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Research Article

Analysis of Winter Concrete Construction in Water Conservation Project

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Abstract: The construction of water conservancy projects should commence during optimal atmospheric conditions and non-flood period to ensure completion before the flood season begin in summer. In most areas of Northern China, the temperature during winter remain at lower level, in which environmental factors play the most important role in the construction of water conservancy projects. In particular, low temperature directly affects the strength of concrete and delays its solidification, this highly affects the quality and progress of concrete construction. In order to overcome this barrier, better planning, for reasonable and effective construction techniques and targeted control measures should be adopted to reduce the adverse effects of low temperature to assure a strong and safe architecture.

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0 Basic principles of winter concrete construction in water conservancy projects

Temperature

The temperature record during winter concrete construction in both cold and warm weather areas are outline as below:

As time changes, the state of concrete in construction will change and it is not possible to overcome it by insulation measures. When the outdoor temperature is below freezing point during winter, the temperature of the material could not decrease below 0°C. When temperature increases, the temperature of the material could not change accordingly. But, the temperature will stay lower for a certain period of time. Therefore, temperature of the material differs from surrounding and change within time gaps. Hence, time factor in winter concrete construction process can be divided into two stages; early winter and late winter. Different insulation measures should be applied in different stages due to the diverse characteristics.

Effect of early frost on concrete performance

It is known from concrete studies that hydration and hardening results from the firm hardness of concrete and is an important factor in building constructions. Hydration is associated with temperature and concrete proportion. Higher temperature will increase the hydration of concrete. On contrary, temperature lower than 0°C will solidify the water within concrete and reduce the rate of the hydration of concrete. In addition, slow hydration will reduce the hardness of concrete. Therefore, appropriate approach should be taken during concrete construction of water conservancy projects in winter season since temperature plays an important aspect.

In addition, when the temperature falls below 0°C in winter, water will solidify within concrete. Since water in solid form is larger compared in liquid form, ice expansion develops. This will destroy concrete structure and affect strength of the concrete and challenge the quality of water conservancy projects. At the same time, frozen water brings ice grains on steel structure and the ice grains soften steel bars and affect the properties of materials thus decreasing the pressure resistance and service life of projects. Lastly, in extreme low temperature, the cohesive strength of aggregate in concrete will be affected. Aggregate increases the inner cohesion of concrete, ensuring a

higher strength and hardness of concrete structure. Once the cohesive strength is decreased, the strength and hardness of concrete could not be maintained. According to the above analysis, it is known that temperature and water are key factors affecting the properties of concrete in winter season. Decreased temperature in winter exerts a great influence on concrete structure it changes the forms of water and material properties which varies the strength and pressure resistance of concrete and affects the service life of water conservancy projects. Therefore, different approach should be proposed to elucidate the problems.

1 Common problems of winter concrete construction of water conservancy projects

1.2 Cracking

During early stage of concrete cracking, cracking on concrete will appear. Even if such cracking does not cause much influence on the quality of concrete, exfoliation occurs easily as time moves which will affect the quality of concrete and aesthetics of buildings.

1.3 Desquamation

Large areas of concrete sheet peeling results from stripping of cement slurry on concrete surface under freeze-thaw effect, which could be found easily in breakwater with enough sunlight and long-term immersion.

1.4 Exposure of coarse aggregate

The coarse aggregate and cement slurry in concrete are stripped. The main reason for coarse aggregate peeling is related to insufficient concrete maintenance, which leads to lower bonding strength between coarse aggregate and cement slurry. In addition, water invaded into concrete and the lower temperature during winter would destroy the cementation of coarse aggregate and cement paste.

1.5 Concrete avalanche

Avalanche is a relatively serious freezing injury of concrete, mainly due to the existence of low-porosity aggregates on the surface of concrete. During freezing, these aggregates would expand and form holes on the surface of cement slurry.

2 Key points of winter concrete construction technologies

2.1 Quality of construction materials

Construction materials should be carefully selected to ensure the quality of the concrete pouring in lower temperature condition. Among all the construction materials, cement is the primary material and 32.5 Portland cement should be adopted in cold winter. Heat insulation for concrete could be done by the heat released by the hydration heat of concrete, preventing the concrete from freezing due to lower temperature and to ensure the quality of concrete. At the same time, more focus should be given on concrete mixing ratios in this project. While the selection of aggregate in concrete mixing ratio should be in high purity aggregate to avoid the negative effect on impermeability and frost resistance. It should be noted that the active materials should not be applied if sodium and potassium are found in antifreeze to ensure a strong construction architecture.

2.2 Concrete pouring technology

Appropriate construction technologies and techniques should be practiced in concrete pouring of water conservancy projects at lower temperature in winter. Four important requirements should be followed in concrete pouring of water conservancy projects:

2.2.1 Reasonable mixing ratios and materials should be selected first to ensure a good property of all kinds of materials;

2.2.2 Appropriate ratios of cement are selected through lab experiment. An effective control of the ratio between water and ash could improve the hydration of concrete and to make sure a better curing characteristic of concrete pouring of water conservancy projects at lower temperature in winter.

2.2.3 Scientifically select additives incorporated to ensure an anti-interference ability of influences of external factors. Moreover, addition of air entraining agent could increase the volume of bubbles during concrete pouring process and the fluidity of mixing. It could also improve the content of water during mixing process to guarantee the adhesiveness and improve the cold resistance of concrete. Apart from air entraining agent, early strength enhancer is another important additive for concrete pouring of water conservancy projects. Early strength

Table 1. Temperature principle for winter concrete construction in water conservancy projects.

Cold-weather areas	Daily mean temperature/℃	⩽5
	Minimum air temperature/℃	⩽-3
Warm-weather areas	Daily mean temperature/℃	⩽3

enhancer could effectively control and improve the solidification period of concrete.

2.3 Concrete maintenance

Concrete maintenance should be followed after concrete pouring procedure. Generally, concrete pouring is done at night and insulted covering is to keep the temperature of concrete. Once the temperature reaches around 0 ℃ during the next day, embossing and other processing should be performed. When concrete laying is done, maintenance will be carried out starting with temperature monitoring. Since it is cold in winter, thermal storage method could be adopted to protect temperature to shorten the strengthen period of concrete. Apart from thermal storage method, furnace heating, steam heating and electronic heating are suitable to be adopted for heating and insulation. In water conservancy projects, appropriate methods should be adopted for concrete maintenance. Concrete maintenance makes concrete to be harder. Since the quality of concrete directly affect the whole projects, focus should be more on to concrete maintenance.

2.4 Construction plan in winter

Winter concrete construction mainly cover concrete mixing: concrete mixing ratios, regenerative technology and external heating technology, the application in which can perfect the winter construction plan, guarantee the safety and improve the quality of water conservancy projects.

2.5 Concrete mixing ratios

Concrete is the basic material in water conservancy projects. Concrete refers to the cement concrete mixed with a certain ratio of cement (as cementitious material), sand and stone (as aggregate) and water. Winter construction encountered lower temperature, affecting the quality of concrete and increase the barriers of the project. As a result, appropriate methods should be adopted to solve problems due to the temperature. Different concrete mixing ratios can be used to make concrete suitable to be applied in winter. Five key points should attract attention in concrete mixing ratios:[1] There are many kinds of cements, cold resistant cement should be selected in winter construction. Also, Portland cement is twice as strong as ordinary cements. Therefore, Portland cement could meet the need of winter construction of water conservancy projects[2]. The ratio of cement dosage should be increased and make the ratio between water and ash as 3:5 in concrete ratio. It takes some time for concrete to achieve its required hardness after laying in water conservancy projects. And it usually takes 7d for ordinary cement to get hardened. However, concrete with higher cement dosage takes only half the time of ordinary cement to get hardened[3]. Add air entraining agent into concrete. In winter construction of water conservancy projects, water within concrete will freeze, affecting the quality of projects. Adding air entraining agent into concrete could create bubbles in concrete and eliminate water in concrete to prevent water from being frozen within concrete and reduce security hidden dangers[4]. Add sodium sulphate into concrete. Sodium sulfate could reduce the period of cement hardening to make the cement quickly meet the strength requirements in winter[5]. Selection of ingredients. Concrete comprises of cement, sand and stone. Sand and stone with higher hardness should be selected while mixing concrete, which could also increase the strength of concrete.

2.6 Thermal storage method

In winter construction of water conservancy projects, the difficult point of concrete laying lies in the failure of concrete standard due to the lower temperature in winter, which could be solved by thermal storage method in large scale projects. The mix of cement, sand and other raw materials creates a certain temperature, which could accelerate the hydration of cement and the formation of concrete. Concrete should be kept warm during winter construction. Concrete with certain temperature can increase its ability to resist cold in laying process. Simple method in winter construction technologies of water conservancy projects, thermal storage method only focuses on the heat preservation of concrete and the reduction of the frozen area of concrete. The application of thermal storage method should focus on three points: first, concrete materials.

Most of the materials of concrete are sand and gravel, which are easy to freeze and affect the hardness of concrete. Therefore, sand and stone should be transported to the construction site before winter to prevent from purchasing frozen sand in winter. While the temperature decreases in construction site, cotton fabric and other materials should be used to cover the sand and stone to prevent them from being frozen. As a result, the heat preservation effect could not be affected while the sand and concrete are stirring in the concrete mixer. Second, concrete heating during the mixing process. Concrete is created by mixing sand, stone and cement. The normal temperature of water is lower in winter. So, water from deep well could be used during winter construction. Since the water temperature in deep well normally vary from 16 to 18℃, it would increase during the mixing process. In addition, insulation method should be applied to cement, additives and other concrete materials. Third, thermal storage during concrete transportation. The transportation of concrete is performed by special concrete transport vehicles. Before transportation, the vehicles should be preheated with warm water and the concrete pipes should be packed with cotton fabric and other devices to prevent them from being frozen. In addition, pipes should be cleaned immediately after using to prevent the residual concrete from being frozen along pipes and affect during the next usage of these pipes.

2.7 External heating methods

Water conservancy projects vary in scales and the quality of medium and small-scale projects could be improved by external heating methods, like steam method. In water conservancy projects, concrete laying should be completed by relevant components, by heating it could be transferred to concrete. Besides, concrete can also be heated directly. Concrete only reaches its standard composition when exposed to external heating makes concrete to harden rapidly. There are three methods of external heating, i.e. furnace heating, steam heating and electronic heating. Furnace heating is the easiest method but with certain disadvantages. Furnace heating applied in small scale water conservancy projects to accelerate the strength of concrete. However, the carbon dioxide emitted by furnace will be attached to the surface and react with concrete to affect its quality. In steam heating, the boilers and other heating equipment, the water will be processed by high temperature to heat the concrete. Steam heating could ensure the quality of concrete, but the cost is higher to cover boiler equipment. Third, electronic heating, concrete in water conservancy projects are related with steel and other building materials. Taking advantage of the electrical properties of steel, electronic heating heat concrete with less heat losing. Disadvantage of electronic heating stays higher due to high electric. External heating methods are more applicable for small and medium scale water conservancy projects. Since disadvantages emerge in each heating method, a reasonable method should be adopted after a solid comparison.

2.8 Application of antifreeze

The quality of concrete is crucial during winter construction and the cold weather in winter is another great challenge to the concrete construction technologies. To ensure the quality of water conservancy projects, antifreeze agent should be applied in concrete construction to overcome freezing problem in winter. In addition, antifreeze technology is easier to be used. Therefore, antifreeze has been applied to many winter constructions of water conservancy projects. Compared with external heating method, the application of antifreeze is more energy efficient with lower cost. Concrete with antifreeze can shorten the strengthening period and prevent concrete from being damaged by cold weather. The role of antifreeze is to reduce the freezing point of materials so that the water in concrete will not freeze at low temperature. During winter, the water in the concrete will be expand after freezing, affecting the structure of concrete and the quality of concrete. However, it can be improved well by the application of antifreeze.

3 Conclusion

The management improvement of winter concrete construction technologies not only can enhance the quality of water conservancy projects, but also improve the construction technologies of enterprises to guarantee a positive development of future water conservancy projects and make greater contributions to the all-round development of the economy and society.

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