EFFECTS OF MAXIMUM SIZE OF COARSE AGGREGATE ON COMPRESSIVE STRENGTH OF CONCRETE

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The thesis titled **"Effects of Maximum Size of Coarse Aggregate on Compressive Strength of Concrete"** submitted by Md. Mahmudul Hasan (ID: 161-47-121), S.M. Rahat Kabir (ID: 161-47-139), and Anukul Sarker Monty (ID: 161-47-129), Session: Spring 2016 has been accepted as satisfactory in partial fulfillment of the requirements for the degree of Bachelor of Science (B.Sc.) in Civil Engineering on March 16 , 2020.

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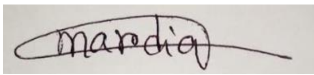

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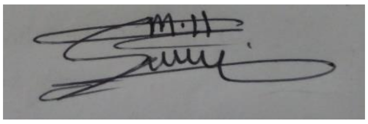
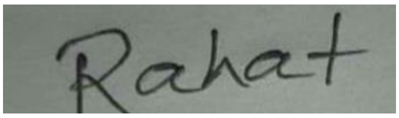
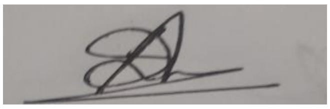
AUTHORS DECLARATION

It is hereby declared that this dissertation or any part of it has not been submitted elsewhere for the award of any degree or diploma.







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DEDICATION

Dedicated

To

Our Family

ACKNOWLEDGEMENT

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ABSTRACT

Concrete is one of the commonly used construction materials throughout the world. Concrete is essentially a mix of coarse aggregate, fine aggregate and cementing materials. ACI method of concrete mix design is one of the widely used methods for proportioning quantity of coarse aggregate, fine aggregate and cementing materials in concrete. According to ACI method of mix design, the volume of coarse aggregate requires to proportion per unit volume of concrete depends on the size of the coarse aggregate and the fine aggregate gradation, expressed in terms of fineness modulus. But the strength and durability of concrete depends on aggregate size distribution (gradation) rather than maximum size of aggregate. In this thesis effects of coarse aggregate size on compressive strength of concrete are examined. The maximum sizes of coarse aggregate are chosen as 3/4 and 3/8 inch for mix design. The design strength of concrete is assumed 3000 psi and water cement ratio of 0.68 on the basis of design strength. The concrete is also assumed non-air-entrained type. The workability of concrete expressed as slump is taken 1-2 inch. The fine aggregate used in this experiment has fineness modulus of 2.5. Ordinary Portland cement is used as cementing material. Two sets of concrete cylinder are prepared with ACI mix design ratios and tested at 28 days. The average compressive strength of 3/4 inch and 3/8 inch aggregates are found 2471 psi and 2518 psi respectively. Experimental results have revealed that, maximum sizes of coarse aggregate have very little effects on compressive strength of concrete.

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LIST OF NOTATIONS AND ABBREVIATIONS

ACI	American Concrete Institute
ASTM	American Society for Testing and Materials
PSI	Pound per square inch
OPC	Ordinary Portland cement
FM	Fineness Modulus

CHAPTER ONE

INTRODUCTION

1.1 General

The compressive strength is typically controlled with the ratio of water to cement when forming the concrete, and tensile strength is increased by additives, typically steel, to create reinforced concrete.

Concrete is stone-like material used for the construction of bridges, pavements, highways, houses and dams. It is produced by mixing sand, gravel or crushed rocks, cement and water and allowed to cure over a period of time. Several factors are known to the strength of concrete. They include their batch ratios, mixing mechanism, transporting and curing processes, aggregate texture and shape and nature of other constituent materials. Additionally, the sizes of the aggregates have been shown to have some influence on the strength of concrete.

Several coarse aggregate types including basalt, quart-dolerite, quartzite, gneisses, granites, limestone, marbles and gabbro have also been shown to affect the compressive strength of concrete.

1.2 Thesis Background

Concrete is by far the most used building material on earth due to its excellent compressive strength, Mouldability to different predefined shapes and a long service life. In many areas, concrete exploits economical local materials (sand, block and stone) and requires generally less measure of concrete and reinforcing steel which can be moved in from one to different areas of the country. Concrete in a structural building structure primarily resists compressive stress created from various loads types, and tensile stress is left for reinforcing steel to dominate.

Compressive strength of concrete depends on numerous factors. The primary affecting variables on quality are taken by and by as: water/cement ratio, degree of compaction, age and temperature. However, there are likewise different variables which influence strength: total/cement ratio, quality of aggregate (surface texture, grading, shape and strength), and the maximum size of aggregate. These factors are regarded as of optional significance when usual aggregates up to a maximum size 40 mm are used (Neville, 2002).

For construction of any concrete structure, compressive strength of concrete is indicated beforehand. Different mix design approaches are accessible to achieve determined strength of concrete. Among the different method being used, the strategy proposed by American Concrete Institute (ACI 211.1-91) is likely the most well-known one. The ACI method requires in absolute seven information parameters to design a normal strength concrete mix. These are: coarse aggregate unit weight, fine aggregate specific gravity, coarse aggregate specific gravity, design compressive strength, slump and fine aggregate fineness modulus, coarse aggregate maximum size. Concrete samples as specified by ASTM Standard are casted and tested in concrete laboratory facility to guarantee that concrete of determined quality are achieved at the construction site. An experimental program will be conducted to assess the Effects of Maximum Size of Coarse Aggregate on Compressive Strength of Concrete to be cured under standard laboratory controlled conditions and to be tested at 28 day.

1.3 Objectives of the study

The main objectives of the thesis are as follows:

- To determine the compressive strength of 4 × 8 in. cylinders with variable sizes of coarse aggregate .

- To compare the design , strength ,workability and durability with the results from the lab tests.

1.4 Scope of the Study

An experimental program will be carried out to determine the Effects of Maximum Size of Coarse Aggregate on Compressive Strength of Concrete. Cylinder sizes of 4×8 in. will be used in the study. Properties like bulk specific gravity, Grain size analysis of fine and coarse aggregate, water absorption capacity, and fineness modulus of coarse and fine aggregates will be evaluated through different laboratory tests. Ordinary Portland cement (OPC), Sylhet sand and stone chips aggregates will be used as ingredients of concrete without any chemical admixture. Concrete compressive strength will be evaluated for 28 days.

American Concrete Institute (ACI) mix design of concrete is the most acceptable method of concrete mix design all over the world as well as Bangladesh. One of the main reason of American Concrete Institute (ACI) mix design of concrete why it is the most common method is Concrete is more available method in Bangladesh.

1.5 Organization of the thesis

The thesis is organized into five chapters.

Chapter 1: This Chapter provides introduces of the chapter, background of the thesis, objectives of the study and scope of the thesis.

Chapter 2: (Literature Review),Provides the discuss about ACI method of concrete mix design, limitations of ACI mix design, progressive research, Fineness modulus, Information about slump have been mentioned.

Chapter 3: (Experimental Works) includes details about the experimental work, which were performed together with their respective standards.

Chapter 4: (Results and Discussions) contains the consequences of test program and the analysis of the obtained outcomes.

Chapter 5: (Conclusions and Recommendations), conclusions of the present study are listed briefly. In addition, a further research scope will be mentioned.

CHAPTER TWO
LITERATURE REVIEW

2.1 General

Compressive strength of concrete is determined by testing on hardened concrete samples which is one of the most significant and fundamental analyses performed broadly for quality affirmation testing. Normally tests of different size and shape as indicated by various standards

Figure 1: Coarse Aggregate

are casted in the field/laboratory and crushed them by using significant testing machines. There are Different kind of aggregates presents but the author worked in the laboratory with the help of 3/4 inch and 3/8 inch stone chips as coarse aggregate and Sylhet sand for fine aggregate.

2.2 American Concrete Institute (ACI) Method of Concrete Mix Design

By American Concrete Institute (ACI) committee 613 , this method of proportioning was published in 1954 the use of air entrained concrete among other modification method was revised.

The estimated weight of the concrete per unit volume. That's the first method calculation of the absolute volume occupied by concrete ingredients (Z. Wadud, 5-7 December 2001). It the other the requirements for workability, consistency, strength and durability are take into consideration by the American Concrete Institute (ACI) methods.

It has the advantages of simplicity in that it applies equally well, and with more or less identical procedures to rounded or angular aggregate, to regular or light weight aggregates and to air entrained or non-air entrained concretes. The methods suggested by the American Concrete Institute (ACI) Committee 211 (1969) are widely used in the USA (KRISHNASWAMI, TECHNICAL MEETING ON 09-05-2009).

Procedure

- From the minimum strength specified need to estimate the average design strength.
- From the strength point of view have to find the water-cement ratio from durability point of view from table.
- Maximum size of aggregate.
- Workability of slump.
- The total water of concrete from table at kg/m^3.
- Water cement ratio which is content is computed by dividing the total water content.
- The bulk volume of dry ridded coarse aggregates per unit volume of coarse aggregate and fineness modulus of fine aggregate from the table.
- The weight of coarse aggregate per cubic meter of concrete is calculated by multiplying the bulk volume with bulk density.
- The solid volume of coarse aggregate in one knowing the specific gravity off coarse aggregate.
- Similarly the solid volume of cement, water and volume of air is calculated in on cubic meter of concrete.

2.3 limitations of American concrete institute (ACI) mix design

According to the research the cement content determination process is not directly related to aggregate gradation. But in the reality the binding action of the hydrated cement paste always takes place on the surface of the aggregate partials. Again so far as the aggregate surface area is concerned fine aggregate is the major contributor. As a result the quantity of fine aggregate is essential to the determination of cement content. American Concrete Institute (ACI) Method gives higher proportion of fine aggregate for the case where coarse aggregate of lower unit weights to be used. Unit weight of a particular coarse aggregate is closely related to the inter particular voids of coarse aggregate particles. Inter partial voids of coarse aggregates, a function of gradation plays a significant role in the prediction of mix proportions. American Concrete Institute (ACI) method fails to rationally predict the proportion of the ingredients when coarse aggregate of higher voids is used in making the concrete. In such cases the amount of fine aggregate is over estimated. This over estimation leads to a higher surface area to be covered by the same amount of cement, which is defined without any reference to aggregate grading. As a result the mix fails to attain the design strength. The American Concrete Institute (ACI) method has no adequate parameter to take this aspects into account. In addition the cement content is determined even before the consideration of any aggregate type, resulting in a lower fine aggregate ratio. This is why mixes designed by the American Concrete Institute (ACI) method fail to gain desired strength, when coarse aggregates of higher voids are used.

2.4 Previous Research

Abdullahi (2012) investigated how quartzite, granite, and river gravel influence the strength of concrete and established that aggregate type has effect on the compressive strength of concrete, and that concrete made from crushed quartzite would give the highest compressive strength at all ages but concrete made with granite as coarse aggregate would give the least strength. On the contrary, Aginam et al. (2013) found that concrete made with granite as coarse aggregate gave higher compressive strength compared to concrete made with washed and unwashed gravels as coarse aggregate component.

Oyewole et al. (2011) also investigated the effects of aggregate sizes on the properties of structural concrete so as to establish the aggregate size that will improve the properties of structural concrete. They concluded that the average compressive strength of concrete increases as the sizes of coarse aggregates are reduced. In another experiment to determine the influence of the size of coarse aggregate on the compressive strength of concrete, Xie et al. (2012)

confirmed the earlier findings that the compressive strength decreased when the maximum coarse aggregate size was increased.

2.4.1 Size of the aggregates:

There are so many Sieve No and their openings but in the topics of ‘American Concrete Institute (ACI) mix design of Concrete. The author need to require that values,

Table 1: Sieve no with opening

Sieve No	Opening
#4	4.75mm
#8	2.36mm
#16	1.18mm
#30	0.60mm
#50	0.30mm
#100	0.15mm
#200	0.075mm

2.4.2 Aggregate Gradation

Table 2: Concrete grade with group

Concrete grade	group
M5	
M7.5	
M10	Ordinary Concrete
M15	
M20	
M25	
M35	Standard Concrete
M40	
M45	
M50	
M55	
M60	High Strength Concrete
M65	
M70	

2.4.3 Aggregate Discuss

Coarse aggregate 3/4 and 3/8 stone chips.

Fine Aggregate is Sylhet sand.

Portland cement (Bashundhara cement).

Water depends on the cement ratio.

Figure 2 Fine Aggregate

There are many kind of coarse and fine aggregates but we hardly need to learn that have to use the economical one.

2.4.4Fineness Modulus

Fineness Modulus is defined as an index to the particle size not to the gradation. Fineness Modulus is calculated from the sieve analysis. It is defined mathematically as the sum of the cumulative percentages retained on the standard sieves divided by 100. The standard size sieves are 6 (150 mm), 3 (75 mm), 1/2 (37.5 mm), 3/4 (19.0 mm), 3/8 (9.5 mm), No. 4 (4.75 mm), No. 8 (2.36 mm), No. 16 (1.18 mm), No. 30 (600 µm), No. 50 (300µm), and No. 100 (150 µm). Always report the fineness modulus to the nearest 0.01

2.4.5 Information about slump

Slump value can be mentioned by ASTM C143 USA. Slump test is for determining the workability of the stone chips. A slump cone is must for the slum test. The diameter of the slump at bottom is 200 mm and 100 at the top and 300 mm at length. During the time of test the materials need to place in 3 layers need to give compaction 25 time by a rod. The rod is a metal which is made through steel.

Figure 3: Slump Test

The slump value need to in the range of 1 inch to 2 inch but it can be increased if any kind of chemicals are used in the concrete mixture. Chemical admixtures are used to increase the durability and workability.

Table 3: Slump value for different type of construction work

Types of construction	Maximum slump value	Minimum slump value
Reinforced foundation walls and footings	3	1
Beams and reinforced walls	4	1
Building columns	4	1
Plain footings , Sub structures	3	1
Pavement and slabs	3	1
Mass concrete	2	1

Table 4: Strength for mix design (Source: American Concrete Institute (ACI) mix design method)

strength For 28 Days (psi)	w/c ratio(Non Air)
2000	0.82
3000	0.68
4000	0.57
5000	0.48
6000	0.41

2.4.6 Performance of the trial Mix

Table 5: Proportion of FA: CA: Cement

Mix Trial	FA: CA: CEMENT
1	**1: 2.9: 3.9**
2	**1 : 3.5 : 2.9**

CHAPTER THREE
LABORATORY INVESTIGATIONS

3.1 General

A wide variety of laboratory scale tests of aggregates and concrete have been conducted in this thesis. This chapter describes test standards, procedures and results for the source materials that have been used in concrete production. For concrete specimens, mix proportions, size, quantity and preparation of the specimens for different phases of the work are also featured in this chapter.

3.2 Materials Used and Selection

The ingredients which are of main concern-

(i) Aggregate (3/4 and 3/8 inch coarse aggregate, fine aggregate (Sylhet sand)

(ii) Ordinary Portland cement.

3.3 Mix design and required tests

Aggregates are the major components in any concrete mixture. For proposing a new concrete mix design method, various properties of aggregates have been tested. Following describes briefly the tests which have been conducted for aggregate samples.

- Specific gravity of fine aggregate.
- Specific gravity of coarse aggregate.
- Crushing strength test for coarse aggregate.
- Sieve analysis of fine and coarse aggregate.

3.3.1 Specific Gravity Tests

Specific gravity of fine aggregate

Standard references:

This test method conforms to the ASTM standard requirement of specification C128.

Procedure:

1. The authors need wt. of pycnometer (gm.) = w_1
2. Wt. of pycnometer + dry soil (gm.) = w_2
3. Wt. of pycnometer (gm.) + dry soil (gm.) + distilled water (gm.) = w_3
4. The wt. of pycnometer which is full of distilled water at a standard level of the pycnometer = w_4
5. Find the wt. of solid (w_d) as well as wt. of water(c).

Wt. of solid = (wt. of pycnometer + dry soil (gm.) - (wt. of pycnometer)

$W_d = W_2 - W_1$

Wt. of water = $W_3 - W_2$

FOR FINE AGGREGATE:

Wt. of pycnometer, w_1=108 gm.

Wt. of pycnometer (gm.) + soil (dry sand), w_2=151 gm.

Wt. of pycnometer + dry sand + distilled water, w_3=381 gm.

The wt. of pycnometer which is full of distilled water at a standard level of the pycnometer, w_4=354 gm.

$W_d = W_2 - W_1 = 151-108 = 43$ gm.

$C = W_3 - W_2 = 381-151 = 230$ gm.

$a = W_4 - W_1 = 354-108 = 246$ gm.

$Ww = a - c = 246-230 = 16$ gm.

So, the specific gravity of fine aggregate (Sylhet sand)

$G = \frac{Wd}{Ww} \times T^o = (43/16) \times 0.99933 = 2.68.$

Specific gravity of Coarse aggregate

Reference Standard

This test method conforms to the ASTM standard requirement of specification C127.

FOR COARSE AGGREGATE:

The wt. of pycnometer (gm.), w = 396 gm.

The wt. of pycnometer + dry soil (gm.), w_2 = 596 gm.

The wt. of pycnometer (gm.) + dry soil (gm.) + distilled water (gm.), w_3 = 1110 gm.

The wt. of pycnometer which is full of distilled water at a standard level of the pycnometer, w_4 = 966 gm.

Wt. of solid W_d =596-396=200 gm.

Weight of water, C =1110-596 =514 gm.

Specific gravity $G=\frac{Wd}{Ww}$

$W_W = (W_4-W_1)-(W_3-W_2)$ = (966-396)-(1110-596)=56 gm.

W_d = 200 gm.

So, the specific gravity of coarse aggregate, $G=\frac{Wd}{Ww} \times T^o$

$=\frac{200}{56} \times 0.99933$ (the room temperature was 23º)

=3.57

(c) Sieve analysis of fine and coarse aggregate

Reference Standard

This test method conforms to the ASTM standard requirements of specification C136.

GRAIN SIZE ANALYSIS (SIEVE ANALYSIS)

Sieve analysis is performed to determine the gradation of different particle sizes of coarse grained soil or coarser portion of a soil containing both coarse and fine particles.

Sieves are made of woven wires with square openings. The above table gives a list of U.S. standard sieve numbers with the corresponding size of openings.

Table 6: Grain Size Analysis

Sieve no	Opening
#4	4.75mm
#8	2.36mm
#16	1.18mm
#30	0.60mm
#50	0.30mm
#100	0.15mm
#200	0.075mm

Test procedure

- The author select the sieve with suitable openings.
- Dry the sample at 110±5ºC in an oven at least 12 hour and if possible then 24 hours.
- Measure the weight of pan in a scale.
- Measure the pan and sample and write the weight in paper.
- The author arrange the sieve no from upper to lower just like #4 sieve at the top and #200 at the bottom as well as the PAN will remain in the lower part of the sieve no.
- The author need to give the sample for shaking in the upper sieve no and give the veil in the upper sieve.
- Then the author start shaking at least 10 to 15 minutes.

Figure 4: Sieve Analysis

Calculation:

- Find the sieve number and sieve opening (mm).
- Sieve weight with material in grams and also the weight of sieve.
- Find how much materials retained (gm.)
- Make the % of materials retained.
- Find the cumulative % of retained.

A DATA SHEET FOR COARSE AGGREGATE

Table 7: Coarse aggregate sieve analysis

sieve no	Opening (mm)	Sieve with materials (gm.)	Weight of sieve (gm.)	Materials retained(gm.)	Percent of soil retained	Cumulative
3in	75	324	323	1	0.33	0.33
¾ in	19	324	322	2	0.68	1.01
3/8 in	9.5	702	507	195	65.08	66.09
#4	4.75	603	500	91	31.20	97.29
#8	2.36	295	292	2	0.68	97.97
#16	1.18	289	288	1	0.33	98.30
#30	0.60	297	296	1	0.33	98.63
#50	0.30	294	293	1	0.33	98.96
#100	0.15	251	250	1	0.33	99.29
#200	0.075	261	260	2	0.68	99.97

Total=657.87

FOR FINE AGGREGATE:

Table 8: Sieve analysis of fine aggregate

Sieve no	Opening (mm)	Wt. of container + soil (gm.)	Wt. of container (gm.)	Retained (gm.)	Percentage of soil retained	Cumulative
#4	4.75	505	500	5	1.71	1.71
#8	2.38	299	292	6	2.05	3.76
#16	1.18	317	288	29	9.94	13.7
#30	0.60	367	296	71	24.34	38.04
#50	0.30	453	293	160	54.8	92.8
#100	0.15	273	250	23	7.8	100
#200	0.075	261	260	1	0.34	100.34 =100
PAN						=250.01

Table 9: Coarse aggregate with percent of passing

opening (mm)	%passing
75	99.67
19	98.99
9.5	33.91
4.75	2.71
2.36	2.03
1.18	1.7
0.6	1.37
0.3	1.04
0.15	0.71
0.075	0

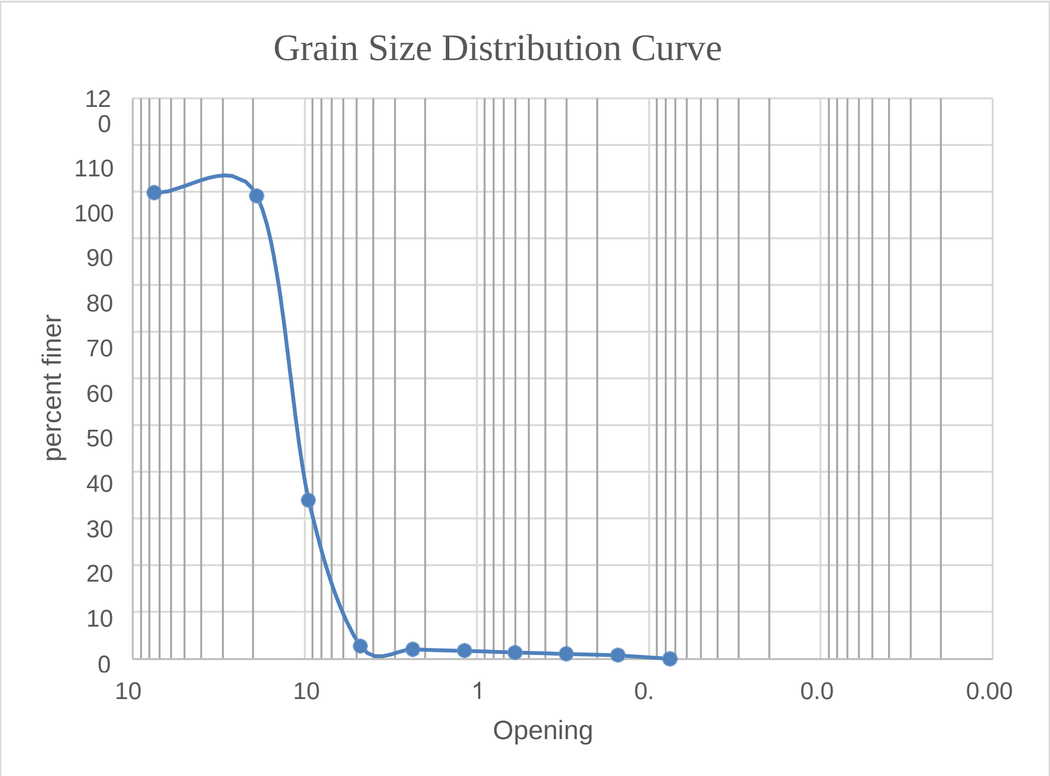

Figure 5: Sieve Analysis of Coarse Aggregate.

Table 10: Fine aggregate with percent finer

opening in (mm)	% finer
9.5	5.63
4.75	0.41
2.36	0.41
1.18	0.21
0.6	0.21
0.3	0.01
0.15	100

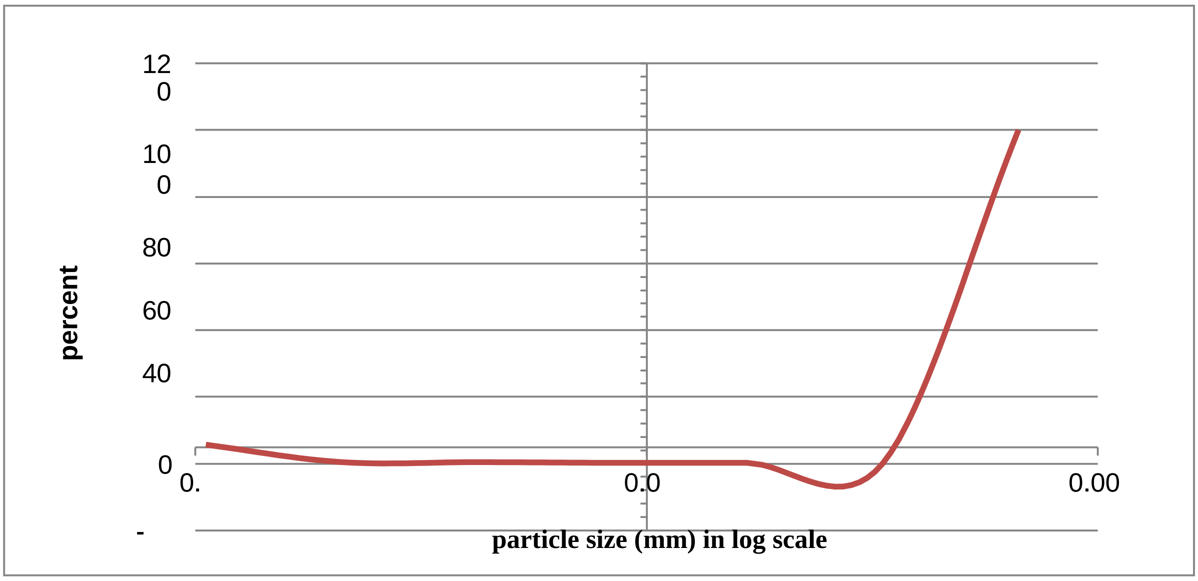

Figure 6: Sieve Analysis of Fine Aggregate.

3.3.2 Fineness Modulus

Fineness Modulus is defined as an index to the particle size not to the gradation. Fineness modulus is calculated from the sieve analysis. It is defined mathematically as the sum of the cumulative percentages retained on the standard sieves divided by 100. The standard size sieves are,

Table 11: Sieve no with opening in mm

Sieve no	Opening (mm)
3 in	75
¾ in	19
3/8 in	9.5
#4	4.75
#8	2.36
#16	1.18
#30	0.60
#50	0.30
#100	0.15

Always report the fineness modulus to the nearest 0.01. The F.M. of fine aggregates should not be less than 2.3 or more than 3.1.

Add the Cumulative % Retained on all of the sieves except the No. 200 (75 µm) and the Pan. Then divide by 100.

If the author need to find the fineness modulus of any sample i.e.; coarse aggregate or fine aggregate then need to identify two term.

1. percent of soil retained.

2. Cumulative percent of soil retained.

The formula of percentage of soil retained =(Materials Retainrd /Wt.of the dry sample)x 100
The formula of cumulative percent of soil retained = Sieve no #4 % of soil retained will add with the sieve no #8. Then cumulative of sieve no #8 will be add with the no of sieve #16's percent of soil retained and then the author will get the result of sieve no #16's cumulative percent. The process will run continuously.

For example,

Fineness modulus of coarse aggregate (the values are collected from table 1.1),

(Stone sieve) = Cumulative percent retained /100

0.33+1.01+66.09+97.29+97.97+98.30+98.63+98.96+99.29)

=657.87÷100

=6.57

Fineness modulus of fine aggregate (Sylhet sand).

The author require data from table 1.2,

= Cumulative percent retained/100

= 250.01÷100

= 2.50

3.3.3 Cement

Although various types of cement are being produced all over the world, but in Bangladesh mainly two types of cement are available - CEM-I and CEM-II B/M. Here, CEM I 42.5 N is an Ordinary Portland Cement (OPC) with ordinary early strength. In CEM I cements, the main constituents are Portland clinker (95-100%) and minor constituents only up to 5%. CEM III B-M 42.5N is a Portland composite cement (PCC) with ordinary early strength.

3.3.3.1 Tests for Cement

Among the physical properties of cement, initial setting time and final setting time have been tested.

(a) Normal Consistency Test Of Cement :

Reference Standard:

This test method conforms to the ASTM standard requirements of specification C187.

Procedure:

- Cement amount is 300 gm.
- The author use water around the range of 23%-29% of cement.
- Cement into a tray and mix water according to the range .wait 30 second while water was given in the cement.
- After finishing the 30 second start to mixing the water and cement till the 90 second finish.
- After 1 and half minutes mixing, then make a round ball from the mixing materials. (Cement and water)
- Then the author give 6 drops from one hand to another hand.
- Then put the mold into an iron circle and smoothly make a finishing the lower part of iron circle the upper part need to made a level.
- Touch the pin of the vicat apparatus.
- At last drop the pin and take the reading.

The author give at least 4 trial

Table 12: Penetration

Trial no	Cement (gm.)	Water (gm.)	Penetration
1	300	75 (25% of cement)	4
2	300	81 (27%0f cement)	7
3	300	84 (28%of cement)	9.9
4	300	87 (29%of cement)	14

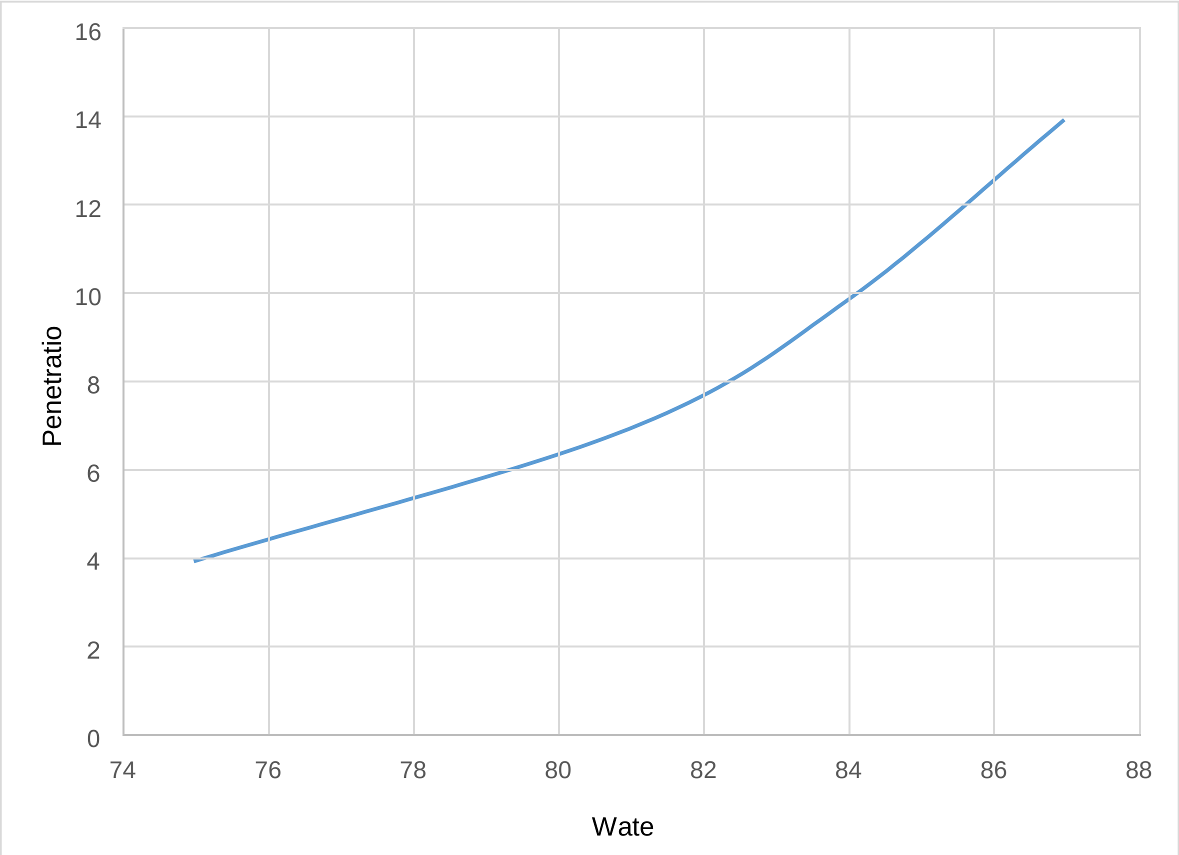

Figure 7: Water VS Penetration graph

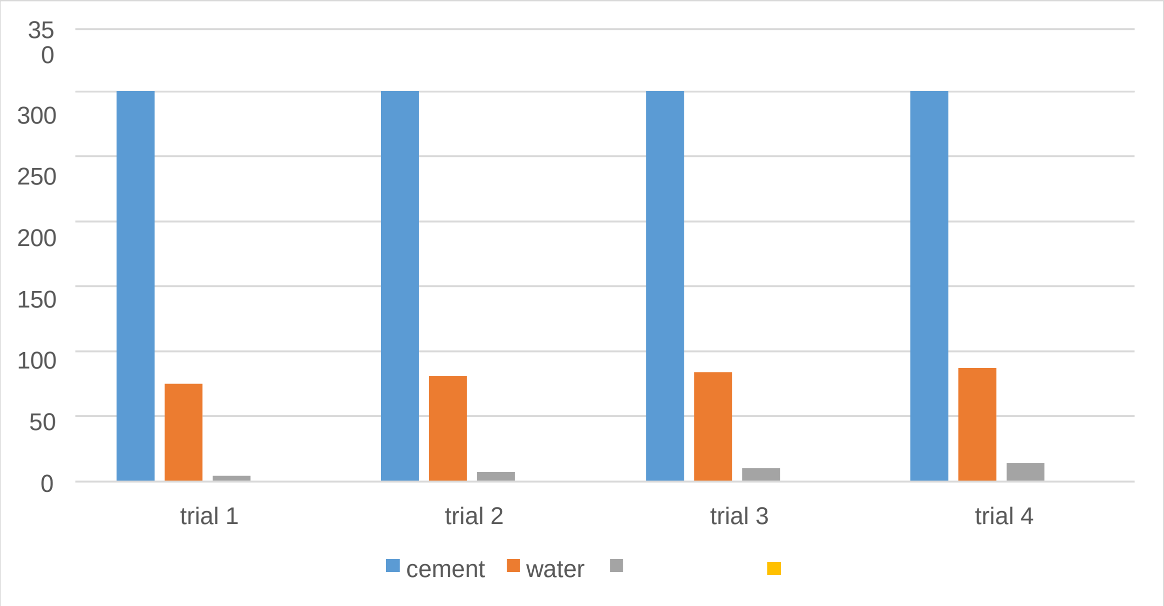

Figure 8: Water, cement and penetration graph

The author plot a graph of water VS penetration. Water in the X axis and penetration in the Y axis. The author found that from the graph then the author need 27.7 gm. of water when its penetration is 10 mm.

(b) Initial and final setting time of cement

References

This test strategy fits in with the ASTM standard necessities of particular C191. According to ASTM C150, Ordinary Portland Cement ought to have the underlying setting time at the very least 45 minutes and last setting time not increasingly 375 minutes

Procedure:

- Firstly have to take the vicat apparatus.
- This time the needle is 1 mm. set the needle in the apparatus.
- From the previous experiment we earn the result is 27.7% for 300gm cement need water is 83.1 gm.
- The author make the mixture according to the procedure.
- 30 second time for water mixing.
- 1.5 min to mixing the water and cement together.
- Then the author make a round ball.
- For removing the void spaces give 6 drops from hand to hand.
- Set the cement ball into the ring.

- Start to take the reading in each 15 minute for initial setting and 30 minute for the final setting.
- Need to know the reading until it comes below the reading of 24 for initial setting and 00 for final setting.

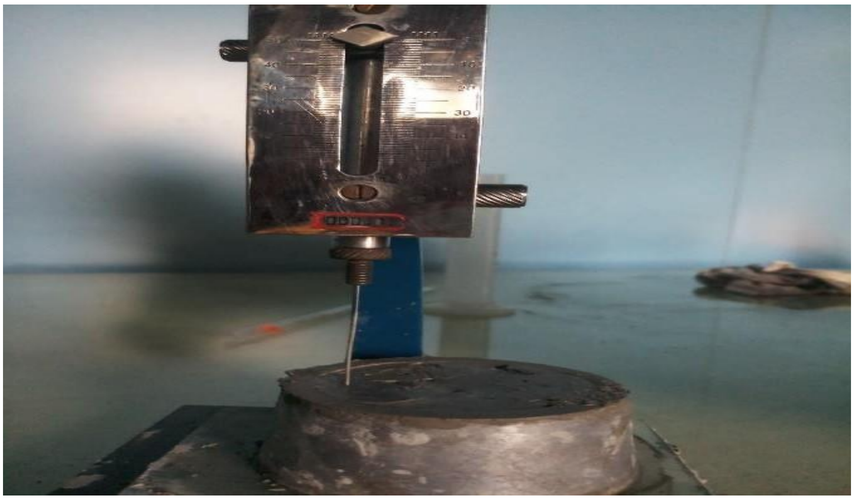

Figure 9: Initial and Final Setting determination Test

Calculation

Initial setting time:

Table 13: Initial setting time of cement

Trial no	Cement (gm.)	Water (gm.)	Time min	Reading place	Reading mm
1	300	83.10	00	Middle point	40
2	300	83.10	15	1 cm far from the point	37
3	300	83.10	30	1 cm	35
4	300	83.10	45	1cm	31
5	300	83.10	60	1cm	30
6	300	83.10	75	1cm	29
7	300	83.10	90	1cm	26
8	300	83.10	105	1cm	25
9	300	83.10	120	1 cm	23

Result: 23 mm is the point of initial setting at 120 minute

Figure 10: Accurate timing for tests

Table 14: Final setting time of cement

Trial no	Cement (gm.)	Water (gm.)	Time min	Reading Place	Reading	Remarks
1	300	83.10	150	1 cm	20	
2	300	83.10	180	1 cm	13	
3	300	83.10	210	1 cm	4.9	
4	300	83.10	240	1 cm	1.5	
5	300	83.10	270	1 cm	0	Done

Result: 0 mm is the point of final setting at 270 min

Its took 4.5 hour to perform the test .

Table 15 :Initial and Final Setting time of Cement

Time (min)	Penetration (mm)
0	40
15	37
30	35
45	31
60	30
75	29
90	26
105	25
120	23
150	20
180	13
210	4.9
240	1.5
270	0

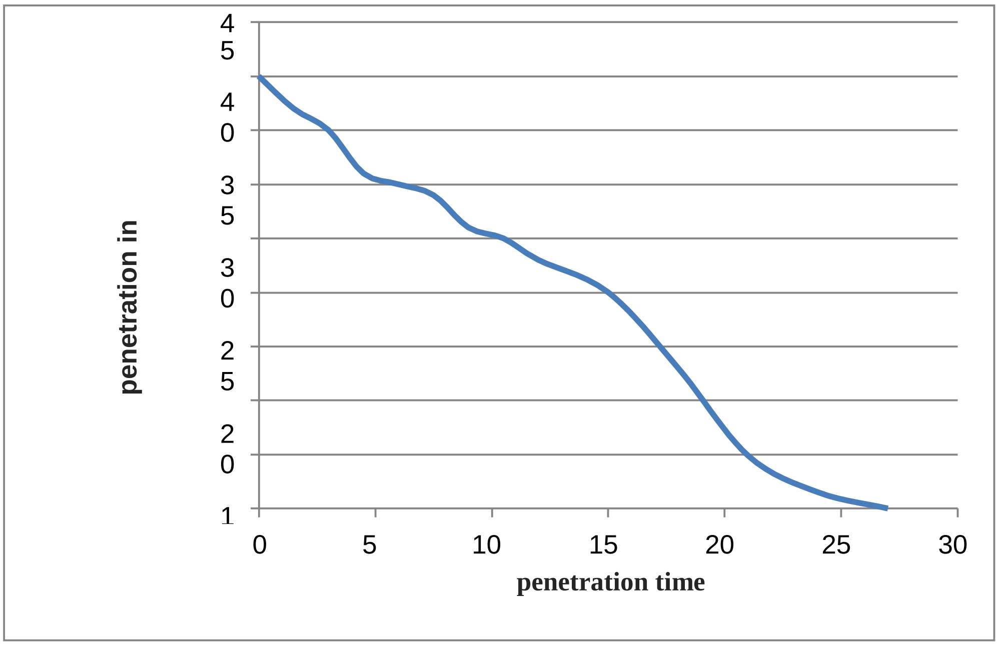

Figure 11: Initial and Final Setting Time Graph

3.4 Slump Test

Procedure:

- A 1/4″ hole in the bottom of the plastic cup with the pen to allow air to escape.
- Fill the cup with freshly mixed concrete and pack it well.
- Fill the cup with freshly mixed concrete and pack it well.
- Place the filled cup upside-down on a flat, rigid surface.
- With hands, carefully vibrate the cup in a steady lifting motion without stopping.
- Measure the separation of the droop with a ruler.
- The perfect droop ought to be about a large portion of the stature of the plastic cup. If the mix is too wet, add more bagged concrete mix by the cup.

Figure 12: Slump Value Test

3.5 Cylinder Preparation

Mix Design Calculation:

Cement: Portland cement (Bashundhara)

Coarse Aggregate (3/4 stone chips):

F.M=6.57
Specific Gravity=3.57
D_{60} = 13, D_{10} = 6 and D_{30} = 9
C_C =1 .03 and C_U = 2.16

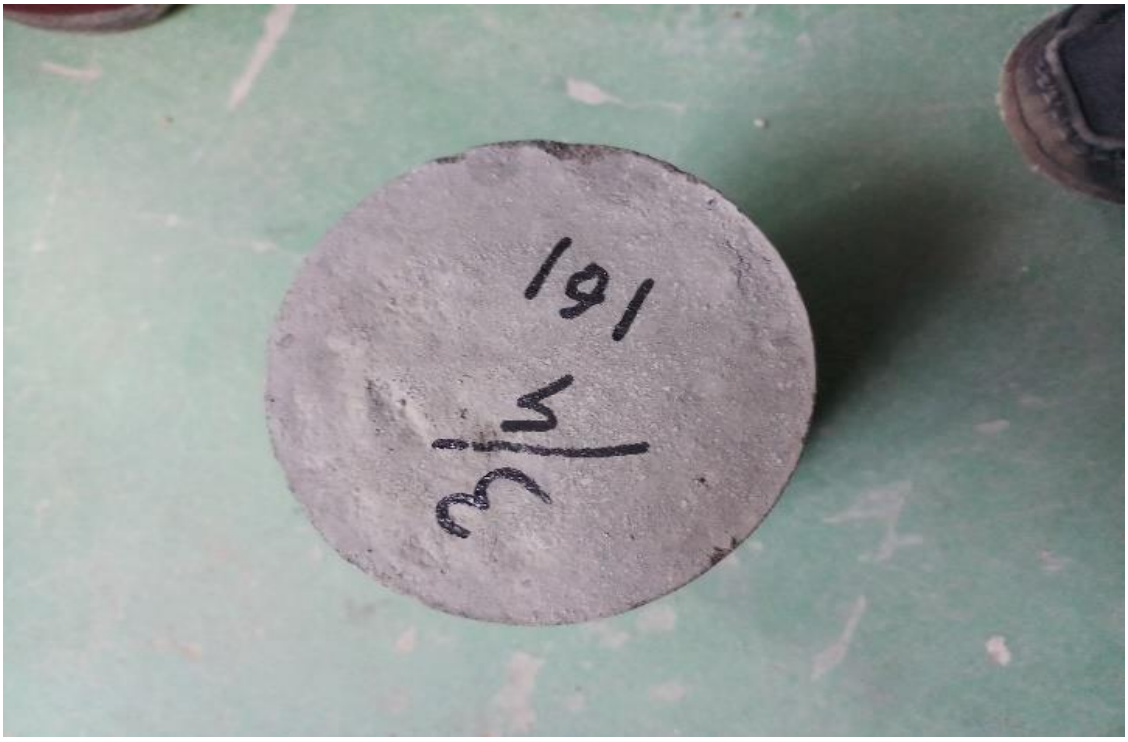

Figure 13: 4×8 inch shape cylinder

3/8 stone chips Retake,

D_{10} = 0.25, D_{30} = 0.23 and D_{60} = 0.24
C_C = 1.058, C_U = 0.864

So it's well graded

Fine Aggregate:

Sylhet Sand F.M = 2.5
Specific Gravity = 2.68

Normal Consistency Test of Cement

At 10 mm penetration need 27.7 gm. of water (from graph)
Initial and Final Setting time of cement.
Initial: Reading 23mm
Time 120mm
Final: Reading o mm
Time 270 min
Total 4 and half hour for initial and final setting of time

Step 1.
Choice of slump
The slump is taken between 1-2 inch

Step 2.

Maximum Size of Aggregate
3/4" down stone chips
3/8 inch retake stone chips

Step 3.

Estimation of mixing air and water content.
Air (2%) 3/4 = 0.75 .... water 315 lb/yd^3 for (1-2) inch slump
Air (3%) 3/8 = 0.375 water 350 lb/yd^3 for (1-2) inch slump.

Step 4.

Table 16: The water cement ratio for Non AE.

28 day compressive strength (psi)	Non AE
2000	0.82
3000	0.68
4000	0.57
5000	0.48
6000	0.41
7000	0.33

Step 5

Weight of water =315 lb/yd^3
W/c ratio=0.68 for 3000 psi
Weight of cement = (315 ÷ 0.68) lb/yd^3
=463 lb/yd^3

Step 6

Determination of Coarse Aggregate (Maximum size of Aggregate)

For ¾ inch the value is = 0.65
For 3/8 inch the value is = 0.49
The fineness modulus is = 2.50
1 Cubic-Yard =27 ft^3
So, the Coarse aggregate will Occupy = 27x0.65 (For ¾ Aggregate)
=17.55

The Coarse Aggregate Will Occupy
=27x0.49
=13.23
Dry rodded unit weight =104 lb/ft^3
For ¾ inch C.A=104×17.55=1825.2 lb/yd^3
For 3/8 inch C.A=104×13.23 =1375.92 lb/yd^3
¾ W_{SSD} = (1 + (1.8/100)*1825.2) lb/yd^3

=1858 lb.
3/8 W_{SSD} = (1 + (1.8/100)*1375.92 lb/yd^3

=1400 lb.

Fine Aggregate:

For 3/4, Water =315/62.4 =5.05 ft^3
For 3/8, Water =350/62.4 =5.60 ft^3
For ¾, Cement =463/ (3.15x62.4)
=2.35 ft^3
For 3/8, Cement =463/ (3.15x62.4) =2.35 ft^3
For ¾ Coarse Aggregate = (1858.05/2.64×62.4)=11.27 ft^3
For 3/8 Coarse Aggregate = (1400.68/2.64×62.4)=8.50 ft^3

FOR ¾	FOR 3/8
Water = 315 lb/yd^3	Water = 350 lb/yd^3
Cement = 463 lb/yd^3	Cement = 463 lb/yd^3
C.A = 1825.2 lb/yd^3	C.A. = 1375.92 lb/yd^3
....	....
Total = 2603lb/yd^3	Total =2188.92 lb/yd^3
F.A. Volume = (3960-2603)	F.A. Volume = (3840-2188)

$=1357\ lb/yd^3$ $=1651.08\ lb/yd^3$

For 3/4 inch,
463:1357:1825

=1: 2.9: 3.9

FOR 3/8 inch,
463:1651:1375.92

=1: 3.5: 2.9

3.6 Cylinder Test

Author use 3/4, and 3/8 stone chips for cylinder concrete

Sylhet sand and Portland cement for making the cylinder.

Figure 14: Testing the fitness of cylinder cube

Procedure:

- The author require the stones and wash it and wait until becomes surface dry.
- According to the proportion we mix the fine aggregate, coarse aggregate and cement the ratio of water depends on the cement ratio.
- Then the author made mold and penetrate it the cube into 3 layer after 30 second need to take the reading for slum test. The correct result of slum test is 1-2 inch and then we made the cylinder.
- Wait 1 day and then give it in the water cube for curing.
- After 28 days the author requires the strength each of the cylinders.

CHAPTER FOUR
RESULTS AND DISCUSSIONS

4.1 General

The experiments were briefly explained in the previous chapter. In this chapter, the outcomes of those experiments will be shown and findings from analyses will be presented, followed by discussions about the results.

The experiments carried out were slump test for fresh concrete and compressive strength of concrete.

Figure 15: A complete cylinder for strength test

4.2 Result from Test

Here,

Cylinder Area = 16 in^2

Cylinder length = 4 in

1 KN = 101.971 KG

1 KG = 2.2046 lbs.

$$\text{Formula} = \frac{\text{Kg}*\text{KN}*\text{Lbs}}{\text{Cylinder Area In Inch}}$$

$A = \pi r^2$

=3.1416 × (16^2)

804.2496

Table 17 &18 : Average Compressive Strength in PSI

Cylinder (For ¾ Coarse Aggregate)	Step 1	Step 2	Step 3 (Average Compressive Strength in PSI)
1st	115 KN	Formula $= \frac{\text{Kg} * \text{KN} * \text{Lbs}}{\text{Cylinder Area In Inch}}$ $= \frac{101.97 * 2.2046 * 115}{201.0624}$ = 2057	=2471
2nd	165 KN	Formula $= \frac{\text{Kg} * \text{KN} * \text{Lbs}}{\text{Cylinder Area In Inch}}$ $= \frac{101.97 * 2.2046 * 165}{201.0624}$ =2946	

3rd	135 KN	Formula $= \frac{\text{Kg} * \text{KN} * \text{Lbs}}{\text{Cylinder Area In Inch}}$ $= \frac{101.97 * 2.2046 * 135}{201.0624}$ =2410	

Cylinder (For 3/8 Coarse Aggregate)	Step 1	Step 2	Step3(Average Compressive Strength in PSI)
1^{st}	145	Formula $= \frac{Kg * KN * Lbs}{Cylinder\ Area\ In\ Inch}$ $\frac{101.97 * 2.2046 * 145}{201.0624}$ =2589	=2518
2^{nd}	110	Formula $= \frac{Kg * KN * Lbs}{Cylinder\ Area\ In\ Inch}$ $\frac{101.97 * 2.2046 * 110}{201.0624}$ =1664	
3^{rd}	185	Formula $= \frac{Kg * KN * Lbs}{Cylinder\ Area\ In\ Inch}$ $\frac{101.97 * 2.2046 * 185}{201.0624}$ =3303	

American Concrete Institute (ACI) mix design Air-Entrained Concrete is one of the greatest advances in concrete technology was the development of air-entrained concrete in the late 1930s. Today, air entrainment is recommended for nearly all concretes, principally to improve resistance to freezing when exposed to water and deicing chemicals. Air-entrained concrete contains billions of microscopic air cells. These ease inward weight on the solid by giving little chambers to the extension of water when it freezes.

All the results are,

For 3/4 inch aggregate,

1st cylinder: 115 KN = 2057 psi

2nd cylinder: 165 KN= 2946 psi

3rd cylinder: 135 KN= 2410 psi

For 3/8 inch aggregate,

4th cylinder: 145KN = 2589 psi

5th cylinder: 110KN = 1964 psi

6th cylinder: 185 KN = 3303 psi

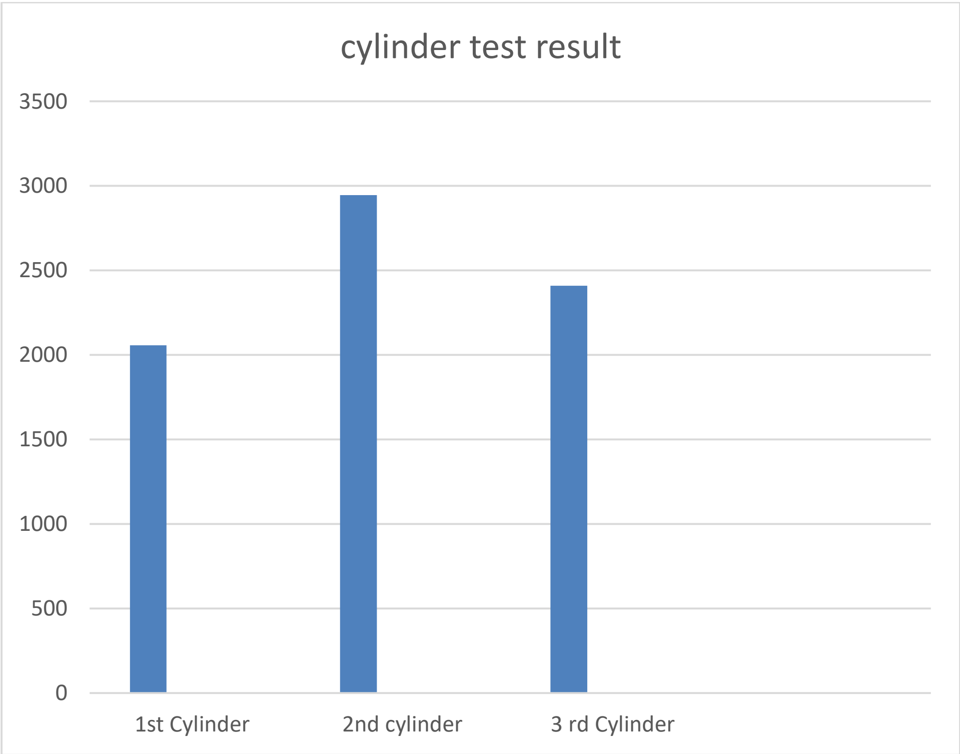

Figure 16: Strength test result in charts for 3/4 coarse aggregate

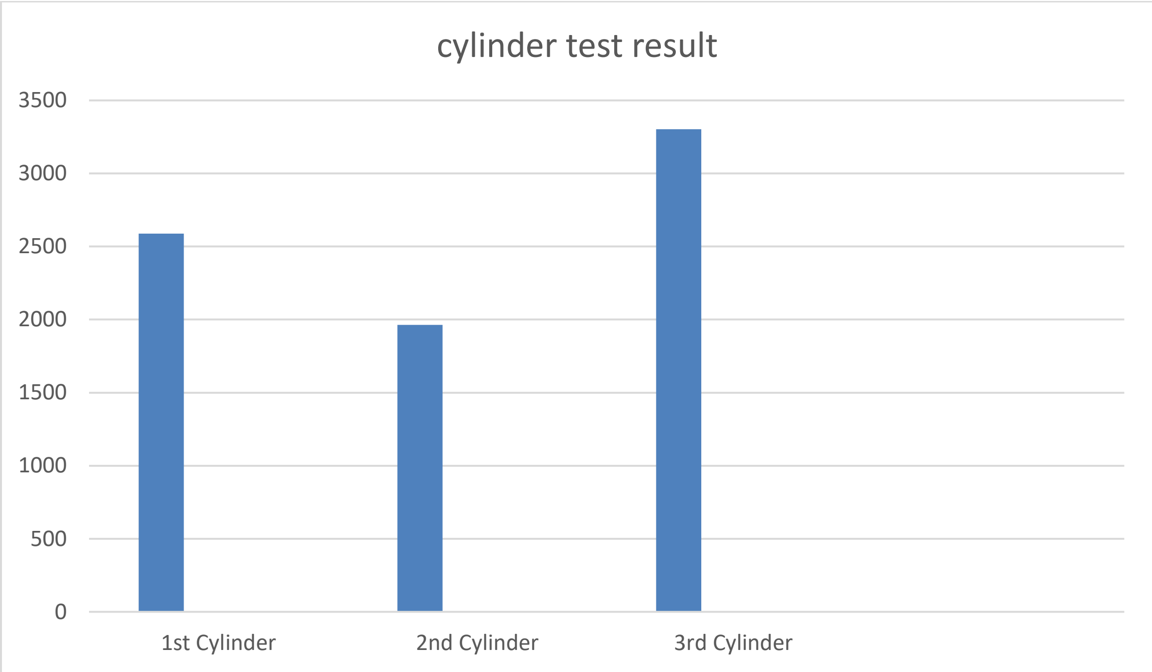

Figure 17 :Strength Test Result in Chart for 3/8 coarse Aggregate.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATION

5.1 General

In the topics of effect of maximum size of aggregate on compressive strength of concrete. Use two coarse aggregate as maximum size of aggregate .the first one is 3/4 inch stone chips and the second one is the 3/8 inch stone chips. Fine aggregate is always same in that thesis. The fine aggregate has no alternative. OrdinaryPortland cement is another element. The maximum size of the aggregate is increased, the amount of water needed for the same workability is reduced. At the same cementations material content, strength is therefore greater because the eater cement ratio is lower.

From the test results the following conclusions can be briefly made :

- Workability of concrete made from uniform size aggregates decreases as the aggregate size Increases.
- Compressive strength of concrete made from uniform size as well as aggregates increases with increase in aggregate size.
- Blending aggregates using the Cement Treated Aggregate gradation procedure does not improve the compressive strength of concrete used for rigid pavements relative to concrete made from uniform size aggregates.
- The aggregate size and gradation affect workability of fresh concrete and compressive strength of hardened concrete.
- Concrete compressive strength increases t hen the maximum size of aggregate decreases.
- Size of maximum aggregate strongly influences the concrete strength.
- The optimum compressive strength of concrete is reached by using aggregates of 9.5mm maximum size.
- For concrete of cement to aggregate ratio below the compressive strength is more changeable in the aggregate size than the cement content.
- Strength of an economical mix can be produced by increasing the cement to aggregate ratio as well as decreasing the maximum size of aggregate.
- If using small sized aggregates Lean mixes can be used for structural purposes.

5.2 Limitation of the Study

The limitations are directly depends on

- Water cement ratio.
- Quality of cement.
- Curing time.
- Mix design proportion if any of these terms are not done correctly then it will be very tricky for the thesis.

5.3. Recommendation for further study

- Further research be carried out to investigate the use of appropriate aggregate gradation for blending aggregate concrete mix for highway pavement .
- Construction engineers should exercise caution in the purpose of arbitrarily graded (mixed) aggregates for design and construction purposes.

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APPENDIX-1

According to American Concrete Institute (ACI) Committee:

Table 6.3.1- Recommended slumps for various types of construction

Types of construction	Slump, in	
	Maximum	Minimum
Reinforced foundation walls and footings	3	1
Plain footings, caissons, and substructure walls	3	1
Beams and reinforced walls	4	1
Building columns	4	1
Pavements and slabs	3	1
Mass concrete	2	1

Slump may be increased when chemical admixtures are used, provided that the admixture treated concrete has the same or lower water-cement or water cementations material ratio and does not exhibit segregation potential or excessive bleeding. Way be increased 1 in. For methods of consolidation other than vibration.

According to American Concrete Institute (ACI) Committee:

Table 6.3.3-Approximate mixing water and air content requirements for different slumps and nominal maximum sizes of aggregates

Water, lb/yd^3 of concrete for indicated nominal maximum sizes of aggregate								
Slump in	3/8 inch	½ inch	¾ inch	1 inch	1-1/2 inch	2 inch	3 inch	6 inch
Non air entrained concrete								
1-2	350	335	315	300	275	260	220	190
3-4	385	365	340	325	300	285	245	210
6-7	410	385	360	340	315	300	270	-
More than 7 +	-	-	-	-	-	-	-	-
Approximate amount of entrapped -air in non-air-entrained concrete percent	3	2.5	2	1.5	1	0.5	0.3	0.2
Air entrained concrete								
1-2	305	295	280	270	250	240	205	180
3-4	340	325	305	295	275	265	225	200
6-7	365	345	325	310	290	280	260	-
More than 7 +	-	-	-	-	-	-	-	-
Recommended averages total air content, percent for level of exposure:								
Mild exposure	4.5	4.0	3.5	3.0	2.5	2.0	1.5***	1.0***
Moderate exposure	6.0	5.5	5.0	4.5	4.5	4.0	3.5***	3.0***
Severe Exposure	7.5	7.0	6.0	6.0	5.5	5.0	4.5***	4.0***

Table 6.3.4 (a)-relationship between water-cement and water-cementitious ratio and compressive strength of concrete.

Compressive strength at 28 days ,PSI	Water-Cement ratio by water	
	Non –air –entrained concrete	Air –entrained concrete
6000	0.41	-
5000	0.48	0.40
4000	0.57	0.48
3000	0.68	0.59
2000	0.82	0.74

Table6.3.4 (b) –

Maximum permissible water cement or water-cementitious materials ratios for concrete in severe exposures*

Type of structure	Structure wet continuously or frequently and exposed to freezing and thawing	Structure exposed to sea water or sulfates
Thin sections (railings, curbs, sills, ledges, ornamental work) and sections with less than 1 in. cover over steel	0.45	0.40+
All other structures	0.50	0.45+

Table 6.3.6 - Volume of coarse aggregate per unit of volume of concrete

Nominal maximum size of aggregate ,in	Volume of oven-dry-rodded coarse aggregate *per unit volume of concrete for different fineness modulus of fine aggregate			
	2.40	2.60	2.80	3.00
3/8	0.50	0.48	0.46	0.44
½	0.59	0.57	0.55	0.53
¾	0.66	0.64	0.62	0.60
1	0.71	0.69	0.67	0.65
1-1/2	0.75	0.73	0.71	0.69
2	0.78	0.76	0.74	0.72
3	0.82	0.80	0.78	0.76
6	0.87	0.85	0.83	0.81

Table 6.3.7.1 - First estimate of weight of fresh concrete

Nominal maximum size of aggregate ,in	First estimate of concrete weight ,lb/yd^3	
	Non air entrained concrete	Air entrained concrete
3/8	3840	3710
½	3890	3760
¾	3960	3840
1	4010	3850
1-1/2	4070	3910
2	4120	3910
3	4200	3950
6	4260	4040
		4110

TABLE –CONVERSION FACTORS, in.-lb. TO SI UNITS

Quantity	In-lb unit	SI unit	Conversion factor (Ratio: in. –lb/SI)
Length	Inch (in)	Millimeter (mm^4)	25.40
Volume	Cubic foot ($ft^{3)}$ cubic yard (yd^3)	Cubic meter (m^3) Cubic meter (m^3)	0.02832 0.7646
Mass	Pound (lb)	Kilogram (kg)	0.4536
Stress	Pounds per square inch (psi)	Mega Pascal (MPa)	6.895*10^-2
Density	Pounds per cubic foot ($lb/ft^{3)}$ Pounds per cubic yard (lb/yd^3)	Kilograms per cubic meter (kg/m^3) Kilograms per cubic meter (kg/m^3)	16.02 0.5933
Temperature	Degrees Fahrenheit (F)	Degrees Celsius (C)	

TABLE – RECOMMENDED SLUMPS FOR VARIOUS TYPES OF CONSTRUCTION (SI)

Types of construction	Slump, mm	
	Maximum	Minimum
Reinforced foundation walls and footings	75	25
Plain footings, caissons, and substructure walls	75	25
Beams and reinforced walls	100	25
Buildings columns	100	25
Pavements and slabs	75	25
Mass concrete	75	25

Appendix 2

Thesis Report Format:

1. Heading 1 (times new roman, 12 pt. bold, capitalized each word, 6 pt. before and 12 pt. after, left alignment)

2. Heading -2 (times new roman, 12pt, bold, capitalized each word, 6 pt. before and 6 pt. after)

3. Heading -3 (times new roman, 12pt, bold, capitalized each word, 6 pt. before and 6 pt. after)

4. Text (times new roman, 12 pt., justify, sentence case, line spacing 1.5)

5. Table (title above, times new roman, sentence case 1.5 line spacing , center aligned ,numbered consequently, one line space before title and one line space after title)

6. Figure (title below, times new roman, sentence case 1.5 line spacing, center aligned ,numbered consequently, one line space before title and one line space after title)

Appendix 3

Lab Instructions

(1) Thesis students must have to be present at laboratory just in time.

(2) Thesis students must have to do the all the assessment work finished before the next test.

(3) Thesis students have to complete the data sheet in the lab class and complete sample calculation and graphs in class.

(4) Students should be very careful about any test. They should conduct the tests by taking maximum care of the equipment during test.