Organizational and technological solutions for controlling concrete structures projects in the dry hot weather in Iraq

Laith S. M. Al-Asadi1, Hussein A.M.S. Al-Juboori2*, Mukhammet A.Fakhratov2

1Department of Civil Engineering, College of Engineering, Al-Mustansiriyah University, Baghdad 10052, Iraq
2Moscow State University of Civil Engineering, 26, Yaroslavskoye shosse, Moscow, 129337, Russia

Abstract. Iraq has suffered from a long period of neglect in projects due to the circumstances it has experienced, and there is a great need to construct infrastructure and development projects. The weather in Iraq is characterized by an increasing rise in temperatures, with summer temperatures reaching 50°C and relative humidity around 24%. The summer season extends for 5 months, and this requires procedures and precautions in projects that include concrete structures in hot climates that are represented by high temperatures and low humidity. Such weather would affect the properties of fresh and hardened concrete, as the rapid evaporation of water from the mix causes different damages to the concrete, the appearance of shrinkage cracks, as well as a lack of workability. It also affects the strength of the concrete and its durability at later ages. Also, there are other problems in such projects related to poor quality and increased costs and time required to implement construction projects. Therefore, problems related to hot climates were studied through literature review in this regard. A questionnaire was also conducted to show the real problems that these projects suffer from, and problems were found that go beyond providing the above precautions that must be available in hot weather. Rather, it requires an increase in allocations, and there are problems related to the need for planning, as well as the necessary administrative, technical and legislative measures to improve performance.

Keywords: Organizational and technological solutions, hot weather concreting, Precautions, Construction projects, Concrete mix, Curing, Additives.

1 Introduction

It is known that projects in Iraq suffer from multiple problems related to several stages of the project’s life. In general, these problems can be summarized as poor quality in implementation, increased costs, and an increase in completion time. The climate of Iraq in

*Corresponding author: hussainjuboori87@gmail.com

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general is characterized by a hot climate with low relative humidity, and there is a weakness in taking the required precautions in hot climates, in addition to problems related to the administrative, technical and legislative aspects of construction project work in Iraq.

2 Definition of dry hot weather

Dry hot climates are defined as a combination of weather conditions that include high temperatures, increased wind speed, and low relative humidity [1, 2], which greatly affects the amount of water evaporation from concrete and increases the speed of reactions, thus negatively affecting the properties of concrete in its fresh and hardened state.

3 Concrete problems in dry hot weathers

There are a number of problems that appear on concrete in dry hot climates, as follows:

- Increased amount of evaporation and increased need for water: Increasing water evaporation than 1 kg/m²/h will require adding more water to maintain workability. It will clearly affect the plastic shrinkage and the occurrence of cracks in the concrete [3], as well as the occurrence of dry shrinkage after the evaporation of water from the pores after the concrete hardens. Such excess in water even when adding cement with water to the mix [4, 5] will increase water cement ratio which will reduce bearing strength, durability and affect other properties of concrete [6-8].

- Increasing the speed of hydration process: The increase in the speed of reactions due to high temperatures will reduce the setting time, and this will affect the time in which the concrete must be transported, placed, compacted, and surface finished. High temperature and increased speed of reactions will result in thermal cracking that result from arising compressive stresses inside and the occurrence of tensile stresses due to the cold surface outside [7]. Also, the concrete surface will show a variation in its appearance due to a difference in the amount of cement hydration speed due to the difference in the ratio of water to cement particles [1].

- A decrease in the bearing capacity of concrete: Due to the increase in the speed of reactions resulting from high temperatures, this will accelerate the acquisition of rapid bearing strength in the early ages, and at the same time the bearing capacity will decrease in the later ages. It has been observed that the temperature of the mixture water has a clear effect on the development of concrete properties [9].

- A decrease in the durability of concrete: Due to the appearance of internal cracks, the lack of control over the trapped and intended amount of air [10, 11], and the lack of strength of the concrete, it will be less durable in its resistance to external conditions such as resistance to attack of sulphate salts, freezing and melting, and also carbonation due to interactions with CO₂.

4 Precautions required in dry hot weathers

The problems described previously require taking a number of precautions which are described below:
4.1 Keep the materials cool and away from the heat of the sun

- Keep concrete mixture sand and gravel away from heat and sunlight by storing the materials in covered places, preferably spraying them with water [12].
- Use white painted silos for storing cement or water [13].
- Use the mixture water chilled or use frozen cubes of water.
- Use white concrete mixers.
- Using nitrogen to cool the concrete mix, but this may require high costs.

4.2 The time and duration factor

- It is preferable to mix the mixture components at night as the temperature is the lowest [14], and also to eliminate traffic congestion during the day when transporting the mixture.
- It is preferable to set the time as short as possible in the process of mixing, transporting, placing the mixture, compacting, and finishing the surface, as the speed of hardening is fast [15].
- It is preferable for curing to take place in hot climates immediately after hardening occurs [16].
- It is preferable that the concrete mixing site be close to the construction project site [17].

4.3 Use additives, materials and covers to reduce evaporation

The additives that are added to concrete to compensate for the loss of some properties in hot climates [18, 19] must be tested and the added proportions determined before use because otherwise it may lead to a decrease in durability and other properties [20].
- It is preferable to use plasticizers and superplasticizers to reduce the water-cement ratio (w/c) in the mixture and increase workability to maintain the properties of concrete [10, 11, 21].
- Using retarders to reduce the speed of hydration process that increases with rising temperatures, to allow sufficient time to transporting, placing, compacting and finishing the surfaces of the concrete.
- Use additives to reduce evaporation and retain water for the purpose of ripening.
- Use plastic covers immediately after casting for the same purpose [14].
- Use low-temperature cement materials with a longer setting time.

4.4 Practical procedures during casting

- Place joints at smaller distances than those placed in normal environments.
- Pay attention to the quantities of the mixture that are applied.
- The formworks must be moistened with water before placing the concrete.
- The parts that touch the formwork must be cured immediately after lifting the formwork.
- Using fibers to reduce cracks resulting from shrinkage [22].
- Pay attention to curing to increase strength and durability in the long term, as the duration and type of curing affects the acquisition of concrete’s strength [23, 24]. The effect of hot climates is not limited to the properties of concrete, but extends to the performance of labors, as it was found that the performance of workers in hot climates is lower than in normal climates [25]. Also, the precautions that mention before must be planned first to organize the actions that can be taken and define responsibilities to control the workflow [26].

5 The reality of work in construction projects in Iraq

Construction projects in Iraq suffer from many problems, some of which are related to the lack of precautions for hot climates, while others suffer from poor quality and increased costs and time required for completion.

The impact of climatic conditions and their consequences may be the largest part of these problems, as the weather in winter is characterized by temperatures ranging between 15-20°C and a relative humidity rate of around 74%, extending for a period of approximately two months. However, in the summer, the temperature ranges between 42-50°C and a relative humidity rate of around 24% and extends for a period of about five months, which requires taking precautions in the summer. Heat affects work performance, as labors are exposed to extreme heat, which requires taking periods of rest in less hot places, which affects productivity, as well as construction machinery, where labors, technicians and drivers are exposed to high heat, in addition to the equipment engines, which requires stopping them for periods to regain their activity after a while, and this is reflected negatively on the productivity and increases the costs and time required for completion, which requires attention and the provision of all efforts and financial allocations to take the necessary precautions for the success of the process of constructing concrete structures in Iraq.

6 Methods (Questionnaire)

For the purpose of identifying all the actual problems facing construction especially for concrete works in the dry hot climates, and to identify the reasons for not completing all precautions in hot weather in Iraq, a questionnaire was conducted for a sample of engineers and faculty members in engineering colleges who have enough experience in construction projects and management. All problems that could occur have been identified through direct inquiry and interviews.

A sample with five choices was adopted, where 1 stands for (strongly disagree) and 5 stands for (strongly agree). used to answer the questions and the statistical analysis was carried out to 64 questionnaires out of a total of 70 forms that were distributed to those concerned with the answer and the results were statically analyzed using SPSS 14.0 program, as follows:

S.D.: Standard Deviation.
R.I.I: relative importance index.
The experience in years for such sample is shown in fig. 1.
7 

Results and Discussion

From the results shown in Table No. 1, it is clear that there are several reasons that concrete works suffer from in construction projects in Iraq, which are ranked in descending order of importance as follows:

Table 1 The analysis of questionnaire results arranged in descending order.

<table>
<thead>
<tr>
<th>Rank</th>
<th>Questionnaire questions</th>
<th>Mean</th>
<th>S.D.</th>
<th>RII</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Insufficient financial allocations to carry out all precautions</td>
<td>4.261</td>
<td>0.75</td>
<td>0.86</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Lack of clear prior planning</td>
<td>4.183</td>
<td>0.77</td>
<td>0.82</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Lack of knowledge about hot weather concreting</td>
<td>3.975</td>
<td>0.89</td>
<td>0.79</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Weak administrative procedures</td>
<td>3.752</td>
<td>0.81</td>
<td>0.76</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Lack of control over the quality of materials and additives</td>
<td>3.569</td>
<td>0.83</td>
<td>0.73</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Absence of national specifications that regulate precautions</td>
<td>3.370</td>
<td>0.85</td>
<td>0.70</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Absence of cooling devices at work sites</td>
<td>3.104</td>
<td>0.87</td>
<td>0.68</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Lack of guarantees and insurance</td>
<td>2.906</td>
<td>0.90</td>
<td>0.65</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Weakness in monitoring operations</td>
<td>2.724</td>
<td>0.92</td>
<td>0.64</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

- Lack of sufficient allocations to provide all precautions for hot climates, as these allocations must be available according to need, which depends on the climatic conditions, project conditions, location, and importance.
- Lack of prior planning for the purpose of taking the necessary precautions for hot weather.
- Lack of sufficient knowledge about the effect of hot climates on concrete.
- Weak administrative procedures regarding providing the necessary precautions for hot climates, ensuring that concrete arrives at the appropriate time, preparing labors and the site for pouring, compacting and finishing work with the required speed, and following up on providing all requirements to facilitate concrete work and avoid delay.
- Lack of control over materials and additives because these materials are usually imported from several sources and there is no local manufacturing of them. The materials and additives available in local markets change from time to time, and the specifications and proportions that require their addition vary according to the source from which the materials were imported. There is no qualitative control over the specifications of these materials, which requires conducting trail mixes and waiting to test them to ensure the performance of these materials.
- There are no national specifications regarding the procedures and precautions that must be provided for concrete work in hot weather. Therefore, taking these precautions depends on the competence and professionalism of the party carrying out the work, the extent of the sense of responsibility, and according to the site conditions.
- The absence of cooling devices such as coolers and fans that work to cool the atmosphere and reduce high temperatures, which are necessary to maintain work in these conditions.
- The lack of guarantee and insurance for workers and technicians in the construction field, as there is no law specifying wages, working hours, retirement benefits after the end of the ability to work, and health insurance. Wages are usually daily, weekly, or monthly according to the agreement concluded with the workers and technicians. Providing these guarantees and insurance motivates many workers and technicians to give their best.
- Weak procedures for monitoring and controlling performance with regard to labors and equipment, especially in hot weather conditions, where most desire to take a break, stay away from the sun’s rays, and drink cold water, in the absence of cameras and monitoring and tracking devices. There is a problem of delay due to traffic congestion in delivering materials, especially fresh concrete, in the absence of tracking devices and detecting the best routes and avoiding these congestions.

8 Conclusions

From the above, it can be concluded that concrete work in construction projects in Iraq needs attention due to a number of problems facing the reality of work in engineering projects, especially in concrete work in hot weather. Such problems are not limited to the precautions required in the previous sources, but rather go beyond that is seen in fig. 2. as shown below:
- There is a need to increase allocations to cover expenses for the precautions required for concrete work in hot weather, which depend on the nature of the weather, the importance of the project, and the available capabilities.
- There is a need to conduct planning before taking the required precautions in hot weather, and these procedures must be efficient, practical, economical, and compatible with the nature of the materials used, the weather and geographical conditions of the
site, as well as the available experience in dealing with these climates before starting implementation work.
- There is a clear lack of awareness and knowledge among concerned technicians, managers, and workers about the impact of hot weather on concrete that requires holding courses, workshops, and seminars to clarify such impacts on concrete in its fresh and hardened state.
- Administrative procedures must be organized, technical conditions and specifications must be set regarding following up and providing all requirements and precautions required in hot climates regarding the quality of materials and additives, monitoring and following up on the performance of workers and mechanisms in accordance with modern technologies, and providing everything required to achieve this, including cameras, GPS tracking devices, drones, etc.
- Paying attention to providing all retirement rights, social security and insurance to workers and technicians, determining the number of working hours and wages, and providing cooling means and fans that reduce the workload in hot climates, which prompts workers to give their best.

![Fig. 2. Problems facing concrete structures in the dry hot weather in Iraq.](image)

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