HIGHER STRENGTH CONCRETE USING BRICK AGGREGATE

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ABSTRACT

In the developed and developing countries the major part of the construction work is done by concrete. The concrete is important for the structural durability as well as longevity of the structure. The main objective of this study is to prepare high strength concrete using brick aggregate. In doing so, the mix proportion of the constituents, water/cement ratio and dosages of admixture are varied. Tests were carried out on cylinder specimens. Generally achieving high strength concrete, it needs to increase cement content and reduce water/cement ratio. In addition the size of aggregate also affects the strength of concrete. The test results showed that by properly proportioning the constituents of the concrete together with careful control the quality in every steps of the production, a high strength concrete can be made with brick aggregate. Four cement content viz. 400 Kg/m^3, 450 Kg/m^3, 500 Kg/m^3, and 550 Kg/m^3, were taken in association of three different water/cement ratios viz. 0.30, 0.40, and 0.45. It has found from the study that a high strength can be achieved using brick aggregate. In the current study, a maximum cylinder strength of 7700 psi at 28 days has been achieved for cement content = 450 Kg/m^3 at water/cement ratio = 0.30 and maximum size of aggregate = 12.5 mm.

NOTATION

P = Load

A = Area

S = Strength

F.M = Fineness modulus

f_c' = Cylinder Compressive Strength

W/C = Water Cement ratio

A_{25} = Maximum size of coarse aggregate = 25 mm

A_{19} = Maximum size of coarse aggregate = 19 mm

A_{12} = Maximum size of coarse aggregate = 12.5 mm

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CHAPTER-I
INTRODUCTION

1.1 GENERAL

Concrete is a stone like material obtained by permitting a carefully proportioned mixture of binding materials, sand and gravel or other aggregate, and water to harden in forms of the shape and dimensions of the desired structure. The most important binding materials are cement and lime. The bulk of the material consists of fine aggregate and coarse aggregate. Cement and water interact chemically to bind the aggregate. Brick aggregate, stone aggregate are commonly used as coarse aggregate in Bangladesh.

Concrete is a key material in today's construction. Today concrete is used widely in building construction, airport installation, highway construction, Water front structures etc. So, an understanding of the properties of concrete is necessary before one can analyze the failure and distress of concrete.

Concrete numerous properties; However the expected property depends on their usage. The properties of concrete can be categories in two groups: (i) Properties for wet concrete; (ii) The properties of hardened concrete. Workability, plasticity, consistency, cohesiveness are the properties of wet concrete, while the strength, durability, permeability, stiffness are the properties of hardened concrete.

The strength is the most important and desirable properties of concrete. The strength of concrete varies on several factors such as the quality of materials, proportion of mixture, workability, proper compaction and curing.

Strength of concrete is its resistance to rupture. The compressive strength of concrete is the most important over tensile, flexural and shear strength. In most structural applications concrete is employed primarily to resist the compressive stresses. In those cases where strength in tension or in shear is of primary importance, the compressive strength is repeatedly used as a measure of these properties.

Normal strength concrete is made without using any type of admixture and its 28-days cylinder strength vary from 2500-3500psi. High strength concrete mixtures are generally characterized by low water/cement ratio, high cement content and presence of several admixtures such as a water reducing mineral admixture.

The compressive strength of concrete is generally determined by testing cube or cylinder specimens. For crushing strength test, cubes are used in United Kingdom, Germany, India and many other countries in Europe. Cylinders are the standard specimens in United States, Canada, Australia, France and New zealand.

1. 2 BACKGROUND OF THE STUDY

Developing high strength concrete is the most important issue in Concrete Technology. Over the last two decades this type of concrete has come more and more into popular use. Now it seems to be universal agreement that the production and use of high strength concrete is a worthy goal.

At present, high strength concrete contains stone aggregate as coarse aggregate. However, stone are not widely available in Bangladesh. Moreover, stone are expensive. As an alternative, brick bats have been being used in preparing concrete for several decades. The cost of brick bats is much lower that of stone.

In addition, BNBC (1993) restricts the use of lower strength concrete (having $f_c^{'}$ is of the order of 2500 psi) that is prepared by using brick aggregate as coarse aggregate. Therefore, it becomes very essential to prepare high strength concrete using brick aggregate for using in building construction with more number of storeys.

1. 3 SIGNIFICANCE OF THE STUDY

This study justifies the use of crushed well burnt brick as a substitute for conventional stone aggregate in concrete construction. The investigation indicates that high grade concrete can be produced by using brick aggregate.

1.4 OBJECTIVES OF THE STUDY

The main objectives of the study are given below:

i. To obtain relationship of the compressive strength of concrete and water/cement ratio, cement content, maximum size of coarse aggregates.
ii. To prepare the high strength concrete using brick bats as coarse aggregate.

1.5 METHODOLOGY

Generally strength of concrete can be increased by increasing cement content decreasing water/cement ratio. However, there may be a threshold value of cement content beyond which strength are met increased for a particular type of coarse and fine aggregate. On the other hand, to prepare a workable concrete, there should have a limiting value of water/cement ratio. Furthermore, researchers (Table- 4.1, 4.2 & 4.3) showed that strength of concrete with a specific cement content, water/cement ratio, and the maximum size of coarse aggregate, the strength of concrete increase with decreasing the maximum size of aggregate up to a limiting value 10 mm. On the basis of the above statement, Cement content, water/cement ratio, maximum size of aggregate are taken as the parameter in the parametric study and different sample are prepared. In the study, the ratio of coarse and fine aggregate are kept fixed at 1:2 by volume, while cement content is varied as 400 Kg/m^3, 450 Kg/m^3, 500 Kg/m^3 and 550 Kg/m^3.

The working methodology of our study is as follows:

a) Selection of materials (bricks, fine aggregate, coarse aggregate, cement content, water/cement ratio, and admixture)

b) Sample preparation

c) Curing

d) Testing

e) Analysis of the test results

f) Conclusion

1.6 SCOPE OF THE STUDY

The most common application of high strength concrete has been in the columns of tall concrete buildings, where normal concrete would result unacceptably large cross section, with loss of valuable floor space. It has been shown that the use of the more expensive high strength mixes in columns not only save floor area but is more economical than increasing the amount of steel reinforcement.

For bridge, too, smaller cross sections bring significant advantages, and the resulting reduction in dead load permits longer span.

CHAPTER -II
LITERATURE REVIEW

2.1 INTRODUCTION

High strength concrete is relatively a new development in building materials technology. It is the latest phase comes after normal strength concrete and has come more and more into popular use. This chapter will describe some literary essential elements of high strength concrete. These are definition, classification and methods of making high strength concrete, properties and such as workability, durability and compaction. It also describes the mechanical properties of high strength concrete, curing, mixing etc.

2.2 HISTORY OF HIGH STRENGTH CONCRETE

High performance concrete is not a revolutionary material, nor does it contain ingredients which are not used in the concrete considered this far. Rather, high performance concrete is a development of the concretes discussed in the last few sections.

The very name 'high performance concrete' smacks of advertising an allegedly distinct product. A former name was 'high performance concrete' but, in many cases, it is a high durability that is the required property, although, in others, it is high strength, either very early, or at 28 days, or even later. (Neville 2005)

Report in the published literature shows that using synthetic materials such as an aggregate composed of carefully graded particles of calcite bauxite and special processing technology (viz. thermal curing and pressure) concrete specimens with up to 260 MPa (37700psi) compressive strength have been produced in the laboratory.

High strength concrete are generally characterized by low water/cement ratio, high cement content and presence of several admixture types such as water reducing, set retarding and mineral admixture (viz. fly ash, ground blast-furnace slag, condensed silica fume and super-plasticizer). From the literature review it is conclude that the materials are selected empirically by extensive laboratory testing. This means that for someone who the first time, would like to make high strength concrete form locally available materials, there are no guidelines similar to practice for selecting proportions for concrete mixture; How than should one proceed to determine the quantities of cement, water, coarse and fine aggregate? The dosage of water reducing admixture as well as with depends on workability required.

2.3 HIGH STRENGTH CONCRETE

2.3.1 Definition of High Strength Concrete

High strength concrete is a concrete with appropriate materials combined according to a selected mix design and properly mixed, transported, placed, consolidated and cured. So, that the resulting concrete gives excellent strength in the structure in which it will be placed, in the environment to which it will be exposed and with the loads to which will be subjected to its design life (Foster 1994).

Vary-high strength concrete may be defined as between 60 and 100 MPa (8700 and 14500 psi) at 28-days, using good quality and well graded aggregates, low water/cement ratio (<0.35), and by adequate compaction and curing. To achive a normal workability mix, a super-plasticizer is necessary.

High strength concrete by present ACI defination covers concretes whose cylinder compressive strength exceeds 6000 psi (41.4 MPa). High strength concrete can be made using carefully selected but widely available cement, sand, smaller size aggregate with low water/cement ratio (<0.35) and by adequate compaction; certain admixture including water reducing agent.

2.3.2 Classification of High Strength Concrete

High strength concrete is classified in the following ways:

a) High strength concrete produced with classic materials and normal compacting procedures. A strength up to 15500 psi (1100 kg/cm^2)
b) Ultra high strength concrete produced with specials techniques. A compressive strength greater than 15500 psi and up to 95000 psi (1100-6700 kg/cm^2).

2.3.3 Methods of making High strength concrete

The following methods are used for making high strength concrete:

a) Use of admixture
b) Inhibition of crack
c) Sulpher impregnation
d) Use of cementitious aggregate

Use of Admixture

The strength of concrete depends upon the water cement ratio. i.e. with in the limit large strength when water cement ratio is less other hand less strength when water cement ratio is more. Use of admixture as water reducing agent is known to increase the workability and to produce higher compressive strength.

Inhibition of Cracks

Concrete fails by the formation and propagation of cracks. If the propagation of cracks is inhibited, the strength will be higher. Replacement of 2~3% of fine aggregate by polythene or Polystyrene "lenticules" 0.25 mm thick and 3 to 4 mm in diameter results in higher strength. They appear to act as crack arresters necessitating extra water for workability.

Sulpher Impregnation

Satisfactory high strength concrete has been produced by Impregnating low strength porous concrete by sulpher. The process consist of moist curing the fresh concrete specimens for 24 hours, during them at 120^0 C for 24 hours, immersing the specimen in molten sulpher under vacuum for 2 hours and then releasing the vacuum and soaking them for an addition 0.5 hour for further infiltration of sulpher. The sulpher-infiltrated concrete has given strength up to 575 Kg/cm^2.

Use of Cementitious Aggregate

It has been found that use of cementitious aggregates has yielded high strength. Cement found is a clinker. This glassy clinker when finely ground results in a kind of cement. When coarsely crushed, it makes a kind of an aggregate known as ALAG. Using ALAG as aggregate, strength up to 1240 kg/cm^2 has been obtained with water/cement ratio 0.32.

2.4 ADVANTAGES OF HIGH STRENGTH CONCRETE

The main advantages of high strength concrete are as follows:

a) Durability

High strength concrete providing durability constitutes. It gives more durability than ordinary concrete.

b) High Compressive Strength

High strength concrete offers high compressive strength resulting from a very compact mix. High performance concrete reaches easily 60 to 90 MPa compressive strength.

c) Impermeability

High strength concrete having low water cement ratio offers a lesser permeability and hence a better durability.

d) Abrasion Resistance

High strength concrete has exceptional high abrasion resistance rivaling that of the hardest rock. This is of particular interest in road and pipe construction.

e) Immunity to Chemical Attack

High strength concrete shows better resistance to chemical attacks than traditional concrete. It is also recommended is the case of potential reaction between the alkalis of the pore solution and reactive aggregate.

f) Ease of Placing

High strength concrete eliminates the shear threshold in the fresh concrete by introducing plastiment and leads the concrete to flow easily. So, Placing and pumping operations become easy and less costly.

g) Early Development

High strength concrete makes it possible to meet the requirement of contractions who ask for high strength in order to achieve a quicker reuse of from or to enhance production rates.

h) Size or Reinforcement Reduce

High strength concrete can be reduced in size of sections of column, beam etc or for the same cross-sections, the amount of steel reinforcement can be reduced.

i) Productivity Increase

High strength concrete will gain its strength at early age lead to higher productivity and therefore to a greater competitiveness of concrete.

2.5 DISADVANTAGES OF USING HIGH STRENGTH CONCRETE

Possible drawbacks in using high strength concrete are listed below:

a) Increased quality control is needed.
b) High quality materials are less available and often cost more.
c) Allowable stresses in codes may discourage the use of high strength concrete.
d) Minimum thickness or cover may govern the design, preventing realization of full benefit of higher strength.
e) Total available pre-stress force may be insufficient to fully develop the strength.
f) Adequate curing can be difficult due to self-desiccation of low w/c ratio mixes. Even with water loss by evaporation there is inadequate water for full hydration.
g) Curing can also be difficult because of the rapidly increasing impermeability of high strength concrete, which prevents applied curing water from compensating for any initial moisture loss.
h) In structural member where excessive deflection controls the design, full utilization of the materials load-carrying when using high strength concrete would not be possible. For instance, the higher flexural strength of high strength concrete flat slab or plate is little consequence since deflection often controls design.

CHAPTER –III

EXPERIMENTAL INVESTIGATION

3.1 INTRODUCTION

This chapter includes the information regarding the type, sources and preparation of materials used. The production of high strength concrete that meet requirements for workability and strength development for lower strength concrete. High strength concrete has been produced using a wide range of quality materials based on the result of trial mixes. The chapter will describe in detail all the component materials to be used in producing high strength concrete including their availability suitability and sources.

3.2 BRICKS

Bricks are artificial stone made of clay. Ordinary bricks are economical and when laid in good mortar form a durable construction. Bricks are comparatively small in size and therefore can easily be handling.

3.2.1 Characteristic of good bricks

(a) Bricks should be uniform in size shape and color
(b) They should be sound compact.
(c) They should be free from cracks, bubbles and stone nodules.
(d) They should not absorb more than 1/6 of their own weight of water when immerged in water for 24 hours.
(e) Compressive strength in the range of 5000 to 8000 psi.
(f) They should neither over burn nor under burnt.
(g) The weight should be generally 6 lbs per bricks.

The strength of a bricks depends upon the following

(a) Composition of brick earth
(b) Preparation of clay for molding.
(c) Nature of molding adopted.
(d) Drying the green bricks.
(e) Burning and cooling process.

The strength of bricks used in the study was 3813.30 psi is given in table 3.1

Table: 3.1 Compressive strength of bricks

Sample	Strength (psi)	Average Strength (psi)
A	3477.04	**3813.30**
B	3402.45	
C	3087.42	
D	3877.97	
E	3541.65	
F	5493.27	

3.3 THE MAJOR PROPERTIES OF HIGH STRENGTH CONCRETE

(a) Mix proportion
(b) Water/content ratio
(c) Type of gradation
(d) The use of chemical admixture, air entraining agent
(e) Mix procedure, order, time and temperature

Following factor will effect on the strength of concrete

(a) Properties of ingredients
(b) Water cement ratio
(c) Proportion of the various ingredients
(d) Workability

(e) Segregation and bleeding
(f) Compaction
(g) Curing of concrete

The following are the important properties of high strength concrete

(a) Strength
(b) Elastic properties
(c) Durability
(d) Impermeability

3.3.1 Properties of ingredients in concrete

(a) Aggregate
(b) Cement
(c) Water
(d) Chemical admixture

3.3.1.1 Aggregates

In ordinary structural concrete the aggregate occupy about 70 to 75 % of the volume of the hardened mass. Aggregate is important that the aggregate have good strength, durability and weather resistance, that its surface be free from impurities such as loam, silt and organic matter which may weaken the cement paste, and that no unfavorable chemical reaction take place between it and the cement.

Natural aggregate are generally classified as:

(a) Coarse aggregate
(b) Fine aggregate

Coarse aggregate:
Materials which will retained on No.4 sieve, i.e, a sieve with four openings per linier inch is termed as coarse aggregate (Nilson 1979). Coarse aggregate greatly influence the strength of the hardened concrete, as they comprises the largest segment of the entire constituent. The course aggregate to be used in making high strength concrete should be clean, well graded, strong and durable should be free from impurities and deleterious materials such as salts, coal readies etc.

Table: 3.2 The physical properties of brick aggregates

Properties	Brick aggregate
Fineness modulus	6.89
Dry rodded unit weight (lb/ft^3)	68.0
Absorption Capacity (%)	15.8
Bulk specific gravity (S.S.D)	2.10

Fine aggregate

Fine aggregate is any materials which pass a No.4 sieve i.e sieve with four openings per linear inch is termed as fine aggregate. Sand and surki are commonly used in Bangladesh. Fine aggregate with rounded particle shape and smooth texture have found to require less mixing water in concrete and for this reason are preferable in high strength concrete. A fineness modulus (F.M) in the range 2.5 to 3.5 is recommended for high strength concrete to facilitate the workability. Lower result in decreased workability and higher water demand (Nawy 2001).

The aggregate to be used should be sound, low absorbent; dams free deleterious materials. The fine aggregate that had been used in this study should be locally available Sylhet sand. There are two types of sand are commonly used in our country. Sylhet sand and local sand.

The requisites for good sand.

(a) The grains should be sharp, angular and coarse.
(b) It should be free from clayey materials and organic matters.
(c) The grain should be durable materials.
(d) The gradation of grain size should be such that it will give minimum voids.
(e) It should be free from salts.

Table: 3.3 The physical properties of fine aggregates

Properties	Fine aggregate
Fineness modulus	2.48
Absorption Capacity (%)	2.60
Bulk specific gravity (S.S.D)	1.86

3.3.1.2 Cement

A cementing material is one which has the adhesive and cohesive properties necessary to bond inert aggregate into a solid mass of adequate strength, durability. For making structural concrete, so called hydraulic cements are used exclusively. Water is needed for the chemical process (hydration) in which the cement powder sets and hardens into one solid mass. Of the various hydraulic cement which have been developed, Portland cement, this was first patented in England in 1824, is by far the most common (Nilson-1979).

The choice of Portland cement for high strength concrete is extremely important. In hydraulic cement that hardens by interacting with water and forms Water resisting compound when it receives its final set. It is highly durable and compressive strength in mortar and concrete. Its specific gravity ranges from 3.12 to 3.16 and weight 1208 kg /m^3 (94 lb/ft^3). Its measured fineness by particle size ranges from 10 micron to 50 micron (Nawy 2001). The specific gravity of cement used in this study was 3.15.

The chemical requirements for good Portland cement are as follows:

(a) Ratio of Lime to silica ≤ 1.02

(b) Ratio of Alumina to iron oxide > 0.66

(c) Weight of Magnesia $\leq$ 5%

(d) Weight of insoluble residue $\leq$ 1.5 %

(e) Sulpher content $\leq$ 2.75%

(f) Loss on ignition $\leq$ 4%

3.3.1.3 Water

Water is essential in the production of concrete in order to precipitate chemical with the cement, to wet the aggregate, and to lubricate the mixture for easy workability. Since the quality of water effects the strength it is necessary to go into the purely of water. Normally drinking water is used in mixing.

Water having harmful ingredients, contamination, salt, oil, sugar or chemical is destructive to the setting properties of cement. It can disrupt the affinity between the aggregate and the cement paste and adversely affect the workability of mixture.

3.3.1.4 Chemical Admixture

Admixture are the materials other than the basic ingredients of concrete; cement, water and aggregate; added to the concrete mix immediately before or during mixing to modify one or more of the specific properties of concrete in the fresh or hardened state. The properties commonly modified are that ratio of hydration or setting time, workability, dispersion and air-entertainment. Some important purpose for which the admixtures could be used for:

(a) To accelerate the initial set of concrete
(b) To increase the strength of concrete
(c) To improve the workability
(d) To reduce the heat of hydration
(e) To increase the durability of concrete
(f) To reduce the segregation in grout mixture
(g) To increase the resistance to chemical attack.

Admixtures are widely used in the production of high strength concrete. These materials include air entraining agent and chemical and mineral admixtures. We used DRACEM-100 super-plasticizer as admixture in the study. The technical data of this admixture are given in table-3.4

High range water reducing admixture (HRWR) is sometimes called super plasticizer. The optimum admixture percentage should be determined on trial and adjustment basis as they can reduce the water demand by almost 30 to 35 % with a corresponding increase in compressive strength. A slump of 1 to 2 inch (25 to 50 mm) is considered adequate. If however, no HRWR admixtures are used, the slump should be increase 2 to 4 inch (50 to 100 mm)

Table: 3.4 Technical data of admixture

Aspect	Dark Brown Liquid
Type	Naphthalene sulphonates and modified lignosulphonates
Specific Gravity (at 25^0 C)	1.20(±0.02)

Dosage: 0.3 %to 1.5 % by weight of cement depending on requirements concerning workability.

3.3.2 Water-cement Ratio and its Effects on Concrete Properties

The proportion between the amount of water and cement used in concrete in a concrete mix is termed as water/cement ratio. The water in the concrete doses primarily the three following functions:

- To wet the surface of the aggregate
- To improve workability
- To combine chemically with cement

Water is needed for wetting of the aggregate. As water is added the fluidity of the mix increases consequently causing larger volume of voids created by the free water .To reduce the free water while retaining the workability,

Admixture must be added. Therefore, the water cement ratio is the chief factor, which controls the strength of concrete.

3.3.2 Workability of high strength concrete

Where structures are heavily reinforced consequently concrete had to be workable enough to be placed and compacted through dense reinforcement. Such cases are often mat by high strength concrete. Therefore, it needs high workability.

According to road research laboratory, U.K. workability of concrete is defined as the property of concrete, which determine the amount of usual internal work necessary to produce full compaction. The factors helping concrete to have more lubricating effect to reduce internal friction for helping easy compaction are given below:

(a) Water content
(b) Size of aggregate
(c) Surface texture of aggregate
(d) Use of admixture
(e) Mix proportion
(f) Shape of aggregate
(g) Grading of aggregate
(h) Slump test

Slump Test

Slump test is the most commonly used method of measuring consistency of concrete which can be employed either in laboratory or at site of work. Additional information on workability and quality of concrete can be obtained by observing the manner in which concrete slumps. A slump of 1 inch to 2 inch measured in the study with no admixture used and of 3 inch to 4 inch measured with admixture.

3.3.4 Segregation and bleeding

Segregation can be defined as separation of constituents of a heterogeneous mixture so that their distribution is no longer uniform. In concrete there are two forms of segregation. First, the coarser particles tend to travel further along a slope or settle more than fine particles particularly in wet mixes and are manifested by the separation of grout form mix.

Bleeding form of segregation in which some of the water in the concrete mix tends to rise to the surface of freshly placed concrete. This is caused by inability of this solids constituent of the mix to hold all the mixing water when they settle downward.

3.3.5 Compaction of concrete

Compaction of concrete is the process adopted for expelling the entrapped air form the concrete. In the process of placing and mixing of concrete, air is likely to get entrapped in the concrete. If this air in not removed fully, the concrete losses strength considerably. It is imperative 100 percent. Compaction of concrete is one of the most important aims to be kept in mind in good concrete making practices.
In order to achieve full compacting and maximum density with reasonable compacting efforts available at site, it is necessary to use a mix with adequate workability.

The following methods are adopted for compact the concrete:

a) Hand compaction

1) Rodding
2) Ramming
3) Tamping

b) Compaction by vibration

1) Internal vibrator (needle vibrator)
2) Formwork vibrator
3) Table vibrator
4) Surface vibrator

c) Compaction by pressure and Jolting

d) Compaction by spining

3.3.6 Curing of concrete

Fresh concrete gains strength the most rapidly during the first few days and weeks. Structural design is generally based on the 28-days strength, about 70% of which is reached at the end of the first week after placing. The final concrete strength depends greatly on the conditions of moisture and temperature during this initial period.

Curing can be defined as the process of maintaining a satisfactory moisture content and favorable temperature in concrete during the period immediately following placement so that hydration of cement may be continue until the desired properties are developed to a sufficient degree to meet the requirement of service. It is given a place of increasing importance as the demand for high quantity concrete is increasing.

3.3.6.1 Methods of curing

Curing method may be defined broadly into four categories

a) Water curing
b) Membrane curing
c) Application of heat

d) Miscellaneous

Water curing:

The method of curing satisfies all the requirements of curing namely, promotion of hydration, elimination of shrinkage and absorption of the heat of hydration. Water curing can be done by following ways:

a) Immersion
b) Ponding
c) Spraying
d) Wet covering

3.4 MIXING OF HIGH STRENGTH CONCRETE

The mixing should ensure that the mass becomes homogeneous, uniform in color and consistency. There are two methods adopted for mixing concrete:

a) Hand mixing
b) Machine mixing

a) Hand mixing

Hand mixing is practiced for small scale and important concreting works. As the mixing cannot be through and efficient, it is desirable to add 10% more cement to cater for the inferior concrete produced by this process.

b) Machine mixing

Mixing of concrete is almost in variably carried out by machine for reinforcement concrete work and for medium or large scale mass concrete work.

3.5 PREPARATION OF TEST SPECIMENS

Using cylinder by revering the steel plates made test specimens. Test specimens were made by using cylinder (6"×12"). Mix the coarse aggregate, cement, water by mixture machine. Then place the concrete in the cylinder in three layers step by step. In each layer vibrate about three minutes properly. Finally apply the finishing on top surface of specimen. After twenty-four hours the specimen was separated form the mold and then specimens were sunk in water bath.

Table: 3.5 Various proportion of mixture

Sample Type	Cement content Kg/m^3	Volumetric ratio of **F. A and C. A**	W/C ratio	Admixture Daracem-100
$\mathbf{A_{25}}$	400	**1 : 2**	0.30	Admixture used
$\mathbf{A_{19}}$			0.40	
$\mathbf{A_{12}}$			0.45	No admixture used
$\mathbf{B_{25}}$	450	**1 : 2**	0.30	Admixture used
$\mathbf{B_{19}}$			0.40 .	
$\mathbf{B_{12}}$			0.45	No admixture used
$\mathbf{C_{25}}$	500	**1 : 2**	0.30	Admixture used
$\mathbf{C_{19}}$			0.40	
$\mathbf{C_{12}}$			0.45	No admixture used
$\mathbf{D_{25}}$	550	**1 : 2**	0.30	Admixture used
$\mathbf{D_{19}}$			0.40	
$\mathbf{D_{12}}$			0.45	No admixture used

3.6 TESTS SCHEME

The following tests are the commonly used in the study

a) Compressive strength of brick
b) Gradation or fineness modulus of coarse aggregate and the fine aggregate.
c) Compressive strength of cylinder.

CHAPTER-IV

TEST RESULTS

4.1 INTRODUCTION

The main aim of the study is to obtain a mix proportion which yields higher strength using brick aggregate. In order to find out the expect ion proportion or proportions, a parametric study has been carried out.

4.2 STRENGTH OF CONCRETE

The Strength of concrete whether direct or indirect, appears to be a good index of the most properties of practical significance. In general stronger concrete are stiffer, more nearly water tight, more resistance to weathering. On other hand stronger concrete are usually more liable to cracking. Strength tests are relatively simple to make.

Strength may be defined as the ability to resist force. Concrete is much weaker in tension and in shear then in compression, and failure of concrete specimen under compressive load are essentially shear failures of oblique planes, since the resistance to failure is due to both cohesive and internal friction.

4.3 COMPRESSIVE STRENGTH OF CONCRETE

The compressive Strength of concrete is one of its most important and useful properties and can be determined easily. In most structural applications, concrete is employed primarily to resist compressive stresses. The compressive Strength of concrete is used as a measure of the overall quality of the concrete and also as an indication of other properties relating to deformation or durability. The compressive Strength of test specimens were determined at 28 days after curing under water bath. The results of compressive Strength of concrete are summarized in Table 4.1, 4.2 & 4.3.

4.4 TEST RESULTS

Table 4.1: Results of Cylinder Compressive Strength According to Cement content

Sample	Range	Cement content Kg/m^3	W/C ratio	Max^m Size of Coarse aggregate (mm)	Compressive Strength f_c' (psi)
A	Max^m	400	0.30	12.5	6975.70
	Min^m		0.45	12.5	4323.35
B	Max^m	450	0.30	12.5	7700.00**
	Min^m		0.45	12.5	3970.60*
C	Max^m	500	0.30	12.5	7450.00
	Min^m		0.45	12.5	4464.64
D	Max^m	550	0.30	12.5	7550.00
	Min^m		0.45	12.5	5157.89

Table 4.2: Results of Cylinder Compressive Strength According to Size of Coarse aggregate

Max^m Size of Coarse aggregate (mm)	Range	Cement content Kg/m^3	W/C ratio	Compressive Strength f_c' (psi)
25	Max^m	550	0.40	7266.40
	Min^m	450	0.45	4089.36
19	Max^m	500	0.30	7386.09
	Min^m	400	0.45	4425.94
12.5	Max^m	450	0.30	7700.00**
	Min^m	450	0.45	3970.60*

Table 4.3: Results of Cylinder Compressive Strength According to Water/Cement Ratio

W/C ratio	Range	Cement content Kg/m^3	Max^m Size of Coarse aggregate (mm)	Compressive Strength fc' (psi)
0.30	Max^m	450	12.5	7700.00 **
	Min^m	400	19	4743.23
0.40	Max^m	550	25	7266.40
	Min^m	400	25	4594.02
0.45	Max^m	550	25	5792.22
	Min^m	450	12.5	3970.60*

Summary: Maximum Compressive Strength found = 7700.00 psi
Minimum Compressive Strength found = 3970.00 psi

CHAPTER-V

ANALYSIS AND DISCUSSION

5.1 INTRODUCTION

Result from various laboratory tests conducted in this study are presented and discussed in this chapter. The laboratory experimental program was set up to develop concrete using brick aggregate with high compressive strength.

Ratio of Fine aggregate and Coarse aggregate is 1: 2 for all specimens

5.2 EFFECT OF CEMENT CONTENT ON THE COMPRESSIVE STRENGTH

Table 5.1 Compressive Strength with various Cement content

Sample	W/C ratio	Cement content Kg/m^3	Compressive Strength $f_c^{'}$ (psi)
A_{25}	0.3	400	6770.93
B_{25}		450	6443.17
C_{25}		500	7243.38
D_{25}		550	6903.33

Table 5.2 Compressive Strength with various Cement content

Sample	W/C ratio	Cement content Kg/m^3	Compressive Strength $f_c^{'}$ (psi)
A_{19}	0.3	400	4743.23
B_{19}		450	7122.93
C_{19}		500	7386.39
D_{19}		550	7043.00

Table 5.3 Compressive Strength with various Cement content

Sample	W/C ratio	Cement content Kg/m^3	Compressive Strength $f_c^{'}$ (psi)
A_{12}	0.3	400	6975.70
B_{12}		450	7700.00
C_{12}		500	7450.00
D_{12}		550	7550.00

Table 5.4 Compressive Strength with various Cement content

Sample	W/C ratio	Cement content Kg/m^3	Compressive Strength $f_c^{'}$ (psi)
A_{25}	0.4	400	4594.02
B_{25}		450	6202.97
C_{25}		500	5221.45
D_{25}		550	7266.40

Table 5.5 Compressive Strength with various Cement content

Sample	W/C ratio	Cement content Kg/m^3	Compressive Strength $f_c^{'}$ (psi)
A_{19}	0.4	400	5410.25
B_{19}		450	6960.94
C_{19}		500	6521.77
D_{19}		550	6311.96

Table 5.6 Compressive Strength with various Cement content

Sample	W/C ratio	Cement content Kg/m^3	Compressive Strength $f_c^{'}$ (psi)
A_{12}	0.4	400	5178.53
B_{12}		450	6772.81
C_{12}		500	5238.62
D_{12}		550	7065.72

Table 5.7 Compressive Strength with various Cement content

Sample	W/C ratio	Cement content Kg/m^3	Compressive Strength $f_c^{'}$ (psi)
A_{25}	0.45	400	4490.96
B_{25}		450	4089.36
C_{25}		500	4922.70
D_{25}		550	5792.22

Table 5.8 Compressive Strength with various Cement content

Sample	W/C ratio	Cement content Kg/m^3	Compressive Strength f_c' (psi)
A_{19}	0.45	400	4425.94
B_{19}		450	4823.53
C_{19}		500	5009.59
D_{19}		550	5575.21

Table 5.9 Compressive Strength with various Cement content

Sample	W/C ratio	Cement content Kg/m^3	Compressive Strength f_c' (psi)
A_{12}	0.45	400	4323.35
B_{12}		450	3970.60
C_{12}		500	4464.64
D_{12}		550	5157.89

Effect of cement content on the Compressive Strength

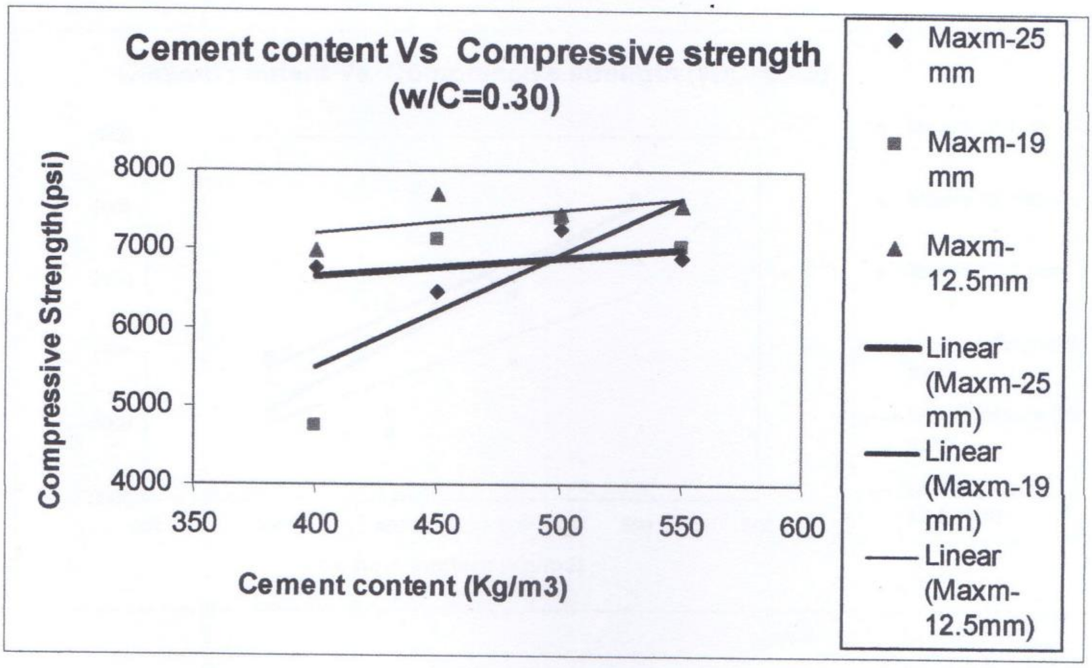

Figure 5.1: Cement content Vs. Compressive strength
For water/cement ratio = 0.30

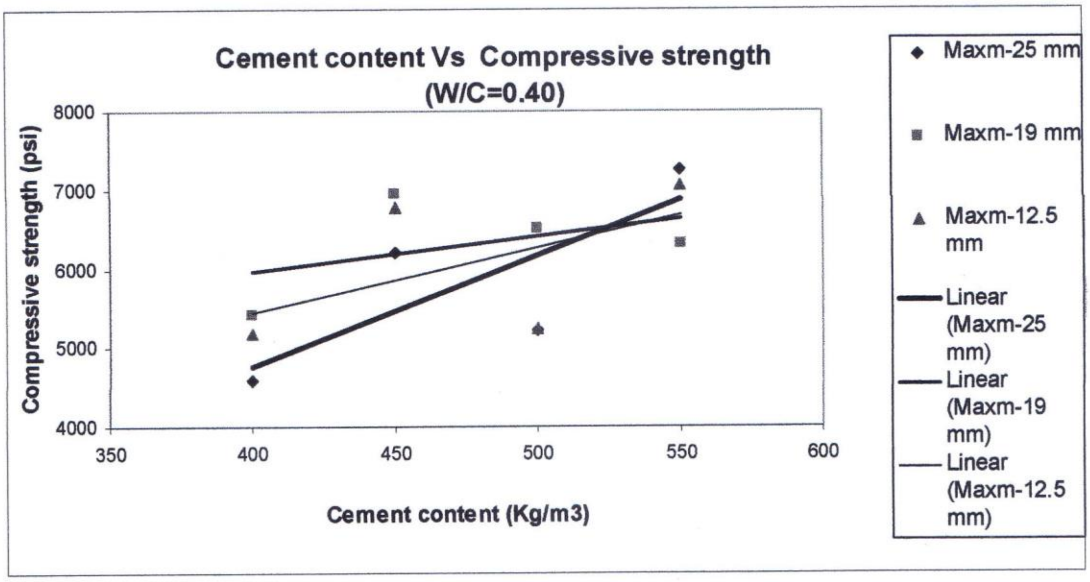

Figure 5.2: Cement content Vs. Compressive strength
For water/cement ratio = 0.40

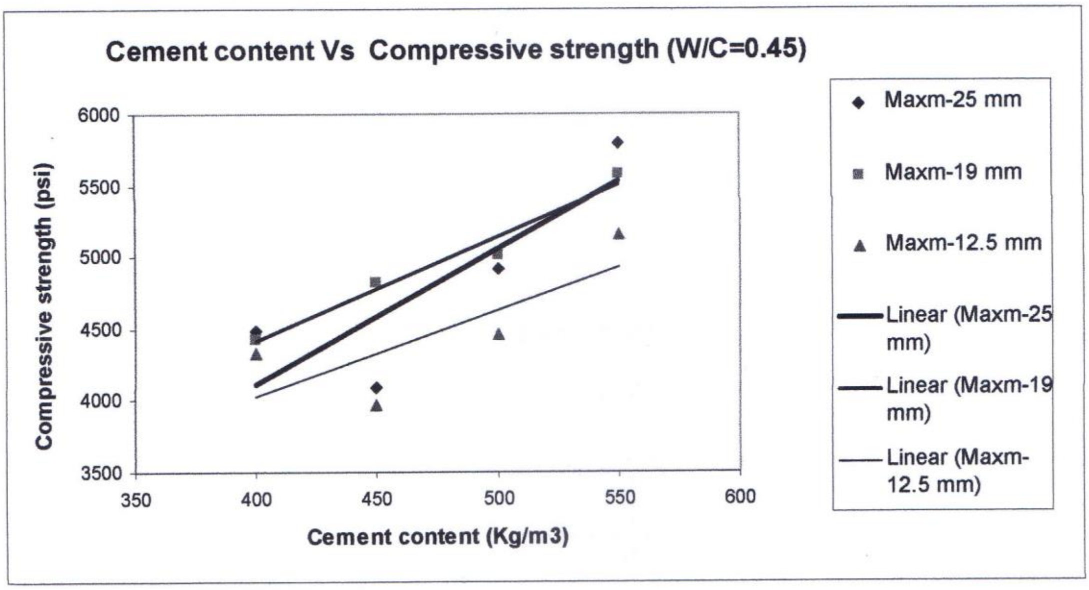

Figure 5.3: Cement content Vs. Compressive strength
For water/cement ratio = 0.45

5.3 EFFECT OF W/C RATIO ON CYLINDER COMPRESSIVE STRENGTH

Abrams water/cement ratio law states that the strength of concrete is only dependent upon water cement ratio provided the mix is workable. When concrete is fully compacted, its strength is taken to be inversely proportional to the water/cement ratio. The effect of water/cement ratio on the 28 days cylinder compressive strength found in the study is shown figure 5.1

Table 5.10 Compressive Strength with various water/cement ratios

Sample	Cement content Kg/m^3	W/C ratio	Strength f_c' (psi)
A_{25}	400	0.3	6770.93
		0.4	4594.2
		0.45	4490.96

Table 5.11 Compressive Strength with various water/cement ratios

Sample	Cement content Kg/m^3	W/C ratio	Strength f_c' (psi)
A_{19}	400	0.3	4743.23
		0.4	5410.25
		0.45	4425.94

Table 5.12 Compressive Strength with various water/cement ratios

Sample	Cement content Kg/m^3	W/C ratio	Strength f_c' (psi)
A_{12}	400	0.3	6975.70
		0.4	5178.53
		0.45	4323.35

Table 5.13 Compressive Strength with various water/cement ratios

Sample	Cement content Kg/m^3	W/C ratio	Strength f_c' (psi)
B_{25}	450	0.3	6443.17
		0.4	6202.97
		0.45	4089.36

Table 5.14 Compressive Strength with various water/cement ratios

Sample	Cement content Kg/m^3	W/C ratio	Strength f_c' (psi)
B_{19}	450	0.3	7122.93
		0.4	6960.94
		0.45	4823.53

Table 5.15 Compressive Strength with various water/cement ratios

Sample	Cement content Kg/m^3	W/C ratio	Strength f_c' (psi)
B_{12}	450	0.3	7700.00
		0.4	6772.81
		0.45	3970.60

Table 5.16 Compressive Strength with various water/cement ratios

Sample	Cement content Kg/m^3	W/C ratio	Strength f_c' (psi)
C_{25}	500	0.3	7243.38
		0.4	5221.45
		0.45	4922.70

Table 5.17 Compressive Strength with various water/cement ratios

Sample	Cement content Kg/m^3	W/C ratio	Strength f_c' (psi)
C_{19}	500	0.3	7386.09
		0.4	6521.77
		0.45	5009.59

Table 5.18 Compressive Strength with various water/cement ratios

Sample	Cement content Kg/m^3	W/C ratio	Strength f_c' (psi)
C_{12}	500	0.3	7450.00
		0.4	5238.62
		0.45	4464.64

Table 5.19 Compressive Strength with various water/cement ratios

Sample	Cement content Kg/m^3	W/C ratio	Strength f_c' (psi)
D_{25}	550	0.3	6903.30
		0.4	7266.40
		0.45	5792.22

Table 5.20 Compressive Strength with various water/cement ratios

Sample	Cement content Kg/m^3	W/C ratio	Strength f_c' (psi)
D_{19}	550	0.3	7043.00
		0.4	6311.96
		0.45	5575.21

Table 5.21 Compressive Strength with various water/cement ratios

Sample	Cement content Kg/m^3	W/C ratio	Strength f_c' (psi)
D_{12}	550	0.3	7550.00
		0.4	7065.72
		0.45	5157.89

Effect of water/cement ratio on the Compressive strength

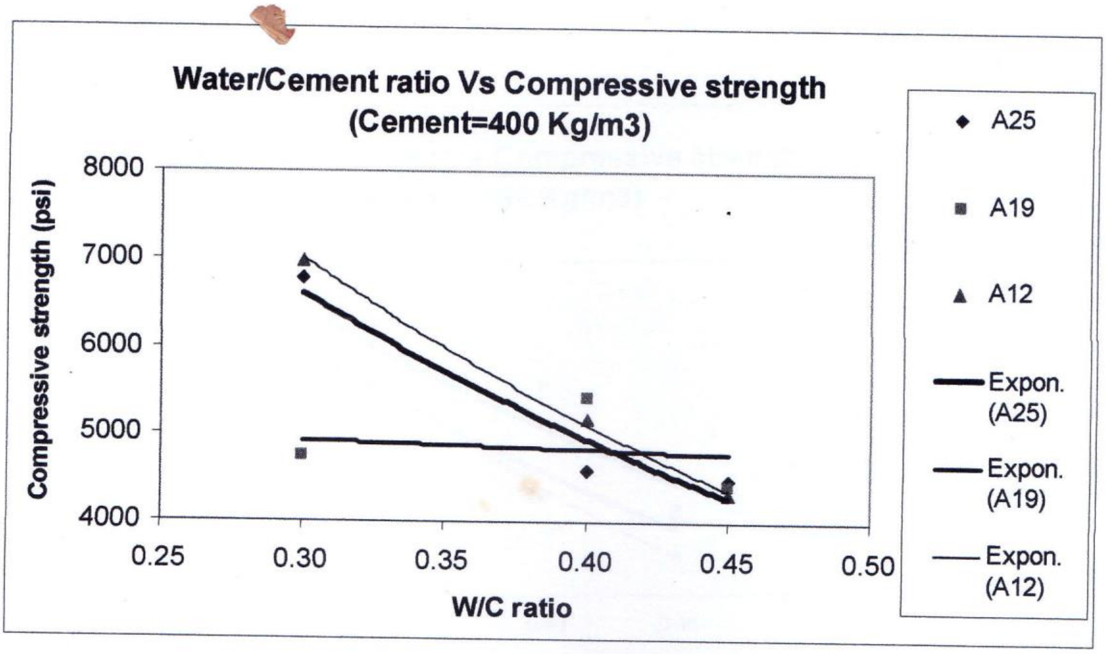

Figure 5.4: Water/cement ratio Vs. Compressive strength
for cement content = 400 Kg/m^3

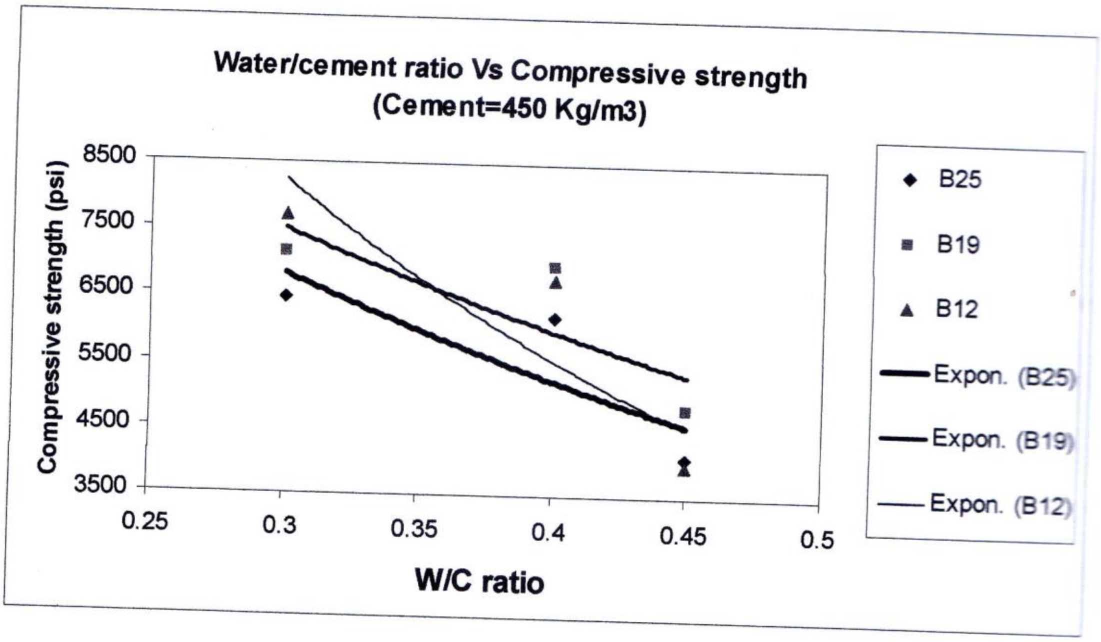

Figure 5.5: Water/cement ratio Vs. Compressive strength for cement content = 450 Kg/m^3

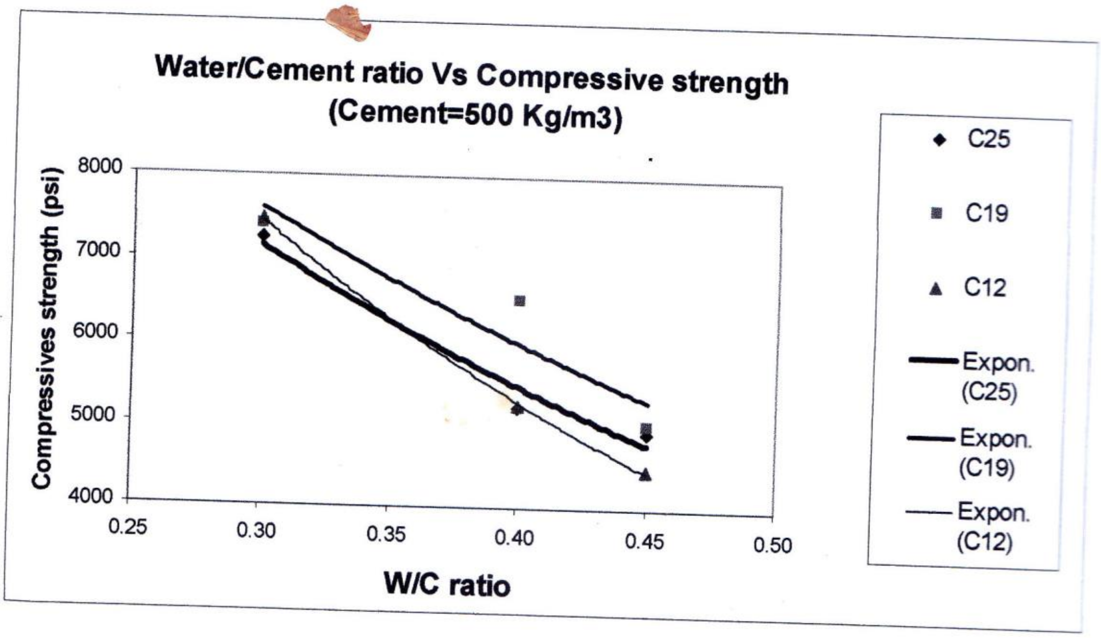

Figure 5.6: Water/cement ratio Vs. Compressive strength for cement content = 500 Kg/m^3

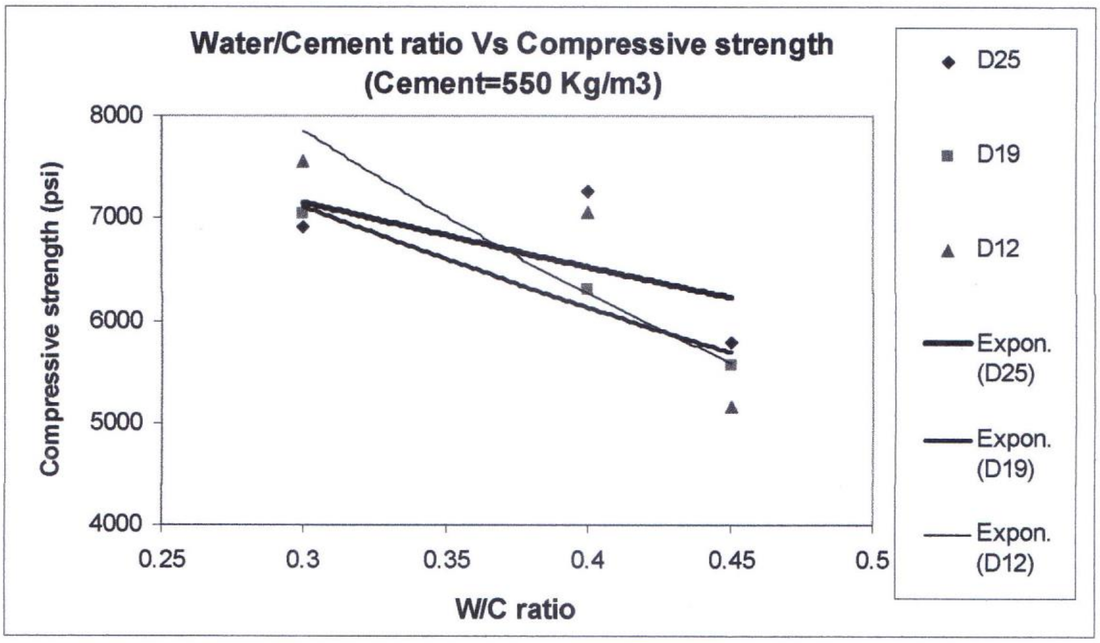

Figure 5.7: Water/cement ratio Vs. Compressive strength
for cement content = 550 Kg/m

Table 5.22 Compressive Strength with various Size of Coarse aggregate:

Sample	Cement content Kg/m^3	W/C ratio	Maximum Size of Coarse aggregate (mm)	Strength f_c' (psi)
A	400	0.3	25	6770.93
			19	4743.23
			12.5	6975.70

Table 5.23 Compressive Strength with various Size of Coarse aggregate:

Sample	Cement content Kg/m^3	W/C ratio	Maximum Size of coarse aggregate	Strength f_c' (psi)
B	450	0.3	25	6443.17
			19	7122.93
			12.5	7700.00

Table 5.24 Compressive Strength with various Size of Coarse aggregate:

Sample	Cement content Kg/m^3	W/C ratio	Maximum Size of coarse aggregate	Strength f_c' (psi)
C	500	0.3	25	7243.38
			19	7386.09
			12.5	7450.00

Table 5.25 Compressive Strength with various Size of Coarse aggregate:

Sample	Cement content Kg/m^3	W/C ratio	Maximum Size of coarse aggregate	Strength f_c' (psi)
D	550	0.3	25	6903.33
			19	7043.00
			12	7550.00

Table 5.26 Compressive Strength with various Size of Coarse aggregate:

Sample	Cement content Kg/m^3	W/C ratio	Maximum Size of coarse aggregate	Strength f_c' (psi)
A	400	0.4	25	4594.02
			19	5410.25
			12	5178.53

Table 5.27 Compressive Strength with various Size of Coarse aggregate:

Sample	Cement content Kg/m^3	W/C ratio	Maximum Size of coarse aggregate	Strength f_c' (psi)
B	450	0.40	25	6202.97
			19	6960.94
			12.5	6772.81

Table 5.28 Compressive Strength with various Size of Coarse aggregate:

Sample	Cement content Kg/m^3	W/C ratio	Maximum Size of coarse aggregate	Strength f_c' (psi)
C	500	0.40	25	5221.45
			19	6521.77
			12.5	5238.62

Table 5.29 Compressive Strength with various Size of Coarse aggregate:

Sample	Cement content Kg/m^3	W/C ratio	Maximum Size of coarse aggregate	Strength f_c' (psi)
D	550	0.40	25	7266.40
			19	6311.96
			12.5	7065.72

Table 5.30 Compressive Strength with various Size of Coarse aggregate:

Sample	Cement content Kg/m^3	W/C ratio	Maximum Size of coarse aggregate	Strength f_c' (psi)
A	400	0.45	25	4490.96
			19	4425.94
			12.5	4323.35

Table 5.31 Compressive Strength with various Size of Coarse aggregate:

Sample	Cement content Kg/m^3	W/C ratio	Maximum Size of coarse aggregate	Strength f_c' (psi)
			25	4089.36
B	450	0.45	19	4823.53
			12.5	3970.60

Table 5.32 Compressive Strength with various Size of Coarse aggregate:

Sample	Cement content Kg/m^3	W/C ratio	Maximum Size of coarse aggregate	Strength f_c' (psi)
			25	4922.70
C	500	0.45	19	5009.59
			12.5	4464.64

Table 5.33 Compressive Strength with various Size of Coarse aggregate:

Sample	Cement content Kg/m^3	W/C ratio	Maximum Size of coarse aggregate	Strength f_c' (psi)
			25	5792.22
D	550	0.45	19	5575.21
			12.5	5157.89

Effect of size of coarse aggregate on Compressive strength at constant cement content

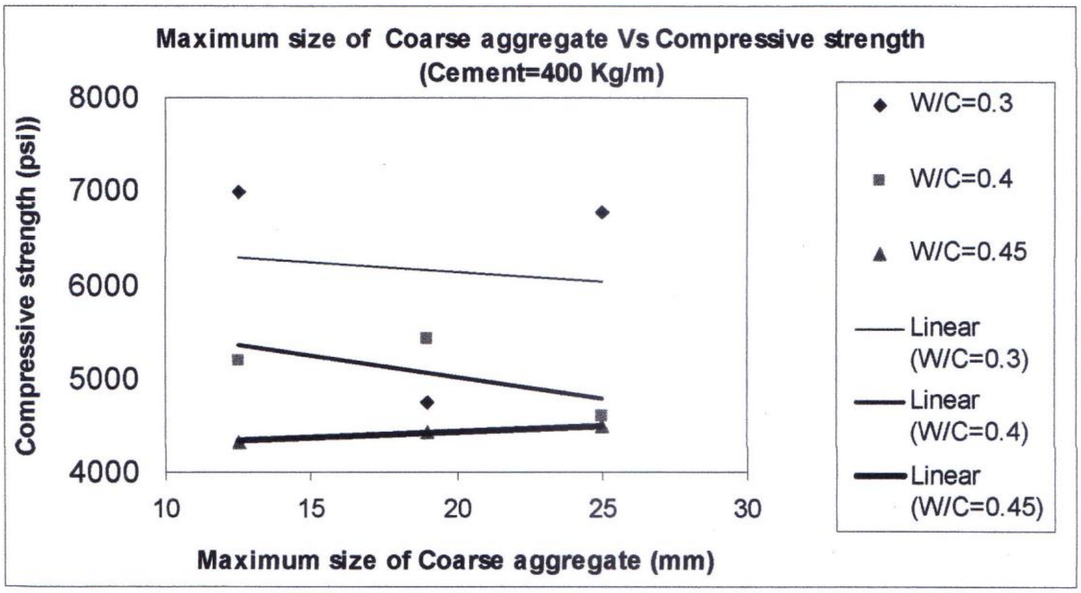

Figure 5.8: Maximum size of coarse aggregate Vs. Compressive strength for cement content = 400 Kg/m^3

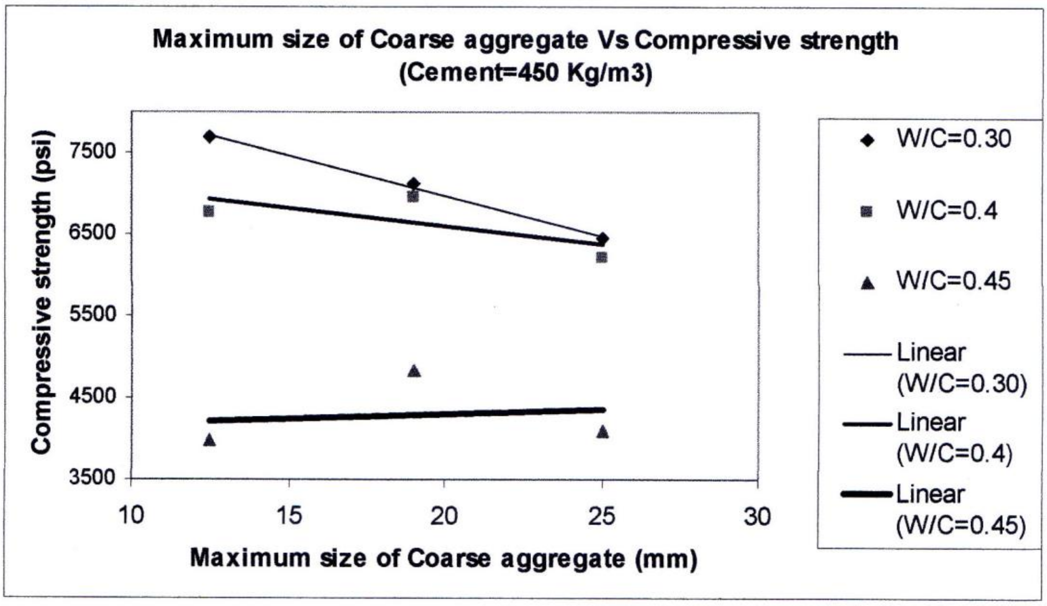

Figure 5.9: Maximum size of coarse aggregate Vs. compressive strength for cement content = 450 Kg/m^3

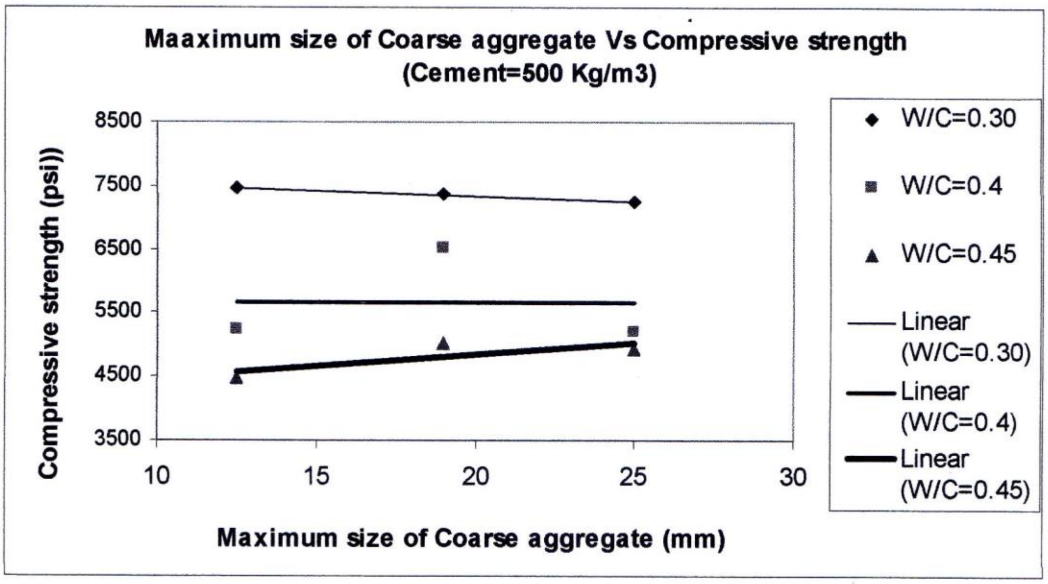

Figure 5.10: Maximum size of coarse aggregate Vs. Compressive strength for cement content =500 Kg/m^3

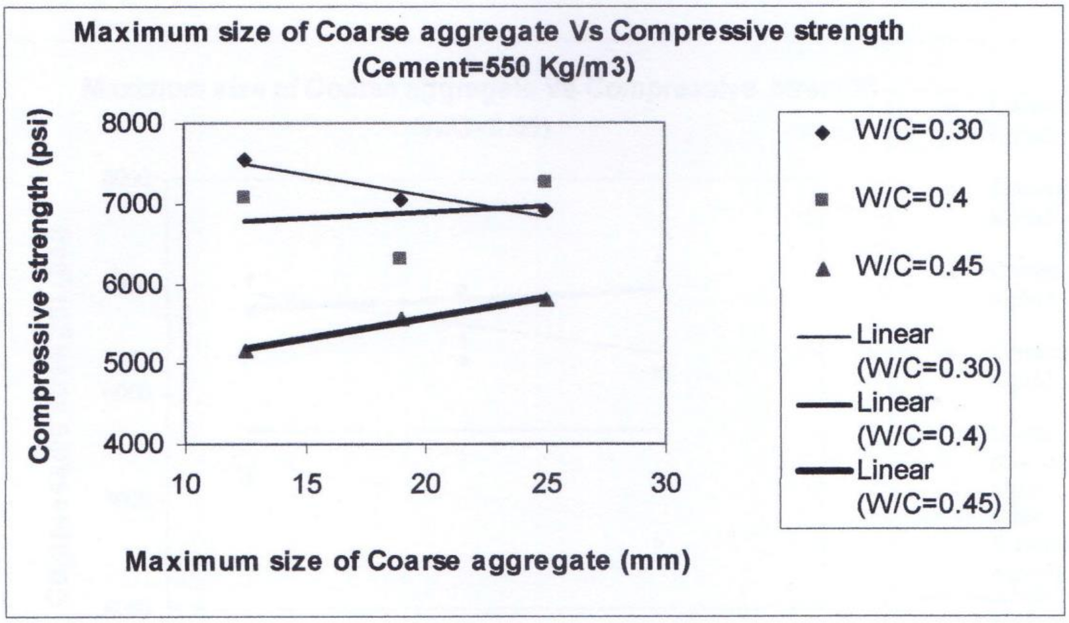

Figure 5.11: Maximum size of coarse aggregate Vs. Compressive strength for cement content =550 Kg/m^3

Effect of maximum size of coarse aggregate on the Compressive strength at constant w/c ratio

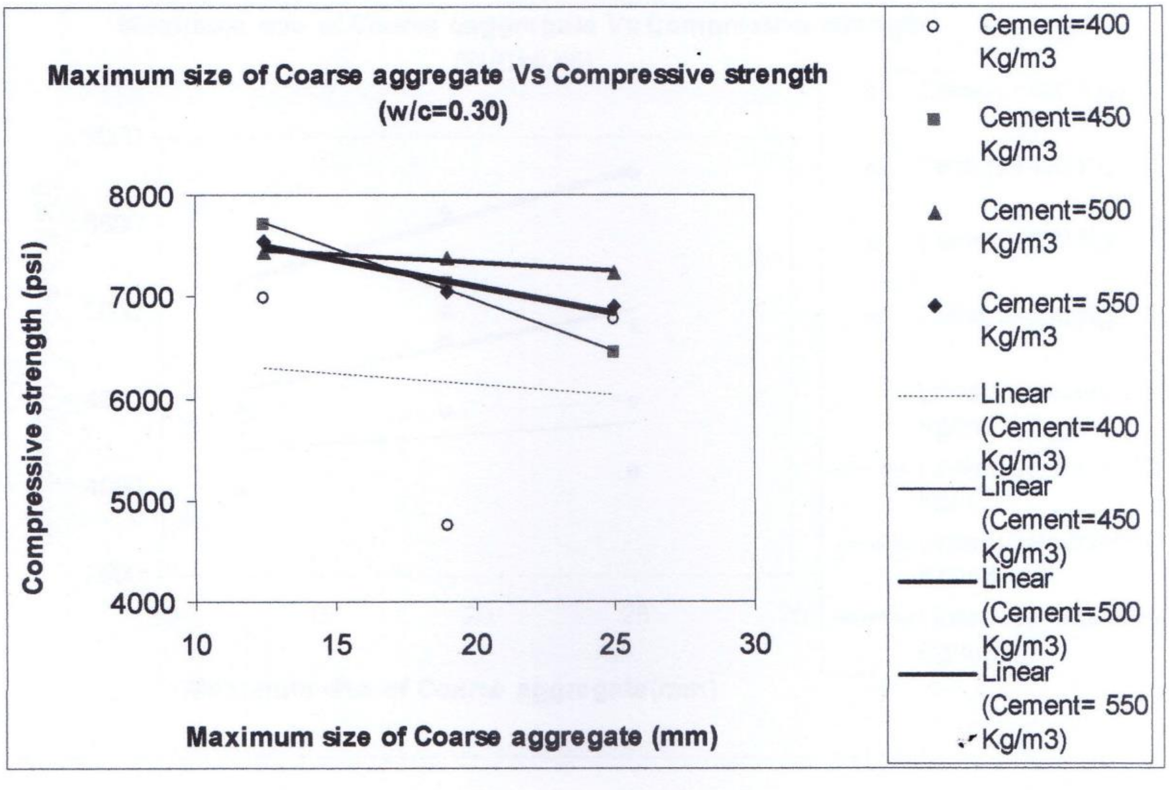

Figure 5.12: Maximum size of coarse aggregate Vs. Compressive strength for water/cement ratio =0.30

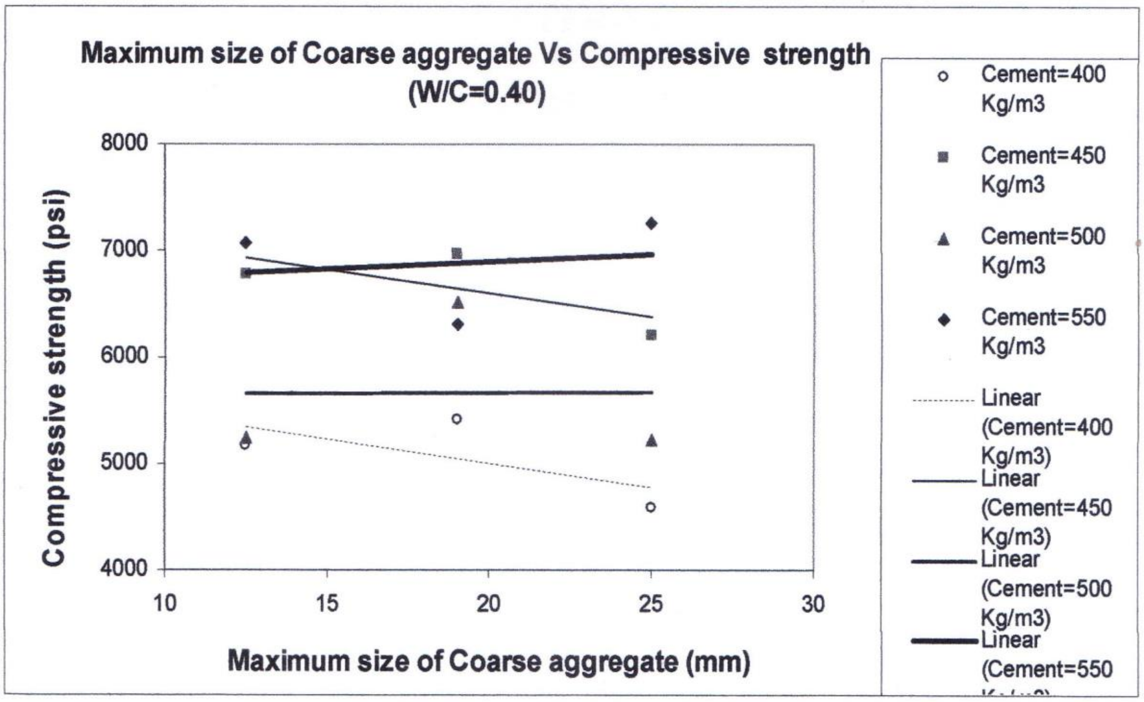

Figure 5.13: Maximum size of coarse aggregate Vs. Compressive strength for water/cement ratio =0.40

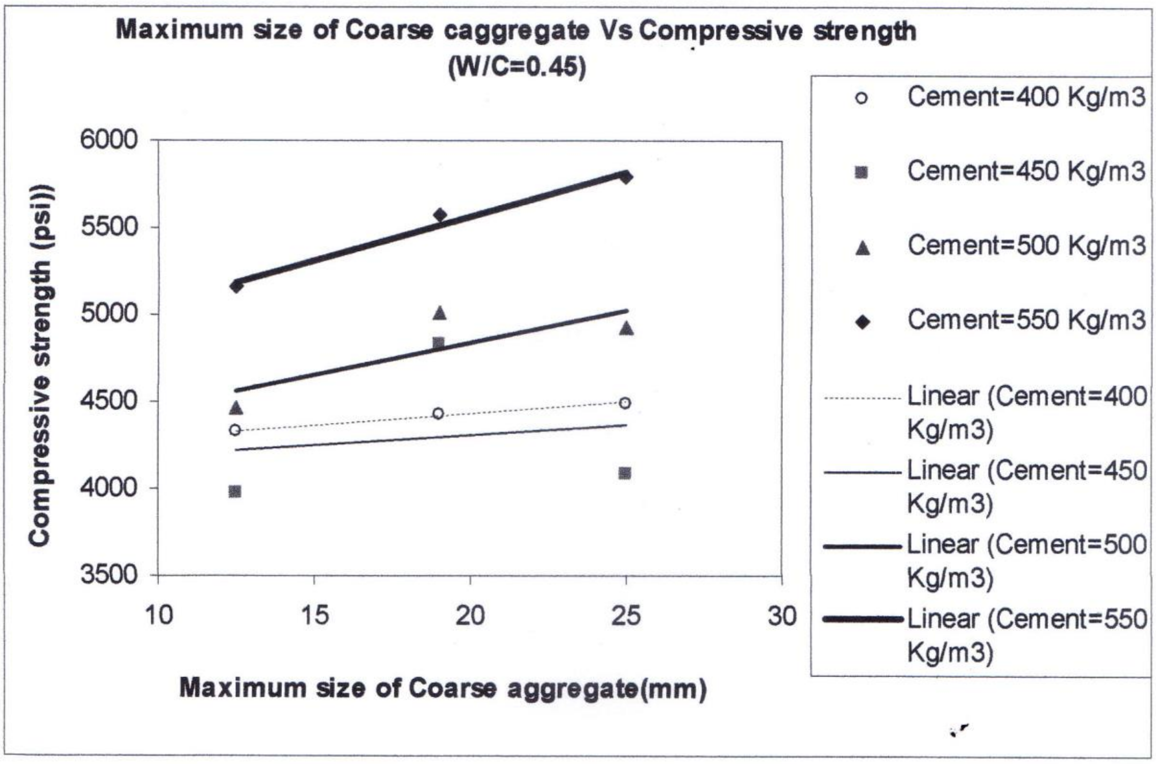

Figure 5.14: Maximum size of coarse aggregate Vs. Compressive strength for water/cement ratio =0.45

CHAPTER-VI

CONCLUSIONS AND RECOMMENDATIONS

6.1 GENERAL

This study gives a thought-out understanding of the high strength gaining of concrete. Mix proportion of fresh concrete, quality control of various ingredients, water/cement ratio, and compaction are maintained carefully, of the present study carefully, a brief conclusion is presented along with recommendations for future study.

6.2 CONCLUSIONS

From the test results of high strength concrete, the following conclusions may be drawn. It may be emphasized here that future investigations are necessary to confirm the findings.

i. Maximum compressive strength at 28-days is found for the water/cement ratio of 0.30, cement content 450 kg/m^3 and maximum size of coarse aggregate 12.5 mm.
ii. The maximum compressive strength obtained in the study is 7700.00 psi (53.10 MPa).
iii. The compressive strength of concrete increases with increasing cement content up to a certain limit. Beyond that limit, the strength decrease.
iv. With decreasing water/cement ratio, the strength increases.

6.4 RECOMMENDATIONS FOR FURTHER STUDY

On the basis of the present study, following recommendations are suggested for further study.

i. In this study 129 specimens were used for obtaining relationships of the compressive strength and different parameters.

ii. In order to obtain rigorous relationship, the range of parameters and the number of parameters may be increased, for further study.

iii. Further study may be carried out for stone aggregate also.

iv. Crushing strength tests may be conducted at different age to obtain the relationships between the compressive strength of concrete and age.

v. Cube specimens may also be used for further study.

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APPENDIX

Table A_1: Grain Size Analysis of Sylhet Sand

Sieve No.	Sieve size (mm)	Wt. of Retained	% of Retained	Cumulative % of Retained	% of Finer	F M
3/4"	19.00	0.00	0.00	0.00	100.00	2.48
3/8"	9.50	0.00	0.00	0.00	100.00	
4 No.	4.75	1.50	0.13	0.13	99.87	
8 No	2.36	51.00	4.27	4.39	95.61	
16 No	1.18	139.50	11.67	16.06	83.94	
30 No	0.60	377.50	31.58	47.64	52.36	
50 No	0.30	424.50	35.51	83.15	16.85	
100 No	0.15	162.50	13.59	96.74	3.26	
200 No		39.00			0.00	
	Sum =	1195.50	Sum = 248.10			

Table A_2: Grain Size Analysis of Coarse aggregates

Sieve No.	Sieve size (mm)	Wt. of Retained	% of Retained	Cumulative % of Retained	% of Finer	F M
3/2"	40.00	0.00	0.00	0.00	100.00	6.89
3/4"	19.00	236.00	9.02	9.02	90.98	
1/2"	12.50	659.20	25.18	34.20	65.80	
3/8"	9.50	555.50	21.22	55.42	44.58	
# 4	4.75	989.30	37.80	93.22	6.78	
# 8	2.36	115.70	4.42	97.64	2.36	
# 16	1.18	50.80	1.94	99.58	0.42	
# 30	0.60	8.00	0.31	99.89	0.11	
# 50	0.30	2.00	0.08	99.96	0.04	
# 100	0.15	1.00	0.04	100.00	0.00	
	Sum =	2617.50	Sum =	688.93		

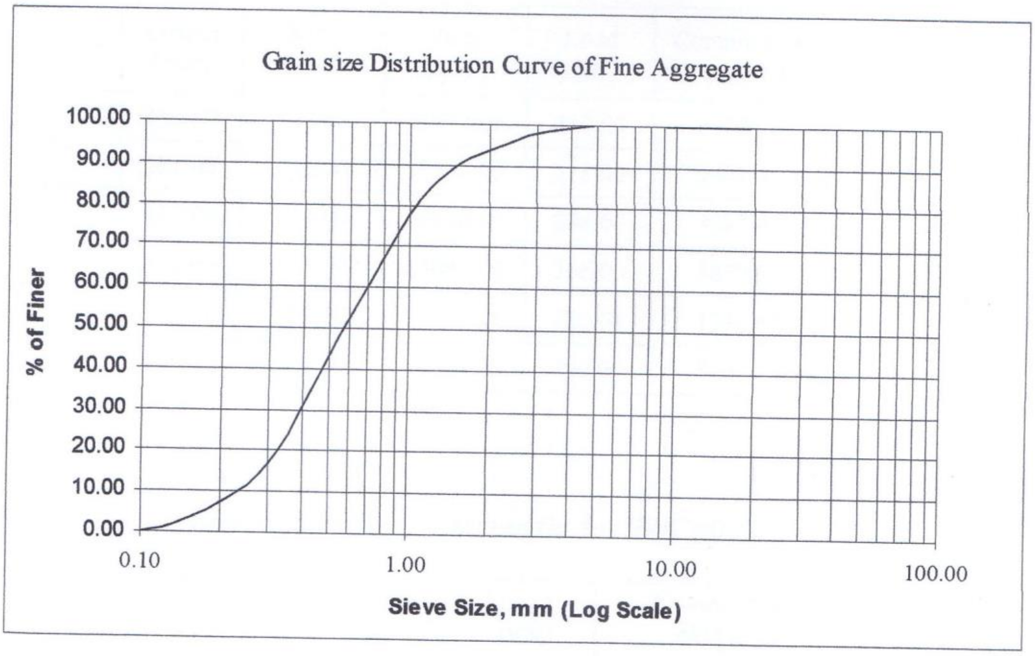

Fig A_1: Grain Size Distribution Curve of Sylhet Sand

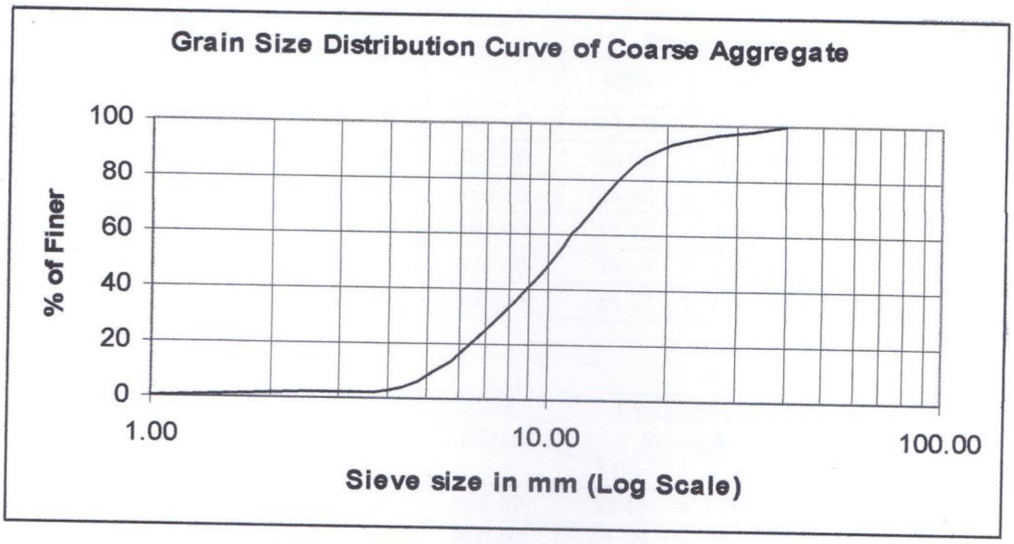

Fig A_2: Grain Size Distribution Curve of Coarse Aggregate

Table A_3: Compressive strength of Bricks

Sample	Length (mm)	Width (mm)	Area (mm^2)	Load (KN)	Compressive Strength (psi)	Average Strength (psi)	Total Avg. Strength (psi)
A	113.80	113.60	12927.68	310.00	3477.04	3439.74	3813.30
	121.00	112.00	13552.00	318.00	3402.45		
B	117.00	114.00	13338.00	284.00	3087.42	3482.69	
	119.00	115.00	13685.00	366.00	3877.97		
C	117.50	111.50	13101.25	320.00	3541.65	4517.46	
	116.00	111.50	12934.00	490.00	5493.27		

Table A_4 : Cylinder compressive strength for W/C=0.30

Sample	Diameter (mm)	Area (mm^2)	Load (KN)	Compressive Strength		Average Strength	
				MPa	psi	psi	MPa
w/c=0.3 A_{25}	149.00	17427.79	822.00	47.17	6839.08	6770.93	46.70
	149.50	17544.95	810.00	46.17	6694.24		
	149.30	17498.03	939.00	53.66	7781.16		
	150.00	17662.50	673.00	38.10	5524.98		
	149.60	17568.43	834.00	47.47	6883.37		
	149.30	17498.03	833.00	47.61	6902.78		

Sample	Diameter (mm)	Area (mm^2)	Load (KN)	Compressive Strength		Average Strengths	
				MPa	psi	psi	MPa
w/c=0.3 A_{19}	149.50	17544.95	767.00	43.72	6338.86	4743.23	38.22
	149.30	17498.03	700.00	40.00	5800.65		
	149.50	17544.95	646.00	36.82	5338.86		
	148.80	17381.03	588.00	33.83	4905.35		
	150.20	17709.63	676.00	38.17	5534.84		
	148.90	17404.40	640.00	36.77	5331.99		

Sample	Diameter (mm)	Area (mm^2)	Load (KN)	Compressive Strength		Average Strength	
				MPa	psi	psi	MPa
w/c=0.3 A_{12}	150.50	17780.45	945.00	53.15	7706.50	6975.70	48.11
	149.80	17615.43	900.00	51.09	7408.28		
	150.00	17662.50	708.00	40.08	5812.31		

Sample	Diameter (mm)	Area (mm^2)	Load (KN)	Compressive Strength		Average Strength	
				MPa	psi	psi	MPa
w/c=0.3 B_{25}	149.80	17615.43	890.00	50.52	7325.96	6443.17	44.44
	150.30	17733.22	880.00	49.62	7195.53		
	149.60	17568.43	650.00	37.00	5364.74		
	149.60	17568.43	875.00	49.81	7221.76		
	150.20	17709.63	870.00	49.13	7123.24		
	148.90	17404.40	590.00	33.90	4915.42		
	149.70	17591.92	826.00	46.95	6808.24		
	150.00	17662.50	650.00	36.80	5336.16		
	150.20	17709.63	818.00	46.19	6697.49		

Sample	Diameter (mm)	Area (mm^2)	Load (KN)	Compressive Strength		Average Strength	
				MPa	psi	psi	MPa
w/c=0.3 B_{19}	149.30	17498.03	882.00	50.41	7308.82	7122.93	49.12
	149.50	17544.95	790.00	45.03	6528.95		
	150.00	17662.50	880.00	49.82	7224.35		
	149.50	17544.95	830.00	47.31	6859.53		
	150.30	17733.22	914.00	51.54	7473.54		
	149.80	17615.43	892.00	50.64	7342.43		

Sample	Diameter (mm)	Area (mm^2)	Load (Ton)	Compressive Strength		Average Strength	
				MPa	psi	psi	MPa
w/c=0.3 B_{12} ****	150.00	17662.50	96.3	54.55	7910.00	7700	53.10
	149.60	17568.43	91.2	51.62	7485.00		
	149.70	17591.92	94.3	53.00	7685.00		

Sample	Diameter (mm)	Area (mm^2)	Load (KN)	Compressive Strength		Average Strength	
				MPa	psi	psi	MPa
w/c=0.3 C_{25}	150.00	17662.50	848.00	48.01	6961.64	7243.38	49.95
	149.80	17615.43	882.00	50.07	7260.11		
	150.30	17733.22	934.00	52.67	7637.08		
	149.50	17544.95	896.00	51.07	7404.98		
	149.80	17615.43	852.00	48.37	7013.17		
	150.00	17662.50	875.00	49.54	7183.30		

Sample	Diameter (mm)	Area (mm^2)	Load (KN)	Compressive Strength		Average Strength	
				MPa	psi	psi	MPa
w/c=0.3 C_{19}	149.80	17615.43	880.00	49.96	7243.65	7386.09	50.94
	149.60	17568.43	856.00	48.72	7064.95		
	150.30	17733.22	960.00	54.14	7849.67		

Sample	Diameter (mm)	Area (mm^2)	Load (Ton)	Compressive Strength		Average Strength	
				MPa	psi	psi	MPa
w/c=0.3 C_{12} ******	149.70	17591.92	93.20	51.96	7535.00	7450	51.38
	149.80	17615.43	85.00	48.31	7005.00		
	150.20	17709.63	94.30	53.65	7780.00		

Sample	Diameter (mm)	Area (mm^2)	Load (KN)	Compressive Strength		Average Strength	
				MPa	psi	psi	MPa
w/c=0.3 D_{25} *****	150.30	17733.22	****	35.60	5160.00	6937.38	47.84
	149.80	17615.43	960.00	54.50	7902.16		
	150.20	17709.63	*****	53.45	7750.00		

Sample	Diameter (mm)	Area (mm^2)	Load (KN)	Compressive Strength		Average Strength	
				MPa	psi	psi	MPa
w/c=0.3 D_{19} *****	149.70	17591.92	****	48.08	6970.00	7049.95	48.62
	149.80	17615.43	950.00	53.93	7819.85		
	150.20	17709.63	*****	54.49	6360.00		

Sample	Diameter (mm)	Area (mm^2)	Load (KN)	Compressive Strength		Average Strength	
				MPa	psi	psi	MPa
w/c=0.3 D_{12} *****	150.20	17709.63	****	50.89	7380.00	7550	52.07
	149.90	17638.96	****	52.86 ·	7665.00		
	150.30	17733.22	****	52.34	7590.00		

Table A_4: Cylinder Compressive Strength For W/C=0.40

Sample	Diameter (mm)	Area (mm^2)	Load (KN)	Compressive Strength		Average Strength	
				MPa	psi	psi	MPa
w/c=0.4 A_{25}	150.00	17662.50	583.00	33.01	4786.13	4594.02	31.68
	149.70	17591.92	560.00	31.83	4615.76		
	149.50	17544.95	530.00	30.21	4380.18		

Sample	Diameter (mm)	Area (mm^2)	Load (KN)	Compressive Strength		Average Strength	
				MPa	psi	psi	MPa
w/c=0.4 A_{19}	150.10	17686.06	738.00	41.73	6050.53	5410.25	37.31
	149.60	17568.43	655.00	37.28	5406.01		
	149.80	17615.43	580.00	32.93	4774.22		

Sample	Diameter (mm)	Area (mm^2)	Load (KN)	Compressive Strength		Average Strength	
				MPa	psi	psi	MPa
w/c=0.4 A_{12}	149.80	17615.43	580.00	32.93	4774.22	5178.53	35.71
	150.00	17662.50	677.00	38.33	5557.82		
	149.90	17638.96	633.00	35.89	5203.54		

Sample	Diameter (mm)	Area (mm^2)	Load (KN)	Compressive Strength		Average Strength	
				MPa	psi	psi	MPa
w/c=0.4 B_{25}	150.50	17780.45	792.00	44.54	6458.78	6202.97	42.78
	149.80	17615.43	777.00	44.11	6395.81		
	149.90	17638.96	700.00	39.68	5754.31		

Sample	Diameter (mm)	Area (mm^2)	Load (KN)	Compressive Strength		Average Strength	
				MPa	psi	psi	MPa
w/c=0.4 B19	150.30	17733.22	863.00	48.67	7056.53	6960.94	48.01
	149.80	17615.43	818.00	46.44	6733.30		
	150.00	17662.50	864.00	48.92	7092.99		

Sample	Diameter (mm)	Area (mm^2)	Load (KN)	Compressive Strength		Average Strength	
				MPa	psi	psi	MPa
w/c=0.4 B12.5	150.20	17709.63	852.00	48.11	6975.87	6772.81	46.71
	149.80	17615.43	822.00	46.66	6766.23		
	149.90	17638.96	800.00	45.35	6576.35		

Sample	Diameter (mm)	Area (mm^2)	Load (KN)	Compressive Strength		Average Strength	
				MPa	psi	psi	MPa
w/c=0.4 C25	150.00	17662.50	654.00	37.03	5369.00	5221.45	36.01
	149.90	17638.96	656.00	37.19	5392.61		
	150.10	17686.06	598.00	33.81	4902.73		

Sample	Diameter (mm)	Area (mm^2)	Load (KN)	Compressive Strength		Average Strength	
				MPa	psi	psi	MPa
w/c=0.4 C19	149.90	17638.96	860.00	48.76	7069.58	6521.77	44.98
	149.80	17615.43	790.00	44.85	6502.82		
	150.00	17662.50	730.00	41.33	5992.92		

Sample	Diameter (mm)	Area (mm^2)	Load (KN)	Compressive Strength		Average Strength	
				MPa	psi	psi	MPa
w/c=0.4 C12.5	149.00	17427.79	639.00	36.67	5316.51	5238.62	36.13
	149.60	17568.43	600.00	34.15	4952.07		
	149.60	17568.43	660.00	37.57	5447.27		

Sample	Diameter (mm)	Area (mm^2)	Load (KN)	Compressive Strength		Average Strength	
				MPa	psi	psi	MPa
w/c=0.4 D25	149.00	17427.79	842.00	48.31	7005.48	7266.40	50.11
	150.00	17662.50	908.00	51.41	7454.21		
	150.50	17780.45	900.00	50.62	7339.52		

Sample	Diameter (mm)	Area (mm^2)	Load (KN)	Compressive Strength		Average Strength	
				MPa	psi	psi	MPa
w/c=0.4 D_{19}	150.20	17709.63	808.00	45.62	6615.61	6311.96	43.53
	149.30	17498.03	706.00	40.35	5850.37		
	149.80	17615.43	786.00	44.62	6469.90		

Sample	Diameter (mm)	Area (mm^2)	Load (KN)	Compressive Strength		Average Strength	
				MPa	psi	psi	MPa
w/c=0.4 D_{12}	149.50	17544.95	840.00	47.88	6942.17	7065.72	48.73
	149.80	17615.43	900.00	51.09	7408.28		
	150.00	17662.50	834.00	47.22	6846.71		

Table A_5 Cylinder Compressive Strength For W/C=0.45

Sample	Diameter (mm)	Area (mm^2)	Load (KN)	Compressive Strength		Average Strength	
				MPa	psi	psi	MPa
w/c=0.45 A_{25}	150.00	17662.50	526.00	29.78	4318.19	4490.96	30.97
	149.30	17498.03	546.00	31.20	4524.51		
	149.60	17568.43	561.00	31.93	4630.18		

Sample	Diameter (mm)	Area (mm^2)	Load (KN)	Compressive Strength		Average Strength	
				MPa	psi	psi	MPa
w/c=0.45 A_{19}	149.80	17615.43	586.00	33.27	4823.61	4425.94	30.52
	150.00	17662.50	520.00	29.44	4268.93		
	151.20	17946.23	518.00	28.86	4185.28		

Sample	Diameter (mm)	Area (mm^2)	Load (KN)	Compressive Strength		Average Strength	
				MPa	psi	psi	MPa
w/c=0.45 A_{12}	149.50	17544.95	499.00	28.44	4123.98	4323.35	29.82
	149.80	17615.43	452.00	25.66	3720.60		
	150.20	17709.63	626.00	35.35	5125.46		

Sample	Diameter (mm)	Area (mm^2)	Load (KN)	Compressive Strength		Average Strength	
				MPa	psi	psi	MPa
w/c=0.45 B_{25}	150.20	17709.63	498.00	28.12	4077.44	4089.36	28.20
	149.30	17498.03	454.00	25.95	3762.14		
	149.80	17615.43	538.00	30.54	4428.50		

Sample	Diameter (mm)	Area (mm^2)	Load (KN)	Compressive Strength		Average Strength	
				MPa	psi	psi	MPa
w/c=0.45 B_{19}	150.10	17686.06	645.00	36.47	5288.06	4823.53	33.27
	149.60	17568.43	578.00	32.90	4770.49		
	149.80	17615.43	536.00	30.43	4412.04		

Sample	Diameter (mm)	Area (mm^2)	Load (KN)	Compressive Strength		Average Strength	
				MPa	psi	psi	MPa
w/c=0.45 B_{12}	150.30	17733.22	468.00	26.39	3826.72	3970.60	27.38
	149.80	17615.43	463.00	26.28	3811.15		
	150.20	17709.63	522.00	29.48	4273.95		

Sample	Diameter (mm)	Area (mm^2)	Load (KN)	Compressive Strength		Average Strength	
				MPa	psi	psi	MPa
w/c=0.45 C_{25}	150.20	17709.63	587.00	33.15	4806.14	4922.70	33.95
	149.90	17638.96	623.00	35.32	5121.33		
	150.30	17733.22	592.00	33.38	4840.63		

Sample	Diameter (mm)	Area (mm^2)	Load (KN)	Compressive Strength		Average Strength	
				MPa	psi	psi	MPa
w/c=0.45 C_{19}	149.80	17615.43	620.00	35.20	5103.48	5009.59	34.55
	149.60	17568.43	623.00	35.46	5141.90		
	150.30	17733.22	585.00	32.99	4783.40		

Sample	Diameter (mm)	Area (mm^2)	Load (KN)	Compressive Strength		Average Strength	
				MPa	psi	psi	MPa
w/c=0.45 C_{12}	150.10	17686.06	555.00	31.38	4550.19	4464.64	30.79
	149.60	17568.43	518.00	29.48	4275.28		
	149.80	17615.43	555.00	31.51	4568.44		

Sample	Diameter (mm)	Area (mm^2)	Load (KN)	Compressive Strength		Average Strength	
				MPa	psi	psi	MPa
w/c=0.45 D_{25}	150.30	17733.22	760.00	42.86	6214.33	5792.22	39.95
	149.80	17615.43	620.00	35.20	5103.48		
	150.20	17709.63	740.00	41.79	6058.85		

Sample	Diameter (mm)	Area (mm^2)	Load (KN)	Compressive Strength		Average Strength	
				MPa	psi	psi	MPa
w/c=0.45 D_{19}	149.00	17427.79	710.00	40.74	5907.23	5575.21	38.45
	150.00	17662.50	688.00	38.95	5648.12		
	150.50	17780.45	634.00	35.66	5170.29		

Sample	Diameter (mm)	Area (mm^2)	Load (KN)	Compressive Strength		Average Strength	
				MPa	psi	psi	MPa
w/c=0.45 D_{12}	150.20	17709.63	607.00	34.28	4969.89	5157.89	35.57
	149.90	17638.96	672.00	38.10	5524.14		
	150.30	17733.22	609.00	34.34	4979.64		

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA
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DEPARTMENT OF CIVIL ENGINEERING

TEST RESULTS OF COMPRESSIVE STRENGTH OF CONCRETE CYLINDER

BRTC No: **2643/08 - 09/CE** Date: 20.09.08
Reference: TB/BUET/0150 Date: 18.09.08
Sample sent by: Chief Executive for Techno Builders
Project Name: N/A
Sample ID: B_{12}
Test standard : ASTM C39 Date of testing : 21.09.08

TEST RESULTS

Sl. No	Date of Casting	Sample Identification Mark	Average Cross Sectional Area sq. in	Ultimate Load Ton	Crushing strength psi	Average Crushing strength psi	Type of Failure
1	13.07.08	-	27.29	96.3	7,910	7700	Combined
2	13.07.08	-	27.29	91.2	7,485		Combined
3	13.07.08	-	27.47	94.3	7,685		Combined

Type of aggregate : Brick Chips
Samples were unsealed.

Mix proportion (as quoted): 1:1.25:2.5

As per client's letter, Admixture used: Daracem 100 Mfg: WR Grace Singapore Ratio : 400ml / bag cement

Annesha 23.09.08

Countersigned by :

Dr. Md. Shamsul Hoque
Professor
Department of Civil Engineering
BUET, Dhaka-1000, Bangladesh

Dr. Md. Shamsul Hoque
Professor
Department of Civil Engineering
BUET, Dhaka-1000

Test Performed by :

Annesha 21.09.08
Annesha Enam
Lecturer
Department of Civil Engineering
BUET. Dhaka-1000

Samples as supplied to us have been tested in our laboratory. BRTC does not have any responsibility as to the representative character of the samples required to be tested. It is recommended that samples are sent In a secure and sealed cover/packet/container under signature of the competent authority. In order to avoid fraudulent fabrication of test results, it is recommended that all test reports are collected by duly authorized person, and not by the Contractor/Supplier.

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DEPARTMENT OF CIVIL ENGINEERING

TEST RESULTS OF COMPRESSIVE STRENGTH OF CONCRETE CYLINDER

BRTC No: **2643/08 - 09/CE** Date: 20.09.08
Reference: TB/BUET/0150 Date: 18.09.08
Sample sent by: Chief Executive for Techno Builders
Project Name: N/A
Sample ID: D_{12}
Test standard : ASTM C39 Date of testing : 21.09.08

TEST RESULTS

Sl. No	Date of Casting	Sample Identification Mark	Average Cross Sectional Area sq. in	Ultimate Load Ton	Crushing strength psi	Average Crushing strength psi	Type of Failure
1	25.05.08	-	27.36	90.1	7,380	7550	Combined
2	25.05.08	-	27.25	93.2	7,665		Combined
3	25.05.08	-	27.22	92.2	7,590		Combined

Type of aggregate : Brick Chips Mix proportion (as quoted): 1:0.95:1.9
Samples were unsealed.

As per Client's letter, Admixture used :
Daracem 100 Mfg:
WR Grace Singapore
Ratio : 400 ml/bag Cement
Annesha 23.09.08

Countersigned by :

Dr. Md. Shamsul Hoque
Professor
Department of Civil Engineering
BUET, Dhaka-1000, Bangladesh

Dr. Md. Shamsul Hoque
Professor
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Test Performed by :

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Annesha Enam
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DEPARTMENT OF CIVIL ENGINEERING

TEST RESULTS OF COMPRESSIVE STRENGTH OF CONCRETE CYLINDER

BRTC No: **2643/08 - 09/CE** Date: 20.09.08
Reference: TB/BUET/0150 Date: 18.09.08
Sample sent by: Chief Executive for Techno Builders
Project Name: N/A
Sample ID: C_{12}
Test standard : ASTM C39 Date of testing : 21.09.08

TEST RESULTS

Sl. No	Date of Casting	Sample Identification Mark	Average Cross Sectional Area sq. in	Ultimate Load Ton	Crushing strength psi	Average Crushing strength psi	Type of Failure
1	13.07.08	-	27.72	93.2	7,535	7450	Combined
2	13.07.08	-	27.18	85.0	7,005		Combined
3	13.07.08	-	27.14	94.3	7,780		Combined

Type of aggregate : Brick Chips
Samples were unsealed.

Mix proportion (as quoted): 1:1.10:2.2

As per client's letter, Admixture used: Daracem 100 Mfg: WR Grace Singapore
Ratio : 400 ml / bag cement
Annesha 23.09.08

Countersigned by :

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TEST RESULTS OF COMPRESSIVE STRENGTH OF CONCRETE CYLINDER

BRTC No: **2643/08 - 09/CE** Date: 20.09.08
Reference: TB/BUET/0150 Date: 18.09.08
Sample sent by: Chief Executive for Techno Builders
Project Name: N/A
Sample ID: D_{19}
Test standard : ASTM C39 Date of testing : 21.09.08

TEST RESULTS

Sl. No	Date of Casting	Sample Identification Mark	Average Cross Sectional Area sq. in	Ultimate Load Ton	Crushing strength psi	Average Crushing strength psi	Type of Failure
1	25.05.08	-	26.96	83.9	6,970	----	Combined
2	25.05.08	-	32.83	93.2	6,360		Combined

Type of aggregate : Brick Chips Mix proportion (as quoted): 1:0.95:1.9
Samples were unsealed.

As per Client's letter, Admixture used: Daracem 100 Mfg: WR Grace Singapore Ratio: 400 ml/bag cement
Annesha 23.09.08

Countersigned by :

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Professor
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TEST RESULTS OF COMPRESSIVE STRENGTH OF CONCRETE CYLINDER

BRTC No: **2643/08 - 09/CE** Date: 20.09.08
Reference: TB/BUET/0150 Date: 18.09.08
Sample sent by: Chief Executive for Techno Builders
Project Name: N/A
Sample ID: D_{25}
Test standard : ASTM C39 Date of testing : 21.09.08

TEST RESULTS

Sl. No	Date of Casting	Sample Identification Mark	Average Cross Sectional Area sq. in	Ultimate Load Ton	Crushing strength psi	Average Crushing strength psi	Type of Failure
1	25.05.08	-	27.94	64.3	5,160	----	Combined
2	25.05.08	-	27.25	94.3	7,750		Combined

Type of aggregate : Brick Chips
Samples were unsealed.

Mix proportion (as quoted): 1:0.95:1.9

As per Client's letter, Admixture used : Daracem 100 Mfg: WR Grace Singapore Ratio : 400 ml/ bag cement
Annesha 23.09.08

Countersigned by :

Dr. Md. Shamsul Hoque
Professor
Department of Civil Engineering
BUET, Dhaka-1000, Bangladesh

Dr. Md. Shamsul Hoque
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Test Performed by :

Annesha 21.09.08

Annesha Enam
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