Effects of High Temperature on the Properties of Concrete

A project report submitted to the Department of Civil Engineering of Sonargaon University (SU) in fulfillment of the requirements for the degree

of

Bachelor of Science in Civil Engineering

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LETTER OF TRANSMITTAL

31th JANUARY, 2020

To
Md. Golam Kibria
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Subject: Submission of Project Report.

Sir,

This is our great pleasure that we are submitting here with the project report of **"Effects of High Temperature on the properties of Concrete"**. It is an important topic. The project report has been done according to the requirement and guidelines of the Sonargaon University (SU).

We hope that this report will certainly help you in evaluating our project report on **"Effects of High Temperature on the properties of Concrete"**. We would be very glad to provide any assistance in interpreting any part of the paper, whenever necessary.

Thanking you
Sincerely your

Shorna Akter
BCE 1602008117
Group Leader

DECLARATION

This is to declare that the work and material presented in the report has been carried out by us and has not previously been submitted to any University/ College / Organization for any academic qualification.

We hereby ensure that the work that has been presented does not breach existing copyright.

We undertake to indemnify the university against any loss or damage arising from breach of the foregoing obligation.

Thank you
Sincerely your

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CERTIFICATION

This to certify that the project paper on **"Effects of High Temperature on the Properties of Concrete"** is the confide record of project work done by Shorna Akter (Student ID: BCE 1602008117) as a group leader and others for partial fulfillment of the requirement of the degree of B.Sc. in Civil Engineering from the Sonargaon University (SU).

This project work has been carried out under my guidance and is a record of the successful work.

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ABSTRACT

Concrete are very much effective in compression and shows less capable to carry tensile load. But this characteristic of concrete shows vulnerable when subjected to heat. Concrete are very much strong at room temperature i.e. 25 ^{0}C, but represents a lower strength when exposed to heat. In this study concrete are tested in several temperatures by the furnace. Concrete are exposed to 100 ^{0}C, 300 ^{0}C, 600 ^{0}C and 1000 ^{0}C and then tested the property of it. To complete this study about 48 cylinders were prepared by both stone aggregate and brick aggregate. The mixing ratio and w/c ratio of these concrete are kept standard with similar to local construction practice i.e. 1:1.5:3 and 0.45 respectively. The compressive strength of concrete in different heat reduce gradually with respect to increase of temperature but in exception of 100 ^{0}C. The unit weight of these concrete reduced remarkably after exposed to heat because of loss of water from the concrete. The capacity of tensile strength is low with compare to normal temperature.

NOTATION

$f'c$ = The 28 days compressive strength of cylinder specimen of concrete

$f'c$ = 28 days compressive strength of concrete made with stone chips plus certain ratio of recycled aggregate in MPa.

W a = water absorption of concrete made with stone chips plus a certain ratio of recycled aggregate in (%)

X = Percent of replacement

F.M = Fineness modulus,

MPa = Mega Pascal.

Psi = Pound per square inch.

S.S.D = Saturated Surface Dry.

W/C = Water Cement ratio.

CC = Crushed Concrete

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CHAPTER-I

INTRODUCTION

1.1 GENERAL

Concrete has been defined as a composite material obtained using cement, aggregate, water and when necessary chemical and /or mineral additives ,placed into molds of various sizes and shapes and hardened under convenient conditions .Today concrete has been used with an increased strength and durability in connection with the developments in technology in pre-stressed concrete ,concrete and reinforced concrete structures.



Fig 1.1: Fire incident in oahid mansion (Chawk bazar)). Source: Prothom alo

pre-stressed concrete, concrete and reinforced concrete structures are sometimes exposed to fires and many structures become damaged and/or out of use. As it is known, high temperatures caused as a result of fire decreases the concrete strength and durability of such structures. Fire resistance of concrete is affected by factors like the type of aggregate and cement used in its composition, the temperature and duration of the fire, size of structure members, and moisture content of concrete. Fire resistance of the aggregate is generally high.



Fig 1.2: Fire incident in oahid mansion (chawk bazar). Source: The daily star

However, having non-uniform high temperature effect of aggregate or cooling the heated aggregate using water spray may cause internal pressure in the aggregates. This pressure may make the aggregate appall. Some of the deformation in the concrete is due to the expansion of cement in its composition. Hydrated Portland cement contains a significant amount of free calcium hydroxide and will decompose into calcium oxide due to loss of water at 100-1000℃[1].



Fig 1.3: Fire incident in F.R Tower (Banani). Source: The daily star

Many of these studies were realized for properties of ordinary concrete exposed to high temperature. Fewer studies have been carried out with high-performance concrete than with ordinary concrete.

Concrete structures are sometimes exposed to the effects of fire. Although there are different ways to extinguish the fire. It is generally done with water spray. This cause different stresses in reinforced concrete members at high temperature and the structural member can loss load bearing capacity. In this study the behavior of ordinary and high-performance concretes exposed to high temperatures is examined after cooling in air or water. In the test's temperatures of 100,300,600, and 1000℃. were chosen for ease of observation of the test results. All series were exposed to same temperatures [News].

1.2 BACKGROUND OF THE STUDY:

During a fire the temperature may reach up to 1100^0C in buildings and even up to 1350^0C in tunnels, leading to serve damage in concrete structure. Fires in tunnels under the English channels (1996 and 2008) in France, Tauern (1999) in Austria and St Gotthard in Switzerland are real examples of damages of structures subjected to high temperatures [16].

Pre-stressed concrete, concrete and reinforced concrete structures are sometimes exposed to fires and many structures become damage and/or out of use. As it is known, high temperatures caused as a result of fire decreases the concrete strength and durability of such structures [3]. Fire resistance of concrete is affected by factors like the type of aggregate and cement used in its composition, the temperature and duration of the fire, sizes of structure members, and moisture content of concrete. Concrete in case of unexpected fire, the concrete properties are changes after fire. R.C.C normally offers high fire resistance at low cost [11]. The engineer building should design for structure can withstand high temperatures and also mainly for fire exposure.

The investigation of the behavior of concreate at high temperature allowed linking this thermal instability to the formation of pressure(thermo-fluid phenomenon) and stress that develop in the heated materials (thermo-fluid phenomenon).high temperatures cause thermal and hybrid gradients which lead to migration of water (diffusion, drying).Especially for high strength and high performance concrete with smaller pore sizes, rapid exposure to high temperatures can cause high pore pressure and lead to explosive spalling, which will be potentially disastrous[12]. Serval parameters can be sources of the thermal instability of concrete the concrete.

Concretes with low W/C have a more significant decrease in strength as concrete with high W/C ratio (from 150^0C) [3].study by Hager and Mindeguia on concrete with calcium-silicate aggregates showed strong thermal expansion beyond the temperature 300^0C[5].Mindeguia showed that the compressive strength of concrete (hot or after cooling) decrease with increasing temperature, thermal loading and mechanical loading. Many investigations have been carried out into the fracture toughness of high performance concreate at room temperature, but the information

about its performance at the high temperatures is still limited [8]. The parameters such as curing time and curing temperature significantly affect the compressive strength of the hardened concrete [8].

We may cite the problems of cracking due to thermal shrinkage and changes in the micros structure of the high temperature cement paste. Research in the field provide a deeper knowledge of the behavior of very high-performance concrete at high temperatures in order to improved the safety of building structure.

Research has indicated that [9,10] strength loss and explosive spalling occur in the concrete exposed to high temperatures. High performance concrete has been found to have greater strength loss in the intermediate temperature range than ordinary concrete when exposed the same heating condition.

High performance concrete specimens are prone to explosive spalling even when heated at a relatively slow heating rate (<50C/min). According to the test results obtained from this study, strength loss of high-performance concrete is more than ordinary plain concrete. but explosive spalling in high performance concrete does not occur in ordinary plain concrete.[17]

1.3 OBJECTIVE OF THE STUDY

The Objective of the study given below:

- To determine the compressive and tensile strength of concrete with respect to different heat.
- To compare the strengths with between stone aggregate and brick aggregate.
- To determine the variation of unit weights after expose to heat
- To determine the residual stresses in the concrete after heating.

1.4 METHODOLOGY

The working methodology in this study is as follows:

- Properly selection of materials.
- Materials preparation
- Standard test for materials
- ACI mix design for mix ratio
- Assume w/c Ratio
- Casting the specimen with proper water content and mix proportion
- Curing the specimen at age 28 days.
- Furnace the specimens
- Test the specimen of identifying the results.
- Analysis the results
- Conclusion and recommendation.

1.5 SCOPE OF THE STUDY

The study consists a volumetric provide different temperature in concrete at 25^0C, 100^0C, 300^0C, 600^0C & 1000^0C. The properties of heating concreate such as $f'c$, f_{sp}, $f_{r,}$ E_c, water absorption and unit weight of concrete have been determined. In this study the temperature was the only variable and everything else remained same, water cement ratio was 0.45 throughout the investigation.

CHAPTER-II

LITERATURE REVIEW

Concrete has been defined as a composite material obtained using cement, aggregate, wand when necessary chemical and/or mineral additives, placed into molds of verso size and shapes and hardened under convenient condition Harlow Essex (1993).

As its non Cioni P, Croce P, Salvatore (2001) . Concrete and Reinforced concrete structures are sometimes exposed to fires and many structures become damaged and/or out of used. High temperatures caused as a result of fire decreases the concrete strength and durability of such structure.

In the test result it is seen that comprasive strength of under the effect of high temperature and cooled in air and water has a decreasing trend when the temperature increases Morita (1992). Strength loss curves obtained from the study for the ordinary concrete have the same trend but different changing ratio.

From Abrams (1991), Morita (1992) and Furumura (1995) from study Nits in the present study it is seen that the strength of concrete exposed to high temperature and cooled in air decreases until 200^0C an increase 200 and 400 and continuous decreases after 400^0C.

These factors include age, moisture content, type of gravel and sand used curing method, rate heating Guise Se (2001) in this study it has been observed that when the temperature is 400-500,approximately 30% of samples produced from plain concrete spalled in may reach up to 1100 in buildings and even up to 1350 in tunnels, leading to served damage in a concrete structures du Baton Lausanne (2007) how ever in same special cases, even much lower temperature may causes explosive destruction of concrete.

Research has demon started, G.A. Khoury (1992). That changes in the strength of a concrete as function of temperature at related to, inter alia, concrete composition the type of aggregate used, the water/cement ratio, the presence of pozzolana additives.

From the literature review shown, the result of compressive strength is changed M. Castellote (2004) demonstrates the temperature at which the main reason of cement paste.

Color changed of heated concrete. It is generally agreed N.R. Short (2001) and M. Colombo (2007) that when heated to between 300© and 600 concrete containing siliceous aggregates will turn red, between 600 and 900, whitish-gray, and between 900 and 1000, a buff color is present.

Recently I. Hager author (2013) has proposed a technique allowing for the evaluation of heated concrete color changed. In this method pictures are taken with a general-purpose flatbed scanner. The use of flatbed scanner allows for images to be taken under constant light conditions.

Concrete as with most building materials, expands during heating .the thermal strain of heated concrete can be measured ,and by this measuring the co-efficient of thermal expansion can be determined U. Diederichs (1989) however the range in which this co-efficient can be consider constant is limited due to the nonlinear character of the curve.

Tensile strength change S. The landersson (1971) and A. Nomee (1994) are both analysis number of publications pre-strength the result of tensile strength change caused by heating restrained. This is as a result of the technical difficulties encountered when testing concrete in direct tension at, hot, stage. Most of the results found in the literature were obtained after having cooled down the materials.

This paper presents the results of the investigation of the cement concrete behavior at a high temperature. It has been shown that the color change of heated concrete might be the first indication of the potential deterioration of concrete due to heating. The most common way to evaluate this deterioration is to expose the material ta a high temperature and test the material in compression and/or tension. Change in the mechanical in properties of concrete caused by heating have been presented in this paper.

The possible explanations of the observed gradual decrease of mechanical properties have been discussed in details. more ever, the important role of water was put forward, both in the context of the changes of concrete properties as well as in the occurrence of the spalling phenomenon. above the temperature, the mismatch of thermal deformation between the aggregate, which expand, and cement paste, which undergoes shrinkage, prevails and results in the development of cracks. Significant cracking continuous, thus altering the material mechanical properties.

CHAPTER –III

EXPERIMENTAL INVESTIGATION

3.1 INTRODUCTION

This chapter includes the experiments required to determine the properties of aggregate and the properties of ingredient of concrete, processes of manufacture of concrete and tests to determine the properties of fresh & hardened concrete.

3.2 THE PROPETIES OF INGREDIENTS OF CONCRETE

Following are the commonly used ingredients in concrete

(a) Aggregate

- ✓ Fine aggregate
  - Sylhet sand
- ✓ Coarse aggregate

(b) Binding Materials

(c) Water



Fig : Stone chips

3.2.1 Aggregate

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 weakened the bond with the cement paste, and that no unfavorable chemical reaction take place between it and the cement.



Fig: Coarse Sand

Aggregate can be classified on the basis of size as

- Fine aggregate
- Coarse aggregate

3.2.1.1 Test for Fine Aggregate

It is the aggregate most of which passes through a 4.75mm IS sieve and contain only that much finer material as is permitted by the specifications. The fine aggregate that had been used in this study was locally available Sylhet sand.
The following tests are employed to determine the properties of fine aggregate:

3.2.1.1.1 Sieve Analysis of Fine Aggregate

Sieve analysis of fine aggregate is used to determine the particle size distribution & fineness modulus of fine aggregate.

The particle size of an aggregate as determine by sieve analysis is termed grading of aggregate.

The test method for sieve analysis of fine aggregate conforms to the ASTM standard requirements of specification C136.

The value of F.M. of Sylhet sand is given in the Table 3.1.

3.2.1.1.2 Specific Gravity and Water Absorption Capacity of Fine Aggregate

The test method for specific gravity and water absorption capacity covers the determination of bulk specific gravity, apparent specific gravity and water absorption of fine aggregate.

In this study saturated surface dry aggregate had been used to determine the specific gravity of fine aggregate.

The test method for specific gravity and water absorption capacity conforms to the ASTM standard requirements of specification C128-97

Calculation

Bulk sp. gr. =A/ (B+S-C)

A =Weight of oven dry specimen in air

B =Weight of pycnometer filled with water

S =Weight of the SSD specimen

C =. Weight of pycnometer filled with specimen and water to calibration mark.

Percent of absorption capacity =(S-A)/A*100

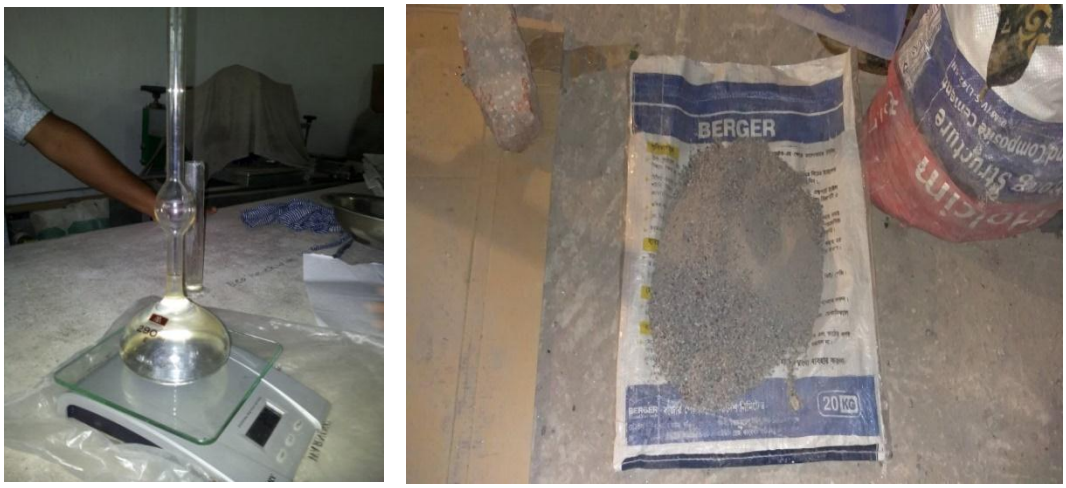


Fig: Test the property of Cement

The values of specific gravity of combined sand and water absorption capacity is given in the Table 3.1

Table 3.1 Properties of Fine aggregate (Sylhet sand)

Properties	Value
Fineness Modulus	2.65
Water Absorption Capacity (%)	1.01
Specific Gravity	2.62

3.2.1.2 Test for Coarse Aggregate

The aggregate most of which are retained on the 4.75mm IS sieve and contain only that much finer material as is permitted by the specifications. Generally, brick chips are used as Coarse aggregate.

3.2.1.2.1 Sieve Analysis of Coarse Aggregate

The test method for sieve analysis of Coarse aggregate conforms to the ASTM standard requirements of specification C136.

The value of F.M. brick aggregate is given in the Table 3.2.

3.2.1.2.2 Specific Gravity and Absorption Capacity

The test method for specific gravity and absorption capacity of Coarse aggregate conforms to the ASTM standard requirements of specification C127.

Calculation:

The bulk specific gravity (SSD basis) =B/ (B-C)

Percentage of absorption = (B-A)/A*100

A =weight of oven dry test sample in air

B= weight of saturated surface dry test sample in air

C= weight of saturated test sample in water.

The values of specific gravity and absorption capacity of recycled aggregate, brick chips and stone aggregate are given in the Table 3.2

3.2.1.2.3 Unit Weight of Coarse Aggregate

Unit weight is the traditional terminology used to describe the property of concrete which is weight per unit volume.

The test method for unit weight conforms to the ASTM standard requirements of specification C 29.

Calculation: M= (G-T)/V

M = Dry rodded bulk density

T = Mass of the measure

G = Mass of the aggregate plus measure

V = Volume of the measure

The values of dry rodded unit weight of recycled aggregate, brick chips are given in the Table 3.2.

Table: 3.2 Properties of Coarse aggregates

Common properties	**Brick Aggregate**
Dry rodded unit weight (Kg/m^3)	1532
Absorption capacity (%)	3
Bulk specific gravity (S.S.D)	2.60
F.M.	8.274



Figure 3.1: Concrete Casting

3.2.2 Cement

A cementing material is one which has the adhesive and cohesive properties necessary to bond inert aggregates 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 solid mass. Various hydraulic cements have been developed, Portland cements, this was first patented in England in 1824, is by far the most common. In hydraulic cement that hardens by interacting with water and forms water resisting compound when it receives its final sets. 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 particles size ranges from 10 microns to 50 microns. The specific gravity of cement used in this study was 3.15. The SCAN CEMENT is manufactured by HEIDELBERG CENENT GROUP was used in this study.

3.2.3 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 affect the strength it is necessary to go into the purely of water. In this study drinking water has been used in mixing of concrete.

3.3 CONCRETE MIX DESIGN

Most of the available mix design methods are based on empirical relationships, charts and graphs developed from extensive experimental investigations.

In this study ACI mix design method has been used. This method if based on the fact that for a given maximum size of fine aggregate, the water content determines the workability of mix. Using the steps of ACI method of mix proportioning, the mix proportion was found 1:1.68:2.45.



Figure 3.2: Mixing concrete in the study.

3.4 PROCESS OF CASTING

Production of quality of concrete requires meticulous care exercised at every stage of manufacture. Of concrete. The various stages of casting of test specimens are:

(a) Batching
(b) Mixing
(c) Compacting
(d) Curing
(e) Finishing

3.4.1 Batching

Weigh batching is the correct method of measuring the materials. For important concrete, invariably, weigh batching system is should be adopted.

In this study weigh batching has been used for measuring the materials.

3.4.2 Mixing

In this study concrete mixing had been done by the tilting type mixer. Speed of the mixer was of about 15-20 revolution per minute. Mixing time was 5-6 minute. The mixing of concrete is shown in Figure 3.1.





Figure: mixing of concrete in the study

3.4.3 Compaction of Concrete

Compaction of concrete is the process adopted for expelling the entrapped air from 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 remove fully, the concrete losses strength considerably.

3.4.4 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 percent of which is reached at the end of the 1st week after placing. The final concrete strength depends greatly on the condition of moisture and temperature during this initial period.



Figure 3.3: Curing of concrete in the study.

3.4.5 Methods of Curing

The best method of water curing is immersion of specimens in water because it satisfies all the requirements of curing namely promotion of hydration, elimination of shrinkage and absorption of the heat of hydration. In the study, the specimen was submerged in water for 28 days.

3.4.6 METHOD OF FOR FURNACING:

The method of furnacing used iso standard and follow the manual of muffle furnace.



Figure 3.4: Furnace of cylinder in the study



Figure 3.5: Furnace of cylinder in the study

3.6 TESTS OF THE SPECIMENS OF CONCRETE

Testing of harden concrete plays an important role in controlling and confirming the quality of cement concrete work. Following tests have been commonly used to determine the

properties of hardened concrete:

3.6.1 COMPRESSIVE STRENGTH OF CONCRETE

The compressive strength of furnace concrete specimens and with room temperature contents of same concert is presented in the figure shows that compressive strength of furnace concrete decreases strength than room temperature concrete content. Decrease in strength is almost marginal for all the furnace specimen. The concrete specimens containing furnace concrete lowest strength. The reduction in compressive strength of the concrete indicates lost their mechanical properties.



Figure 3.6: Compressive strength as a function of heating concrete.

3.6.2 Splitting tensile strength: The splitting tensile strength of heating concrete using plain concrete in the composition is presented in the **Figure** It observed that additional of heating concrete in the composition adversely effects on the tensile strength. The decrease in tensile strength of the heating concrete using 1:1.5:3



Figure 3.7: Tensile strength as a function of heating concrete.

The tensile stress can be computed as

f_{sp} =[2p/(3.1416*L*D)]

Where,

f_{sp}=Split cylinder tensile strength

P= Compressive load on the cylinder

L=Length of the cylinder

D=Diameter of the cylinder.

The test method confirms to the ASTM standard requirements of specifications C496 for cylinder.

3.6.2.1 Flexural Strength Test

Illustrates the effect of recycled aggregate on the flexural strength. It is observed that the recycled brick aggregate has adverse effect on the flexural strength. The pattern of reduction in flexural strength with the modifiers content in the composition of concrete is almost similar to that of reduction in compressive strength. The decrease in tensile and flexural strength of modified concrete can be explained by poor bond between the cement paste and brick aggregates. Size and shape of aggregates, surface of aggregates, and sequence of loading also is determinant factor for reduction in strength. Flexural strength as a function of recycled

aggregate (RA) content in the concrete. And it is computed by $\frac{Mc}{I}$

$$\frac{Mc}{I} = \frac{\frac{PL}{4} \times \frac{h}{2}}{\frac{bh^3}{12}} \qquad M = \frac{PL}{4}$$

$$= \frac{PLh}{8} \times \frac{12}{bh^3} \qquad c = \frac{h}{2}$$

$$= \frac{3PL}{2bh^2} \qquad I = \frac{bh^3}{12}$$

Where,

P=maximum total load on the beam

L=Span

b=width of the beam

h= depth of the beam

4. Water Absorption properties:

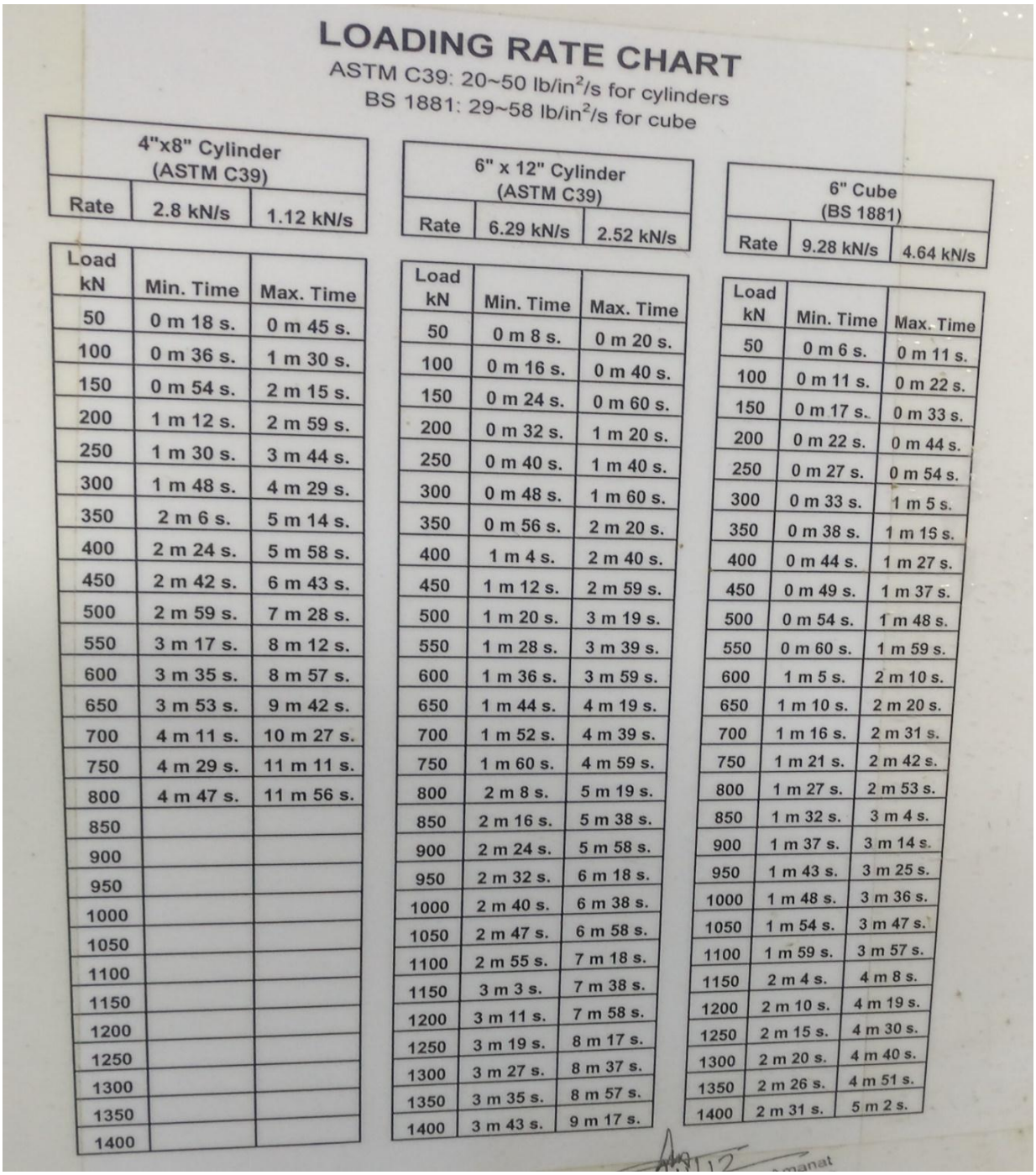
Water absorption kinetics of modified concrete using various composition of aggregate content as a function of soaking time *t*. The figure shows that initially, the water absorption rate is very fast for all composition of the concrete and then gradually the water uptake attains equilibrium. Also shows that the ultimate water sorption value of the concrete specimens decreases with the addition of waste agggregate content. Babu and Babu reported 3% water absorption of the modified.

5. Unit Weight Test:

Unit weight is the traditional terminology used to describe the property of concrete which is weight per unit volume.

Density of the concretes modified with recycled brick aggregate also decreases significantly with the brick aggregate content as shown in **Figure**. Being a less density material, provides less unit weight property to the concrete compared to other two modifiers (HDPE or vulcanized rubber). Concrete modified with more than 50% replacing conventional aggregates exhibited too light weight to float on water in this study, density of modified concrete with 50 vol% content is found to be 700 kg/m^3. The difference in density properties may be due to differences in the composition of the modified concrete.

It indicates that the based waste packaging material can provide light weight properties to the modified concrete, which is significant for floating structure and where light weight material is recommended.



LOADING RATE CHART

ASTM C39: 20~50 lb/in^2/s for cylinders
BS 1881: 29~58 lb/in^2/s for cube

4"x8" Cylinder (ASTM C39)		
Rate	2.8 kN/s	1.12 kN/s
Load kN	Min. Time	Max. Time
50	0 m 18 s.	0 m 45 s.
100	0 m 36 s.	1 m 30 s.
150	0 m 54 s.	2 m 15 s.
200	1 m 12 s.	2 m 59 s.
250	1 m 30 s.	3 m 44 s.
300	1 m 48 s.	4 m 29 s.
350	2 m 6 s.	5 m 14 s.
400	2 m 24 s.	5 m 58 s.
450	2 m 42 s.	6 m 43 s.
500	2 m 59 s.	7 m 28 s.
550	3 m 17 s.	8 m 12 s.
600	3 m 35 s.	8 m 57 s.
650	3 m 53 s.	9 m 42 s.
700	4 m 11 s.	10 m 27 s.
750	4 m 29 s.	11 m 11 s.
800	4 m 47 s.	11 m 56 s.
850		
900		
950		
1000		
1050		
1100		
1150		
1200		
1250		
1300		
1350		
1400		

6" x 12" Cylinder (ASTM C39)		
Rate	6.29 kN/s	2.52 kN/s
Load kN	Min. Time	Max. Time
50	0 m 8 s.	0 m 20 s.
100	0 m 16 s.	0 m 40 s.
150	0 m 24 s.	0 m 60 s.
200	0 m 32 s.	1 m 20 s.
250	0 m 40 s.	1 m 40 s.
300	0 m 48 s.	1 m 60 s.
350	0 m 56 s.	2 m 20 s.
400	1 m 4 s.	2 m 40 s.
450	1 m 12 s.	2 m 59 s.
500	1 m 20 s.	3 m 19 s.
550	1 m 28 s.	3 m 39 s.
600	1 m 36 s.	3 m 59 s.
650	1 m 44 s.	4 m 19 s.
700	1 m 52 s.	4 m 39 s.
750	1 m 60 s.	4 m 59 s.
800	2 m 8 s.	5 m 19 s.
850	2 m 16 s.	5 m 38 s.
900	2 m 24 s.	5 m 58 s.
950	2 m 32 s.	6 m 18 s.
1000	2 m 40 s.	6 m 38 s.
1050	2 m 47 s.	6 m 58 s.
1100	2 m 55 s.	7 m 18 s.
1150	3 m 3 s.	7 m 38 s.
1200	3 m 11 s.	7 m 58 s.
1250	3 m 19 s.	8 m 17 s.
1300	3 m 27 s.	8 m 37 s.
1350	3 m 35 s.	8 m 57 s.
1400	3 m 43 s.	9 m 17 s.

6" Cube (BS 1881)		
Rate	9.28 kN/s	4.64 kN/s
Load kN	Min. Time	Max. Time
50	0 m 6 s.	0 m 11 s.
100	0 m 11 s.	0 m 22 s.
150	0 m 17 s.	0 m 33 s.
200	0 m 22 s.	0 m 44 s.
250	0 m 27 s.	0 m 54 s.
300	0 m 33 s.	1 m 5 s.
350	0 m 38 s.	1 m 15 s.
400	0 m 44 s.	1 m 27 s.
450	0 m 49 s.	1 m 37 s.
500	0 m 54 s.	1 m 48 s.
550	0 m 60 s.	1 m 59 s.
600	1 m 5 s.	2 m 10 s.
650	1 m 10 s.	2 m 20 s.
700	1 m 16 s.	2 m 31 s.
750	1 m 21 s.	2 m 42 s.
800	1 m 27 s.	2 m 53 s.
850	1 m 32 s.	3 m 4 s.
900	1 m 37 s.	3 m 14 s.
950	1 m 43 s.	3 m 25 s.
1000	1 m 48 s.	3 m 36 s.
1050	1 m 54 s.	3 m 47 s.
1100	1 m 59 s.	3 m 57 s.
1150	2 m 4 s.	4 m 8 s.
1200	2 m 10 s.	4 m 19 s.
1250	2 m 15 s.	4 m 30 s.
1300	2 m 20 s.	4 m 40 s.
1350	2 m 26 s.	4 m 51 s.
1400	2 m 31 s.	5 m 2 s.

Figure 3.8: Loading rate chart.

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DEPARTMENT OF CIVIL ENGINEERING

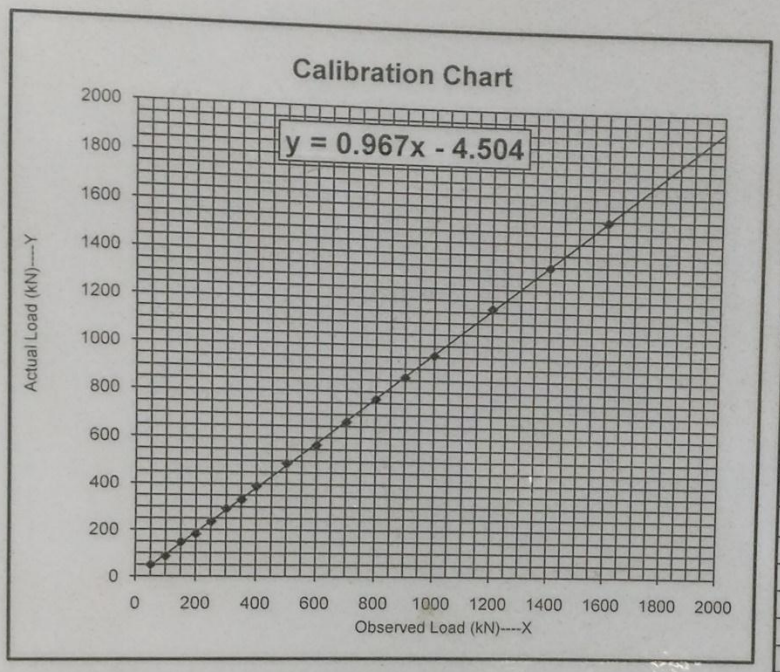
Mobile: 01819 557 964; PABX: 966 5650-80 Ext. 7226; www.buet.ac.bd/ce/

BRTC Bureau of Research, Testing & Consultation

CONCRETE LABORATORY

Calibration of Compression Testing Machine

Machine: Tecnotest, Modena-Italy (Machine Series KD 300/R)
Capacity: 3000 kN
Calibration Device: CCDHA-200t-004; S/N: 49626 (Capacity: 200 ton)
Temperature: 29°C
Date of Calibration: 24.10.2019



Observed Load (kN)	Actual Load (kN)
50.0	48.1
100.0	85.8
150.0	147.0
200.0	181.0
250.0	235.1
300.0	291.5
350.0	330.1
400.0	389.1
500.0	488.9
600.0	569.0
700.0	668.5
800.0	766.6
900.0	863.0
1000.0	958.2
1200.0	1164.5
1400.0	1347.2
1600.0	1544.3

Countersigned by :

Dr. Md. Abdul Jalil
Professor
Department of Civil Engineering
BUET, Dhaka-1000, Bangladesh

Department of Civil Engineering * BUET, Dhaka-1000, Bangladesh *

Calibrated by :

26/10/19

Anindya Samya Saha
Lecturer
Department of Civil Engineering
BUET, Dhaka-1000, Bangladesh

Figure 3.9: Calibration chart.

CHAPTER-IV

TEST RESULTS AND ANALYSIS

4.1 INTRODUCTION

Testing of furnace concrete and important role in controlling the quality of cement concrete work. To perform this study in total 18 standard cylinder among 11 cylinders were tested to determine the compressive strength and 7 cylinders were tested to determine tensile strength. All specimens are tested 28 days normal water curing.

4.2 TEST RESULTS

Table 4.2.1 The properties of all data in this study.

Mix Ratio	Temp. ^{0}C	No. of sample	Type of Cylinder	Sample Weight before heating (gm)	Sample Weight before heating (gm)	% loss	Compressive Stress (KN)	Tensile Stress (KN)	Failure load (Ib)
1: 1.5: 3	25	S -1	Brick	3.45	3.45	0	216		
		S -2	Stone	4.3	4.3	0		140	31454
		S -3	Stone	4.3	4.3	0	232		52123
	100	S -4	Brick	3.450	3.37	2.37	144		32352
		S -5	Stone	4.32	4.158	3.90	294		66053
		S -6	Brick	3.51	3.309	6.07		34	7639
	300	S -7	Brick	3.42	2.973	15.04	170		38194
		S -8	Brick	3.5	3.047	14.87		82	6291
		S -9	Stone	4.2	4.08	2.94	152		34150
	600	S -10	Stone	4	3.693	8.31	162		36396
		S -11	Stone	4.12	3.815	7.99		28	6291
		S -12	Brick	3.52	2.974	18.36	122		27410
	1000	S -13	Stone	4.22	3.784	11.52	10		2247
		S -14	Stone	4.3	3.937	9.22		14	3145
		S -15	Brick	3.3	2.738	20.53	20		4493

Table 4.2.2 The properties of unit weight of concrete obtained by volumetric fresh brick chips of different temperature heating.

Temperature (^{0}c)	Weight (kg)	Weight (lb)	Volume (in^3)	Volume (ft^3)	Unit Weight (lb/ft^3)	Weight Loss (%)
25	3.5	7.71	100.53	0.058	132.6	0
100	3.37	7.43	100.53	0.058	127.7	4
300	2.973	6.55	100.53	0.058	112.6	18
600	2.973	6.55	100.53	0.058	112.6	18
1000	2.738	6.03	100.53	0.058	103.7	28

4.3.1 Unit Weight: Graphical representation shows that the unit weight of brick aggregate at different temperatures.

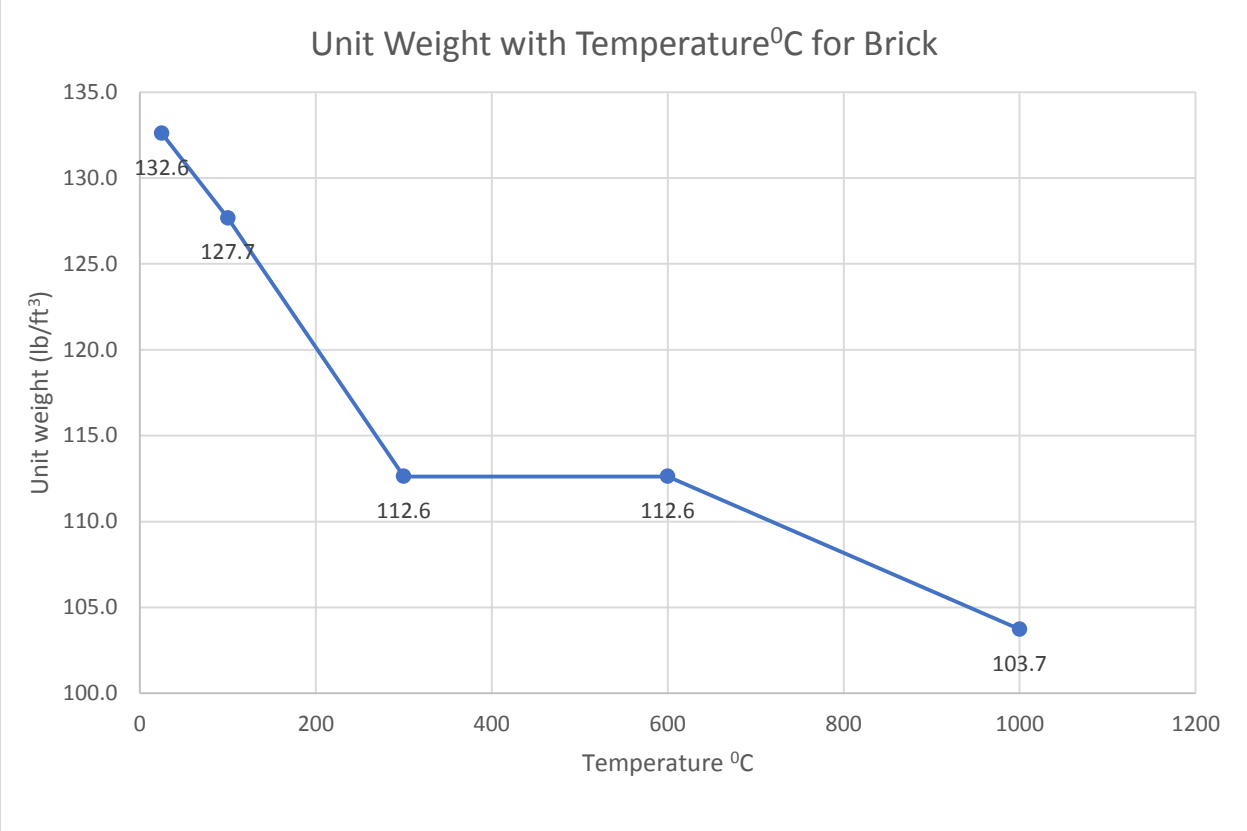


Figure 4.3.1 Graphical represent of unit weight at brick chips of heating concrete at different temperatures.

Table 4.2.3 The properties of unit weight of concrete obtained by volumetric fresh stone chips of different temperature heating.

Temperature (^{0}c)	Weight (kg)	Weight (lb)	Volume (in^3)	Volume (ft^3)	Unit Weight (lb/ft^3)	Weight Loss (%)
25	4.35	9.59	100.53	0.058	164.8	0
100	4.158	9.16	100.53	0.058	157.5	5
300	4.08	8.99	100.53	0.058	154.6	7
600	3.815	8.41	100.53	0.058	144.5	14
1000	3.784	8.34	100.53	0.058	143.4	15

4.3.2 Unit Weight: Graphical representation shows that the unit weight of stone aggregate at different temperatures.

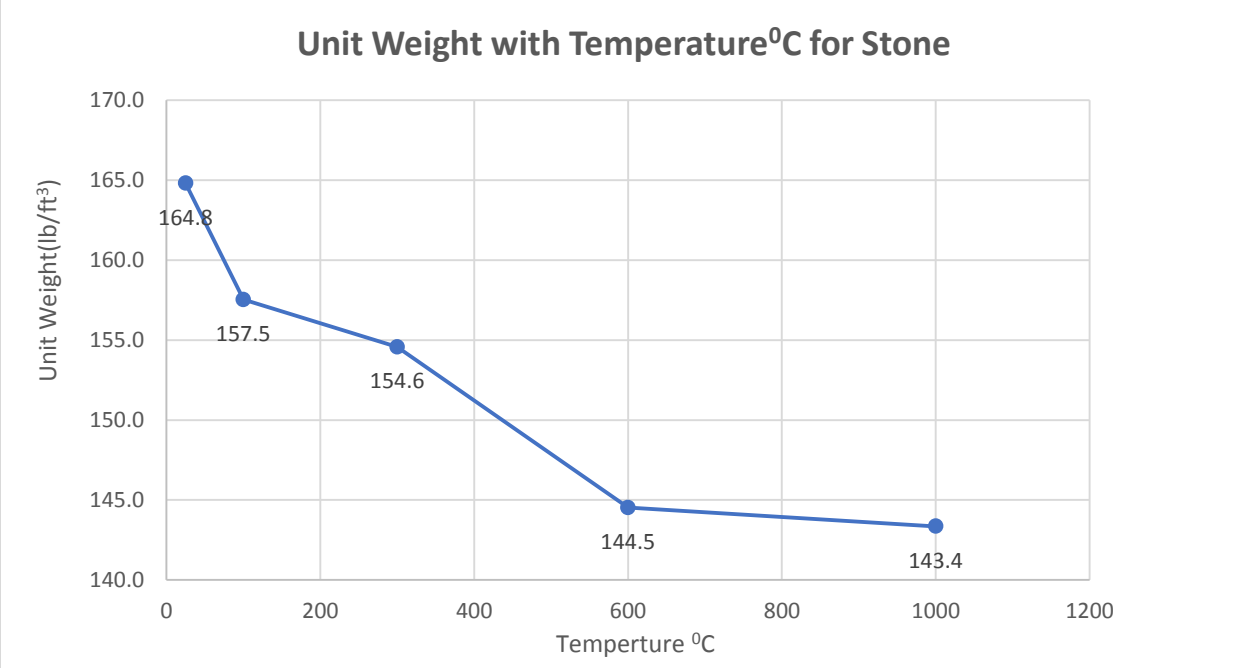


Figure 4.3.2 Graphical represent of unit weight at stone chips of heating concrete at different temperatures.

Table 4.2.4 The properties of compressive Strength of concrete obtained by volumetric fresh brick chips of different temperature heating.

Temperature (^{0}c)	Load (KN)	Load (Ib)	Area (in^2)	Compressive stress (Psi)
25	216	48528.44	12.56	3862.50
100	144	32352.29	12.56	2575.00
300	170	38193.68	12.56	3039.93
600	122	27409.58	12.56	2181.60
1000	20	4493.37	12.56	357.64

4.3.3 Compressive strength: Graphical representation shows that the compressive strength of brick aggregate at different temperatures.

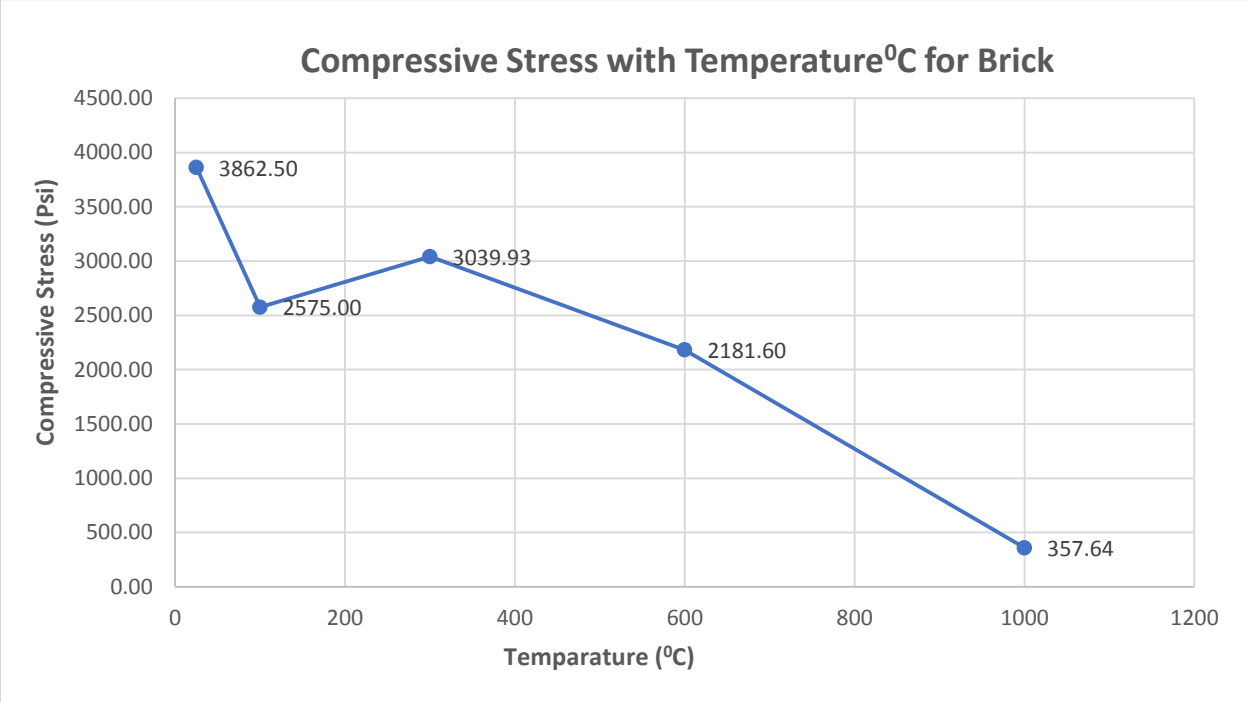


Figure 4.3.3 Graphical represent of compressive strength at brick chips of heating concrete at different temperatures.

Table 4.2.5 The properties of compressive Strength of concrete obtained by volumetric fresh stone chips of different temperature heating.

Temperature (^{0}c)	Load (KN)	Load (lb)	Area (in^2)	Compressive stress (Psi)
25	232	52123.14	12.56	4148.61
100	294	66052.60	12.56	5257.29
300	152	34149.64	12.56	2718.06
600	80	17973.50	12.56	1430.56
1000	10	2246.69	12.56	178.82

4.3.4 Compressive strength: Graphical representation shows that the compressive strength of stone aggregate at different temperatures.

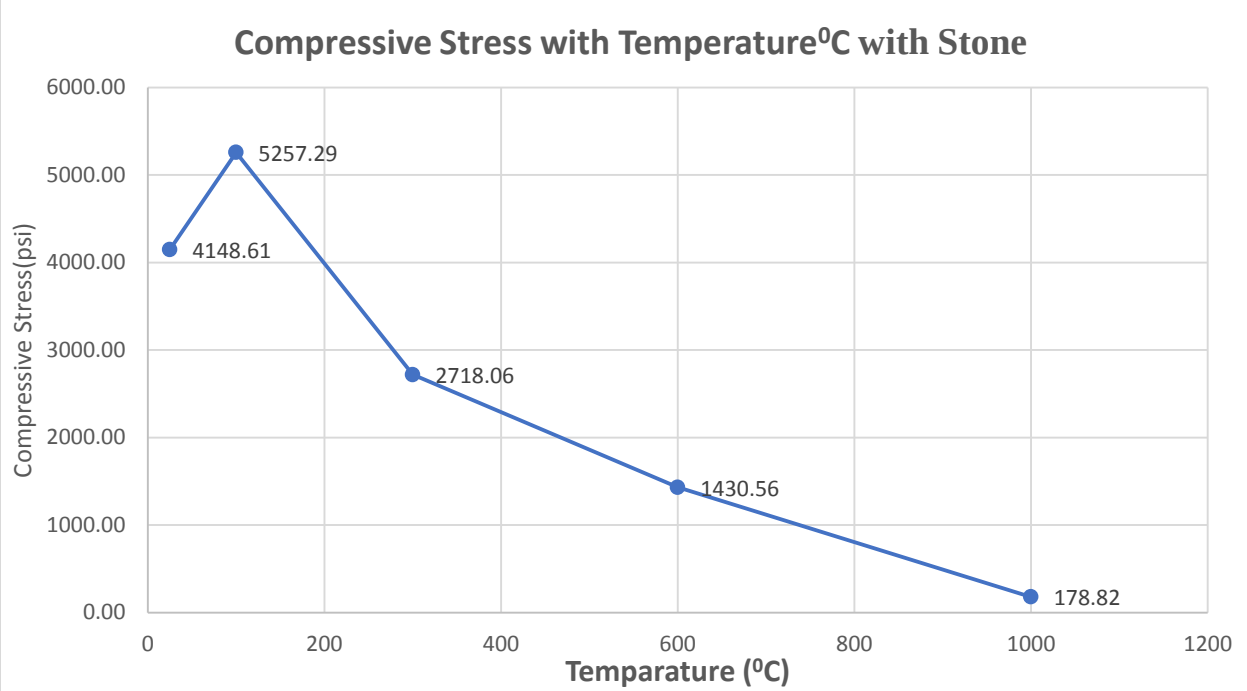


Figure 4.3.4 Graphical represent of compressive strength at stone chips of heating concrete at different temperatures.

4.3.5. Compressive strength: Graphical represent shows that the compressive strength between brick and stone chips of heating concrete at different temperatures.

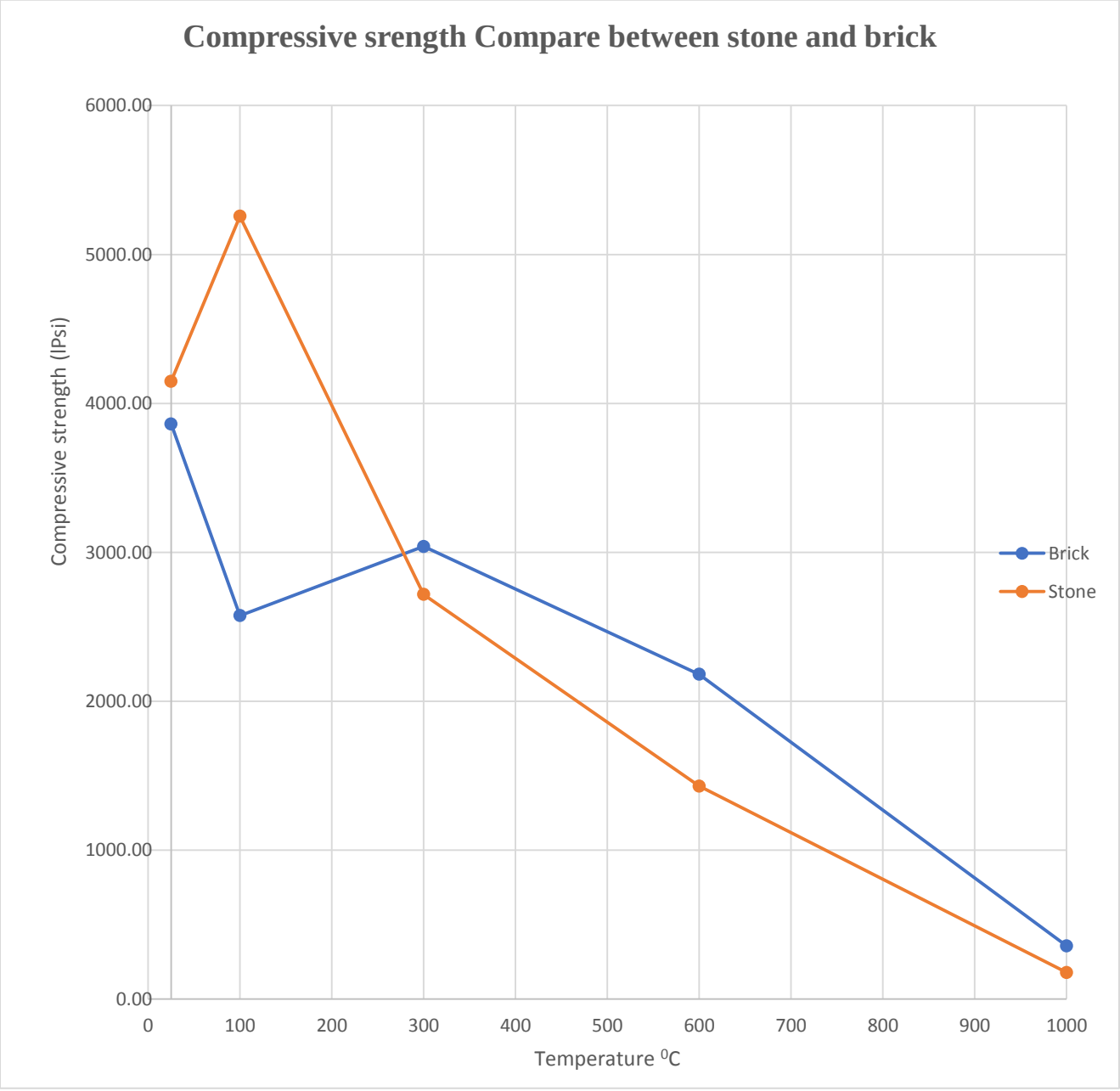


Figure 4.3.5. Graphical represent of compressive strength between brick and stone chips of heating concrete at different temperatures.

Table 4.2.6: The properties of tensile Strength of concrete obtained by volumetric fresh brick & stone chips of different temperature heating.

Temperature (^{0}c)	Load (KN)	Load (lb)	Area (in^2)	Tensile stress (Psi)
25	140	31453.62	12.57	2502.99
100	34	7638.74	12.57	607.87
300	82	18422.83	12.57	1466.04
600	28	6290.72	12.57	500.60
1000	14	3145.36	12.57	250.30

4.3.6 Tensile strength: Graphical representation shows that the compressive strength of brick & stone aggregate at different temperatures.

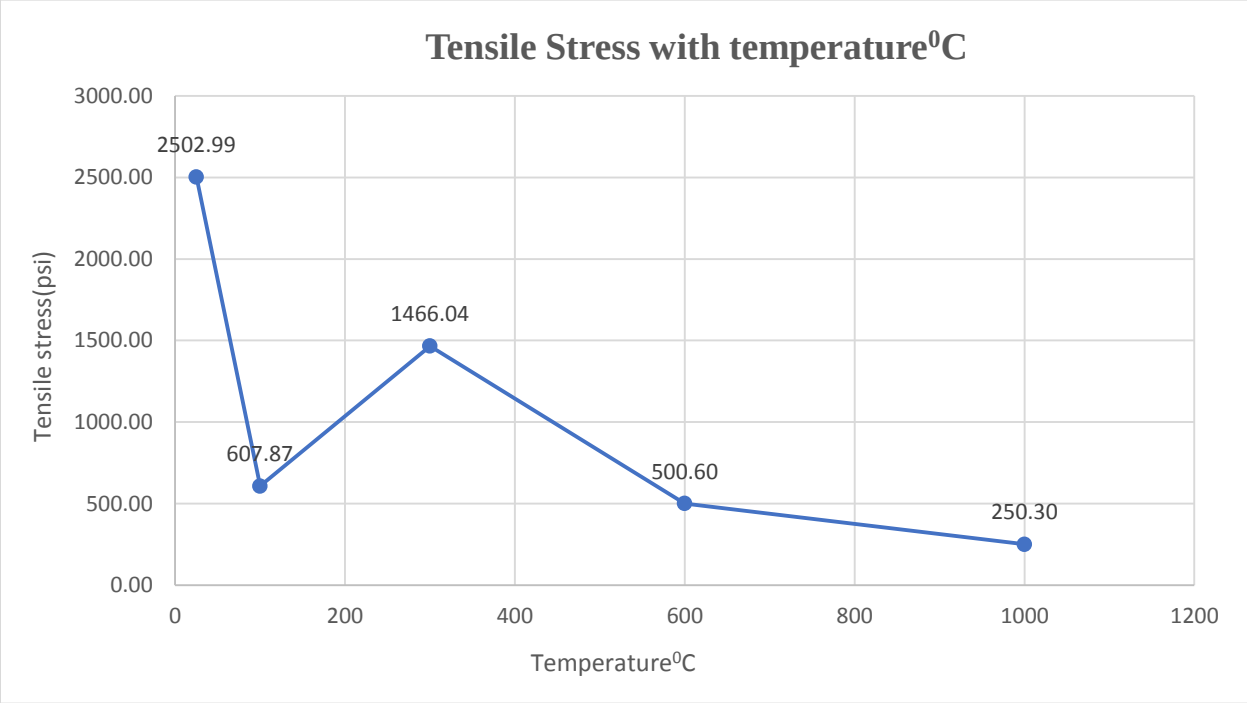


Figure 4.3.6 Graphical represent of tensile strength at brick & stone chips of heating concrete at different temperatures.

Table 4.4.1 Residual compressive strength of concrete exposed to different temperatures.

Type of concrete mix	Residual compressive Strength (PSI)				
	Temperature				
	25	100	300	600	1000
Brick	3862.50 (100%)	2575 (67%)	3039.93 (79%)	2181.60 (56%)	357.64 (10%)
Stone	4148.61 (100%)	5257.29 (126%)	2718.06 (65%)	1430.56 (34%)	178.82 (5%)

4.3.5. Residual stress: Graphical represent shows that the residual stress between brick and stone chips of heating concrete at different temperatures.

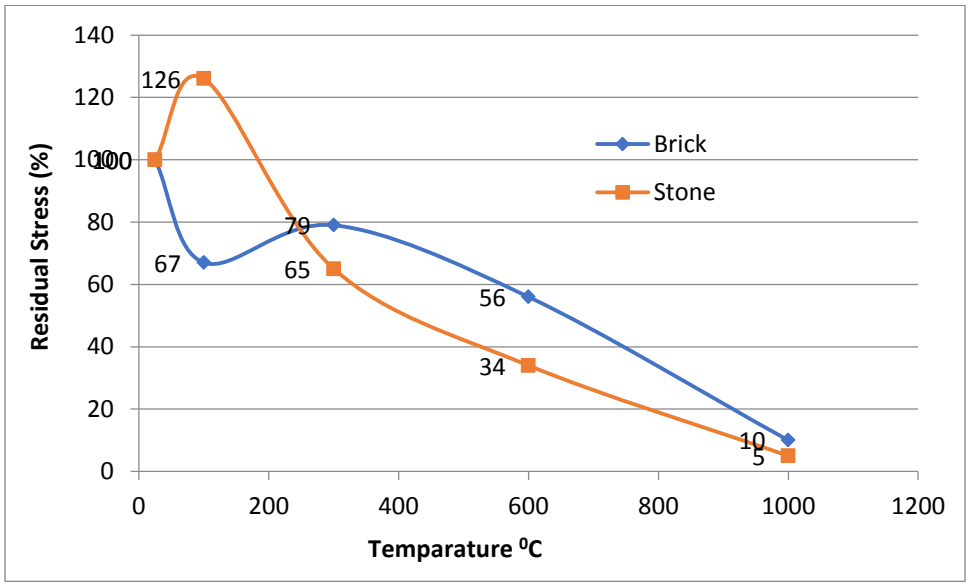


Fig4.3.7 : Residual compressive strength of concrete.

CHAPTER-V

CONCULATION AND RECOMMENDATION

5.1 GENERAL

This chapter was set out to represent the results of the investigation of cement concrete behavior at ahigh temperature. Lastly, some testing, investigation and studies were also recommended after the conclusion, to further the strength characteristics of furnace concrete.

5.2 CONCLUSION

Concrete is widely used commodity. It is used in a variety of environments. concreting, through a relatively easy concept is less under stood sometimes and even small factors like temperature can play a big role in the proper and satisfactory performance of concrete. The guidelines for concrete extreme weather condition should be properly followed to have a durable, serviceable and relatively better concrete. More ever keeping in mind the loss of concrete strength under severe temperature conditions the factor of safety should be accordingly modified in special structures like nuclear reactors.

- The compressive strength of concrete is decreasing with the increasing of temperature.

- The unit weight of concrete is decreasing with the increasing of temperature.
- The tensile strength of concrete is decreasing with the increasing of temperature.

5.3 RECOMMENDATION

The following information can be made based on the analysis and design in concrete.

- The variation of w/c ratio in concrete.
- Use carbonate stones (lime stone and dolomite) in concrete.
- Can be Use Very High-Performance Concrete (VHPC) in fire risk structure.
- Adding some admixture or partial replacement of cement and fine aggregate in concrete such as silica fume, copper slag, fly ash etc.
- Hydrated Portland cement contains a signification amount of free calcium hydroxide and will decompose into calcium oxide due to loss of water at 400-450 ^{0}C.

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