COMPARATIVE STUDY BETWEEN NATURAL AND ARTIFICIAL AGGREGATES
(A Experimental study of Quality of Artificial and natural Aggregates Used for Construction in Mogadishu City)

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Abstract

The utilization of two types of aggregate for concrete work is investigated in this paper. Concrete is being produced from different types of aggregate and this imparts different property to the resulting concrete. The most important property of concrete is its compressive strength. The purpose of this work, two types of coarse aggregates, crashed (Artificial) and natural aggregates were used. At beginning, the laboratory investigation was conducted to determine the suitability of using the aggregates for construction work. Tests conducted include sieve analysis, bulk density, specific gravity and absorption capacity. For each type of coarse aggregate 6 cubes (150x150mm) were cast to allow the compressive strength to be monitored at 7, 21, and 28 days.

The highest compressive strength was obtained from concrete made with crushed (Artificial) aggregate, followed by Natural Aggregate. The void ratio is to be found in range of 25% to 32%, which is enough for pervious concrete. The Fineness modulus of natural aggregates in the three samples is 6.9, 6.5, 6.9 and the average number is 6.8. The result

shown the fineness modulus of sample-2 is below the average and the sample-1 is above the average. The value of specific gravity of crashed aggregate is 2.56 and natural aggregates are 3.14 respectively. The specific gravity of aggregates normally used in road construction ranges from about 2.5 to 3.0.

Test result show that concrete made from natural the highest workability followed by crushed (Artificial) and aggregates. The result shows the highest slump was obtained with concrete made with both natural and crashed aggregate with 0.8 w/c ratio by improper compaction.Both aggregates are recommended to use 0.5 w/c ratio with proper compaction to get minimum slump hight and true slupm

It is suggested that crushed (Artificial) aggregate may be working for concrete work in places where concrete practitioners have selection of choices available.

Keywords: Aggregate, Concrete, Compressive strength, natural aggregate, crashed aggregage.

1. Introduction

In Somalia, due to the booming of construction of infrastructure, the demand of virgin aggregate for construction is high. Therefore, there are two types of aggregate used for construction purpose, first natural aggregate and Artificial aggregate (crushing aggregate).The annual growth rate of cement production is 4% due to rapidly increasing construction in developing countries (World Business Council for Sustainable Development 2005). Approximately 80% of greenhouse gas emissions associated with concrete is released during the Portland cement manufacturing process (Flower and Sanjayan 2007).

In natural aggregate it consist of fine and course aggregate as same as crushing aggregate also consist of fine and course aggregate.

Aggregates are inert granular materials such as sand, gravel or crushed stone that, along with water and Portland cement are an essential component in concrete. The aggregates occupy 70-80 percent of the volume of concrete. For a high-quality concrete mix, aggregates need to be clean, hard, strong particles free of absorbed. Aggregate shape and grading can significantly influence concrete workability. Poorly shaped and poorly graded aggregates typically have a lower packing density than well shaped and well graded aggregates, resulting in more paste being required to fill the voids between aggregates (P.J.Patel).

Sometimes excessive silt and clay contained in the fine or coarse aggregate may result in increase shrinkage or increased permeability in addition to poor bond characteristics (Shetty, M.S).

This chapter presents the state-of-the art literature review and background information about physical properties of Aggregate.

Objective:

The main Objectives of this study is

- ✓ To compare the properties of strength concrete made by natural aggregate and Artificial aggregate (crushing)
- ✓ To investigate the properties of strength concrete both aggregates (Specific Gravity, Unit Weight, Absorption capacity, Void ratio, Workability)
- ✓ To investigate the mechanical properties of both aggregates concrete

Problem Statement

Currently, two types of aggregates were used. Based on their shape characteristics, the aggregates were classified as flaky, angular and irregular. The aggregates occupy 70-80 percent of the volume of concrete.

As such its selection and proportioning should be given carefully attention in order to control the quality of the concrete structures. To get high strengh of concrte depends on the quality of aggregates, there fore, in this stduy provides the necessary information on materials used for concrete manufacturing with a strong focus on concrete aggregates like properties of aggregates both natural and Artificial (crushing)

Terms

Aggregates: Aggregates are inert granular materials such as sand, gravel, or crushed stone

Natural Aggregate: Natural aggregates, which consist of crushed stone and sand, gravel

Crushed Aggregate (Artificial): Aggregate used concrete aggregate crushing plant making defferent size of aggregates.

2. Leterture Riview

Physical properties of Aggregate

There is strong evidence that aggregate type is a factor in the strength of concrete. Ezeldin and Aitcin (1991) compared concretes with the same mix proportions containing four different coarse aggregate types. Herewith the flowing subsections represent physical properties and their effect of the concrete strength

Grain /particles size

Gradation is evaluated by passing the aggregates through a series of sieves (ASTM-C136, E11).The sieve retains particles larger than the opening, while smaller ones pass through.

Aggregates are usually classified by size as course aggregates, fine aggregates. ASTM defines course aggregate as particles retained on the 4.75 mm (No.4) sieve, fine aggregates as those passing the 4.75-mm sieve.

Grading is the particle-size distribution of an aggregate as determined by a sieve analysis (ASTM C 136). The gradation of the aggregate, or distribution of particle sizes, should meet the specifications outlined in ASTM C33, "Standard Specification for Concrete Aggregates." ASTM C33 suggests that the gradation curve be smooth, with neither a shortage nor excess of material of any one size. A smooth gradation curve decreases the voids between the aggregate particles in a homogeneous concrete mix, and, because the voids must be filled with a mixture of cement and water, it therefore decreases the amount of cement required. Tests by Zhou, Barr, and Lydon (1995) show that compressive strength increases with an increase in coarse aggregate size. However, most other studies disagree. Walker and Bloem (1960) and Bloem and Gaynor (1963) concluded that an increase in aggregate size results in a decrease in the compressive strength of concrete. Cook (1989) showed that, for compressive strengths in excess of 69 MPa (10,000 psi), smaller sized coarse aggregate produces higher strengths for a given water-to-cement ratio.

Walker and Bloem (1960) studied the effects of coarse aggregate size on the properties of normal-strength concrete. Their work demonstrates that an increase in aggregate size from 10 to 64 mm (3/8to 2 $^{1}/2$. in.) results in a decrease in the compressive strength of concrete, by as much as 10 percent.

Bloem and Gaynor (1963) studied the effects of size and other coarse aggregate properties on the water requirements and strength of concrete. Their results confirm that increasing the maximum aggregate size reduces the total surface area of the aggregate.

The fineness modulus is a measure of the fine aggregates gradation and is used primarily for Portland cement concrete mix design.

Fineness Modulus. The fineness modulus (FM) of either fine or coarse aggregate according to ASTM C 125 is calculated by adding the cumulative percentages by mass retained on each of a specified series of sieves and dividing the sum by 100. Neville (1981) in his research findings published that entirely smooth coarse aggregates lowered the strength of concrete by 10% than when the aggregates were roughened

Void ratio

Permeability is the amount of water passage through concrete when the water is under pressure or to the ability of concrete to resist penetration by water or other substances (liquid, gas, or ions) Kosmatka et al. (2002). Concrete durability increases as concrete permeability decreases and that reduced permeability increases the concrete resistance to freeze and thaw, sulfate penetration, chloride-ion penetration, and chemical attack (IMCP 2006; Mindess et al. 2003; Kosmatka et al. 2002; Mehta and Monteiro 1993).

Increasing the maximum size of aggregates will increase the concrete permeability because the coarse aggregate size affects the micro cracks in the interfacial transition zone (IMCP 2006; Mindess et al. 2003; Kosmatka et al. 2002; Mehta and Monteiro 1993).

Workability

Workability defines as "that property of freshly mixed concrete or mortar that determines the ease and homogeneity with which it can be mixed, placed, compacted and finished to a homogenous condition" American Concrete Institute (ACI) 116R.

Workability can be recognized by three main parameters (Kosmatka et al. 2002; Chen and Duan 2000): Cohesiveness: the resistance to segregation,

Consistency: the ease of flow, and Plasticity the ease of molding.

Workability is usually assessed by engineers using the slump test (ASTM C143). Gradation, shape, and surface texture of aggregates, Well-graded aggregates will increase workability. Increasing fine aggregate content increases workability but an extreme amount can cause mixtures to become humid. Spherical, smooth surfaced aggregates will increase workability whereas angular, rough surfaced aggregates will decrease workability (IMCP 2006; Mindess et al. 2003; Mehta and Monteiro 1993).

Aggregates constitute 60 % to 75 % of the total volume of concrete; therefore their collection is very important in the mix design process. Gradation, shape, porosity, and surface texture of aggregates affect the workability of concrete (Kosmatka et al. 2002). Aggregates should be well-graded to attain the preferred workability because fine aggregates have a high water requirement due to their high specific surface area and insufficient amount of fine aggregate causes mixtures to become stiff and segregate (IMCP 2006; Mindess et al. 2003; Shilstone 2002; Mehta and Monteiro 1993).

Aggregate shape and texture influence workability through their effect on cement paste requirements. Spherical, well rounded with smooth surfaced aggregates increase workability whereas angular, elongated, rough surfaced aggregates decrease workability and cause segregation (Mindess et al. 2003).

Effect of Strength

Strength is the measured maximum resistance of a concrete specimen to axial loading (Kosmatka et al. (2002)). Although other parameters such as durability and shrinkage may be more critical to assess concrete quality, strength is still commonly used for this purpose, particularly in structural applications (IMCP 2006 p. 116).

Aggregates: Rough and angular aggregates will increase strength (IMCP 2006; Mindess et al. 2003; Mehta and Monteiro 1993). Rough and angular aggregates will increase strength because they bond better to the cement paste (IMCP 2006; Mindess et al. 2003; Kosmatka et al. 2002; Mehta and Monteiro 1993).

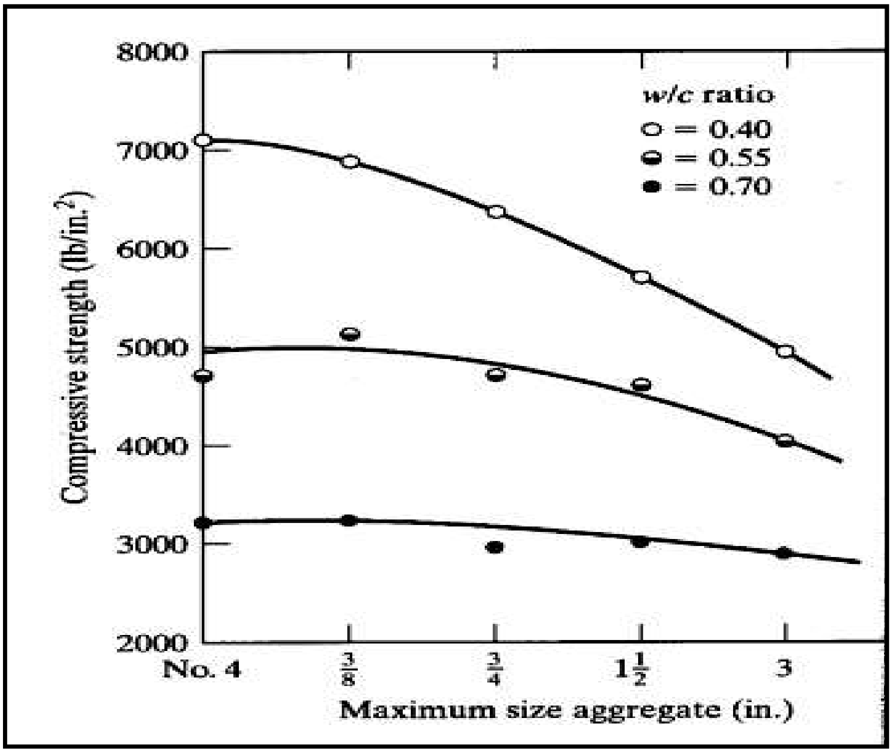

Figure 1: Effect of maximum size of aggregate on compressive strength

(Source: Cordon and Gillespie 1963)

However, once the chemical interaction between aggregate and cement paste is effective at later ages, the surface texture of aggregate reduces its influence on strength (Mehta and Monteiro 1993).

Large aggregate particles reduce compressive strength by exhibiting a high stress concentration when they are subjected to compressive load (Mindess et al. 2003).

Moreover, large aggregate particles forms interfacial transition zones exhibiting more micro cracks compared to the smaller aggregate particles (Mehta and Monteiro 1993).

Durability

ACI Committee 201 (2008) defines durability of concrete as "the ability to resist weathering action, chemical attack, abrasion, or any other process of deterioration and retain its original form, quality, and serviceability when exposed to its environment".

Aggregates: Use of hard, dense and strong aggregate that is free of reactive silica will improve durability (IMCP 2006; Mindess et al. 2003; Kosmatka et al. 2002; Mehta and Monteiro 1993).

Increasing the maximum size of aggregate will increase durability by decreasing the cement paste content that will be under the physical or chemical attack (Mindess et al. 2003). However, reducing the aggregate size will increase durability when concrete is subjected to freeze-thaw condition (Mindess et al. 2003).

Aggregates should be unsound to prevent volume change by resisting a high internal stress when water inside the aggregate is frozen. The degree of saturation, porosity, permeability, and size of aggregate determines this stress (Mindess et al. 2003).

Use of hard, dense and strong aggregate will improve durability by providing good wear resistance (IMCP 2006; Mindess et al. 2003; Kosmatka et al. 2002; Mehta and Monteiro 1993).

In addition, aggregates should be free of reactive silica that causes a chemical reaction between the alkali in the cement paste and silica in the aggregate. Because alkali-silica reaction is very damaging for concrete and it significantly decreases the durability of concrete by causing map cracking, popouts and staining (Mindess et al. 2003).

Table 1. Durability of concrete influenced by aggregate properties

Durability	Relevant Aggregate Property
Resistance to freezing and thawing	Soundness, porosity, pore structure, permeability, degree of saturation, tensile strength, texture and structure, clay minerals
Resistance to wetting and drying	Pore structure, modulus of elasticity
Resistance to heating and cooling	Coefficient of thermal expansion
Abrasion resistance	Hardness
Alkali-aggregate reaction	Presence of particular siliceous constituents

Source: Mindess et al. 2003

3. Methodology

In an attempt of study the strength of concrete, a thorough survey of the available literature was carried out.Various physical and engineering properties of natural an artificial aggregate samples used in the study were determined.

Following the method as explained. After designing the concrete mix, a batch of concrete mix was casted into cubic and cured. The cubic was then tested for compresion test. Test results were than calibrated. Some recommendations have drawn based on those results. Finally a suggestion for future study was also offered. While carrying out this investigation and design, methods prescribed by American Society for Testing and Materials (ASTM) were thoroughly followed.

In this section, the whole experimental methods of two types of coarse aggregate natural and Artificial has been summarized. It includes collection of aggregate, preparation of aggregate, investigations of aggregate and mix design. Various physical and engineering properties of the aggregate samples used in the study were determined.

Flow diagram of methodology is shown in the following section

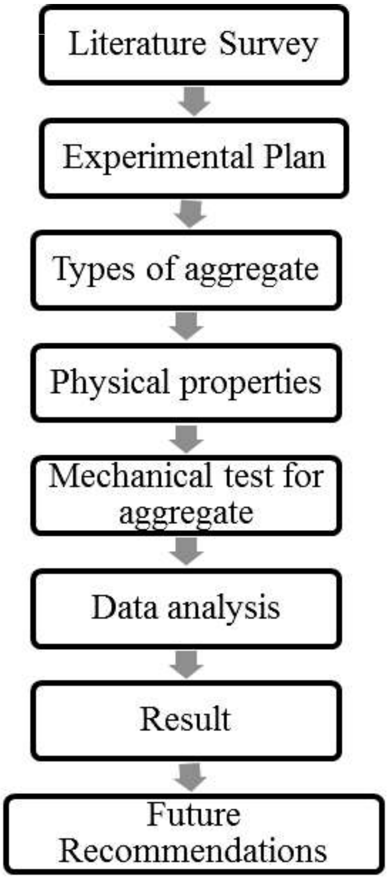

Figure 2: process flow diagram

Materials and Method

Cement: Commercially available Ordinary Portland Cement was used for this research.

Water: Potable drinking water obtained from Civil Engineering Laboratory, Mogadishu University of, Somalia was used for this work

Methodology

Physical properties:

Properties of aggregate are defined by characteristics of both the individual particles and the characteristics of combined material.

Types of aggregate

Two types of course aggregate were used. Based on their shape characteristics, the aggregates were classified as flaky, angular and irregular as per the classification

Sieve analysis of course Aggregate

The main purpose of sieve analysis to determine particle size distribution and fineness modulus of course aggregate by sieving.

Fineness modulus is the sum of the total percentages of material in the sample courser than (cumulative percentage retained) each of the following sieves and divided by 100: No.8, No.3/8 in., 3/4., 1/12 in.

Gradation of Aggregates

The particle size distribution of an aggregate as determined by sieve analysis is termed as grading of the aggregates. If all the particles of an aggregate are of uniform size, the compressed mass will have more voids whereas aggregate comprising particles of various sizes will give a mass with lesser voids. The particle size distribution of a mass of aggregate should be such that the smaller particles fill the voids between the larger particles.

The Grading Curve

The grading of aggregates is represented in the form of a curve or an S CURVE. The curve showing the cumulative percentages of the material passing the sieves represented on the ordinate with the sieve openings to the logarithmic scale represented on the abscissa is termed as Grading Curve

Specific Gravity and Absorption capacity

Bulk specific the weight-volume characteristics of aggregates are not so significant sign of aggregate quality, but they are important for concrete mix design. However, specific gravity (Sp.Gr) the mass of material divided by the mass of an equivalent volume of distilled water. Four types of specific gravity are defined based on how voids in the aggregate particles, three types are this bulk-dry, bulk-saturated surface-dry and apparent specific gravity. Gravity is the ratio of the weight in air of a unit volume of aggregate.

Absorption capacity, defines the amount of water the aggregate absorb is important in the mixing of water to the Portland cement concrete.

Bulk Dry Sp.Gr. = $\frac{A}{B-C}$

Bulk SSD Sp.Gr = $\frac{B}{B-C}$

Apparent Sp.Gr = $\frac{A}{A-C}$

Absorption (%) = $\frac{B-A}{A}$ X (100)

A = dry weight

B = SSD weight

C= submerged weight

Unit weight and voids

Unit weight is the weight in air of a unit volume of a permeable material (including both permeable and impermeable voids). To calculate the unit weight

Unit weight = $\frac{A}{V}$ Ib/ft3 or kg/m3

Where A is net weight of aggregate and V is volume of measure.

To calculate the percentage of voids in aggregate, Void (%) = $\frac{S\ X\ W-B}{S\ X\ W}$ X100

Mixing design

Two types of aggregates were used to conduct the study. Frist sample is natural aggregate and second sample is crashing (Artificial) aggregate. The Water-Cement (W/C) ratio is keeping 0.5 and 0.8.

The table below shows the mix design proportion:

Table 2: Mix design

Sample-1				Sample -2			
Type	W/C	proportion	Aggregate Designation	Type	W/C	proportion	Aggregate Designation
Natural	0.5 &0.8	1: 2: 4	Subrounde	Crashing	0.5&0.8	1: 2: 4	Irregular
		C S A				C S A	
Where			C = Cement		S= Sand	A=Aggregate	

Workability

Workability is defined as the ease with which a fresh concrete mix can handle from the mixer to the final structure. Good workability requires a fairly high proportion of cement, adequate quantity of fine materials, low course aggregate content and high water content.

Workability of concrete is mainly affected by consistency i.e. wetter mixes will be more workable than drier mixes, but concrete of the same consistency may vary in workability.

The following methods give a measure of workability.

Slump test

The mould for the slump test is a cone, 305 mm (12 in) high. The base of 203mm (8 in) diameter is placed on a smooth surface with the smaller opening of 102mm (4 in) diameter at the top and container is filled with concrete in three layers. Each layer is tamped 25 times with a standard 16 mm (5/8 .in) diameter steel rod. Immediately after filling, the cone is slowly lifted. The decrease in the height of the center of the slumped concrete is called slump. (Ismail., Sam, et all, 2009)

The slump test gives the following three results:

- True slump: if the concrete subsides evenly then it is called true-slump, and is aimed to be calculated.
- Shear slump: If one half of the cone slides down, it is called shear-slump and is difficult to measure. It occurs in harsh mixes (mixes deficient in fine aggregate).
- Collapse: If the concrete slides down as soon as the mould is removed, it is known as collapse-slump. It occurs in very wet mix

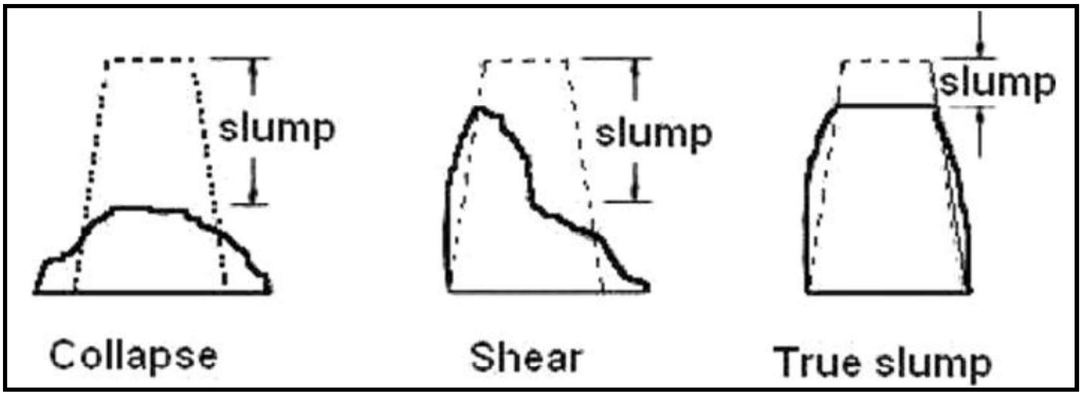

Figure 3: Different types of slump

Compacting factor test

The degree of compaction achieved by a standard amount of work is determined and also the amount of work necessary to achieve full compaction, the degree of compaction called the compaction factor, is measured by the density ratio. (Ismail., Sam, et all ,2009)

The compacting factor shall be calculated from the equation:

$$\textbf{Compacting factor} = \mathbf{M_p / M_f}$$

Where,

$\mathbf{M_p}$ is the mass of the partially-compacted concrete

$\mathbf{M_f}$ is the mass of the fully compacted concrete

The results shall be expressed to two decimal places

Table 3: Workability, slump, and compacting factor of concrete with 19 mm or 38 mm maximum size of aggregate

	Slump			
Degree of workability	**Mm**	**in**	**Compaction factor**	**Use for which concrete is suitable**
Very low	0-25	0-1	0.78	Roads vibrated by power-operated machines.
Low	25-50	1-2	0.85	Roads vibrated by hand operated machines
Medium	25-100	2-4	0.92	At the less workable , manually compacted flat slabs using crash aggregate
High	100-175	4-7	0.95	For sections with congested reinforcement. Not normally suitable for vibration

Source: Ismail, M.A.K., Sam, A.R.M., et al. (2009)

Compressive Strength Test

The compressive strength of concrete depends on the water to cement ratio, degree of compaction, ratio of cement to aggregate, bond between mortar and aggregate, and grading, shape, strength and size of the aggregate (Roccoand Elices, 2009; Elices and Rocco, 2008).

For the compressive strength test, the universal compression test machine was used to conduct the study. Cubes of size 150mm x 150mm x 150 mm are tested in compression in accordance with the test procedures given by ACI. The ratio of the water to cement is the principal factor for determining concrete strength. The lower the water-cement ratio, the higher is the compressive strength

Preparation of Specimens

Six Specimens were prepared using 150 mm x 150mm x 150mm moulds. The specimens cast were demoulded after 24 hours and kept in normal curing for the required age such as 7, 21 and 28 days.

After one day of casting, the concrete cubes were removed from the mould and were transferred to a water tank for curing until the time of test. The curing of the cube was done according to ACI.

The data analysis and result was used Excel package for the model development. Several model statistics and graphical plots were obtained which can be used to explain the adequacy of the regression models.

Figure 4: Natural Aggregate casting cube

Figure 5: Crashing Aggregate casting cube

4. Result and discussion

The experimental results are discussed as follows:

Properties of Aggregates

The results for the sieve analysis test on the aggregates are shown in Figures 4.1 and 4.2. The grading curve for the crushed (Artificial) aggregates shown us a uniformly graded aggregate it refers to a gradation that contains most of the particles in a very narrow size range. In essence, all the particles are the same size. The aggregates are not are not effectively full, and the resulting concrete will be more porous, unless a lot of paste is employed. Generally the crashed (Artificial) aggregate require excessive amount of cement paste to fill the voids

- Narrow range of sizes
- Grain-to-grain contact
- High void content
- High permeability
- Low stability
- Difficult to compact

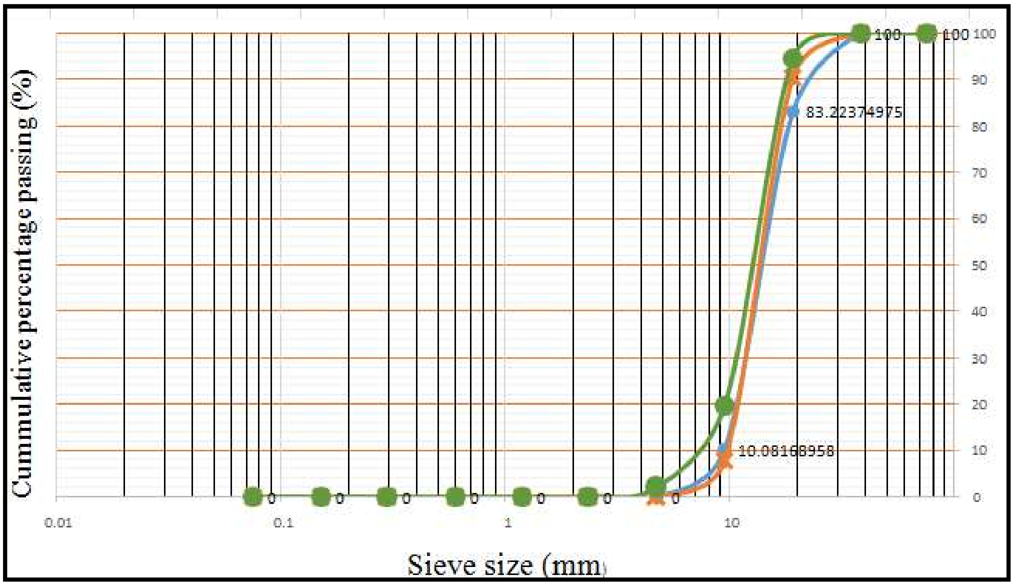

Figure 6: Sieve analysis for crushed aggregate

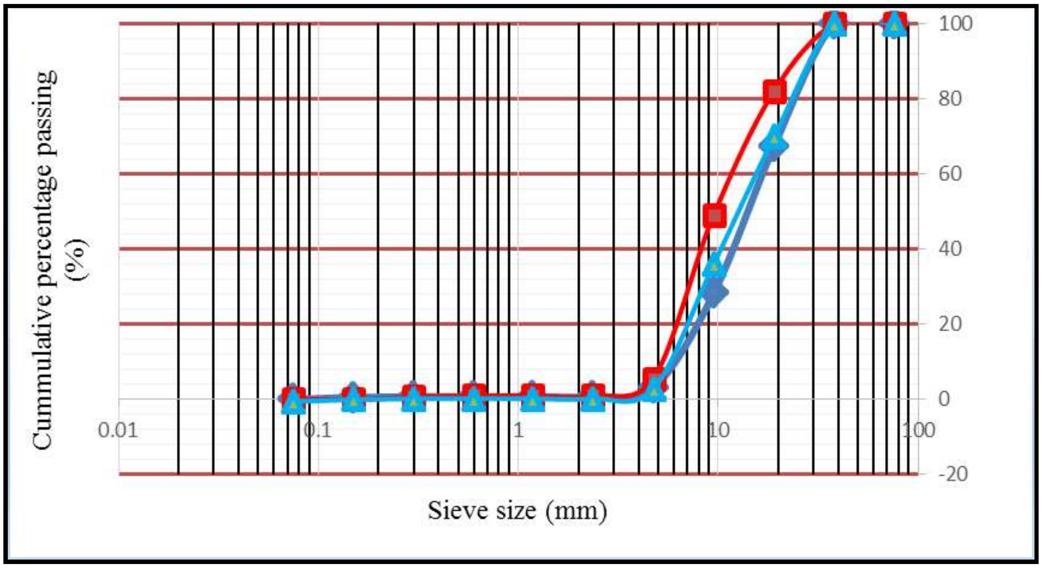

Figure 7: Sieve analysis for natural aggregate

Fineness modulus

The result for the fineness modulus test on the crashed and natural aggregates is shown in Figures 8 and 9. The Fineness modulus of natural aggregates in the three samples is 6.9, 6.5, 6.9 and the average number is 6.8. The result shown the fineness modulus of sample-2 is below the average and the sample-1 is above the average. The average of FM is medium course, and has more permeability then the fine aggregate.

Higher fineness modulus of aggregate represents larger aggregate size. Compressive strength of aggregate are closely related with the aggregate grading as well as size also. Generally concrete compressive strength increases with the increase of aggregate fineness modulus, size of aggregate. If size of aggregate in concrete increases, surface area will reduce. Then quantity of cementing materials per unit surface area will increase which increase bond stress with resulting increase of concrete compressive strength

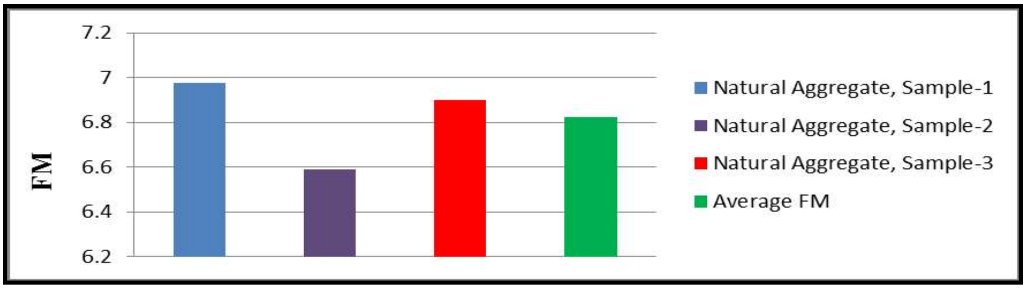

Figure 8: Fineness Modulus of Natural Aggregate

The fineness modulus of crashed aggregate from figure analysis it can easily be found that, the sample-1 FM is 7.0, sample-2 FM is 7.0 and sample-3 FM is 6.8, the average value of FM is 6.8. The analysis shown the sample-3 is equal the average value of FM and the average value are indicated medium course also has more permeable

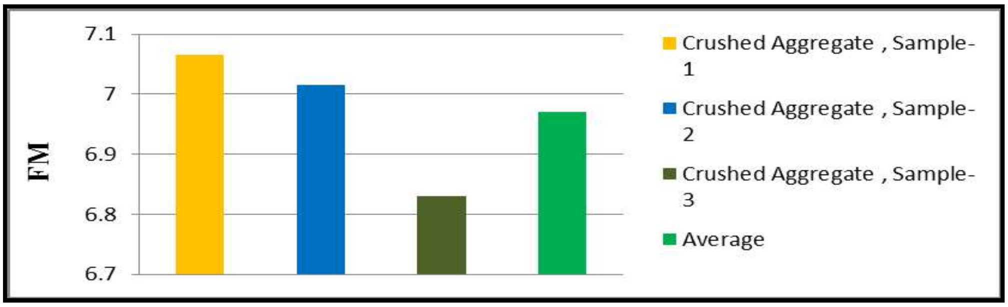

Figure 9: Fineness Modulus of crashed aggregate

The specific gravity and water absorption of aggregates are important properties that are required for the design of concrete and mixes.

The result for the specific gravity and absorption capacity test of the Natural aggregate is shown in Figure 10. The values of the specific gravities of the aggregates are from 2.56 to 3.14.

The value of specific gravity of crashed aggregate is 2.56 and natural aggregates are 3.14 respectively. Though high specific gravity is considered as an indication of high strength.

The specific gravity of aggregates normally used in road construction ranges from about 2.5 to 3.0

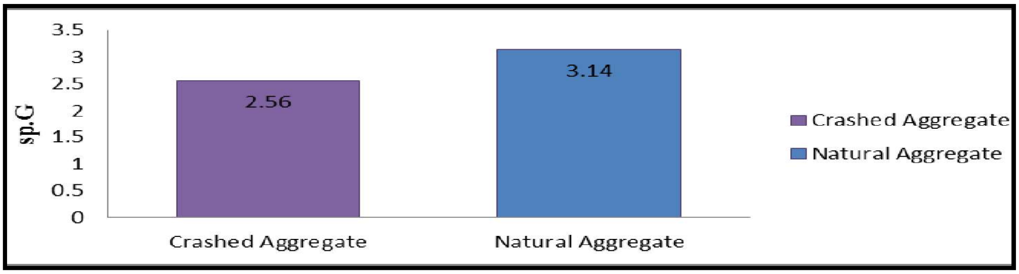

Figure 10: Specific gravity of Crashed and Natural aggregates

The absorption of the aggregate indicates the quantity of water which will be absorbed into the pore structure. Most commonly, aggregates will have a moisture content that is either below or above this absorption limit.

The moisture content and absorption of aggregates are important in calculating the proportions of concrete mixes since any excess water in the aggregates will be incorporated in the cement paste and give it a higher water/cement ratio than expected

The value of % of absorption of crashing aggregate is 7% and natural aggregate is 6% respectively (Figure 11)

Water absorption values ranges from 0.1 to about 2.0 percent for aggregates normally used in road surfacing.

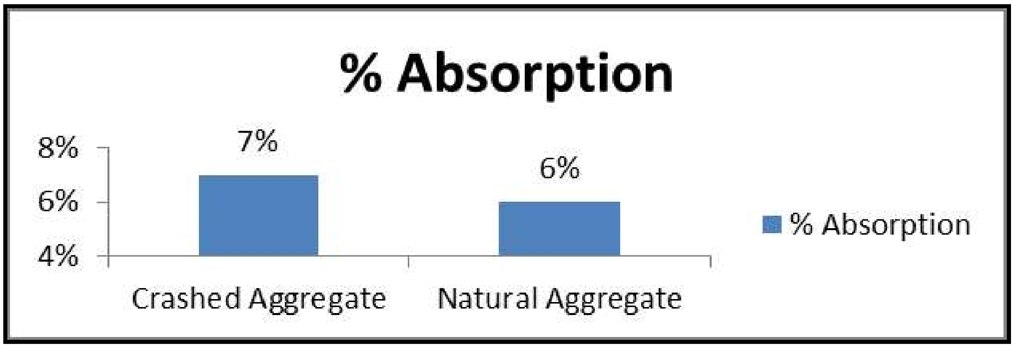

Figure 11: Absorption capacity of crashed and natural Aggregates

Slump test

The result for the slump test of concrete is shown in the tables below. The slumps obtained are in natural aggregate for 0.5 and 0.8 w/c ratio was respectivley true and collapse e (Table 4). For crashed aggregates due to w/c ratio 0.5 and 0.8 the slumps was respectivly true and collapse (Table 5). The result shows the highest slump was obtained with concrete made with both natural and crashed aggregate with 0.8 w/c ratio by improper compaction.Both aggregates are recommended to use 0.5 w/c ratio with proper compaction to get minimum slump hight and true slupm.

Compaction factor for natural Aggregate is recommended for 0.5 w/c ratio required proper compaction but 0.8 w/c ratio no need mechanical compaction.

Radius of slump (r) = 0.0508m

Radius of slump (R) = 0.1016m

Height of slump = 0.3048m

Volume of slump = $(\pi h/3)(R^2 + \mathrm{Rr} = r^2)$

=0.0057m

Specific Weight of Concrete = 2400 kg/m^3

Weight of Concrete = 13.68Kg

Wastage Factor of 50%

So, Total weight of Concrete = (0.5*13.98 kg) + (13.68 kg) = 21 Kg

Mix Ratio Design = 1:2:4

Weight of Cement= 3Kg

Weight of Sand = 6Kg

Weight of Aggregate = 12Kg

W/C=0.8

Weight of Water = 2.4litre

Table 4: Slump test for natural Aggregate

Trial No	W/C Ratio	No of Temping	Slump Height (mm)	Type of Slump
1	0.5	5	177.3	Collapse
2	0.5	10	25.4	Shear
3	0.5	15	25.4	Shear
4	0.5	25	12	True
5	0.8	5	254.6	Collapse
6	0.8	10	203.2	Collapse
7	0.8	15	177.4	Collapse
8	0.8	25	165	Collapse

Table 5: Slump tes for crashed aggregate

Trial No	W/C Ratio	No of Temping	Slump Height (mm)	Type of Slump
1	0.5	5	168	Collapse
2	0.5	10	18	True
3	0.5	15	18	True
4	0.5	25	14	True
5	0.8	5	220.1	Collapse
6	0.8	10	203.2	Collapse
7	0.8	15	177.8	Collapse
8	0.8	25	165.1	Collapse

Table 6: compaction factor for natural Aggregate

SL	Description	W/C = 0.5	W/C = 0.8
1	Mix Ratio	1:2:4	1:2:4
2	Weight of Cement	3Kg	3Kg
3	Weight of Sand	6Kg	6Kg
4	Weight of Aggregate	12Kg	12Kg
5	Weight of Water	2.4L	2.4L
6	Weight of Cylinder (W1)	3.25kg	3.25kg
7	Weight of Cylinder + Weight of Partial Compacted (W2)	12.42KG	13.69KG
8	Weight of Partial Compacted (W3)	9.17KG	10.4KG
9	Weight of Cylinder + Weight of Full Compacted (W4)	13.68kg	14.21kg
10	Weight of Full Compacted (W5)	10.61kg	10.69kg
11	Compaction Factor (W6) = W3/W5	9.17/10.61 = 0.86	10.41/10.96 = 0.95
12	Compaction Factor %	86%	95%
13	ACCEPTANCE Of RESULT	Properly Compaction YESS ACCEPTED	Over Compacted NOT ACCEPTED

Table 7: compaction factor for crashing Aggregate

SL	Description	W/C = 0.5	W/C = 0.8
1	Mix Ratio	1:2:4	1:2:4
2	Weight of Cement	3Kg	3Kg
3	Weight of Sand	6Kg	6Kg
4	Weight of Aggregate	12Kg	12Kg
5	Weight of Water	2.4L	2.4L
6	Weight of Cylinder (W1)	3.25kg	3.25kg
7	Weight of Cylinder + Weight of Partial Compacted (W2)	13.2KG	14.5KG
8	Weight of Partial Compacted (W3)	10.1KG	11.9KG
9	Weight of Cylinder + Weight of Full Compacted (W4)	14kg	16.8kg
10	Weight of Full Compacted (W5)	11.61kg	11.69kg
11	Compaction Factor (W6) = W3/W5	10.1/11.61 = 0.87	11.9/11.96 = 0.99
12	Compaction Factor %	87%	99%
13	ACCEPTANCE Of RESULT	Properly Compaction YESS ACCEPTED	Over Compacted NOT ACCEPTED

Compressive Strength

For the two types of concrete, it was observed that the compressive strength increases with age at curing.

For all the ages at curing, the highest strength was obtained from concrete made with crushed (Artificial) aggregate, followed by Natural Aggregate. The amount of paste required is believed to depend on the amount of void spaces to be filled and the total surface of the aggregate to be coated with paste (Mindess,Young, and Darwin 2003). The important portion of the gradation curve for the crushed aggregate as earlier mentioned, falls outside the recommended range and it is lower than the lower limit. This implies that the coarse aggregate has greater voids to be occupied by mortar. This may affect the workability of the concrete, unless mixture proportioning adjustment is carried out to improve. This quality has the possible of producing concrete with weaker mortar/aggregate interface. Natural Aggregate, even though the gradation characteristic is good, has rounded particles and may not appropriately join each other during compaction resulting to reduction in strength compared to where full or higher compaction is achievable.

5. Conclusion and Recommendation

Aggregate type has effect on the compressive strength of normal concrete. Highest compressive strength was achieved from concrete containing crushed aggregate. Concrete containing crushed aggregate shows the strength development at all ages.

It has been concluded that mixing of smaller and bigger size of aggregate gives better Compressive strength than a single size of aggregate.

Aggregate of this nature requires more amount of water when used for concrete work to provide for aggregate coating and lubrication (ACI Committee 211.1-91).

The concrete containing both crushed and natural Aggregates shows the highest slump with 0.8 w/c ratio workability compared to concrete made natural and crushed aggregate with 0.5 w/c ratio.

It is suggested that crushed aggregate may be working for concrete work in places where concrete practitioners have selection of choices available.

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