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Modern Construction Techniques on Concrete In Extreme Weather Conditions

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Abstract: — In the modern world, new techniques are being introduced in the field of civil engineering that makes construction simple and quick. Therefore, in accordance with our proposal, we are talking about concrete construction methods for adverse weather. Our project's primary focus is the distinction between typical concreting and extreme weather conditions. When the strength of a regular concrete block was tested in a lab, it passed with good strength; however, when concrete is applied to a building site or other structure, its strength is lowered. The atmospheric situation is to blame for this. When the block is evaluated in a lab, the influence of the atmosphere is either nonexistent or little, so the concrete has high strength. However, when the block is applied to a building, the influence of the atmosphere is significant, thus the strength of the concrete is decreased. We, therefore, learned from this matter about the many issues that concrete construction can meet due to atmospheric conditions.

Keywords: Modern Construction Techniques, Extreme Weather Conditions, Strength, Workability

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Introduction

These are the two main categories of extreme weather: hot and cold. These two conditions have a negative impact on the concrete-making environment and have an impact on the strength of the concrete. Hot weather and cold weather are the two conditions under which concreting is carried out [1]. The removal of moisture from the concrete block during hot weather concreting is difficult because of the temperature rise. This major issue is what is causing concrete's strength to decline. Second, cold weather concreting, also known as concreting, is carried out. It is highly challenging to manage the concreting process in this situation because the temperature drops, reducing the concrete's setting time. This makes it challenging to manage the concrete mix and apply the concrete on the construction site. These are the two issues that develop as a result of temperature changes. In order to counteract the effect and reach a safe and acceptable strength, we explore the influence caused by temperature fluctuations in this project [2].

A. Definition of Hot Weather Concreting

The quality of concrete depends on the condition of the site when the site temperature is more than 77 degrees Fahrenheit it greatly affects the quality of concrete. It can be challenging to produce high-quality concrete when the surrounding temperature is above 90 degrees Fahrenheit and there is no protected area for placing and completing the concrete [3]. The surrounding of concrete plays a major role in the placement and particular use of concrete. In order to overcome the aforementioned effect, the temperature should be minimized if site temperatures are greater than 77 degrees Fahrenheit [4].

B. Definition of Cold Weather Concreting

In the case of cold weather concreting careful evaluation should be done because cold weather concreting is a widespread and essential procedure. According to ACI 306, "where the air temperature has fallen to or is likely to dip below 40 degrees Fahrenheit during the protection period," is the definition of cold weather concreting given by the current American Concrete Institute [5]. This definition can result in issues with concrete freezing at a young age. First and foremost, no concrete should be exposed to freezing temperatures until it has acquired a minimum compressive strength of 500 psi, which usually occurs during the first 24 hours. Additionally, the following general concerns should be taken into account whenever the air temperature is below 40 degrees Fahrenheit at the time of concrete placement, and freezing temperatures within the first 24 hours of placement are excluded:-

- Recognition of Initial concrete temperature.
- Protection should be kept while concrete is placed, consolidated, and finished.
- Curing temperature to obtain good quality concrete.

C. Effect of hot and cold weather in concreting

In accordance with IS:7861, it is not advised to pour concrete at temperatures over 40°C and below 5°C. The hot weather concrete is covered in IS 7861 Part 1, while the cold weather concrete is covered in IS:7861 Part 2.

The preparation, placing, and curing of the concrete all present unique challenges. In hot weather, a high temperature causes the hydration of cement quickly, the requirement for mixing water to increase, the evaporation of mixing water, and huge volume changes that result in cracks. The effects of hot weather on concrete are made worse by a variety of circumstances, including the use of cement that set quickly and the handling of greater batches of concrete [6].

Concrete production in cold climates brings about unique and peculiar issues that do not exist while producing concrete in climates with average temperatures. In addition to the issues with cement concrete setting and hardening, concrete that is still in the plastic stage may suffer serious damage if exposed to low temperatures, which causes ice lenses to form and pore structure expansion [7]. Therefore, it is crucial to maintain the concrete's temperature above a certain point before it is poured into the formwork. With the aid of an appropriate insulating technique, concrete can be held above a particular temperature after placement before the covering is removed. Special methods must be used to cure the concrete while it is in the formwork or after it has been removed during times of low ambient temperature. Cold weather concreting refers to any construction activity carried out when the outside temperature is below 5 degrees Celsius. A specific precaution should be taken when pouring concrete in cold weather, according to IS:7861 (part 2) [8].

II. MATERIALS AND METHODS

A. *Process of handling concrete in hot weather conditions*

There are following measures or procedures are adopted during the preparation of concrete:-

Unfavorable site conditions may affect the quality of the concrete when the freshly mixed concrete has a temperature of more than 77 degrees Fahrenheit. It may be typical to manufacture high-quality concrete when there isn't a covered area for pouring and finishing concrete when the temperature is above 90 degrees Fahrenheit. Liquid nitrogen can be used as one technique to reduce the temperature of concrete during hot weather construction. Depending on the particulars of the concrete installation process and the purpose for which the concrete will be operated, various safety measures will need to be followed to ensure quality and product. Necessarily, if the temperature will be higher than 77 degrees Fahrenheit while the concrete is being placed, an objective should be established to lessen the effects of the high temperature. The following warning might be appropriate:

- Prior to placing concrete, perform a moist subgrade test, install steel reinforcement, and prepare forms.
- Put up temporary sunshades and windbreaks to cool the concrete's surface temperatures.
- The addition of cool aggregates and mixing water helped to decrease the initial temperature of the concrete mixture. Concrete's temperature is barely impacted by hot cement.
- Use concrete with a quick-setting, consolidating consistency.
- For maintaining the initial moisture of the concrete mix, the concrete surface should cover while it is being placed with evaporation retarders or plastic sheeting.
- Provide adequate labour to complete the concrete placement and finishing as quickly as possible given the hot weather.
- To increase the relative humidity and meet the ambient air's moisture needs, you can think about fogging the region above the concrete placement.
- As soon as the concrete finishing operations are finished, provide suitable curing techniques.
- Take into account altering the time of concrete pouring to benefit from cooler conditions during inclement weather, such as early in the morning or late at night.

Concrete can be laid effectively and completed to generate good-quality, long-lasting concrete while temperatures is 95 degrees Fahrenheit or greater with the right design and execution. Due to the shortened window of opportunity for placing, finishing, and consolidating concrete as well as the heightened risk of cold joints, thermal cracking, plastic shrinkage cracking, potential loss in strength because of high demand of water and high temperature at curing, air content controlling difficulty, and increased urgency, the impact of high ambient temperature and high-temperature concrete ingredients materials on the setting time of concrete mix is a very concern topic. As a rule of thumb, a concrete mixture can set up to 50% faster when the temperature is raised by 20 degrees Fahrenheit. For instance, a concrete mixture that takes 3 hours to set when the temperature is 60 degrees Fahrenheit may only take 1.5 hours to set when the temperature is 80 degrees Fahrenheit. The setting time decreases even further when concrete's temperature rises. The atmosphere at the project site, the machinery used to mixing and transporting the concrete, as well as the temperature of the various components, all have an impact on the concrete mix's actual temperature as it is delivered. Depending on the intended use, applications of concrete that are exposed to temperatures between 77 and 95 degrees Fahrenheit may be deemed hot weather concrete. Precautions need to be made well before the use of high temperatures is implemented in order to avoid these impacts. Use of a material with a record of performance in high temperature environments, cool down of concrete mixture or concrete materials, crew and equipment availability for quick placement, decrease in transport time, and placement scheduling to controlled exposure to atmospheric conditions are all examples of techniques. A plan to limit moisture loss and consideration of the use of an evaporation retarder are some precautions that may be taken as well. Set up a pre-construction meeting with each party to discuss the plan for reducing the consequences particular to the project [9].

B. Process of handling concrete in hot weather conditions

When a mix of the concrete is defined, designed, or opted, or when specimens of concrete are kept and experimented in the laboratory, the weather conditions at the project site may differ significantly from the ideal settings. It could be warm, windy, dry or humid, etc. Concrete can be poured in the winter as long as the necessary precautions are followed to lessen the impact of the less ambient temperature. According to American Concrete Institute ACI 306, "cold weather concreting" is "a time where for more than three consecutive days the average daily air temperature dips below 40 Fahrenheit and remains below 50 degrees Fahrenheit for more than one half of any 24-hour period." With time, this definition might associate problems with fresh concrete freezing. Till attaining a minimum strength of 500 psi the concrete must be kept at freezing completely which normally takes 24 hours. Concrete that freezes while wet or before it has established the capacity to withstand the stresses of the expanding water may convert to ice. All of the examples were cast in steel moulds with lubricated contact surfaces before concrete was poured to prevent adherence [10].

C. Test Specimens

According to ASTM C 192-90a, a minimum of three cylinders required to be tested at 1, 3, and 28; hence, the cylinders of having size 6 in. x 12 in. were cast for testing of compressive strength. The splitting tensile strength of three specimens was tested using 6 in. x 12 in. test cylinders at ages 1, 3, and 28. Prisms of the dimensions 4 inches by 4 inches by 20 inches were cast to test the modulus of rupture, and the broken specimens were also put to the test for equivalent cube strength[11].

Fig. 1. *Manufacturing of concrete by hand mixing in Lab*

Fig. 2. *Moulding of concrete cubes*

The main aim of the study/research, namely the impact of harsh weather (temperature) on freshly laid concrete during the first three days on various concrete qualities, i.e.

- Compressive Strength
- Workability (Slump test)
- Compacting factor
- Modulus of Rupture
- Splitting tensile strength
- Equivalent cube strength

Compressive Strength: The strength of concrete in compression is governed by the proportions of cement, sand coarse aggregates, water, and other admixtures. Figure 1 shows that water to cement ratio is the key factor of concrete strength. As the water-to-cement ratio falls, the compressive strength rises. The appropriate chemical action in the hardening of concrete requires a specific minimum amount of water; the addition of more water increases the workability (how readily concrete flows), but decreases strength. A slump test produces a workability measurement. The absolute strength of the concrete in a construction site is significantly impacted by techniques of quality control for installation and inspection. In the US, the strength of concrete is determined by performing the compressive strength test of cylindrical moulds having size 6 inches in diameter and 12 inches in height on the 28th day after they are made and went through proper curing.

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Fig. 3. *Curing of Concrete cubes for compressive strength*

Workability (Slump test): Use a slump test to determine concrete's consistency. Its consistency tells us how stiff the mixture is or how much water has been added. The stiffness of the concrete mixture should be in accordance with the specifications for the quality of the finished product. Using the concrete slump test, a property of freshly poured concrete is determined. It is an empirical test that evaluates the ease of working with new concrete. It provides a more precise measurement of uniformity between batches. The test is popular since it requires simple equipment and a simple process. The results of the slump test serve as a predictor of the behavior of a compacted, inverted concrete cone when it is subjected to gravity. It evaluates the concrete's consistency or dampness.

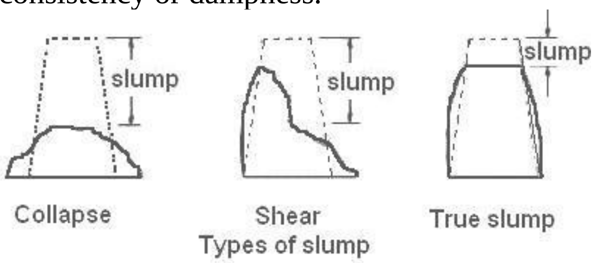

Fig. 4. *Types of slump*

Fig. 5. *Slump Test*

Modulus of Rupture Test: According to test results, samples made at room temperature displayed greater tensile strength on day 28 than samples made at high temperatures. When compared to the samples, the samples with admixture demonstrated a larger modulus of rupture. Which were free of admixtures. The values of the rupture modulus of concrete are thus significantly influenced by temperature changes.

Tensile Strength Test: To find out how temperature affects the material's tensile strength, concrete underwent a splitting tensile strength test. It was found that as the temperature increases, the tensile strength increases right away, but after 28 days, it decreases, much as it did with compressive strength. The tensile strength, on the other hand, progressively increases at low temperatures, but by 28 days, it is discovered to be completely normal and even higher. At high temperatures, the 28-day tensile strength of the mixture AR-340 has reached a level where it nearly equals the sample strength at room temperature. Sodium nitrite initially produced significant gains, but its 28-day tensile strength was lower.

III. RESULTS AND DISCUSSIONS

A. *Compressive Strength Test Results*

The proportions of cement, fine and coarse aggregates, water, and other admixtures influence the strength of a concrete mix. Figure 1 illustrates how the main factor affecting concrete strength is the ratio of water to cement. The compressive strength increases with a decreasing water-to-cement ratio. Since the right chemical action in the hardening of concrete requires a specific minimum quantity of water, the addition of more water increases the workability (how readily the flow of concrete occurs) but decreases strength. The slump test is performed to determine workability. The quality control techniques for placement and inspection have a considerable impact on the absolute strength of the concrete used for the construction of the building. In the US, the strength of concrete in compression is tested by performing a compression test on cylindrical moulds a size 6 inches in diameter and 12 inches in height and kept for 28 days for curing.

TABLE I. **STRENGTH OF NORMAL CONCRETE**

Grade of Concrete	Compressive Strength In 7 days (In N/mm^2)	Compressive Strength In 28 days (In N/mm^2)
M-15	10.0	15.0
M-20	13.5	20.0
M-25	17.0	25.0
M-30	20.0	30.0
M-35	23.5	35.0
M-40	27.0	40.0
M-45	30.0	45.0

Effect of Compressive Strength: It was noted that the first three days after casting saw strong early strength as a result of the high temperature, but after one week the situation drastically reversed. In comparison to specimens made at room temperature, those made at low temperatures (8°C) showed a modest increase in one-day compressive strengths. In comparison to cylinders placed at room temperature, those placed at a higher temperature (50°C) quickly increased their one-day strength by roughly 25%. Up until the three-day strength, this situation persisted, but at the 7-day level, everything changed. The 7-day strength of the specimens made at higher temperatures was lower than that of specimens made at ambient temperature (25°C). However, those exposed to low temperatures began to recover by the seventh day, and their strength was nearly equivalent to that of those kept at normal temperatures.

In comparison to cylinders formed at ambient temperature, the compressive strength of cylinders placed at high temperatures over the first three days had significantly decreased by day 28. Due to a high early three-day temperature, there was a loss in compressive strength of roughly 17.5% over 28 days. However, cylinders that were cured at low temperatures eventually recovered and appeared to have more strength than cylinders that were formed at room temperature. Admixtures for high and low temperatures appear to have certain advantages. The introduction of the admixture AR-340 has decreased 28-day strength loss caused by high temperatures. Similar to this, the intensity of the sodium nitrite admixture increased initially but decreased after 28 days. This discrepancy could be the result of a dosing issue. Hope that further research will be able to resolve this. The results of the equivalent cube test, which measures compressive strength, follow a similar pattern to the results of cylinder testing. Values from cube tests are low since a cylinder's strength is typically 0.8 times that of a cube.

TABLE II. STRENGTH OF HOT CONCRETE

TABLE III.

B. Workability (Slump cone) Test Results

Grade of Concrete	**Compressive Strength In 7 days (In N/mm^2)**	**Compressive Strength In 28 days (In N/mm^2)**
M-15	**8**	**10**
M-20	**9.5**	**13**

S.NO	**Type of work**	**Slump (in mm)**	**Ratio of W/C**
1.	Concrete for Road Purpose	25 -50	0.70
2.	Concrete for RCC Beam	52-100	0.55
3.	Column and Retaining wall	71-125	0.45
4.	Mass Concrete in Foundation	25-50	0.70

TABLE IV. **SLUMP VALUE OF NORMAL CONCRETE**

Three crucial considerations for managing construction projects in hot weather were identified by the data and analyses. These three are labour force, experience (local knowledge), and forward planning. As seen in the UAE, hot weather construction may be managed without impacting project handover deadlines. The heated weather conditions, as mentioned by Interviewee C, illustrate the management and planning issues that occur and may go ignored throughout the completion of a project. It's crucial to schedule site activities in advance and arrange them according to the lessons discovered from managing projects in such extreme temperatures in order to decrease labor-intensive duties throughout the summer. By controlling the labor-ship to be feasible in changing shifts and work during night shifts, this is accomplished. On paper, scheduling these duties can seem simple, but as the respondents noted, leading a sizable crew on a big project can be a difficult and complicated endeavor

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