Investigation for Temperature Impact

On Compressive Strength of Concrete

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A thesis submitted to the Department of Civil Engineering in partial fulfillment for the degree of

Bachelor of Science in Civil Engineering

Department of Civil Engineering

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147/I, Green Road, Dhaka-1215, Bangladesh

Section: 16 (D+F)

Semester: Summer-2022

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DECLARATION

We hereby declare that this thesis represents our own work done after registration for a bachelor's degree in civil engineering at Sonargaon University, and was not previously included in a thesis or dissertation submitted to this or any other degree, diploma or other degree institution. We guarantee that the current work does not infringe any copyright. We also re-initiate the reassurance of the university against any loss or damage resulting from the breach of previous obligations. Temperature impact on compressive strength in Structural Concrete. We expect more hypotheses to continue on this topic with advanced data in the upcoming future by others.

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Dedicated

to

“This thesis is dedicated to our honorable parents

and teachers”

ACKNOWLEGEMENTS

Regardless of our efforts, the success of this dissertation is largely dependent on the encouragement and direction of many others. We would like to take this opportunity to thank everyone who contributed to the successful completion of this thesis. first and foremost, we would like to praise and thank Allah, the almighty, for bestowing countless blessings, knowledge, and opportunities on the writer, allowing us to finally complete the thesis, without which we would not have been able to complete this work on time. We would like to express our heartfelt gratitude to our guide, the department of civil engineering at Sonargaon University, for their invaluable assistance.

I would first like to thank my supervisors Md. Lutfor Rahman Assistant Professor Department Of Civil Engineering Sonargaon University for their unwavering support and guidance over the course of this research.

I would also like to thank the many other individuals who had a direct hand in helping with my research. Namely, the Civil Engineering Department lab Assistant Md. Robiullah whose help during this research was simply invaluable, whose efforts left me more than one framework with which to work.

Finally, to my colleagues at the University of Sonargaon, their time and effort during my project whether it involved shoveling, sieving, casting, or batching, heating, crushing, a sincere thank you. This work would not have been possible without your help.

ABSTRACT

In this study we are going to discuss about the strength of concrete after heating. Sometime building catches fire. As a result it loses strength. So our aim is to determine the strength of concrete after heat As part of an investigation on the effect of temperature on the crushing strength of concrete, tests have been carried out using 4 in. diameter by 8 in. long specimens made with ordinary Portland cement, Sylhet sand and gravel aggregate, having various mix proportions and water/cement ratios. The crushing strength of concrete at temperatures up to 200°C was independent of the water/cement ratio used but was influenced by the aggregate/cement ratio. Concrete specimens loaded to produce normal design compressive stress during the period of heating showed less reduction in strength than specimens without imposed load. There was a further loss in the compressive strength of the specimens when cooled after heating. [1]

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CHAPTER 1

INTRODUCTION

1.1 Importance of the Study

The properties of concrete will deteriorated when it was subjected to high temperature. This is due to the changes of physical properties and chemical composition of concrete. Concrete will undergo different type of damages depending on level of temperature. The effects of concrete component to high temperature were reduction in compressive strength, micro-cracking within the concrete microstructure, color changes consistent with strength reduction, increase in pore structure, and various degree of spelling. There was certain reduction in strength of concrete when it is exposed to high temperature. Based on Ma Qet al. Residual compressive strength of concrete after being exposed to high temperature occurs in three stages which at room temperature-300°Cthe compressive strength keeps constant. Then at 300-800°C, compressive strength of concrete drop drastically and at more than 800°C temperature, concrete lost its compressive strength. [2]

Concrete specimens loaded to produce normal design compressive stress during the period of heating showed less reduction in strength than specimens without imposed load. There was a further loss in the compressive strength of the specimens when cooled after heating to a given temperature.

In Bangladesh, Dhaka is a most populated city and sometimes building catches fire. Building are damages due to excess heat. In this study we are going to have a discussion how much building are damaged and compare results.

1.1 Objective of the Study

The objectives of thesis are:

- To observe the compressive strength of heated & normal concrete cylinder Using different mixing ratio of aggregate.
- To compare compressive strength results for different temperature.
- To evaluate prospect of using heated aggregate.

1.3 Thesis Layout

This thesis consists of five chapter organized as follows:

Section 1.01 Chapter 1: Introduction

Introduction is an introductory chapter that gives the reader the background to the topic, the objective and scope of the thesis.

Section 1.01 Chapter 2: Literature Review.

- This paper reviews the long-term properties of heated aggregate concrete structure, including long-term strength, shrinkage, creep, impermeability. Most studies have shown that the long-term properties of heated concrete are inferior to those of natural aggregate concrete (NAC).

- Temperature impact on concrete properties is affected by many factors such as mixing ratio of aggregates, duration of heating, water-cement ratio, mineral admixtures and mix proportions.

- This paper will be helpful for a comprehensive understanding of and further research on heated concrete, and provides an important basis and references for the engineering applications of temperature impact on concrete.

Section 1.02 Chapter 3: Research Method

This is the experimental methodology of this thesis is shown. This chapter will present the basic properties of heated aggregate, concrete mix proportions and test methods.

Session 1.04 Chapter 4: Result and discussion

This Chapter presents the general results and discussion of the study on heated Aggregate.

CHAPTER 2
LITERATURE REVIEW

2.1: Introduction

The compressive strength of the concrete cylinder is one of the most common performance measures performed by engineers in the structure design. Here the compressive strength of concrete cylinder is determined by applying continuous load over the cylinder unit failure occurs. The test is conducted on a compression testing machine. Concrete is a structure material, a mix of cement, fin aggregate, coarse aggregate, water and additives. if necessary, which is the final form of cement which is initially hydrated and in a plastic like concentration- after .

The curing method used for precast concrete curing method. Steam curing is usually employed in precast concrete because it accelerates the rate of strength development. However, this curing method alters the properties of the produced concrete. It was found that steam curing reduced the creep of concrete by up to 50 % compared to that of normal moist-cured concrete. Although plenty of information is available on the effect of curing on concrete properties. There is a need to gain more information on the effect of curing on the strength and durability of concrete produced with high percentages of aggregates.

2.2: Material and Method

Materials and method used in this study are explained in this section.

2.2.1: Cement

Portland cement is obtained by heating limestone and clay or other silicate mixtures at high temperatures (>1500°C) in a rotating kiln. The resulting clinker, when cooled, is mixed with gypsum (calcium sulfate) and ground to a highly uniform fine powder. Anhydrous Portland cement consists mainly of lime (CaO), silica (SiO_2), and alumina (Al_2O_3), in addition to small amounts of magnesia (MgO), ferric oxide ($Fe2O_3$), sulfur trioxide (SO_3), and other oxides that are added as impurities in the raw materials during its manufacture. When these oxides are blended together, they form the four basic components of Portland cement, namely: tricalcium silicate, dicalcium silicate, tricalcium aluminate, and tetra calcium alumina-ferrite. Table 2.1 describes the main oxide compositions and abbreviations, in addition to listing the average of each in commercially available ordinary Portland cement (OPC) (wt.%). [3]

Table 2.1 : The Main Oxide Compositions and abbreviations in addition to the average of each in commercially available Portland cement(wt%)

Oxide constituent	**Oxide composition and abbreviation**	**Average weight (%)**
Tricalcium silicate	$3CaO\cdot SiO_2$ (C_3S)	40–60
Dicalcium silicate	$2CaO\cdot SiO_2$ (C_2S)	13–50
Tricalcium aluminate	$3CaO\cdot Al_2O_3$ (C_3A)	4–11
Tetracalcium aluminoferrite	$4CaO\cdot Al_2O_3\cdot Fe_2O_3$ (C_4AF)	7–13
Others		7–10

2.2.2: Coarse Aggregate

The coarse aggregate was prepared according to the specified mix type. The mix types included fully saturated coarse aggregate, partially saturated coarse aggregate, and oven dry coarse aggregate. In each case, a water content sample was taken following the saturation procedure in order to gauge the actual water content of each mixture.

2.2.3: Fine Aggregate

Locally procured natural sand was used in the experimental program. Fine aggregate resulting from the natural disintegration of rocks and which has been deposited by streams or glacial agencies

2.3.1: Function of Aggregate in Concrete

Section2.01 : Functions of Fine Aggregate in Concrete

Fine aggregates perform the following functions:

1. It assists in producing workability and uniformly in mixture.
2. It assists the cement paste to hard the coarse aggregate particles.
3. It helps to prevent possible segregation of paste and coarse aggregate particularly during the transport operation of concrete for a long distance.
4. Fine aggregate reduces the shrinkage of binding material.
5. It prevents the development of a crack in the concrete. [4]

2.3.2: Function of water in Concrete

Water Cement Ratio signifies the ratio among the weight of water to the weight of cement applied in concrete mix.

Generally, water cement ratio remains under 0.4 to 0.6 with adherence to IS Code 10262 (2009),for nominal mix (M10, M15 …. M25)

The strength of concrete is directly impacted by the water cement ratio. It enhances the strength if employed in perfect ratio and if the ratio is improper, the strength will be reduced.

The importance of Water in Concrete :

Concrete refers to a macro content. It comprises of micro constituents like cement, sand, fine aggregate &Coarse aggregate. With the purpose of obtaining high strength concrete to resist the desired compressive strength, it is required to set exact ratio of admixture to unite these materials.

The function of water is important here to accelerate this chemical process by adding 23%-25% of the cement volume. It produces 15% of water cement paste also called gel to fill the voids in the concrete.

Impact of too much water in concrete: If additional water is added more than the permissible limit of 23%, the strength of concrete will be significantly affected.

If the task of adding water is continued to improve the workability then the concrete contains lots of fluid materials where the aggregates will settle down. As soon as the water is evaporated it puts down lots of voids in concrete which influences the concrete strength.

But if the guidelines are followed to retain the strength of the concrete then it will change the concrete workability and makes it difficult to manage and place them.

Workability signifies the capacity of concrete to manage, convey and place devoid of any segregation. The concrete becomes perfectly workable if it can be easily dealt with, placed and transported devoid of any segregation at the time of being placed in construction site.

For this purpose, plasticizers & super plasticizers are utilized to enhance the workability by keeping the W/C ratio unchanged. [5]

2.3.3 : Properties of Concrete

Concrete is a composite material obtained by mixing Cement, sand, aggregates, and water in suitable proportions. Concrete has become a universal building material which is extensively used in civil engineering construction.

It is necessary to know about important properties of concrete for every civil engineer to design a structure. Properties of concrete are controlled and influenced by the various factors, out of them mix proportions plays an important role in concrete strength and these proportions control the properties of strength. [5]

2.3.4 : Strength of Concrete

Type of Concrete Strength:

1. **Compressive Strength:**

Compressive strength of specimen Treated in a standard manner which includes full compaction and wet curing for a specified period give results representing the potential quality of the concrete. There are three types of loading in compressive test:

a. uniaxial loading
b. biaxial loading
c. triaxial loading

There are three types of failure

a. tension failure
b. shear failure
c. companied failure.

2.3.5 : Elastic Properties of Concrete

Concrete isn't flawlessly versatile for any scope of stacking, Flexible properties of cement change with the extravagance of cement change with the power of pressure. (powers, 1968)

2.3.6 : Durability of Concrete

Concrete durability depends upon the degree of exposure, the concrete grade (or strength) and the cement content. A high density, alkali-resistant concrete will better resist the effects of moisture penetration. Since concrete is a porous material reinforcement bars within the concrete will be subject to possible corrosion if safeguards are not taken. Adequate concrete „cover" to the reinforcement should be included in the specifications in order to reduce moisture or salts penetrating to the rebar. Should the rebar corrode it will expand and the considerable forces involved cause the concrete to crack. [6]

2.3.7 : Impermeability of Concrete

Impermeability is the ability of a material to resist the pressure water or the infiltration of other liquids. It plays an important role in the durability of concrete moreover, it also directly affects the frost-resistance and anti-corrosion of concrete. [7]

2.3.8 : Deformation of Concrete

As with all other materials, concrete is deformable, and is considered to exhibit linear elastic behavior under short duration moderate loads. This means that its deformation is proportional to the applied loads. The instantaneous elastic modulus of concrete is between 30,000 and 35,000 MPa. Deformation under long duration loads: creep

When loads exceed a certain level, concrete behaves as a plastic body. After removal of the load there is still a residual permanent deformation, known as creep.

The deformation due to the process of creep, which continues for months or even years, is of the order of three times the instantaneous deformation. [8]

2.3.9 Curing Time

Curing plays a vital role in concrete strength development and durability. After adding water to the concrete mix (Cement, Sand & Aggregate), the exothermic reaction (hydration) takes place, which helps the concrete to harden. Hardening of concrete is not instant and continues for a longer period, which requires more amount of water for processing hydration. So, the concrete kept moist until the hydration reaction in concrete completes. This process called the curing of concrete. [9]

Minimum curing time for cement concrete:-

The early strength of concrete is most important, and it is responsible for the ultimate strength of concrete. We should do proper curing by considering the environmental conditions, type of structural members, atmospheric temperature. Maintaining the proper temperature also plays a vital role in concrete as mentioned, it should not be colder than 5^0C. Concrete is kept moist for at least 28 days. Nowadays, due to lack of time, the curing can be achieved by following modern techniques in 14-20 Days. Nevertheless, it is always advisable to keep concrete moist for at least 14 days.

As per IS 456 – 2000, concrete should not be cured less than 7 days for ordinary Portland Cement, & it must be at least 10 days for concrete with mineral admixtures or blended cement. In case of hot weather and arid temperature conditions, the curing should not be less than 10 Days for OPC and 14 days for concrete with blended cement & mineral admixtures. [9]

2.3.10 : Method

A total number of 4 cubic concrete samples were produced at two different sizes, 8x8 cm using stream aggregate and basaltic crushed aggregate. The concrete produced were then tested for fresh and set state. Slump test was conducted on the concrete samples in order to test the place ability of concrete before casting the concrete. Slump test was conducted in accordance with the TS EN standard in order to obtain information on the place ability concrete and flow diameter range of 420-480 mm was taken for the F3 class available.

CHAPTER 3

METHODOLOGY

3.1 Materials

In this study, five materials are used top reduce desired concrete mixture. Them arterials are cement, fine aggregate, natural coarse aggregate and potable water.

3.1.1 Cement

Cement is used as a binding materials which is used to set, harden and to bind the materials withits adhere properties. Shah Special cement is one of the most used cement in Bangladesh. We used Shah Special cement for research purpose. Shah Special cement is ordinary Portland cement shown in figure 3.1. Shah Cement Portland Cement surpasses the requirements of BDS EN 197-1:2000CEM-I 52.5 N Grade. It is produced from high-quality clinker ground with high purity gypsum. Shah Cement Portland Cement provides high strength and durability to structures because of its optimum particle size distribution, superior crystalline structure, and balanced phase composition. It was used for its high early strength and very fast setting time. Cement was uniform in color, there were nohard lumps and cement were cool when hand was plunged into the bag before using

Figure-3.1Cement (Lab)

3.1.2 Fine Aggregate

It is the aggregate most of which passes through No.4 (4.75m) sieve and contain only that much coarser material as is permitted by the specifications. Same type of sand were used as the fine aggregate for both NAC and RAC in this study as shown in the figure. The sand were oven dried before being use to obtain SSD.

Figure-3.2 Sand (Lab)

3.1.3 Coarse aggregate

Stone chips were used as coarse aggregate for research purpose shown in figure3.3.

Figure-3.3 Coarse aggregate (Lab)

3.2 Particle Size Distribution

3.2.1 Sieve Analysis

For particle size distribution for both coarse and fine aggregate sieve analysis method were used according to ASTM C136.

3.2.1.1 Apparatus

For sieve analysis, following apparatuses were used-

(a) Balance;

(b) Sieves;

(c) Oven and

(d) Containers.

Figure: 3.4 Apparatus (Lab)

3.2.1.2 Test Procedure

The samples were dried to a constant mass at a temperature of around 110℃ and after drying samples were weighted. A set of IS sieves with suitable openings were used to sieve the samples. Quantity of materials was limited so that all the materials could reach the sieve opening a number of times during sieve analysis. Sieving process was continued for a sufficient period until the particles were not passing through the sieve. On completion of sieving, the materials retained on each sieve were weighted on balance. Cumulative weight retained into each sieve and percentage of cumulative weight retained was calculated.

3.3 Mix Proportions of Concrete

For this research mixture proportion of different groups of concrete were determined in accordance with following conditions-

a) water/cement ratio 0.55 and 0.50

b) Same maximum grain size (20mm)

c) Same type and quantity of fine aggregate

d) Variable type and quantity of coarse aggregate.

e) Mixing ratio 1:1.5:3 and

f) Mixing ratio 1:2:4

3.3.1 Mix Proportions for Concrete cylinder

To perform compressive and tensile strength test, 100 mm x 200 mm cylinder concrete were made. The mix proportions were 1:1.5:3 and 1:2:4 for cement: sand: coarse aggregate. Amount of concrete for a cylinder of each batch are shown in the following table:

Table3.1: Estimation of materials for concrete cylinder

Mixing Ratio: 1:1.5:3

Batch No	**Cement (gm)**	**Sand (gm)**	**Coarse Aggregate (gm)**	**Water ratio %**
1	6005	10535	6538	0.55
2	6005	10535	6538	0.55

Table 3.2 : Estimation of materials for concrete cylinder

Mixing Ratio : 1:2:4

Batch No	**Cement (gm)**	**Sand(g)**	**Coarse Aggregate (gm)**	**Water ratio %**
1	4500	9945	19890	0.50
2	4500	9945	19890	0.50

3.4 Mixing of Concrete

A smooth, water tight surface was selected as platform and it were washed before mixing of concrete. Sand were measured for each mixing batches and was spread evenly to the platform. There required quantity of cement was dumped on the sand and spread evenly. Sand and cement we remixed properly until the mixture became uniform in color. Sand and cement mixture was spread evenly and required amount of coarse aggregate was spread on the mixture. After spreading coarse aggregate, whole mass were mixed with shovel properly until the mixture wasuniform.Mixingratio1:1.5:3 and same for 1:2:4.

3.5 Preparation of mold and de molding

3.5.1 Process of molding

1. For compressive and tensile strength test, steel cylindrical mold were used. Height and diameter of the mold were 200mm and100mm respectively.
2. Molds were cleaned and grease was applied on the inner surface of the mold.

3. Concrete were filled in the mold in 3 layers.

4. Each layer was ridded 25 times in an even pattern using a tamping rod.

5. After tamping, the top surfaces are leveled.

6. The molded specimens were kept at normal temperature to dry.

Molding of cylinder concrete specimens are shown in figure.

Figure-3.5 Mold of Cylinder. (Lab)

3.5.2 Process of De molding

After 24 hours of casting, the concrete specimens were removed from the mold and allowed for curing.

3.5.3 Curing

After de molding, the specimens were placed under water up to 3days, 7days and 28days. The specimens were fully immersed under water. Figure3.6 shows curing of cylinder concrete specimens.

Figure3.6:Curing of concrete specimens (Lab)

Total number of specimens for each test and their age and size are given below:

Table3.3: Details of property, test method a geat test, Number and size of specimens

Mixing Ratio	Test Method	Age at Test (days)	Size of Specimen	No. of specimen
1:1.5:3	ASTM C39	3	100 mm dia × 200 mm height Cylinders	6
		7	100 mm dia × 200 mm height Cylinders	6
		28	100 mm dia × 200 mm height Cylinders	6
1:2:4	ASTM C39	3	100 mm dia × 200 mm height Cylinders	6
		7	100 mm dia × 200 mm height Cylinders	6
		28	100 mm dia × 200 mm height Cylinders	6

3.6 Compressive Strength Test

Compressive strength test is a method to measure the strength of concrete. In this study, the compressive strength of specimens was measured according to ASTM C39. ASTM C39 [10]determines the compressive strength of cylindrical concrete specimens such as molded concrete cylinders and drilled cores. However, this is limited to concrete having unit weight more than800kg/ m3.

In this method, axial compressive load is applied to the cylinder specimen at a standard load rate the machine can provide. Load is applied until the failure occurs. The strength test can be used for quality control i.e. acceptance of concrete to use in construction.

3.6.1 Apparatus

1. Compression testing machine and

2. Balance.

3.6.2 Procedure

1. The weight of specimen was measured and then it was placed on the lower bearing block So the axis of the specimen is aligned with the center of thrust of the spherically seated Bearing block.

2. Age, weight, type and peak load was provided in the screen of testing machine and a Compressive load of.25MPa/s was applied continuously and without shock until failure.

3. Maximum load carried by the specimen during the test was recorded and the type of fracture pattern was noted.

Figure3.7: Compressive Strength Test (lab)

CHAPTER 4
RESULT AND DISCUSSION

4.1 Introduction

Compressive strength of concrete is the engineering properties of concrete which designs are concerned of. It gives an overall view of quality of concrete as it is directly related to the structure of hardened concrete. Concrete has been made with different percentage of coarse aggregate from different sources for target strength. OPC & local sand were used as fine aggregate to make the concrete. Compressive strength has been tested for3, 7 & 28 days.

4.1.1 Sieve Analysis of Sand:

Fineness Modulus is defined as an index to the particle size not to the gradation. Fineness Modulus is calculated from the sieve analysis. It is defined mathematically as the sum of the cumulative percentages retained on the standard sieves divided by 100. The standard size sieves are 3/4 (19.0 mm), 3/8 (9.5 mm), No. 4 (4.75 mm), No. 8 (2.36 mm), No. 16 (1.18 mm), No. 30 (600 µm), No. 50 (300µm), and No. 100 (150 µm). Always report the fineness modulus to the nearest 0.01. In fineness modulus, the finer the material the more the water demand is. It is used for the purpose of estimating the quantity of coarse aggregate to be used in the concrete mix design.

Table 4.1: Result of Sieve Analysis of Sand

Sieve Analysis For Fine Aggregate						
Sieve Number	**Sieve Opening (mm)**	**Material Retained (gm)**	**Material Retained (%)**	**Cumulative Percentage Retained (%)**	**F.M**	**Percent Finer (%)**
4	4.75	15	2.171	2.171		97.829
8	2.36	54	7.815	9.986		90.014
16	1.19	371	53.690	63.676		36.324
30	0.59	164	23.734	87.410	3.618	12.590
50	0.3	79	11.433	98.842		1.158
100	0.15	6	0.868	99.711		0.289
Pan	-	2	0.289	100.000		0.000
Summation	-	691	-	361.795		-

4.1.2 Sieve Analysis of Course Aggregate

Table 4.2: Result of Sieve Analysis Coarse Aggregate

Sieve Analysis For Fine Aggregate						
Sieve Number	**Sieve Opening (mm)**	**Material Retained (gm)**	**Material Retained (%)**	**Cumulative Percentage Retained (%)**	**F.M**	**Percent Finer (%)**
3/4''	4.75	668	51.227	51.227	2.510	48.773
3/8''	2.36	633	48.543	99.770		0.230
4	1.19	3	0.230	100.000		0
8	2.36	0	0	-		-
16	1.19	0	0	-		-
30	0.59	0	0	-		-
50	0.3	0	0	-		-
100	0.15	0	0	-		-
Pan	-	0	0	-		-
Summation	-	1304	-	250.997		-

4.2 Strength Test

4.2.1 Compressive Strength Test Results for Varying Mixes

Compressive strength of concrete by applying heated aggregates and natural aggregates were compared using normal curing. The compressive strength of cylinder was determined with the help of compression testing machine (CTM). Table below gives the result of compressive strength of concrete of both heated and fresh concrete at the age of 3, 7 and 28 days.

4.2.2 Resultant of Compressive Strength Test for mixing proportion 1:1.5:3

Table: 4.3 Compressive Strength Test Results

Curing Duration	Temperature	Trial	Weight (gm)		Load (kn)	Mean load (kn)	Strength psi
3 Days	at normal temperature	1	4146		75	81.5	1465
		2	4150		88		
	100º	1	Before heat	4108	105	108.5	1951
			After heat	4054			
		2	Before heat	4089	112		
			After heat	4014			
	200º	1	Before heat	4014	70	77.5	1393
			After heat	3857			
		2	Before heat	4198	85		
			After heat	4096			
7 Days	at normal temperature	1	3981		105	107.5	1933
		2	4099		110		
	100º	1	Before heat	4172	114	125.5	2526
			After heat	4113			
		2	Before heat	4096	137		
			After heat	4024			
	200º	1	Before heat	3947	117	115	2068
			After heat	3904			
		2	Before heat	4002	113		
			After heat	3963			
28 Days	at normal temperature	1	4122		168	164.5	2958
		2	4232		161		
	100º	1	Before heat	4104	150	151.5	2724
			After heat	4047			
		2	Before heat	4130	153		
			After heat	4105			
	200º	1	Before heat	4290	120	117	2104
			After heat	4198			
		2	Before heat	4182	114		
			After heat	4070			

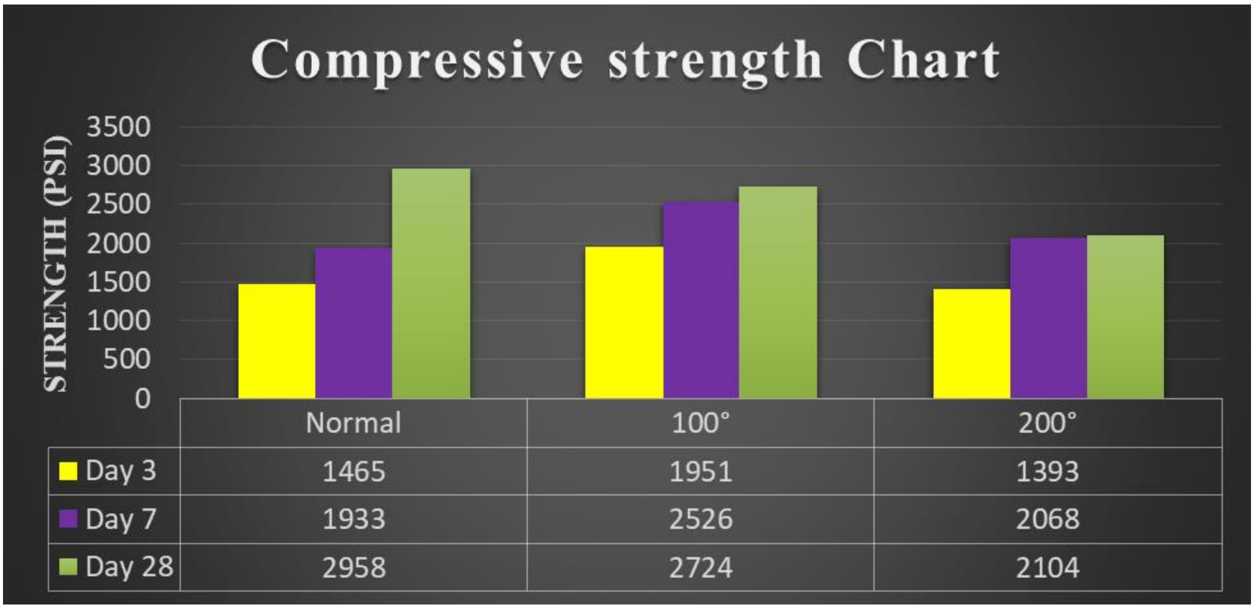

Figure: 4.1 Compressive strength Chart

From the figure we find that compressive strength after 3, 7- and 28-days using ratio of 1:1.5:3. Here we put the average value of cylinder compressive strength between two cylinders. There is given the value of normal temperature and other two is after impacting 100º & 200º temperature.

From this curve we can see that after at the age of 3, 7 and 28 days comparing normal to 100° centigrade temperature maximum strength grow up on the other hand after increasing temperature up to 200° centigrade the strength of concrete fall down.

4.2.3 Resultant of Compressive Strength Test for mixing proportion 1:2:4

Table: 4.4 Compressive Strength Test Results

Curing Duration	Temperature	Trial	Weight (gm)		Load (kn)	Mean Lad (kn)	Strength psi
3 Days	at normal temperature	1	4233		90	91	1636
		2	4089		92		
	100º	1	Before heat	3988	94	91.5	1645
			After heat	3957			
		2	Before heat	4013	89		
			After heat	3980			
	200º	1	Before heat	4112	75	73	1402
			After heat	3960			
		2	Before heat	3920	71		
			After heat	3809			
7 Days	at normal temperature	1	4101		97	101	1816
		2	4339		105		
	100º	1	Before heat	3967	125	123	2212
			After heat	3931			
		2	Before heat	3952	121		
			After heat	3930			
	200º	1	Before heat	4183	91	88	1582
			After heat	4102			
		2	Before heat	4168	85		
			After heat	4087			
28 Days	at normal temperature	1	4267		152	146	2625
		2	4204		140		
	100º	1	Before heat	4074	145	152.5	2742
			After heat	4028			
		2	Before heat	4172	160		
			After heat	4138			
	200º	1	Before heat	4304	145	145	2607
			After heat	4196			
		2	Before heat	4157	145		
			After heat	4050			

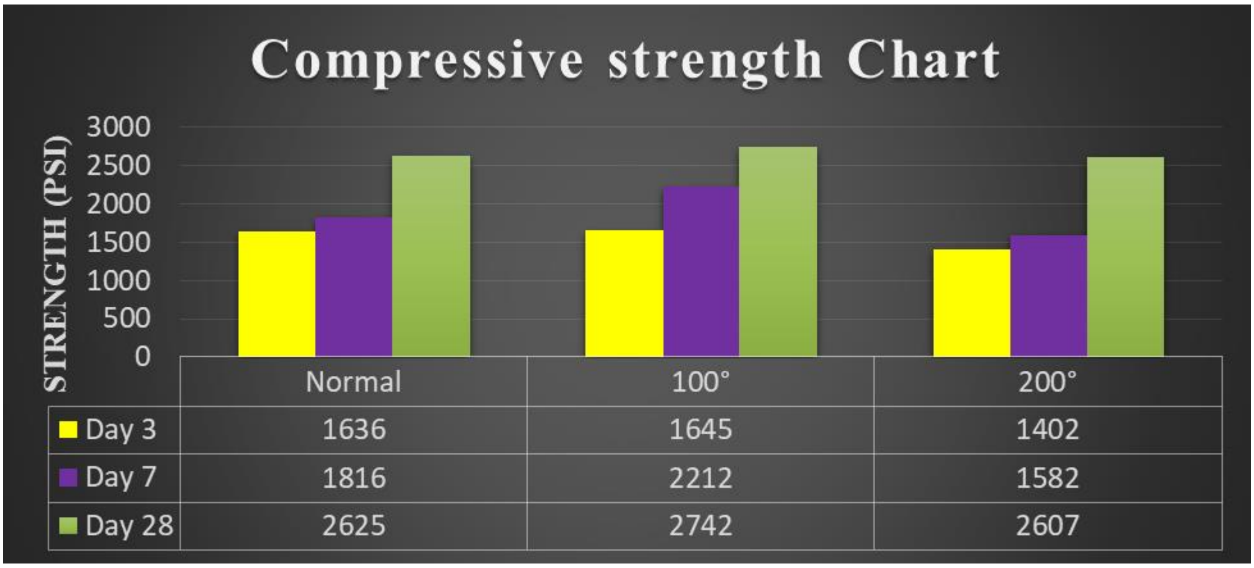

Figure: 4.2 Compressive strength Chart

From the figure we find that compressive strength after 3, 7 and 28 days using ratio of 1:2:4. Here we put the average value of cylinder compressive strength between two cylinders. There is given the value of normal temperature and other two is after impacting 100º & 200º temperature.

From this curve we can see that after at the age of 3, 7 and 28 days comparing normal to 100° centigrade temperature maximum strength grow up on the other hand after increasing temperature up to 200° centigrade the strength of concrete fall down.

4.2.4. Weight loss of concrete cylinder after heat for 1:1.5:3 ratio

Table 4.5: weight loss of concrete specimen

Curing Duration	Temperature	Trial	Weight (gm)		Weight Loss (gm)	Percent (%)
3 Days	100º	1	Before heat	4108	54	0.54
			After heat	4054		
		2	Before heat	4089	75	0.75
			After heat	4014		
	200º	1	Before heat	4014	157	1.57
			After heat	3857		
		2	Before heat	4198	102	1.02
			After heat	4096		
7 Days	100º	1	Before heat	4172	59	0.59
			After heat	4113		
		2	Before heat	4096	72	0.72
			After heat	4024		
	200º	1	Before heat	3947	43	0.43
			After heat	3904		
		2	Before heat	4002	39	0.39
			After heat	3963		
28 Days	100º	1	Before heat	4104	57	0.57
			After heat	4047		
		2	Before heat	4130	25	0.25
			After heat	4105		
	200º	1	Before heat	4290	92	0.92
			After heat	4198		
		2	Before heat	4182	110	1.10
			After heat	4070		

In table 4.5 shows results weight loss of concrete specimen different temperature. From this table we found that after increasing temperature the moisture of specimen decreases. So the concrete losses weight.

4.2.5. Weight loss of concrete cylinder after heat for 1:2:4 ratio

Table 4.6: weight loss of concrete specimen

Age	Temperature	Trial	Weight (gm)		Weight Loss (gm)	Percent (%)
3 Days	100º	1	Before heat	3988	31	0.31
			After heat	3957		
		2	Before heat	4013	33	0.33
			After heat	3980		
	200º	1	Before heat	4112	152	1.52
			After heat	3960		
		2	Before heat	3920	111	1.11
			After heat	3809		
7 Days	100º	1	Before heat	3967	36	0.36
			After heat	3931		
		2	Before heat	3952	22	0.22
			After heat	3930		
	200º	1	Before heat	4183	81	0.81
			After heat	4102		
		2	Before heat	4168	81	0.81
			After heat	4087		
28 Days	100º	1	Before heat	4074	46	0.46
			After heat	4028		
		2	Before heat	4172	34	0.34
			After heat	4138		
	200º	1	Before heat	4304	108	1.08
			After heat	4196		
		2	Before heat	4157	107	1.07
			After heat	4050		

In table 4.6 shows results weight loss of concrete specimen different temperature. From this table we found that after increasing temperature the moisture of specimen decreases. So the concrete losses weight.

CHAPTER 5
CONCLUSION AND FUTURE WORK

5.1 Conclusions

The study is a part of comprehensive program where in experimental investigations have been carried out to assess the effect of temperature on aggregate by different percentages in concrete on compressive strength of heated concrete for the period of 3, 7 and 28 days.

Test results indicate that heated aggregate, is not a suitable for industry, commercial etc. building. The compressive strength of concrete at the age of 3, 7, 28 days is decreasing. The resultant of this thesis paper we can say that, the temperature impact on concrete reduces the compressive strength of concrete.

So we can also say that, it loses strength when a building catches fire. For high temperature if this process continues for a long period of time the building loses its strength and becomes inhabitable.

5.2 Limitation and Recommendations for Future Work

In this research we have performed normal to 200º centigrade temperature impact on concrete. We could perform up to 1000° centigrade temperature. But insufficient of apparatus we have performed up to 200° centigrade temperature.

In future we can performed this research for high temperature at long period of time. We can also compare the physical changes and chemical changes for high temperature on concrete.

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APPENDIX

CONCRETE MIX DESIGN

Required Data M20 Grade Concrete [11]

- Grade of concrete =M20
- Characteristic compressive strength of concrete at 28days = 20N/mm^2
- Nominal maximum size of aggregate = 20mm
- Specific Gravity of cement = 3.15
- Specific gravity of fine aggregate = 2.5
- Specific gravity of Coarse aggregate = 2.8

Step 1: Calculation of Target Strength

Target mean strength of concrete is derived from the below formula

$$\mathbf{f_t = f_{ck} + 1.65\ s}$$

Where S = standard deviation which is taken as per below table= 4

Grade of concrete	Standard deviation (N/mm^2)
M10	3.5
M15	3.5
M20	4.0
M25	4.0
M30	5.0
M35	5.0
M40	5.0
M45	5.0
M50	5.0

Characteristic compressive strength after 28 days $f_{ck} = 20N/mm^2$

$f_t = 20 + 1.65 \times 4$

Therefore, target mean strength $\mathbf{f_t = 26.6N/mm^2}$

Step 2: Selection of Water-Cement Ratio

From Table 5 of IS 456, (page no 20)[11]

Maximum water-cement ratio for Mild exposure condition = 0.55

Based on experience, adopt water-cement ratio as 0.5.

0.5<0.55, hence OK.

Let, **W/C ratio = 0.55**

Step 3: Air Content Calculation

Nominal maximum size of aggregate taken is = 20mm

Nominal maximum size of aggregate	**Air content (% of the volume of concrete)**
10mm	5%
20mm	2%
40mm	1%

So, from the table entrapped air content in % of the volume of concrete = 2%

Step 4: Water Content Calculation

For nominal maximum size of aggregate of 20mm, the required water content is selected form the table-

Nominal maximum size of aggregate	Maximum water content
10mm	208
20mm	186
40mm	165

The aggregate nominal maximum size is 20mm and they belong to zone 2 (From Table 3 of IS 10262- 2009). So, Adjustment for compacting factor is to be applied.

Therefore, water content = 186 + (186 x 3/100) = **191.6 lit / m^3 of concrete.**

Step 5: Cement Content Calculation

From step 2, Water cement ratio = W/C = 0.55
From step 4, Water content W = 191.6 liters = 191.6kg
191.6 / C = 0.55
Finally, C = 348.36Kg / m^3 of concrete

Step 6: Aggregate Ratio for Concrete

Table 3 Volume of Coarse Aggregate per Unit Volume of Total Aggregate for Different Zones of Fine Aggregate

(*Clauses* 4.4, A-7 *and* B-7)

Sl No.	Nominal Maximum Size of Aggregate mm	Volume of Coarse Aggregate[1] per Unit Volume of Total Aggregate for Different Zones of Fine Aggregate			
		Zone IV	Zone III	Zone II	Zone I
(1)	(2)	(3)	(4)	(5)	(6)
i)	10	0.50	0.48	0.46	0.44
ii)	20	0.66	0.64	0.62	0.60
iii)	40	0.75	0.73	0.71	0.69

[1] Volumes are based on aggregates in saturated surface dry condition.

From the table, ratio of volume of coarse aggregate to volume of total aggregate, for 20mm nominal maximum size aggregate and zone-2 fine aggregate is

Therefore, **P = 0.62**

Step 7: Aggregate Content Calculation

Volume of concrete (with entrapped air) = 1 m^3

From step 3, Entrapped air % = 2% = 0.02

Therefore, volume of concrete (without air content) = 1-0.02 = 0.98m^3

Fine aggregate content F.A is determined from below formula,

$$\mathbf{V = [W + C/Gc + (1/ (1-P) \times (F.A)/Gf)] \times 1/1000}$$

0.98 = [191.6 + 348.36/3.15 + (1/ (1-0.62) X (F.A)/2.5)] x 1/1000

Therefore, amount of fine aggregate **F.A = 643.92 kg**

$$\mathbf{V = [W + C/Gc + (1/ P) \times (F.A)/Gf)] \times 1/1000}$$

0.98 = [191.6 + 348.36/3.15 + (1/ 0.62) X (F.A)/2.5)] x 1/1000

Therefore, amount of coarse aggregate **C.A = 1050.59 kg**

Step 8: Final Mix Proportions of Ingredients

W/C ratio = 0.55

Cement quantity = 348.36Kg = 345kg

Fine aggregate quantity = 673.52kg = 669.67 kg

Coarse aggregate Quantity = 1050.59 kg

Mix proportion for M25 Concrete = Cement: F.A : C.A = 1 : 1.5 : 3