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Effects of Curing Temperature on Compressive Strength of Concrete: A Short Review

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ABSTRACT: This paper presents the effect of the temperature of curing on the rate of gain of strength of concrete. The effect of a high temperature on concrete cover changes taking place in cement paste, and aggregates, as well as the interaction of these two constituents, that result in changes in the mechanical and physical characteristics of concrete. Different samples of concrete were cast at different temperatures and various properties of concrete in the fresh and hardened state were determined. It was observed that the strength parameters i.e., the compressive strength of concrete is adversely affected when the temperature during the first 24 hours is more or less or equal to zero degrees Celsius. The compressive strength of concrete of M20 and M40 grades was determined using 150 mm x 150mm x150mm cubes and a comparison was made on the following cubes a relationship was developed between 7 days,14 days and 28 days strength,From the results it was observed that there is a gradual decrease in compressive strength of the concrete as the temperature is increased.

KEYWORDS: - Curing, Temperature, Compressive strength, Celsius, Concrete, Construction material.

I. INTRODUCTION

By its nature concrete is placed under many different environmental conditions. Concrete is a crucial material in construction, and it is essential to investigate the effects of engineering environments on its behaviour, particularly its strength development. Factors such as temperature, water/cement (W/C) ratio, coarse/fine aggregate ratio, relative humidity, concrete age, and curing influence the strength of concrete. Temperature, in particular, has a significant effect on the compressive behaviour of concrete as it affects the hydration process between cement and water. Higher temperatures result in a faster reaction and higher early-age strength but may lead to lower final strength due to the less well-structured and more porous form of the hardened cement paste at high temperatures. In winter, concrete is often placed at cool temperatures and cured at even lower temperatures. In summer, concrete is often placed at warm temperatures and cured at even higher temperatures due to either heat of hydration effects or ambient temperature conditions. Considering the amount of research done on concrete, surprisingly very little has been done on the effects of placing and curing temperatures on fresh and hardened concrete. By far, most research on concrete has been done under controlled laboratory conditions where casting and curing temperatures are always at or near 23°C (73° F). This work was undertaken to recognize the importance of producing data that would help predict the performance of concrete at temperatures often encountered in normal construction practice. To isolate the effects of temperature, no adjustments were made to the concrete mixes to offset the change in work-ability due to temperature effects. In actual construction, adjustments are often made to a concrete mix to maintain its workability at the anticipated casting temperature. Typical adjustments may include a change in water content, use of a chemical admixture(s), and/or change in cement content.

Data in this report are useful for judging the relative changes in fresh and hardened concrete that are solely due to temperature effects and should be useful in making judgments as to the most appropriate adjustments in mix design to account for casting and curing temperatures.[1][2][3][8][11]

II. LITERATURE REVIEW

SO OsujiUet al [1]

The results of the investigation of the effects of elevated temperatures on the compressive strength of Grade 40 concrete. A total of thirty cube specimens were cast, cured in water at ambient temperature in the laboratory and subjected to various temperature regimes before testing. A concrete mix of 1:1:3 (cement: fine aggregates: coarse aggregates) with a water content ratio of 0.44, fine aggregates lying in zone 2 of sieve tests as well as the granite of maximum size 12.5mm was designed for these investigations using the Department of Environment Method. Specimens cured for 7 and 28 days were subjected to uni-axial compressive loading tests at room and elevated temperatures of 24, 100, 150, 200, 250 and 300 degrees Celsius at one-hour duration. The result indicated a 14.49%, 25%, 51%, 35.51% and 43.88% decrease in compressive strength at the earlier quoted temperatures respectively. At an elevated temperature of 300 degrees Celsius, a peak decrease of 53.47% in compressive strength was observed.[1] Table III.

Anand N. et al [2]

A review is presented based on experimental studies on the performance of concrete when exposed to higher temperatures. The compiled test data revealed distinct differences in mechanical properties of normal, high-strength and self-compacting concrete. The shape of the specimen (cube, cylinder, beam etc.), size of the specimen, the magnitude of temperature load applied on the specimen, time duration maintained for heating, reference on a time-temperature curve, rate of heating, rate of cooling, time taken for hot test after curing period, time taken for load test after heating, heat test on stressed/unstressed member, type of cooling adopted on the heated specimen by natural cooling or cooling by spraying water etc. are the parameters that influence the test results. To understand the behaviour of concrete under elevated temperatures, several factors must be taken into account for each experiment. The strength of concrete, type of cement, type of aggregate, water-cement ratio, the density of concrete, percentage of reinforcement, cover to the reinforcement etc. are some of the important factors that affect the performance of concrete at elevated temperatures.[2]

Durga Rama Naidu. et al [3]

The structural element subjected to high temperatures leads to significant losses due to the reduction in the strength of the concrete. with the mode toward urbanization, the rate of construction and hazards related to it have increased to a high extent. One such major source is fire accidents. The structure can undergo fire accidents, but because of this the structure cannot be denied or abandoned. To make a structure functionally viable after the damage due to fire has become a challenge for the civil engineering community. The problem is where to start and how to proceed. The root of such a problem lies in the strength parametric study of component material that is used in the construction industry. One such major item is concrete, which has very distinct chemical and physical properties because of its elemental components. The study done in this project is basically for M20 grade concrete subjected to various temperatures and thus the changes in properties are marked and highlighted. This project aims to show the behaviour of concrete at various temperatures and changes in its compressive strength and physical properties. Results show markable behaviours of concrete which make it furthermore topic of interest. Results show the markable behaviour of concrete which makes it furthers more topic of interest. The study reveals that concrete has very distinct bonding properties that change with changes in exposure conditions.[3] Table IV.

Misba Gulet al [11]

The effect of temperature on the rate of gain of strength of concrete. Different samples of concrete were cast at different temperatures and various properties of concrete in the fresh and hardened state were determined. It was observed that the three strength parameters viz. the compressive strength, the split tensile strength and the flexural strength of concrete are adversely affected when the temperature during the first 24 hours is less than or equal to zero degree Celsius. The compressive strength of concrete was determined using 100mm and 150 mm cubes and a comparison was made between the two. It was observed that the strength of 100 mm cubes was greater than that of 150 mm cubes. Later a relationship was developed between 7 days, 14 days and 28 days strength.[11] Table II.

S.h. chowdhury et al [12]

High-strength concrete (HSC) is a material often used in the construction of high-rise buildings. In case of unexpected fire, building elements such as columns, slabs and walls will be subjected to extreme temperatures. To assess the performance of high-rise concrete members to such exposure, it is important to understand the changes in the concrete properties due to extreme temperature. This paper presents an experimental study undertaken to quantify the effect of elevated temperatures of 60, 75, 100, 200, 400 and 600°C with various exposure durations of 4, 8, 12, 72 hours and one

month on HSC cylinders. HSC cylinders made of two strengths, namely 80 and 100 MPa are used. For comparing their performance with normal strength concrete, cylinders made with 40 MPa concrete are also investigated. Residual tensile and compressive strengths of concrete as well as weight loss values after high-temperature exposures were determined. The detrimental effects of using silica fume for higher-strength concrete mixtures are exhibited by the test results.[12]

J.-k. Kim, et al [13]

In this experimental and analytic research, the strength development for various curing histories was investigated with particular regard to the influences of curing time points with given temperatures. For this purpose, four different points of curing time were considered with an individual interval of 24 h. Two different temperatures of 5°C and 40°C were applied for the selective intervals, whereas the rest period days were under the reference curing condition of 20°C. A new model for strength prediction was suggested based on the rate constant model. In this model, the equivalent ages introduced in the Saul and Arrhenius models were modified to show the effects of curing temperature at different ages. Test results show that the concrete subjected to a high temperature at an early age attains higher early-age strength but eventually attains lower later-age strength. The concrete subjected to a low temperature at an early age leads to lower early-age strength but almost the same later-age strength. Moreover, the proposed model showed better agreement with the test results than the existing models.[13]

III. OBJECTIVE AND SCOPE

The objective of the study is to identify the properties of materials and then find the compressive strength of the concrete mixed and cured at different temperatures and compare the study with standard concrete properties and strength. And study the results and application of it.

The results obtained showed that the average compressive strength values for 24 hours vary with curing temperature.

IV. MATERIALS AND METHODS

Name of material	Source
Cement	Locally available (Ultratech)
Coarse aggregate	Locally available
Fine aggregate	Locally available
Water	Tap Water

Table I: Material used

Cement: - Cement is a generic name that applies to all binders, with Portland cement being the most commonly used type of cement in concrete production. Ordinary Portland cement (53) conforming to IS: 8112 was used throughout the experimental study

Fine Aggregate: -Fine aggregates are defined as aggregates smaller than 4.75mm. They pass through a number 4 sieve with a mesh size of 4.75mm.

Coarse Aggregate: - Coarse aggregates are larger than 4.75mm and are typically natural stones or gravel that have not been crushed or processed. These aggregates reduce the amount of water needed in a concrete mix, which may decrease workability but improve the inherent strength of the concrete. They are derived from natural rocks and sand.

Water: - Water is a crucial ingredient in the production of concrete, and the quality of water used should be carefully considered. So potable water was used throughout the study.

Mix design

The concrete mix of 1: 1.5: 3 and 1:0.25:0.5 is taken with a w/c ratio of 0.50. A nominal mix M20 and M40 grade of concrete was used. The concrete mixes were prepared by hand mixing on a non-absorbing platform. The mix design was carried out according to the IS design method and several trial mixes were conducted to obtain the optimum mix. Once the optimum mix was determined, it was prepared to find out the compressive strength. In this study, a design mix of M20 (1:1.5:3) and M40(1:0.25:0.5) is used.



Equipment used

1. Accelerated Curing Tank
2. Compression Testing Machine

V. RESULTS

The most valuable property of concrete is compressive strength because it gives the overall quality of hardened concrete. The hardened concrete tests conducted were compressive strength tests. After 24 hours the concrete samples were removed from the moulds and were kept in the curing tank till the date of testing. The compressive strength test was conducted on 150 mm x 150mm x150mm size of cubes at 7 and 28 days after the curing process at different temperatures. The compressive strength is determined using a 2000 KN compression testing machine by IS: 516-1959. The values of compressive strength after 7 days and 28 days are shown in Table II.

The following results were derived from a recent study by Misba Gul, and Riyaz Ahmad Qasab, "Effect of Temperature on the Rate of Gain of Strength of Concrete" (11). To study the effect of temperature on the properties of fresh and hardened concrete, a comparative study of the results achieved at different minimum temperatures (during the first 24 hours of casting) was performed. [11]

		150 mm x 150mm x 150mm cubes		
		7 days	14 days	28 days
1.	0	14.12	18.94	23.25
2.	-1.2	13.27	18.44	20.84
3.	-2.5	13.00	18.18	20.14
4.	0.8	13.97	19.64	23.51
5.	1.4	14.80	21.28	24.31
6.	1.6	15.55	21.51	24.57
7.	2	15.64	22.66	24.66
8.	4.5	16.35	23.26	25.06
9.	5	17.77	23.16	25.15
10.	11	18.33	24	25.77

Table II: - Results of M20 mix (11)

The following results were derived from a recent study by SO Osuji, U Ukeme. " Effects of Elevated Temperature on Compressive Strength of Concrete: A Case Study of Grade 40 Concrete"[1]

Table III: - Results of M40 mix (1)

Temperature (°C)	Decrease in Compressive strength (%)
24	14.49
100	25
150	51
200	35.51
250	43.88
300	53.47

The following results were derived from a recent study by Durga Rama Naidu. "Behaviour of M20 grade concrete at different temperatures." [3]

Table IV: - Results of M20 mix (3)

Specimen	Temperature (°C)	Variations of average compressive strength (%)
1	27	100
2	50	98.83
3	100	95.87
4	150	129.27
5	200	97.93
6	250	94.86
7	300	93.87

VI. CONCLUSION

Based on the experimental works from this research work, the following conclusions are drawn:

1. The water content used in all mixes is different 0.35, 0.45, 0.50. The proportion of Cement: Sand: Aggregate is (1:1.5:3).
2. The compressive strength of concrete is adversely affected under the conditions when temperatures drop to around 0°C and especially when temperatures reach below 0°C. It is observed that under conditions of temperature at 0°C (during the first 24 hours), there is a decrease in the compressive strength of concrete.
3. The variation in values of compressive strengths of concrete when testing is done states that there is a 32% decrease in the overall strength of concrete.
4. The value drops as temp decreases and increases as the temperature increases to a certain level of point.
5. The 7 days and 14 days compressive strength is of the order of 64.4 % and 89.4% of 28 days strength respectively.

REFERENCES

- [1] SO Osuji, U Ukeme. "Effects of Elevated Temperature on Compressive Strength of Concrete: A Case Study of Grade 40 Concrete." Nigerian Journal of Technology (NIJOTECH) Vol. 34 No. 3, July 2015, pp. 472 – 477.
- [2] Anand N.Arulraj G. Prince "The effect of elevated temperature on concrete materials." International Journal of Civil & Structural Engineering Year : 2011, Volume : 1, Issue : 4
- [3] G. Durga Rama Naidu. "BEHAVIOUR OF M20 GRADE CONCRETE AT DIFFERENT TEMPERATURES." International Journal of Civil Engineering and Technology (IJCIET) Volume 8, Issue 3, March 2017,
- [4] Malhotra, H. L. "The effect of temperature on the compressive strength of concrete." Magazine of concrete research 8.23 (1956): 85-94.

- [5] Kim, Jin-Keun, Sang Hun Han, and Young Chul Song. "Effect of temperature and aging on the mechanical properties of concrete: Part I. Experimental results." *Cement and Concrete Research* 32.7 (2002): 1087-1094.
- [6] Naus, Dan J. *The Effect of Elevated Temperature on Concrete Materials and Structures-a Literature Review*. No. ORNL/TM-2005/553. Oak Ridge National Laboratory (ORNL), 2006
- [7] Heikal, Mohamed. "Effect of temperature on the physicochemical and mineralogical properties of Homra pozzolanic cement pastes." *Cement and Concrete Research* 30.11 (2000): 1835-1839.
- [8] Kim, J. K., Han, S. H., & Park, S. K. (2002). Effect of temperature and aging on the mechanical properties of concrete: Part II. Prediction model. *Cement and Concrete Research*, 32(7), 1095-1100.
- [9] Sallam, H.E.M. and Ibrahim, K.I.M. The Compressive Strength of Fiber Reinforced Concrete (FRC) at High Elevated Temperatures. *International Journal of Civil Engineering and Technology*, 6 (8), 2015, pp 53-60
- [10] G. Prasanna Kumar, G. Durga Rama Naidu, P. Pusalatha, P. Manoj Kumar, An Experimental Study on Non-Destructive Tests and Stress Strain Curves of M20 Grade Concrete with Nano -Silica Using M-Sand. *International Journal of Civil Engineering and Technology*, 8(3), 2017, pp. 385–390
- [11] Misba Gul, Riyaz Ahmad Qasab, J.A. Naqash, Iqra Shafi, Khurshid Yaqoob, Mudasir Ahmad Bhat "Effect of Temperature on the Rate of Gain of Strength of Concrete" *International Journal of Engineering and Advanced Technology (IJEAT)* ISSN: 2249 – 8958, Volume-8 Issue-6, August 2019.
- [12] S.H. Chowdhury "EFFECT OF ELEVATED TEMPERATURE ON MECHANICAL PROPERTIES OF HIGH STRENGTH CONCRETE" 23rd Australasian Conference on the Mechanics of Structures and Materials (ACMSM23
- [13] J.-K. Kim,¹ * Y.-H. Moon,* and S.-H. Eo "COMPRESSIVE STRENGTH DEVELOPMENT OF CONCRETE WITH DIFFERENT CURING TIME AND TEMPERATURE" *Cement and Concrete Research*, Vol. 28, No. 12, pp. 1761–1773, 1998.



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