of basalt aggregate content and its combinations with lime stone with variation of percentages in concrete mixes. Different aggregate percentage combinations were used in this study for basalt limestone (0%,100%),(25%,75%),(50%,50%),(75%,25%),(100%,0%) and respectively. The laboratory investigation included measurement of compressive strength and workability. In addition the source aggregate properties were considered in this study: Los Angeles abrasion, specific gravity and absorption for coarse aggregates and fine aggregate. The result of this investigation indicate a general improvement in mix properties with the introduction of basalt aggregates in the mix. Five design mixes were used including limestone controlmix,25%,50%,75% and 100% basalt for each set.

The laboratory test results in compressive strength, seems to indicate that the increase in basalt percentage enhances the mix strength over the conventional limestone mix. This is due to the fact that basalt is denser and more durable and less water absorbing than limestone. Also higher workability is obtained for more basalt aggregate content mix which reduces the cost of labour.As basalt aggregate isa natural aggregate also available in plenty at low cost, an economical and relatively high strength concrete is obtained by using basalt aggregate as coarse aggregate in concrete mixes.

3- Hadeel Maiah : , Department of Civil Engineering, Jordan University of Science and Technology, P.O. Box 3030, Irbid, 22110 Jordan.

study aims at investigating the effect of basalt and limestone aggregates combinations on the Superpave aggregate properties. The limestone material was obtained from Al-Rjoub quarry in Irbid city in the north part of Jordan, while the basalt aggregate material was obtained from a quarry in Al- Hallabat area in the southeast part of Jordan. Different aggregate combinations were used in this study for basalt and limestone respectively: (0, 100), (20, 80), (30,70), (40, 60), (50, 50), (60, 40), (70, 30), (80, 20), and (100, 0). The effect of these combinations was investigated on the Superpave aggregate consensus properties: Flat and Elongated (F&E) particles, Coarse Aggregate Angularity (CAA), Fine Aggregate Angularity (FAA), and Sand Equivalent (SE). In addition the source aggregate properties were considered in this study: Los Angeles abrasion, specific gravity and absorption for coarse aggregates, and specific gravity and absorption for fine aggregates. This study is expected to reveal important findings about the effect of aggregate combinations on the Superpave consensus properties as well as source properties.

Basalt is that type of volcanic rocks, grey to black in color, contains less than 20% quartz, 10% feldspathoid and at least 65% of the feldspar of its volume. Basalt is considered an igneous rock with fine grains due to the rapid cooling of lava.

On the other hand Limestone is a sedimentary rock mainly composed of mineral calcite and aragonite. Due to impurities (clay, sand, iron oxide) in limestone, more than one color can be found especially that on surfaces.

For the considered percent of aggregate contained in HMA, base and sub base layers of pavements, the properties of aggregate become crucial in HMA design. These include the Superpave consensus properties that are expected to affect pavement performance, and source properties.

Superpave tests results classified basalt to be stronger than limestone while limestone is more likely to be better in bonding due to the fine filler materials that limestone can have. Although there is a good bonding between limestone and asphalt binder, basalt can perform better than limestone in rutting of pavements. Broad researches are done on basalt to determine the weak and strength points of basalt's performance at pavements.

Superpave tests were conducted on blended samples using different aggregate combinations for basalt and limestone respectively: (0, 100), (20, 80), (30, 70), (40, 60), (50, 50), (60, 40), (70, 30), (80, 20), and (100, 0). The effect of these aggregate combinations on the Superpave aggregate consensus properties as well as source properties was investigated.

The used aggregate gradation had a 12.5 mm Nominal Maximum Aggregate Size (NMAS), and 19.0 mm Maximum Aggregate Size (MAS).

Different aggregate combinations were used for basalt and limestone respectively: (0, 100), (20, 80),(30, 70), (40, 60), (50, 50), (60, 40), (70, 30), (80, 20), and (100, 0).

Coarse Aggregate prepared and the test was done according to the AASHTO .

It was conducted on the prepared samples for the portion retained on No. 4 (4.75 mm) sieve.

Coarse and Fine Aggregate Specific Gravity and Absorption , The values of apparent, dry and SSD specific gravities for the coarse aggregate were about 2.800, 2.650, and 2.700, respectively. Fine aggregate apparent specific gravity values ranged from 3.069 to 3.243, bulk SSD and bulk oven dry fine aggregate specific gravities ranged from 2.745 to 2.902 and from 2.585 to 2.759, respectively.

4- P.RAMTEJA P.G Student Siddartha Group Of Educational Acadamy Tirupati.

Concrete innovation has been changing quickly and continually since its revelation. The way toward selecting appropriate elements of concrete and deciding their relative sums with the goal of delivering a concrete of the required, quality, sturdiness, and workability as monetarily as could reasonably be expected, is termed the solid blend outline. The extent of this work is constrained to the improvement of an appropriate blend configuration to fulfill the necessities of workability and quality of the solid blend utilizing basalt aggregates as a coarse aggregate. To assess the workability of concrete blends utilizing basalt total as coarse total. To assess the quality of solidified cement utilizing basalt total as coarse total The consequences of the compressive quality tests will be directed on the trial blends containing 0%,25%, 50%,75% and 100% basalt, separately. The compressive quality will be tried as the rate of basalt substance in the blend is expanded. Five blends were readied; in particular 0% basalt (as a control blend), 25% basalt, half basalt, 75% basalt and 100% basalt for every arrangement of outline blend. The arrangement of every blend was 60% coarse total of 20 mm size and 40%coarse total of 10mm size. Fine total limits to zone-I.

In this study used sand of Zone-II, known from the strainer examination using differing sifter sizes (10mm, 4.75mm, 2.36mm, 1.18mm, 600µ, 300µ, 150µ) grasping IS 383:1963. Whose Specific Gravity is 2.65, Water assimilation 0.6% and Fineness Modulus 2.47 was used. Ordinary Portland cement (53 grade) whose Fineness – 340 m2/kg ,Specific gravity- 3.1 Initial setting time - 90 min, Final setting time – 190 min. was used.

The coarse aggregate utilized here with having most extreme size is 12.5mm. We utilized the IS 383:1970 to discover the extent of blend of coarse aggregate. Whose Specific Gravity is 2.65, Water absorption 0.4% what's more, Fineness Modulus 4.01 was utilized. Based on the present experimental investigation, the following conclusions are :

1.While using the basalt in concrete the original water cement ratio of concrete mix is to be corrected by the amount of water available in basalt aggregate.

2.The laboratory test results in compressive strength, seems to indicate that the increase in basalt percentage enhances the mix strength. This is due to the fact that basalt is denser and more durable and less water absorbing than limestone. Also higher workability is obtained for more basalt aggregate content mix which reduces the cost of labor.

3.As basalt aggregate is a natural aggregate also available in plenty at low cost, an economical and relatively high strength concrete is obtained by using basalt aggregate as coarse aggregate in concrete mixes.

4.Coarse aggregate replacement with 25% basalt to increase in Compressive Strength, Split Tensile Strength.

5.For M50 Grade with basalt 25%, 50% 75%, 100% the percentage increase in Compressive Strength, Split Tensile Strength are 25.21%,10.5%.

6.For M60 Grade with basalt aggregate25%, 50% 75%, 100% the percentage increase in Compressive Strength, Split Tensile Strength are 6.46%, 4.62 % respectively.

7.There is an increase in Compressive Strength of Cylinders for M50 & M60 with basalt100% is 27.12 % and 24.91 % respectively higher than Conventional Concrete .

CHAPTER THREE

EXPERIMENTAL WORK

CHAPTER THREE
EXPERIMENTAL WORK

3-1 Introduction:

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 placement .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 .

3-2 Mix of Materials :

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

3-2-1 Cement(OPC) :

The Ordinary Sudanese Portland cement of PC 42.5 manufactured by Berber Cement 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 (3.3) below:

Table (3.1): Results of Cement tests

Test No	Name Test	Result	BS .No (12-1996)
1	Fineness	2.3%	Not more than 10%
2	Consistency	31%	26%-33%
3	Sitting Initial Time	115	Not less than 45 min
4	Sitting Final Time	5.5	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	**----**

Table (3.2): Chemical Combination Result of Cement

No	Oxide Name	Oxide%
1	Sio2	19.487
2	Al2O3	4.182
3	Fe2O3	3.545
4	CaO	63.149
5	MgO	2.785
6	P2O5	0.313
7	K2O	0.332
8	Na2O	0.360
9	SO3	3.083
10	CL	0.016
11	MNO	0.160
12	NiO	0.008
13	Zno	0.015
14	Cuo	0.017

3-2-2 Aggregate :

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, lower shrinkage and greater durability.

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 (3.5) and Figure (3.9) shown below:

Table (3.3): Sieve Analysis of Coarse Aggregate &Grading According to British Standard

Sieve Size (mm)	Mass Retrain(g)	Percentage Retrain	Cumulated Retrain	Percentage Passing	BS 882:1992
50	0	0	0	0	-
37.5	3.313	66.26	70.44	29.46	100
20	0.209	4.18	4.18	95.82	85-100
12.5	1.01	20.2	90.64	9.26	-
10	0.402	8.04	98.68	1.22	0-25
4. 75	0.06	1.2	99.88	0.02	0-8
2.36	0.0015	0.03	99.91	-	-
Pan	0.0015	0.03	99.94	-	-
Fine Modulus =Σ Cumulative percentage Retained/100=5.636					

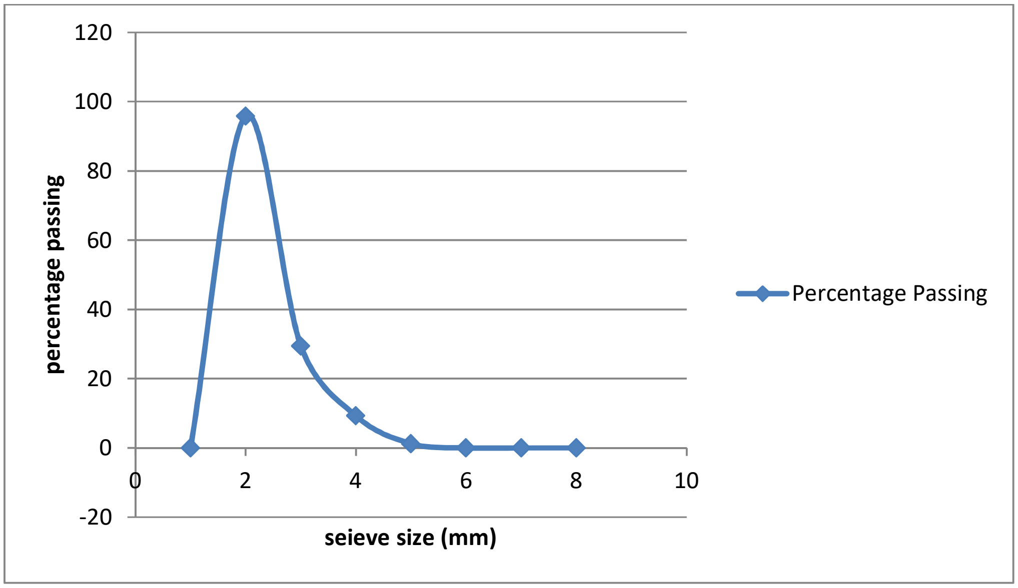


Figure (3.1) Sieve Analysis of Coarse Aggregate & Grading According to British Standard .

Table (3.4): Sieves Analysis of Fine Aggregate & Grading According British Standard

Sieve Size (mm)	Mass Retrain(g)	Percentage Retrain	Cumulated Re. Retrain	Percentage of Passing	BS 882:1992
10mm	15.33	1.53	1.53	98.47	-
4.75	33.7	3.37	4.90	95.10	-
2.36	23.33	2.33	7.41	92.59	60-100
1.18	129.2	12.92	20.33	79.67	30-90
600mic	415.7	46.85	49.18	50.82	15-54
300mic	319	41.99	96.07	3.93	5-40
150mic	51.67	5.17	98.60	2.00	-
75mic	14.00	1.40	100.00	00	-
Pan	0	0	100.00	00	-
Fine Modulus = Cumulative percentage retain/100=2.91					

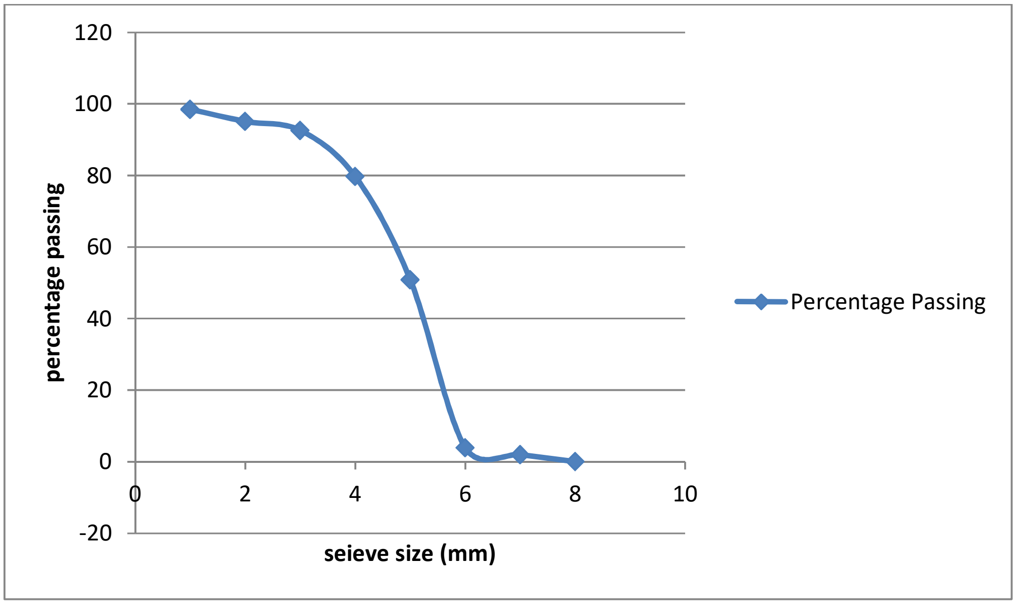


Figure (3.2) Sieve Analysis of Coarse Aggregate &Grading According to British Standard .

3-2-3 Basalt and limestone in mix design :

Basalt and limestone in this study used as replacement of course aggregate (by weight) as a supplementary addition to achieve different properties of concrete, basalt and limestone in this study from Turia Mount in Omdurman .

Results of Fine, Coarse Aggregate and basalt & limestone Test The most important tests of fine and coarse aggregate given in Table below (3-5) & (3-6) .

Table (3.5) Results of Basalt and Limestone Test

Property	**Basalt**	**Limestone**
Specific Gravity	2.88	2.63
Moisture Content	0.32	0.36
Water Absorption%	0.65	0.9

Results of Fine & Coarse Aggregate Test :

The most important tests of fine and coarse aggregate given in Table (3.8) below:

Table (3.6): Results of Fine & Coarse Aggregate Test

Property	Fine Aggregate	Coarse Aggregate
Fineness modulus	2.91	5.63
Specific Gravity	2.59	2.68
Moisture content	0.4	0.4
Absorption%	0.88	0.7

3.2.4 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.

3-3 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, basalt & lime stone , and then work all the necessary 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.

3-4 Mix Design by British Standard Method :

Standard Method Step-1

*Characteristic Strength =25N/mm^2 at 28days.

*Proportion defective =5%

*From Table(2.5) K=1.64

*From Figure (2-1) standard deviation=4N/mm^2

*Target mean strength = 25+1.64*4=31.56 N/mm^2

Step-2

*Compressive strength from Table (2.6)

*Type of cement O.P.C

*type of aggregate =Uncrushed

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

*From Figure (2.2) we draw parallel line to the nearest carve strength 31.56 N/mm2

*w/c= 0.5 w/c = 0.5 (at strength 31.56 /mm^2)

Step-3

*The water requirement from Table (2.7)

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

*water requirement=180 kg/m^3

Used=180kg/m^3

Step-4

* Cement content= content water/percentage w/c

=180/0.50=360kg/m^3

Step-5

*Fresh density of concrete water require =180kg/m^3

*Specific gravity aggregate=2.65

*From Figure (2.3) Fresh density of concrete=2410

*Aggregate =density -cement-water

All aggregate =2410-360-180=1870 kg/m^3

Step-6

*From Figure (2.4) max size=20mm, slump (30-60), fine aggregate passing from 600mm=50.8 %, w/c = 0.50

*Property fine aggregate=45%

*Coarse aggregate=All aggregate –fine aggregate. Coarse aggregate=1870*0.45= 841.5 kg/m^3

Used = 842 kg/m^3

*Fine aggregate=all aggregate - coarse aggregate =1870-842=1028 kg/m^3

Used=1028kg/m^3

CHAPTER FOUR

RESULTS AND DISCUSSION

CHAPTER FOUR
RESULTS AND DISCUSSION

4-1 Introduction :

Laboratory tests were conducted on each of the materials Concrete (Cement - natural Aggregate - Basalt -Limestone-fresh concrete and hard concrete) The result of hardened concrete testes conducted by adding different ratios basalt & limestone (25%,75%and 100%) is replace natural aggregate and are shown in tables(4.1- 4.2- 4.3 – 4.4 – 4.5 – 4.6)

4-2 The Results of fresh and Hardened Concrete:

Table (4.1): Results of Compressive Strength Tests of Control Mix using (Natural Aggregate 100%).

	Using Natural Aggregate 100%				
Age Day	Slump(mm)	Weight of cube(kg)	Failure Load(KN)	Strength(N/mm2)	Average Strength (N/mm2)
7	60	2.4	210	21	22
		2.45	220	22	
		2.4	230	23	
28		2.49	290	29	31
		2.54	290	29	
		2.54	350	35	
56		2.57	360	36	37
		2.59	370	37	
		2.65	380	38	

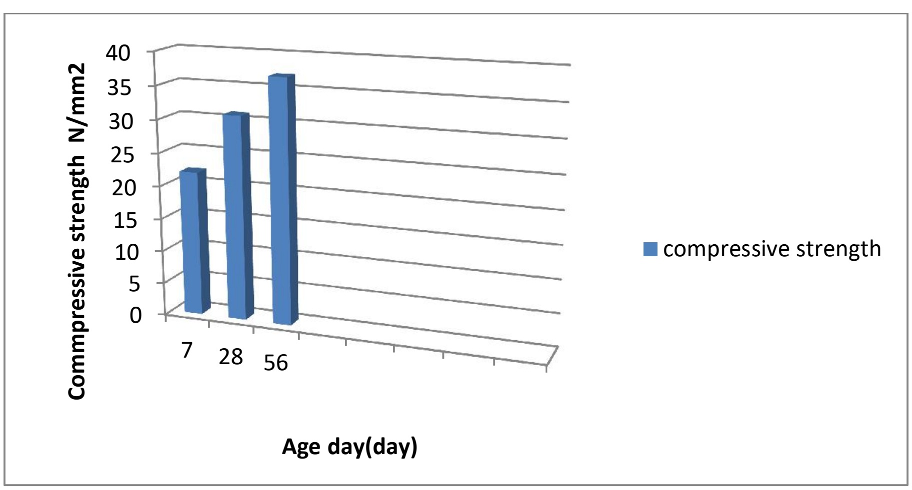


Figure (4-1) : Results of Compressive Strength Tests of Control Mix using (Natural Aggregate 100%) at (7,28,56) days.

Table (4-1) & Figure (4-1) shown that the Compressive strength of mix design in 7days give (22 N/mm2) it's good indicate , also in 28 days give (31 N/mm2) over (90%) of target strength and it give (37 N/mm2) in 56 days.

Table (4.2) : Results of Compressive Strength Tests Mix of (Basalt 100% and limestone 0%) .

	Using Basalt 100% and limestone 0%				
Age Day	Slump(mm)	Weight of cube (kg)	Failure Load(KN)	Strength(N /mm2)	Average Strength (N/mm2)
7	60	2.67	260	26	28
		2.71	280	28	
		2.74	300	30	
28		2.73	315	31	34
		2.76	340	34	
		2.77	380	38	
56		2.75	420	40	42.5
		2.78	430	43	
		2.81	450	45	

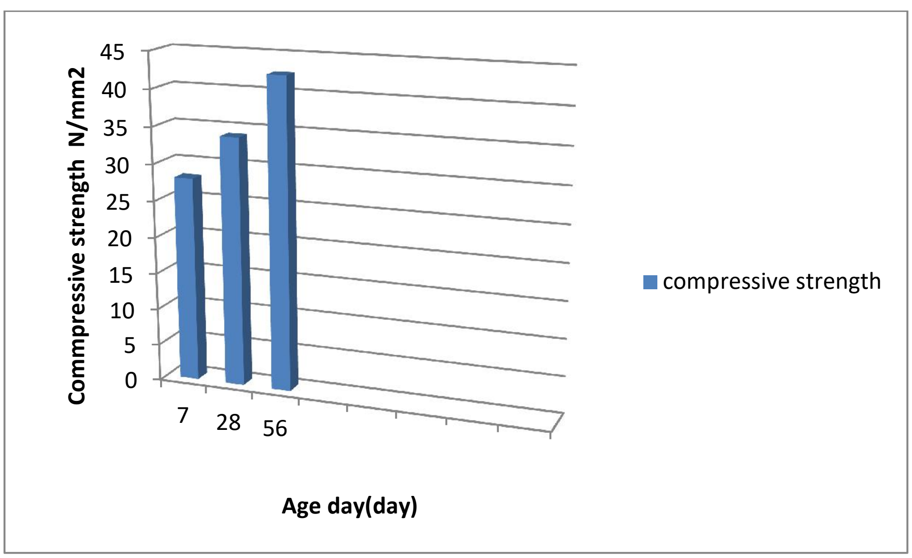


Figure (4-2) : Results of Compressive Strength Tests of Basalt (100%) at (7,28,56) days.

Table (4-2) & Figure (4-2) shown that the compressive strength of basalt (100 %) at curing age (7,28,56) days is (28,34,42.5) Respectively.

Table (4.3): Results of Compressive Strength Tests Mix of (Basalt 0% and limestone100%) .

Using Basalt 0% and limestone100%					
Age Day	Slump(mm)	Weight of cube (kg)	Failure Load(KN)	Strength(N/mm2)	Average Strength (N/mm2)
7	45	2.51	200	20	23
		2.53	235	23.5	
		2.53	250	25	
28		2.52	250	25	27
		2.54	270	27	
		2.54	285	28.5	
56		2.57	315	31.5	33
		2.59	330	33	
		2.59	350	35	

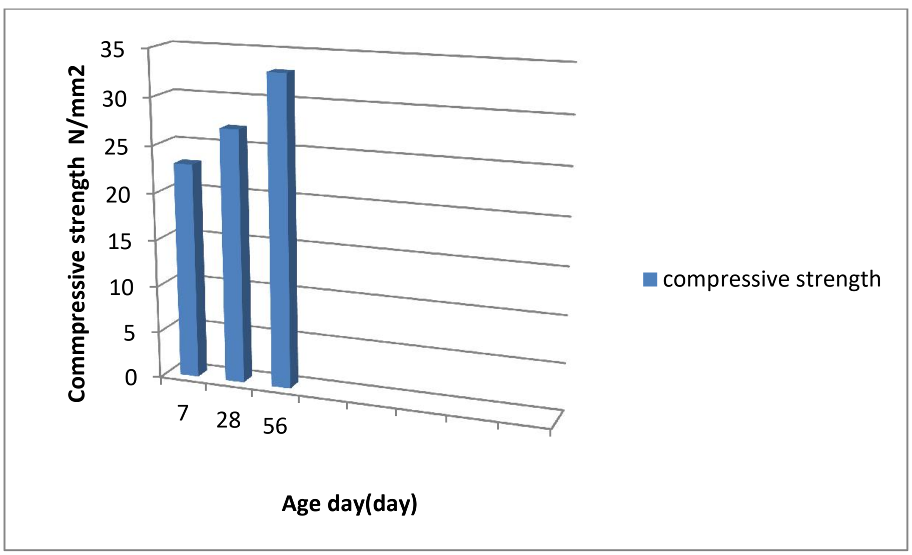


Figure (4-3) : Results of Compressive Strength Tests of Limestone (100%) at (7,28,56) days.

Table (4-3) & Figure (4-3) shown that the compressive strength of Limestone (100 %) at curing age (7,28,56) days is (23,27,33) Respectively .

Table (4.4) : Results of Compressive Strength Tests Mix of (Basalt 50% and limestone 50%) .

	Using Basalt 50% and limestone 50%				
Age Day	Slump(mm)	Weight of cube (kg)	Failure Load(KN)	Strength(N /mm2)	Average Strength (N/mm2)
7	58	2.67	225	22.5	23.5
		2.77	230	23	
		2.78	250	25	
28		2.75	290	29	31.5
		2.79	320	32	
		2.79	340	34	
56		2.78	370	37	39
		2.8	385	38.5	
		2.82	410	41	

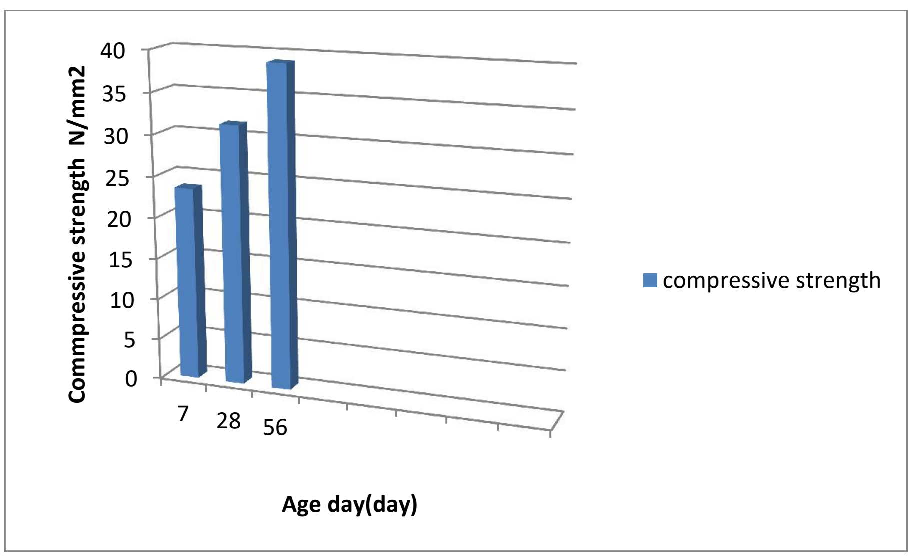


Figure (4-4) : Results of Compressive Strength Tests of Basalt (50%) & limestone (50%) at (7,28,56) days.

Table (4-4) & Figure (4-4) shown that the compressive strength of basalt (50%) & Limestone (50%) at curing age (7,28,56) days is (23.5,31.5,39) Respectively.

Table (4.5) : Results of Compressive Strength Tests Mix of (Basalt 75% and limestone 25%) .

	Using Basalt 75% and limestone 25%				
Age Day	Slump(mm)	Weight of cube (kg)	Failure Load(KN)	Strength(N /mm2)	Average Strength (N/mm2)
7	60	2.68	245	24.5	25
		2.69	250	25	
		2.75	260	26	
28		2.77	310	31	33.5
		2.76	330	33	
		2.8	370	37	
56		2.82	395	39.5	41
		2.88	410	41	
		2.85	430	43	

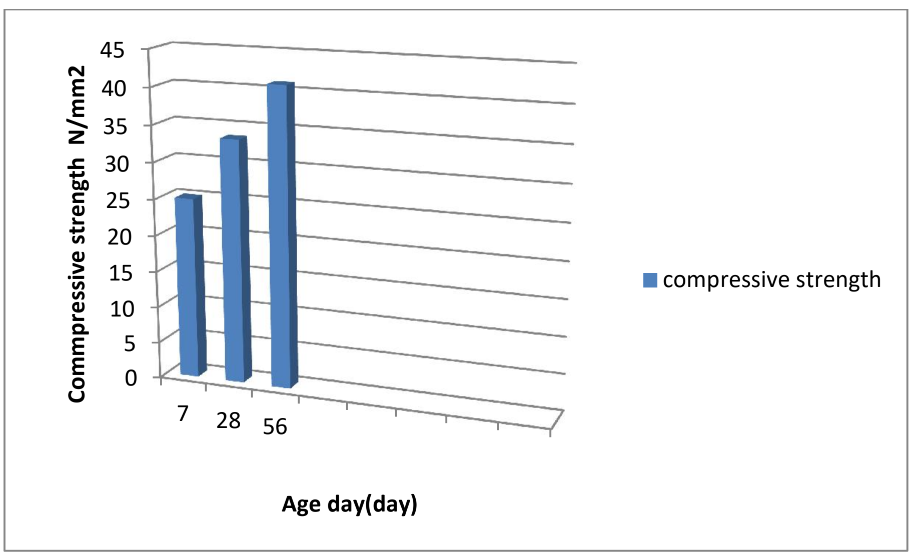


Figure (4-5) : Results of Compressive Strength Tests of Basalt (75%) & limestone (25%) at (7,28,56) days.

Table (4-5) & Figure (4-5) shown that the compressive strength of basalt (75%) & Limestone (25%) at curing age (7,28,56) days is (25,33.5,41) Respectively.

Table (4.6) : Results of Compressive Strength Tests Mix of (Basalt 25% and limestone 75%).

	Using Basalt 25% and limestone 75%				
Age Day	Slump(mm)	Weight of cube (kg)	Failure Load(KN)	Strength(N /mm2)	Average Strength (N/mm2)
7	55	2.61	200	20	23
		2.75	220	22	
		2.73	270	27	
28		2.8	280	28	29
		2.83	280	28	
		2.82	310	31	
56		2.92	330	33	36
		2.9	350	35	
		2.89	400	40	

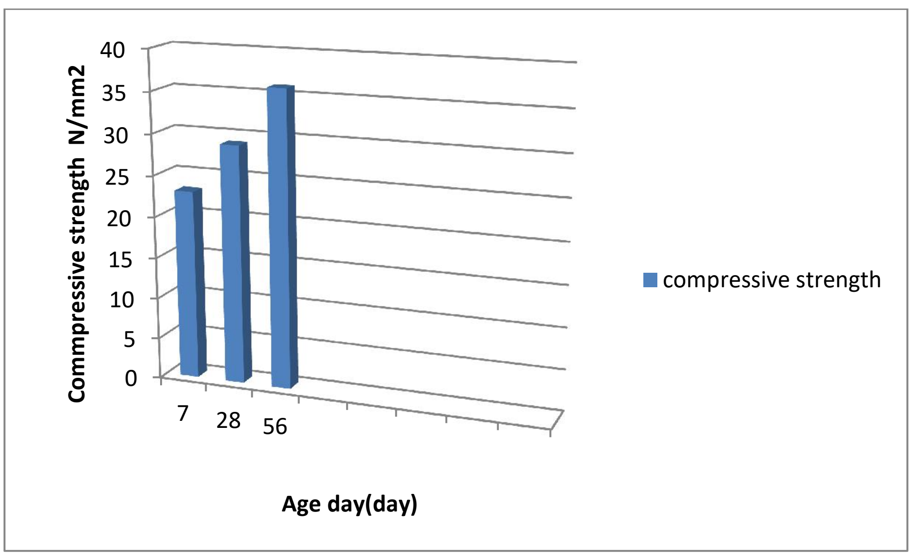


Figure (4-6) : Results of Compressive Strength Tests of Basalt (25%) & limestone (75%) at (7,28,56) days.

Table (4-6) & Figure (4-6) shown that the compressive strength of Limestone (75 %) & Basalt (25%) at curing age (7,28,56) days is (23,29,36) Respectively.

Table (4.7) : Average for result of Compressive Strength tests using(Basalt & Limestone) .

No	Type of Concrete Mix	Basalt %	Limestone %	Compressive Strength at 7days (N/mm2)	Compressive Strength at 28days (N/mm2)	Compressive Strength at 56days (N/mm2)
1	Mix(1)	0	0	22	31	37
2	Mix(2)	100	0	28	34.5	42.5
3	Mix(3)	0	100	23	27	33
4	Mix(4)	50	50	23.5	31.5	39
5	Mix(5)	75	25	25	33.5	41
6	Mix(6)	25	75	23	29	36

Table (4.8) : Relation between Mixes and slump tests of Concrete

No	% of recycle natural aggregate	Slump test
1	M 1	60
2	M 2	60
3	M 3	45
4	M 4	58
5	M 5	60
6	M 6	55

Table (4-8) shown that At Mix 2 give high workability same as control mix . Also At Mix 3 & Mix 6 give lower workability , it increase at basalt mixes and decrease by added limestone .because have the ability to absorb water mixing ratio .

4-3 Analysis of the results :

compressive strength and slump test results were presented in Figures below:

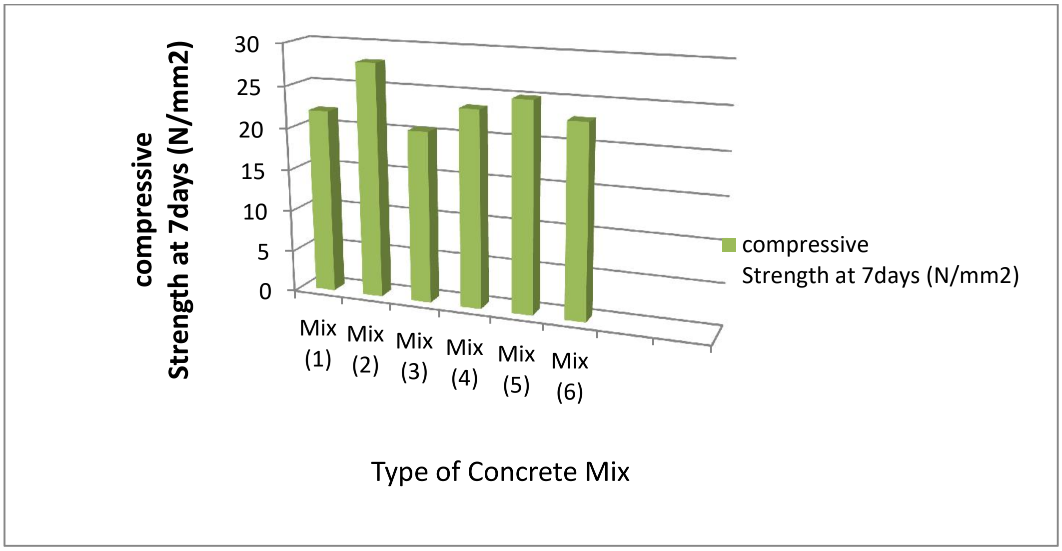


Figure (4-7) : Compressive strength of all mixes at 7 days .

Figure (4-7) shown that the compressive strength of basalt (100%) is greater than all mixes and the second mix is basalt (75%) & Limestone(25%) .That mean the compressive strength increase were we add basalt and decrease were the ratio of basalt decrease by increase limestone **.**

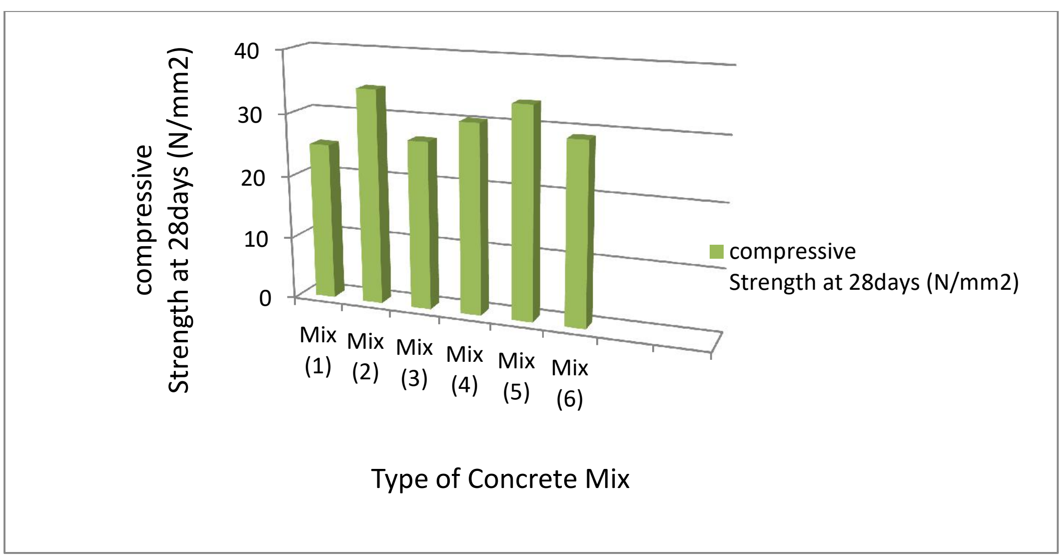


Figure (4-8) : Compressive strength of all mixes at 28 days .

Figure (4-8) shown that the compressive strength of basalt (100%) is greater than all mixes and the second mix is basalt (75%) & Limestone(25%) .That mean the compressive strength increase were we add basalt and decrease were the ratio of basalt decrease by increase limestone . Also shown that the mix design give compressive strength greater compare with limestone (100%) and limestone (75% with basalt 25%).

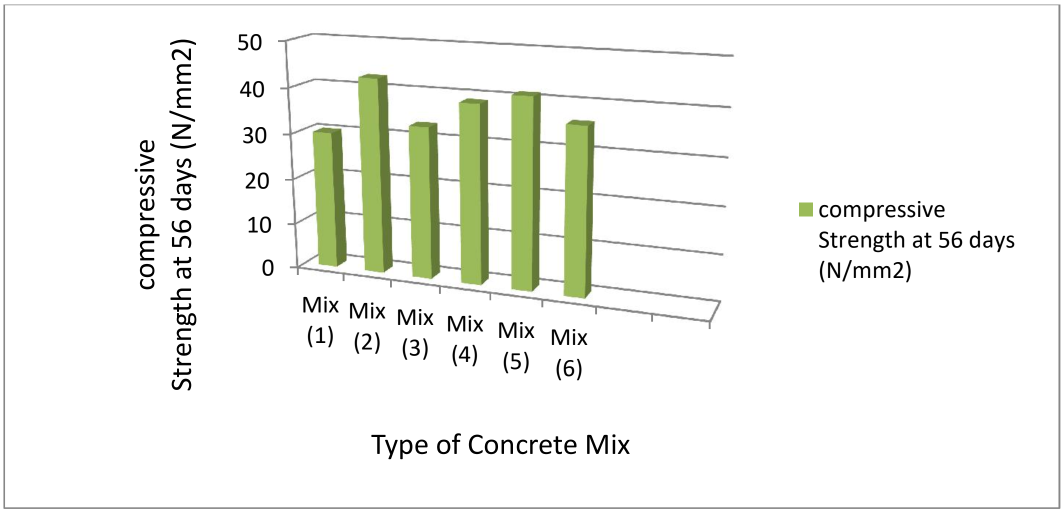


Figure (4-9) : Compressive strength of all mixes at 56 days .

Figure (4-9) shown that the compressive strength of basalt (100%) is greater than all mixes and the second mix is basalt (75%) & Limestone(25%) .That mean the compressive strength increase were we add basalt and decrease were the ratio of basalt decrease by increase limestone . Also shown that the mix design give compressive strength greater compare with limestone (100%) and limestone (75% with basalt 25%) .

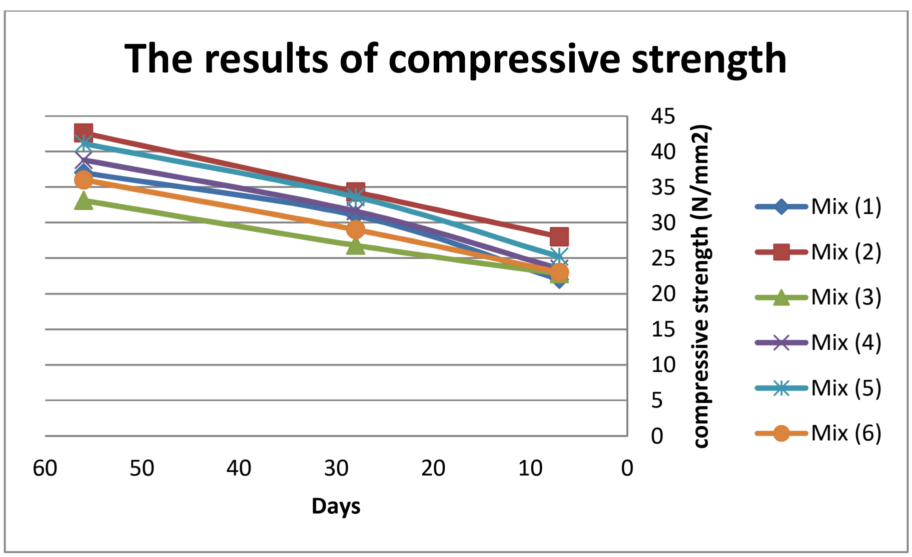


Figure (4-10): The results of compressive strength of all mixes at (7,28,56) days.

Figure (4-10) shown that the compressive strength of basalt (100%) is greater than all mixes at all curing age, the second mix is basalt (75%) & limestone (25%) , the third mix is basalt (50%) & limestone (50%) , the fourth mix is mix design shown that it's greater than mix of limestone (100%) and limestone (75%) with basalt (25%) .That lead to the compressive strength increase were we add basalt and decrease were we increase limestone and decrease basalt, This is due to the fact that basalt is denser and more durable and less water absorbing than limestone .

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

CHAPTER FIVE
CONCLUSION AND RECOMMENDATIONS

5-1 Conclusions :

This study shown the basic properties of basalt & limestone and natural coarse aggregate & also compares these properties. The laboratory test results in compressive strength and workability , seems to indicate that the increase in basalt percentage enhances the mix strength over the limestone mix. This is due to the fact that basalt is denser and more durable and less water absorbing than limestone. Also higher workability is obtained for more basalt aggregate content mix . As basalt aggregate is a natural aggregate also available in plenty at low cost, an economical and relatively high strength concrete is obtained by using basalt aggregate as coarse aggregate in concrete mixes.

Based on the results obtained from the experiment the following conclusions are Drawn below:

1- Results tests conducted on basalt and limestone compared with natural coarse aggregates are satisfactory .

2- The compressive strength and workability in basalt greater when compare with limestone .

3- The compressive strength in basalt 100% greater than The compressive strength limestone and control mix in all proportion.

4-The compressive strength and workability in natural aggregate greater than limestone were the proportion of limestone over (50%).

5- Optimum proportion of replacement in natural coarse aggregate is 100% basalt .

6- The second optimum proportion of replacement by using basalt (75%) & limestone (25%) , the third proportion by using basalt (50%) & limestone (50%), the fourth proportion by using natural aggregate .

7- The ideal ratio for high compressive strength over the mix design about (27% in 7days & 11% in 28 days and 11.5% in 56 days of curing) its satisfactory .

5.2 Recommendations :

In this experimental study discussed basalt and limestone requirements and compressive strength was achieved according to British Standard method .

5.2.1 Recommendations from the studies can follow as:

1- Basalt in all ratio must be adopted in normal Concrete mixes since they obtained the highest value of compressive strength of Hardened concrete Except the lower ratio (25%) from all days of curing.

5.2.2 Recommendations for future studies can follow as:

1- Use different aggregate with basalt to achieve the better proportion than optimum proportion obtain in this research by using basalt 100% by added natural aggregate .

2- Use additive with basalt and limestone to improve the compressive strength and workability.

3- Recommend to use the basalt in all construction building when we need high compressive strength and workability .

4- Recommend to use the limestone in light buildings when we need medium compressive strength and workability .

References :

1- BS 812 Testing aggregates - Part 110: Methods for determination of aggregate Crushing value (ACV). BSI , 1990.

2- Edward .W, "construction engineering hand book". Second edition, Taylor and Francis group 2003.

3- British Standards Document EN 933 Tests for geometrical properties of aggregates-Part 3: Determination :1997 [current until 29/02/2012].

4. IS code 2386 Methods of Test for Aggregates for Concrete, Part I: Particle Size and Shape : 1963.

5- IS code 516 Method of Tests for Strength of Concrete 1959 June 2006.

6- Kaplan M. F. Ph.D., B.Sc.(Eng.), B.A., B.Com., A.M.I.C.E., A.M.I. Struct .E, A.M.(S.A.)I.C.E ,The effects of the properties of coarse aggregates on the workability of concrete , Volume 10 Issue 29, August 1958.

7- Neville , A. M. "Properties of concrete " . Longman Group, Harlow, 2004.

8- Bang Seng. C, John. N., "Advanced concrete technology". First published, Elsevier Ltd 2003.

9- B.S 1881: part116 "Method of Determination of Compressive Strength of Concrete Cubs".389 Cheswick High Road, London, British Standard Institute:1983.

10- Ministry of Mineral, Geological Research Authority of Sudan, Chemical laboratory, Khartoum Nile Street.

11- P.Ramteja. " basalt aggregate as coarse aggregate in high strength concrete mixes " . International Research Journal of Engineering and Technology (IRJET) . Volume :03 Issue : 8 aug 2016.

12- Siva , Kishora and L, Mounika. "Experimental study on the use of basalt aggregate in concrete mixes ". International Journal of civil Engineering (SSRG – IJCE) .Volume :2 Issue :4 apr 2015 .

13- Hadeel Maiah **:** , Department of Civil Engineering, Jordan University of Science and Technology, P.O. Box 3030, Irbid, 22110 Jordan.

14- BS 812 Testing aggregate , part -113 :1990

15- Pankaj Swarnakar , R S Pandy : M. Tech Scholar BTIRT , Sagar , M.P.India Asst . prof. of hod , ctmbtirt : Analysis of use of basalt aggregate in concrete mixes with granite stone M-20 & M-25 grades . Issue May 2017

16- https://en.wikipedia.org/wiki/ Construction - engineering June 2017 .

Appendix of pictures

Basalt stone

Crushed basalt

Limestone

Gradation of basalt

Basalt sample

Basalt cubes

Cubes

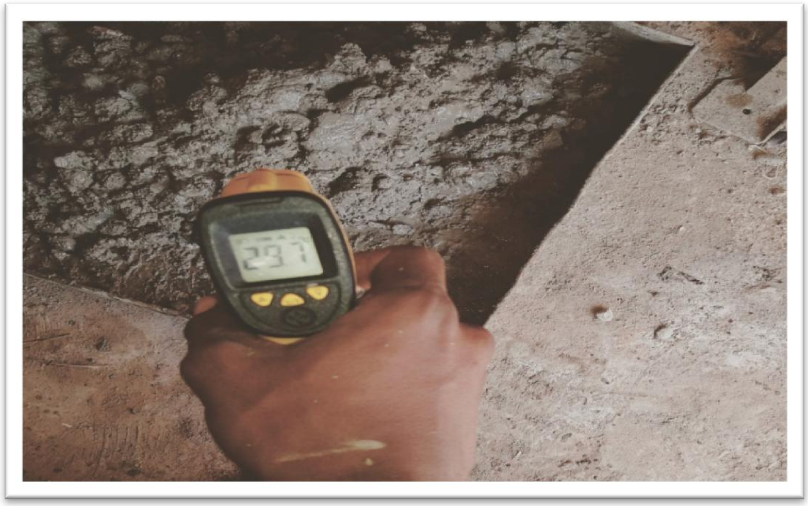
temperature gauge

Crushing machine

Curing of cubes

Concrete mixer

Mixing



Gauge of temperature for mix

Slump

Limestone sample

Electric oven

Gradation of sand