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HOT WEATHER CONCRETE: A REVIEW PAPER ON CONCRETING IN HOT TEMPERATURE

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ABSTRACT

The temperature of the weather has a great effect on the hardening and strength acquisition of fresh flexible concrete. The rate of hardening of concrete increases at higher temperatures, The temperature of 15°C to 40°C is considered best for concreting. This temperature is often found in the plains region of India. But very high temperature found in deserts. It is necessary to take some precautions while working concrete at temperatures above 40°C or below 4.5°C.

Keywords: Hot Weather Concrete, Effects Of Hot Weather On Concrete, Precautions While Concreting In Hot Weather, Concreting In Hot Temperature.

I. INTRODUCTION

When the temperature at the construction site is above 40°C at the time of placing the concrete, it is taken under hot weather concreting. However, high temperature bonding is not considered when the concrete curing is adopted by steam. The strength, dimensional stability, weather resistance etc. of concrete are affected by hot weather, low humidity and strong winds. To make concrete easier at higher temperatures, additional water has to be added and more care has to be taken in pouring the concrete. Have to keep Concrete work should be stopped in extremely hot weather. in place of peak noon It is better to pour concrete in the evening or at night. Concrete mixing work as far as possible It should be done under a covered place only.

1.1 Effects of Hot Weather on Concrete:

High temperature has the following effects on concrete-

(i) Accelerated setting,

(ii) Reduction in Strength,

(iii) Tendency to Cracks,

(iv) Evaporation of Curing Water

1. Acceleration of setting action - Temperature has a direct effect on the hydration action of cement. Concrete starts setting quickly at high temperature, due to this very less time is available for the activities of mixing, hauling, laying, crushing etc. and these activities are not done properly. If concrete hardens too quickly, water may need to be added several times to make it workable. This adversely affects the quality of concrete.

2. Reduction in Strength - At higher temperatures, more water has to be added to make concrete easier, due to which the strength of concrete decreases. At high temperatures, the strength of concrete increases rapidly for the first day or two, but this rate decreases significantly during the subsequent days. The formation of jelly formed under hydration of cement at high temperature is also of low level.

3. Probability of cracks - Due to high temperature, the moisture on the upper surface of the concrete dries quickly, while the moisture remains in the inner part. Due to this partial hardening, the possibility of occurrence of shrinkage cracks in the concrete mass increases. During subsidence, cracks may develop in concrete even after the concrete cools down from its initial high temperature. These cracks become difficult to close later.

4. Rapid evaporation of Curing water – Curing water evaporates quickly at high temperature, hence more water is required. This increases the cost of pouring concrete. There is also a problem in maintaining the same temperature of concrete in curing period.

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1.2 Controlling Temperature of Concrete Ingredients :

The simplest way to reduce the temperature of concrete is to control the temperature of its components- cement, adaggregate and water. Mixing in it and controlling the temperature of water is more effective and also easier. Normally stored cement is pre-cooled. Therefore, before starting the concrete work in hot weather, the temperature of the mixed and water is reduced.

(a) Reducing the temperature of the aggregate - To reduce the temperature of the aggregate, the following measures were taken. –

(i) Fine and thick aggregates should be kept under a tree or shed.

(ii) The temperature should be reduced by pouring cold water on the hot aggregate. While sprinkling water, it should be kept in mind that the water should be poured evenly on the entire pile.

(iii) While applying the mortar in hot weather, water should be sprinkled on its different layers. Due to this, the inner part of the aggregate remains cool.

(iv) Refrigerated water can be circulated in large works by laying pipes in the aggregate piles.

(b) Reducing the temperature of water—The temperature of the water added to the concrete mix has a big impact on the temperature of the concrete. For a 2°C difference in the temperature of water in concrete, there is a difference of about 0.5°C in the temperature of the concrete. The relative heat of water is 45 to 5 times that of cement and admixture. Then it is easier to control the temperature of water than to mix it. The amount of water added to concrete is also much less than other ingredients. The following points are important regarding water temperature control-

(i) As far as possible, cold water should be arranged for the concrete mix and it should be protected from strong sunlight.

(ii) Water storage tank and pipes should be covered with heat-insulating material or heat-insulating paint should be applied on them.

(iii) Water tankers should also be insulated.

(iv) Before mixing water in concrete on important works, it should be cooled by putting crushed ice in it. Ice absorbs 80 kcal of heat per kg due to its internal latent heat. But before crushing the concrete, the ice should be completely melted in the water, otherwise the pore space in the concrete remain, which affect its quality. To prevent rise in temperature of concrete in bulk works like dams, tunnels etc. for this, copper pipes are laid in the concrete block and salt solution is made to flow through them.

1.3 Precautions while Concreting in Hot Weather: In the preparation and laying of concrete at a temperature higher than 40°C, the setting and hardening rate of cement definitely increases, but the ultimate strength decreases greatly. Fresh concrete should be protected from direct sunlight and dry air. In extremely hot weather, concrete work should be stopped if possible. It is better to pour concrete at night than to work in the hot afternoon.

Following are the necessary precautions before pouring concrete, at the time of pouring and at the end of the work.

1.3.1 Precautions before pouring concrete: On hydration of cement, heat is generated from it. If the weather is also hot at the time of concreting, the concrete overheats and the water demand of the concrete increases. By using low heat cement and retarders for concrete, the effect of high temperature can be reduced or neutralized. High temperature can be controlled by the following measures before concreting

(i) The hot mixture should be cooled by sprinkling water. if the water temperature If it is more, it should also be cooled and poured into concrete.

(ii) Mixing of concrete should not be done more than necessary, because the energy of mixing And the temperature of concrete increases due to the heat of the sun.

(iii) The body of the mixer should be protected from overheating. Due to the yellow or white color of the mixer, it absorbs less external heat.over the drum It is kept cool even by sprinkling water.

(iv) After mixing, the concrete should be taken to the place immediately and laid, because The temperature of concrete increases on hydration

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1.3.2 Precautions while pouring concrete- While pouring concrete, its temperature should not exceed 40°C. Before laying concrete in hot weather, it should be cooled by sprinkling water on the inner surfaces of reinforcement steel and formwork. Its temperature can be reduced by sprinkling water on the construction site. This also reduces the evaporation of concrete water. In order to prevent evaporation of concrete water in hot weather, concrete work should be started in the same area, which can be completed as soon as possible. This maintains the workability of the concrete. This should be taken care of in road construction, otherwise there is a possibility of waves on the road surface. Such a method should be adopted in laying concrete so that the concrete remains cool. If the temperature at the work site is out of control, then it is better to pour concrete at night instead of during the day.

1.3.3 Precautions after concreting – If the concrete is drying fast due to high temperature, then after completing the crushing of concrete immediately, it should be damped with tarpaulin, mat or wet sack. This reduces the evaporation of concrete. Efforts should be made that the temperature of the concrete should not increase during its hardening. When the concrete is set, its pouring should be started after about 12 hours. Curing should be done evenly and continuously. On repeated wetting and drying of incomplete curing or concrete, cracks start appearing on its surfaces. Settling period depends on the type of concrete and the condition of the work; Never the less, Curing must be continued for 10 days. Special attention should be paid to the curing on the sloping surfaces. Water should be poured from above even on the decree. Systematic curing should be started on the surfaces where the compaction has been opened. After the pouring is complete, the concrete surfaces should be protected from direct exposure to fast moving dry air. The gunny bags/sacks etc. laid/put for curing should not be removed as long as moisture remains in them. By removing them immediately, the concrete surface is suddenly exposed to dry air, which is not suitable for curing.

1.4 Use of Retarders: In hot weather, retarders are added to concrete to prolong the setting time of cement. Concrete remains workable for a long time by the use of retarders. In hot areas where the rate of setting of concrete is very fast, so that more time is available for carrying out the concreting operations.

1.4.1 Admixture- The following substances are used as diluents-

(i) At the time of final grinding of cement, 2 to 3% gypsum is added to it. The addition of gypsum (calcium sulphate) in excess has an undesirable effect on cement.

(ii) Sugar: ts quantity is taken as 0.2% by weight of cement. it is an effective retarder

(iii) Starch.

(iv) Sodium bicarbonate, ammonium chloride, calcium ligno-sulphate. Retardants are available in the market under various trade names.

II. LITERATURE REVIEW

There are many research references that we can pick up on to help our review thesis on the Hot Weather Concrete and Concreting In Hot Temperature.

The review work mainly is based on these reports. There are many papers which are as follows:

2.1 Initial and final setting time of concrete in hot weather B. H. Ahmadi October (2000)

Initial and final setting time of concrete tests were conducted in hot weather. The effect of field temperature, relative humidity, wind velocity, and admixture on setting time of concrete were studied. Two correlations based on a single OPC for predicting the initial and final setting times of concrete in hot weather were developed.

2.2 Importance of Concrete Temperature Control During Concrete Pavement Construction in Hot Weather Conditions Anton K. Schindler and B. Frank McCulloughView all authors and affiliations Volume 1813, Issue 1 (2002)

The development of high concrete temperatures could cause a number of effects that have been shown to be detrimental to long-term concrete performance. High concrete temperatures increase the rate of hydration, thermal stresses, the tendency for drying shrinkage cracking, and permeability and decrease long-term concrete strengths and durability as a result of cracking. Data from the Texas Rigid Pavement database were analyzed to reveal whether there are increased numbers of failures as the air temperature at placement increases. It was shown that this was the case for both major coarse aggregate types: limestone and siliceous river gravel. The results of the analysis emphasize the importance of concrete temperature control during concrete pavement construction in hot weather conditions. Most states specify a maximum concrete temperature at placement to mitigate the detrimental effects of placement during hot weather. The specified limit remains the same irrespective of the type of mineral or chemical admixtures used. To produce specifications that encourage contractor innovation and the use of improved materials, modern specifications should account for these materials to ensure improved concrete performance under all placement conditions. To provide improved performance for sections paved under hot weather conditions, it is proposed that the continuously reinforced concrete pavement reinforcement standards be redesigned to provide steel quantities for specific use during hot weather conditions and that an end-result specification that limits the maximum in-place concrete temperature during hydration be implemented.

2.3 Effect of type and dosage of silica fume on plastic shrinkage in concrete exposed to hot weather Omar S. Baghabra Al-Amoudi, Mohammed Maslehuddin, Taofiq O. Abiola (2004)

The source and dosage of silica fume were varied to investigate their effect on the plastic shrinkage of concrete exposed to hot weather conditions. Highest plastic shrinkage was noted in the concrete specimens prepared with undensified silica fume. The physical properties of silica fume, such as fineness and bulk density, and microscopic properties, such as average pore radius and the total pore volume, were correlated with plastic shrinkage strains. No relationship was noted between the microscopic properties and the maximum plastic shrinkage strains. However, a good correlation was noted between the plastic shrinkage strain and the fineness and bulk density of the silica fume.

2.4 CRACK MINIMIZATION MODEL FOR HOT WEATHER CONCRETING M.H. Baluch*, M.K. Rahman, A.H. Al-Gadhib, A. Raza, and S. Zafar Department of Civil Engineering King Fahd University of Petroleum & Minerals Dhahran, Saudi Arabia (2006)

This paper addresses fundamental issues of influence of elevated temperature and moderate wind speed on mass transport properties of concrete including moisture diffusivity D and convective moisture transfer coefficient hf . Using a combined experimental–numerical approach, the influence of varying temperature T (in the range of 35°C–70°C) and wind speed ω (of maximum intensity 22 km/h) on moisture loss, moisture diffusivity, and convective transfer coefficient in concretes of three water– cement ratios is investigated. Based on this data, certain invariant functional forms are postulated for variables of interest including free shrinkage, moisture loss, average moisture diffusivity, wind speed, ambient temperature, and water–cement ratio, leading to the development of a minimum crack mix design model. Key words: Crack minimization model, hot weather concreting, high temperature and moderate winds, finite element model, moisture transport in concrete, multiple invariant forms, mix design for minimum crack.

2.5 ISSN 1747-650X | E-ISSN 1747-6518 No AccessEffects of heat and mixing time on self-compacting concrete Authors: S. Al-Martini, and M. Nehdi (2010)

The coupled effects of ambient temperature and mixing time on the slump loss of self-compacting concrete (SCC) are critical for hot weather concreting. Ordinary Portland cement concrete mixtures were made with a water/cement ratio of 0·38 and incorporating polycarboxylate-, melamine sulfonate-, or naphthalene sulfonate-based super plasticisers. The concrete mixtures were continuously agitated for up to 110 min using a low-shear rate mixer under controlled temperature ranging from 22 to 45°C. The effects of such a prolonged mixing scheme under various temperatures on the slump loss and compressive strength of concrete at ages of 12 h, 1, 3, 7 and 28 days were investigated. The results show that concrete can undergo substantial slump loss when subjected to prolonged mixing at high temperature. Knowledge of the superplasticiser effects at high temperature and prolonged mixing time is critical to achieve adequate rheological properties of concrete in hot weather. The results also indicate that the compressive strength of concrete mixtures is dependent on temperature, mixing time and superplasticiser type. The early-age strength of concrete at high temperature may be about four-fold that at moderate temperature. On the other hand, the long-term compressive strength of concrete subjected to early-age high temperature can decrease by more than 10%.

2.6 Hot Weather Comparative Heat Balances in Pervious Concrete and Impervious Concrete Pavement Systems John T. Kevern*1 , Liv Haselbach*2, Vernon R. Schaefer*(2012)

Many pavements contribute to the urban heat island (UHI) effect due to their bulk mass and heat absorption capacities. Granular ground surfaces composed of soils or sands do not contribute to the UHI effect in a similar manner. Their porous nature may lessen the effect, both with an increased insulating capacity and with an enhanced mechanism for evaporative cooling from absorbed water. Pervious concrete is a novel pavement that is being developed to aid in preventing stormwater-related environmental problems. Pervious concrete has a network of interconnected voids, which allow water exfiltration to the subbase below. Limited studies indicate that a pervious concrete surface can have more elevated temperatures than those of similar traditional impervious pavements, but also that temperatures are lower under the pavements. This study focuses on a site in Iowa where both a pervious concrete and a traditional concrete paving system have been installed and where temperatures were recorded within the systems for extended time periods. The analyses cover days with negligible antecedent precipitation and high air temperatures, which are extreme conditions for UHI impact. This paper compares the increase in overall heat stored during several diurnal heating cycles in both of these systems. These analyses include not only the temperatures at various depths, but also the heat stored based on the bulk mass of the various layers in each system and below grade.

Results suggest that pervious concrete pavement systems store less energy than do traditional systems and can help mitigate UHIs.

2.7 An Experimental Study on the Self-Consolidating Concrete (SCC) under Hot Weather and Hauling Time Samer Al Martini*, Muhammad Al Khatib (2016)

Self-consolidating-concrete (SCC) has gained wide acceptance in the construction industry given its ability to reduce construction duration and cost. All ready-mix concrete commonly used in hot weather countries, such as United Arab Emirates (UAE), is subjected to continuous agitation during hauling to construction sites. Prolonged mixing, especially at high temperatures can lead to loss of workability and increased difficulties for concrete placement and consolidation. This may result in lower mechanical and durability properties. In this paper, the mechanical and durability properties of self-consolidating concrete (SCC) under hot weather conditions were investigated. Mixing and testing were conducted outdoor at the construction material lab of Abu Dhabi University during last summer of 2014. The test results showed that the mixing time and hot weather adversely affected the fresh properties. The SCC mixtures were continuously mixed for 2 hours under a temperature ranged from 25 to 40 °C, to simulate concrete in a transit truck during transportation to a construction site under hot weather. Polycarboxylate-based high-range water-reducing admixture (PC) and fly ash were incorporated in the investigated SCC mixtures. The results showed that both the compressive strength and durability of SCC were highly affected by fly ash dosage and temperature. Keywords: Hot weather; hauling time, self-consolidating concrete.

2.8 PROPORTIONING SELF COMPACTING CONCRETE IN HOT WEATHER OF SUDAN UTILIZING LIMESTONE POWDER Yousif Hummaida Ahmed1 and Khalid Salah Eldin Babikir2 (2018)

Self-compacting concrete (SCC) is a special type of concrete able to flow and compact under its self-weight. The SCC requires high powder content (mainly of cement) up to 600kg/m3 to achieve its properties. This will be problematic if all cement content in the powder exceeded 400 kg/m3 used in hot weather of Sudan. This paper investigates addition of Sudanese limestone powder (LSP) to reduce cement content. The LSP dosages between 20% and 28 % (by cement weight) are used in six mixes having maximum cement content 380kg/m3 Results show that five trial mixes achieved the self-compactibility tested by slump flow, sieve segregation, V-funnel and U-box tests. Compressive strength of these mixes show that the LSP increases strength with dosage. Therefore, further investigations of hardened concrete properties are recommended for the successful mixes to be applied in real projects in the Sudan. Also it has been found that dry batching and forced-action pan mixers are the most suitable for producing SCC with high homogeneity compared to commercial tilted-drum mixers.

2.9 Prediction of Properties of Concrete Cured Under Hot Weather Using Multivariate Regression and ANN Models Muhammad Nasir, Uneb Gazder, Mohammed Maslehuddin, Omar S. Baghabra Al-Amoudi & Imran Ali Syed * (2020)

Concreting in hot weather poses special problems, and the properties of concrete are significantly influenced by mix parameters, construction practices and environmental conditions. In this study, mix design parameters, casting temperature and curing conditions were varied to study the mechanical properties and durability characteristics with the ultimate aim of developing models relating the concrete properties and the experimental parameters. The effect of w/c ratio (0.3 to 0.45), in situ concrete temperature (25 to 45 °C) and curing method (ponding, covering with wet burlap or applying curing compound followed by curing under laboratory or field conditions) was assessed by measuring compressive strength (f′c), split tensile strength (ft), pulse velocity (PV) and depth of water penetration (WP) up to 180 days. Prediction models were developed utilizing quadratic regression models and artificial neural networks (ANNs). The regression models indicated that moist curing, in situ concrete temperature and curing period have a positive impact on the strength parameters and PV, while the former two variables had a negative effect on the WP. The w/c ratio had a significant positive impact on the WP. The concrete properties predicted by ANN models were more accurate than those predicted by regression models. A combined ANN model, developed for predicting strength and PV simultaneously, had a better correlation coefficient compared to ANN models developed for each variable separately. The developed models are expected to assist concrete technologists in the selection of appropriate concrete mixture parameters to obtain concrete with desired properties under hot weather conditions.

2.10 Effect Of Hot Weather Concreting On The Mechanical And Durability Properties Of Concrete-A Review Issn 2959-331x (2022)

Nowadays, hot weather is an essential motivator that leads concrete to lose its special characteristics. The high loss of moisture by evaporation and rapid hardening encourage the cracking potential and placement operations. The fresh mixed and hardened concrete tend to be damaged due to several conditions such as: high concrete temperature, High ambient temperature, low relative humidity, and high wind speed. These circumstances accelerate the rate of moisture loss and cement hydration. This article briefly reviews hot weather concreting problems precautions, and curing methods and also discusses the role of incorporation SCMs in reducing the temperature of concrete and enhancing its mechanical and durability performance.

III. CONCLUSION

Hot Weather Concreting Presents Several Challenges That Can Impact The Quality And Durability Of Concrete Structures. High Temperatures Can Cause Rapid Evaporation Of Moisture From The Concrete Mix, Leading To Increased Risk Of Cracking, Decreased Workability, And Reduced Compressive Strength. However, There Are Several Strategies That Can Be Employed To Mitigate These Challenges, Including The Use Of Cooling Techniques, Appropriate Concrete Mix Designs, And Careful Placement And Curing Practices.

It Is Essential To Carefully Monitor The Temperature Of The Concrete During Placement And Curing And Take Appropriate Measures To Control The Temperature And Ensure The Concrete Remains Within Acceptable Limits. Hot Weather Concreting Can Be Successfully Accomplished With Careful Planning, Effective Communication, And Adherence To Best Practices. Further Research Is Needed To Explore New Techniques And Materials That Can Improve The Performance Of Concrete In Hot Weather Conditions. Ultimately, With Proper Planning And Execution, Hot Weather Concreting Can Result In Durable, Long-Lasting Structures That Meet The Desired Performance Requirements.

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