International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 10 Issue: 11 | Nov 2023 www.irjet.net p-ISSN: 2395-0072

STUDY OF EFFECT OF TEMPERATURE VARIATION ON CONCRETE PARAMETERS OF CONCRETE DURING MATURITY PERIOD.

Dr. Pradeep P. Tapkire [1], Atul S. Chandanshive [2], Rakeshkumar R. Gaikwad [3]

[1] *H.O.D. Civil Dept., N.B. Navale Sinhgad College of Engineering, Solapur, Maharashtra, India-413255*
[2] *Lecturer Civil Dept., Solapur Education Society's Polytechnic Solapur, Maharashtra, India-413002*
[3] *Research Scholar at N.B. Navale Sinhgad College of Engineering,* Solapur, Maharashtra, India-413255

---***---

Abstract - *This study examines the effects of temperature variations on the mechanical and durability characteristics of concrete over its maturation phase. The research examines variables including compressive strength, tensile strength, porosity, and durability-related features by casting concrete specimens and exposing them to regulated temperature settings. The study intends to identify correlations between temperature changes, hydration kinetics, and consequent concrete features by applying the maturity concept, which takes both time and temperature into account. The research's conclusions will help advance concrete technology and more reliably and sustainably build concrete mix designs and curing procedures in areas with demanding temperature ranges.*

Key Words: Concrete maturity, Temperature variation, Durability, Thermal effects, Maturity period.

1.INTRODUCTION

Hydration, a chemical process that happens when water and cement are combined, produces heat. The strength of the concrete may be impacted by cracks caused by this heat. Calcium silicate hydrate (CSH) and calcium hydroxide (CH) are produced during the hydration of cement's essential constituents, such as tricalcium silicate (C3S) and dicalcium silicate (C2S). The rate of hydration is influenced by variables such as cement type, water temperature, and admixtures. It's critical to comprehend how temperature affects concrete strength, especially during the first several months following construction. This investigation intends to investigate how temperature changes throughout this time effect concrete's compressive strength, offering knowledge for building techniques and long-term durability.

1.1 AIM & Objective

This paper aims to find the Effect of Temperature Variation on Compressive Strength of Concrete for Early Maturity Period

1. To investigate the link between temperature change and the development of compressive strength in early-maturity concrete.
2. To determine the crucial temperature ranges that have a negative impact on the strength of concrete during this time.
3. To make suggestions and recommendations for limiting the impact of temperature on concrete's strength and durability.

2. LITERATURE REVIEW

F. S. Rostasy U. [1] describe how a motor and concrete behave under very low temperatures. At low temperatures and following cyclic temperature-time histories, the behavior of specimens of hydrated cement paste, mortar, and concrete (age 110 days) was studied. Researchers looked at how thermal strains, compressive and tensile splitting strengths, and pore structure all changed in relation to one another. With a drop in temperature and a rise in moisture content, the frozen state's strength improves. Reheating the frozen, water-saturated mortar or concrete to room temperature results in a loss of strength.

Ed. T. Naik [2] Describe the effect of temperature rise and fall on concrete at early ages is rarely measured. At later ages, the strength of concrete that was cured at a high temperature is reduced. Calcium hydroxide [Ca (OH) 2] concentration has been used to gauge the changes that take place in the hydration products. The measurement of permeability was required since it is, in part, dependent on the strength and water/cement ratio.

Abhijit Mukherjee [3] Nuclear engineering places a high priority on describing the behavior of concrete structures when subjected to intense thermo-mechanical loads. Concrete exhibits non-linear mechanical properties at high temperatures. Its response is controlled by exceedingly complicated and temperature-dependent characteristics. Additionally, the constituent materials, such as aggregates, have a big impact on the reaction. The stress-strain curve has been attempted to be traced using rheological and mathematical methods. It has been challenging to incorporate all the influencing aspects in the mathematical model, nevertheless. In this research, the issue is examined using artificial neural networks, a novel programming paradigm. A feed forward network and a back propagation algorithm are used to record the material's stress-strain relationship. The neural networks for uniaxial behavior prediction.

V. K. R Kodur [4] Describe For use in fire resistance calculations, High-strength concrete's (HSC) pertinent thermal characteristics were established as a function of temperature. These characteristics comprised the plain and steel fiber-reinforced concrete's thermal conductivity, specific heat, thermal expansion, and mass loss, which was constructed of siliceous and carbonate aggregate. Equations expressing the values of the thermal characteristics as functions of temperature in the range of 0 to 1,000°C are used to present the thermal properties. Discussion is had on how the temperature affects the HSC's thermal conductivity, thermal expansion, specific heat, and mass loss. According to test results, the kind of aggregate has a substantial impact on the thermal characteristics of HSC, but the presence of steel fiber reinforcing has a negligible impact.

Panellvan Janotka [5] Explain how the Temelin (Czech Republic), Mochovce (Slovakia), and Penly (France) nuclear power plants' experimental investigation into the thermo-mechanical properties of concrete revealed structural integrity degradation between 100 and 200 °C due to both a loss of water bound in hydrated cement minerals and subsequently air void formation. The findings of the tests show that Mochovce specimens subjected to temperatures as high as 400 °C experienced changes in strength, average pore radius, and computed permeability coefficients. It illustrates that the permeability coefficient calculated using a mercury intrusion porosimeter based on pore diameters is an appropriate method for assessing the quality of concrete.

J. McCarter [6] Describe the sensor system used in a previous laboratory study [Chrisp TM, McCarter WJ, Starrs G, Basheer PAM, Blewett J. Depth related variation in conductivity to study wetting and drying of cover-zone concrete. Mag Conc Res 1995:47(172):243-51; McCarter WJ, Emerson M, and Ezirim H. Properties of concrete in the cover-zone: developments in monitoring techniques. To determine the spatial distribution of electrical conductivity inside the cover-zone of concrete specimens subjected to a variety of natural exposure circumstances, Cem Conc Comp 2002; 24(5):415-27] is utilized. The testing approach allows for in-situ electrical conductivity monitoring, and technical concerns with regard to site measurements are highlighted. Since the electrical conductivity of the cover Crete vary with time, depth, and environment, the experiment also emphasizes the necessity for ongoing monitoring of the system.

Zdenek P. Bazant [7] Describe For the effects of temperature (not exceeding 100°C), the previously proposed micro restress-solidification hypothesis for concrete creep and shrinkage is generalized. The solidification model distinguishes between the chemical aging of the material, which is brought on by cement solidification and is defined by the development of the volume fraction of hydration products, and the viscoelasticity of the solid ingredient, the cement gel. This allows for the non-aging assumption of the viscoelastic component. Two transformed time variables based on the activation energies of hydration and creep identify the temperature dependency of the rates of creep and volume increase.

Venkatesh Kodur [8] Describe how understanding high temperature thermal characteristics is essential for assessing how concrete buildings will react to a fire. This study examines how temperature affects the thermal characteristics of several high-strength concrete (HSC) kinds. For three different forms of concrete—HSC, self-consolidating concrete (SCC), and fly ash concrete (FAC)—specific heat, thermal conductivity, and thermal expansion are tested in the temperature range of 20 to 800 °C. Investigation is being done into how steel, polypropylene, and hybrid fibers affect the thermal characteristics of HSC and SCC. In the 20–800°C temperature range, experiment results indicate that SCC has greater thermal conductivity, specific heat, and thermal expansion than HSC and FAC. Utilizing test data, simpler relationships for expressing various thermal parameters as a function are developed.

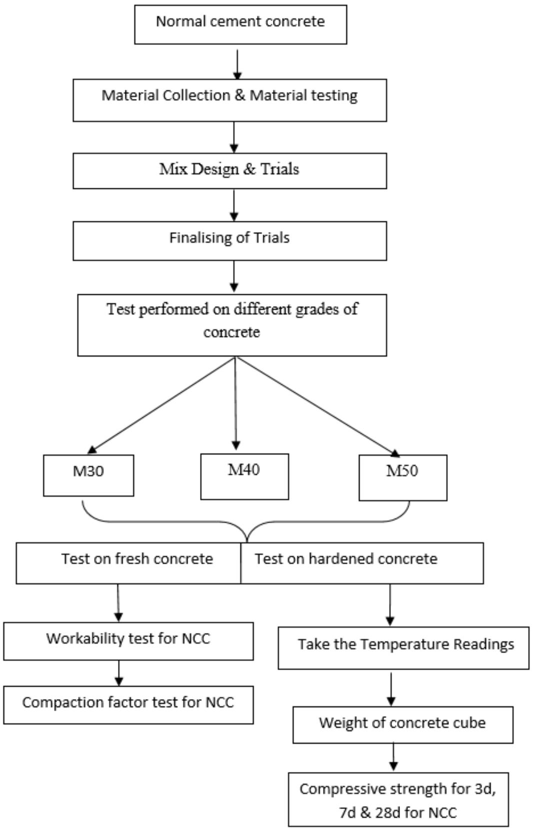
N.J. Carino [9] Describe the maturity method is a technique to account for the combined effects of time and temperature on the strength development of concrete. The technique offers a comparatively straightforward way for determining accurate estimations of in-place strength during construction. The research on concrete steam curing that was done in England in the late 1940s and early 1950s can be linked to the invention of the technology. The Federal Highway Administration's attempts to export technology have rekindled interest in the technique in the United States. The goal of this essay is to discuss the fundamental ideas that underlie the approach and to describe how it is used. The National Institute of Standards and Technology (formerly the National Bureau of Standards) research is the main subject of the evaluation. Background: A number of events led to the development of the maturity technique.

3. PROBLEM FORMULATION

3.1 General: -

The purpose of this study is to comprehend how temperature variations impact concrete's early growth strength. The research specifically attempts to explore how various temperature conditions affect concrete's capacity to endure compression and transport weights. Studying how temperature changes affect the compressive strength of concrete during its early maturation stage is part of the problem formulation process. The initial days following the concrete's pour are referred to as the early maturity period because during this time the concrete goes through major changes and strengthens quickly. The study intends to find crucial temperature ranges that can significantly alter the strength of the concrete by analyzing the link between temperature and concrete strength. By using this information, building procedures may be improved, long-term durability, and safety of concrete structures.

3.2 Flow of Work: -



3.3 Cases Considered

The project considers three different cases, each representing a specific grade of concrete

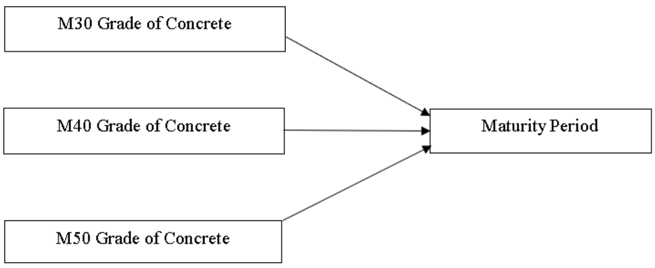


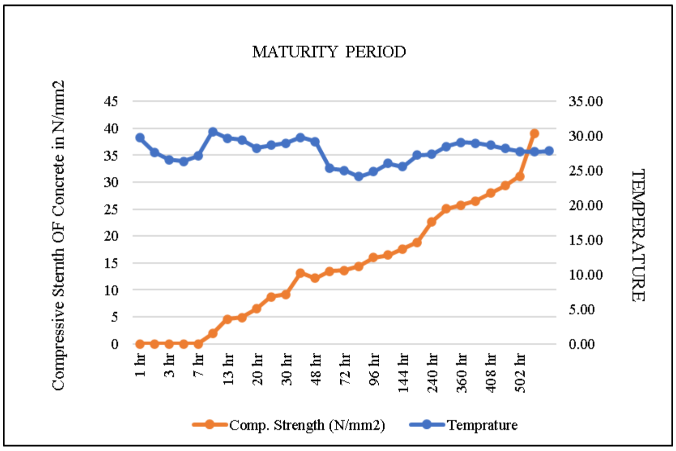
Fig. Cases considered in Project

4. RESULTS

The current project work is from first initial setting time number of maturity period trials are decided up to 28 days the temperatures are noted. For noting the temperature three sensors have been used which are embedded in the three different cubes as shown in the picture. Average of the temperature is calculated accordingly the three cubes at each and every maturity period is loaded under compressive strength and compressive strength of concrete is noted for cube trials for each and every maturity period which are been decided

Variation of compressive strength against maturity period for M30 grade.

1. Effect of different loading on deformation.



G1- Vvariation of temperature vs compressor strength during maturity period of concrete is plotted for M30 grade of concrete

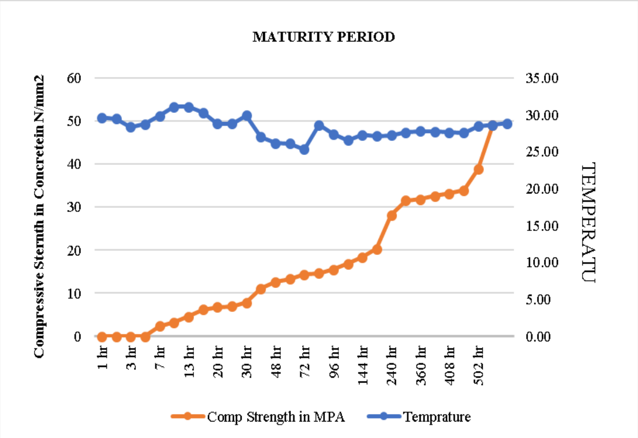
Observations:

From the above graph following points are noted.

1. The temperature of the cube rises slowly between 5 degrees to 30 degrees. During the initial Maturity period Slight variation is observed, particularly at 48hrs.
2. From 48 hours there is Continuation of variation is observed till 240 hours. There is slight change in the Meddle temperature is observed up to 402 hours (no of days).
3. The current temperature varies regarding concrete; concrete cube loses temperature initially up to 20 hours from initial setting time. Thereafter it is observed that slight increase in the temperature and thereafter again temperature reduces up to 240 hours and slight increase in temperature which contains up to the last 22 days.
4. From this graph it is noted that though the temperature is reducing, strength is increasing for medium maturity period

International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 10 Issue: 11 | Nov 2023 www.irjet.net p-ISSN: 2395-0072

4.1 Variation of temp vs compressive strength of concrete for M40 grade.



G2- variation of temperature vs compressor strength during maturity period of concrete is plotted for M40 grade of concrete

Observations:

From the above graphs following points are noted.

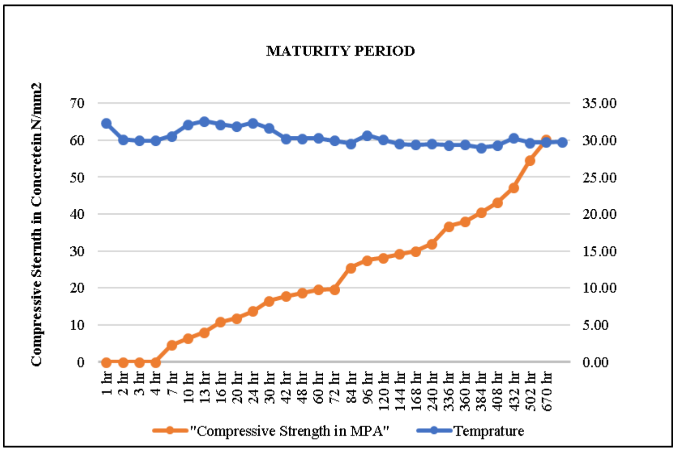
1. Compressive strength increases up to 30 hours and there is a slight change in slope. That increase continues increasing up to 160 hours and thereafter a sudden increase in the compressive strength which we observe up to 28 days.

2. Compressive strength variation is observed periodically in maturity hours. Like the M30 grade of concrete, the temperature varies from initial setting time it is increasing up to 16 hours then there is a slight decrease of temperature is observed, then little bit increases again decrease it's observed.

3. After 48 hours the temperature almost remains constant, But at the same time strength of concrete is increasing on this continue after the final maturity.

4. The variation of temperature after 72 hours is noted on a graph of M40.

4.2 Variation of temp vs compressive strength of concrete for M50 grade:



G3- Variation of temperature vs compressor strength during maturity period of concrete is plotted for M50 grade of concrete.

Observations:

From the above graph following points are noted.

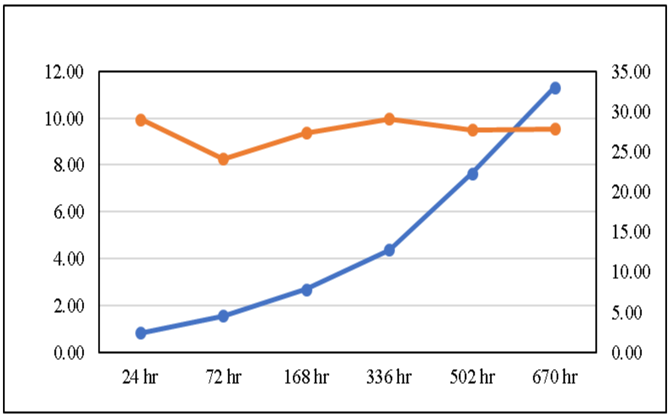
1. M50 grade of concrete from the graph 3) is noted that there is a refinement graph in compressive strength as well as temperature variation Is observed as compared to M40 and M30 grade.

2. In M50 grade of concrete compressive strength, having increasing slope up to 72 hr. maturity period. And thereafter slightly change Slope a little bit Mild Slope is there up to 30 to 40 hours. And there is a slight increase in steep slope in the last period of maturity, it is observed Related to compressive strength.

3. In temperature there is smoothness observed initially again during the Initial setting time there is variation like M30, M40 grade but after Initial setting time the rising temperature continues up to the 20 hours and there is decrease in temperature and the practical temperature remains same up to final Maturity.

4. So, from the M50 grade of concrete is observed after 42 hours, The temperature variation is almost practically zero, then the strength is increased.

5.5 M30 tensile strength and temperature data:

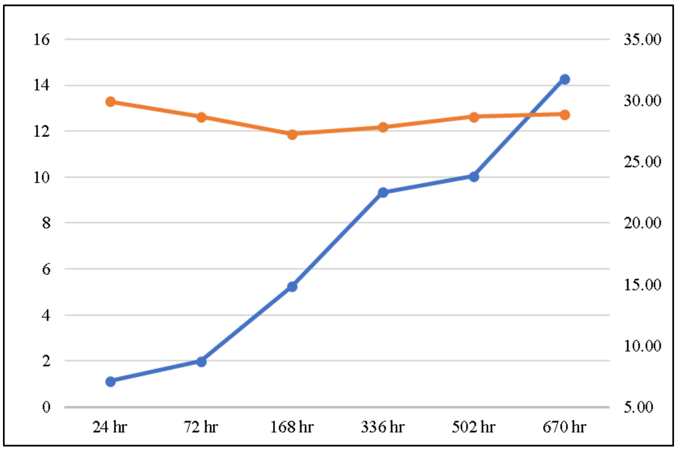


G4- Tensile strength and temperature against maturity period for M30 grade of cylinder

<u>Observations:</u>

From the above graph following points are noted.

5.6 M40 tensile strength and temperature data:



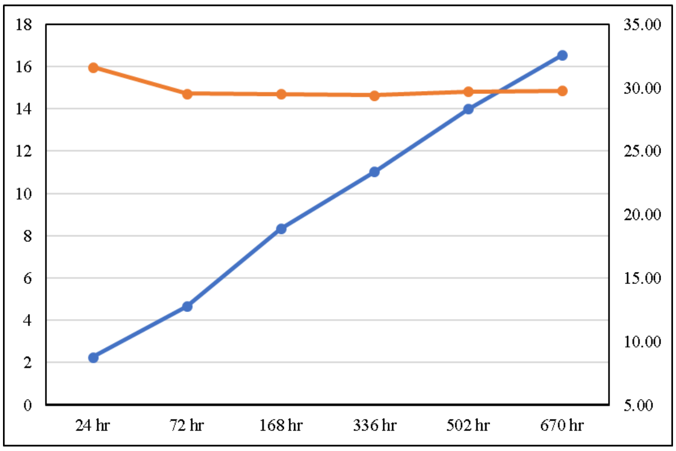
G5- Tensile strength and temperature against maturity period for M40 grade of cylinder

<u>Observations:</u>

From the above graphs following points are noted.

In this graph it shows there is slowly increase in the tensile strength and there is steep slope is developed up to 168 hr. and then increase is shows in the temperature.

5.7 M50 tensile strength and temperature data:



G6- Tensile strength and temperature against maturity period for M50 grade of cylinder

<u>Observations:</u>

From the above graphs following points are noted.

In this graph it shows there is rapid increase in the tensile strength and there is decrease slope is developed and it goes straight which is shows in the temperature..

5. CONCLUSIONS

In conclusion, the study examined the relationship between temperature and concrete properties for various grades of concrete (M30, M40, and M50). The heat generated during the cement-water reaction was found to cause surface cracking in mass concreting, posing a risk to concrete integrity. Lower-grade concrete showed slight variations in temperature during early maturity due to lower cement content, while M40 grade exhibited smoother temperature changes after 72 hours. Higher-grade concrete demonstrated a slight increase in temperature during initial maturity, leveling off with almost constant temperatures until the end of the maturity period. The compressive strength of concrete was influenced by temperature variations, with lower-grade concrete experiencing fluctuations in strength up to 48 hours. In moderate-grade concrete, strength variations continued after notable maturity periods, with a sudden increase in strength up to the second last maturity stage. For higher-grade concrete, variations in strength were refined during the initial 72 hours. Additionally, temperature variations affected the tensile strength, with M50 grade showing higher strength due to proper mixing and strength increasing over time. Overall, the study highlighted the significance of temperature control during concrete production and its impact on the resulting properties.

REFERENCES

[1] Rostasy, F. S., U. Schneider, and G. Wiedemann (1979) "BEHAVIOUR OF MORTAR AND CONCRETE AT EXTREMELY LOW TEMPERATURES" Cement and Concrete Research 9, no. 3 (1979): 365-376

[2] Carino, Nicholas J., and Hai S. Lew. (2001) "THE MATURITY METHOD: FROM THEORY TO APPLICATION." In Structures 2001: A structural engineering odyssey, pp. 1-19. 2001

[3] Kodur, V. K. R., and M. A. Sultan (2003) "EFFECT OF TEMPERATURE ON THERMAL PROPERTIES OF HIGH-STRENGTH CONCRETE." Journal of materials in civil engineering 15, no. 2 (2003): 101-107

[4] Panellvan Janokta (18 Nov 2004) "EFFECT OF TEMPERATURE ON STRUCTURAL QUALITY OF THE CEMENT PAST AND HIGH-STRENGTH CONCRETE WITH SILICA FUME".

[5] McCarter, W. John, and Øystein Vennesland (2004) "SENSOR SYSTEMS FOR USE IN REINFORCED CONCRETE STRUCTURES." Construction and Building Materials 18, no. 6 (2004): 351-358

[6] Khaliq, Wasim, and Venkatesh Kodur (2011) "THERMAL AND MECHANICAL PROPERTIES OF FIBER REINFORCED HIGH PERFORMANCE SELF-CONSOLIDATING CONCRETE AT ELEVATED TEMPERATURES." Cement and Concrete Research 41, no. 11

[7] Shoukry, Samir N., Gergis W. William, Brian Downie, and Mourad Y. Riad (2011) "EFFECT OF MOISTURE AND TEMPERATURE ON THE MECHANICAL PROPERTIES OF CONCRETE." Construction and Building Materials 25, no. 2 (2011): 688-696.

[8] Naik, Tarun R., Rakesh Kumar, Bruce W. Ramme, and Fethullah Canpolat (2012) "DEVELOPMENT OF HIGH-STRENGTH, ECONOMICAL SELF-CONSOLIDATING CONCRETE." Construction and Building Materials 30 (2012): 463-469

[9] IS 456-2000

[10] M.S. SHETTY