Prevention Research into Mass Concrete Crack of Roadbed in Northwest Arid Region of China

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Abstract

In northwest arid region of China, winter temperature is pretty low while in summer it is the opposite with dry air and large evaporation capacity. In concrete roadbed, mass concrete crack phenomenon is extremely common in the construction and operation process. According to the characteristics of the northwest arid region, combining with the construction site and highway operation feedback, the causes of the mass concrete cracks of roadbed have been analyzed and the corresponding prevention measures have been put forward.

Keywords

Northwest arid region; roadbed; mass concrete; cracks; prevention measures.

1. Introduction

With the development of social economy and higher demand for regional transportation, in northwest arid region of China, the construction technology of mass concrete pouring process is widespread in roadbed engineering construction, but at the same time the cracks in mass concrete are generated. The existence of such cracks often directly affects the quality rating and reduces the social credibility of construction units, even affects the normal use of structure. According to the quality inspection of the construction site, combined with construction experience in the process of operation, for the common features of mass concrete cracks in highway roadbed in northwest arid region of China, its causes have been analyzed and corresponding prevention measures have been formulated, which has received the good effect after verification in construction application.[1]

2. Characteristics of the mass concrete

2.1 Definitions

Definitions of mass concrete are not yet clear. At present, several representative definitions have the following:

(1)The definition from the ACI(American Concrete Institute) is that any of the mass concrete poured-in-place with large size must be required to take steps to solve the problem of the volume deformation caused by hydration heat, so as to minimize cracking.

(2) The standard definition of the AIJ(Architectural Institute of Japan) holds the view that it's called mass concrete when minimum thickness of structural section is above 80 cm, and at the same time the difference between outside temperature and highest temperature inside the concrete caused by the hydration heat is expected to more than 25℃.[2, 3]

(3) China's current national standard puts forward the definition of mass concrete that, the scope of this standard is the common concrete for industrial and civil construction, therefore, the mass concrete generally refers to the smallest size of 1 m or more in the structure.

2.2 Features

Although the countries are different in definition, the features of mass concrete are essentially the same, namely the large fracture surface of the structure, large length to thickness ratio and volume,

dense rebar, high dosage of cement, intensive concrete strength, complicated engineering conditions and high construction technical requirements, etc..[4]

2.3 Technical problems

The specific technical problem of mass concrete is that when the internal temperature of concrete rises as the result of hydration heat released by cement hydration and then the temperature stress caused by temperature difference causes the cracking of concrete. Technical challenge of crack control of mass concrete is an international problem. There are many theoretical achievements. In specific project of different religions, it is still difficult to employ one certain theory to guide the on-site construction. So in the construction process, corresponding prevention measures should be formulated according to the specific region and the characteristics of the construction.[5, 6]

3. Causes of mass concrete cracks in northwest arid region

The temperature in the northwest region is often low in winter and high in summer. The air is dry and the amount of evaporation is high. In such an environment, the causes of the mass concrete cracks in highway roadbed are mainly the following:

3.1 Problem of temperature rise

Heat released in the process of hydration of cement is the main factor of the body temperature rise of concrete. After 3 ~ 5 days of concrete pouring the temperature can rise to the top. The actual temperature rise of concrete is close to the adiabatic temperature rise, and the high temperature lasts a long time. The temperature will come down after about 10 days. Due to the poor thermal conductivity performance of concrete, in early pouring stage its strength and elastic modulus are very low, so the constraint for sharp temperature rise caused by hydration is not strong and the corresponding temperature stress is smaller. [6]As the growth of the age of concrete, elastic modulus increases, then the constraint for temperature drop shrinkage inside the concrete is greater. If not to reduce the adiabatic temperature rise of concrete, it will produce large tensile stress in the concrete, then the crack is hard to control.

For example in the roadbed construction, according to the conventional mix, it uses 525 # Portland cement, coal ash and calcium lignosulphonate water reducing agent, while mixing C40 concrete, it generally uses cement dosage of about 390 kg, and after calculation, the adiabatic temperature will reach about 80℃, and the temperature of concrete pouring into the mold is around 10℃.[7]The highest temperature inside the concrete will reach 90℃at this time. As you can imagine, such a high temperature to be cooled to normal temperature will produce a great chilling shrink and surely will make the concrete cracks.

3.2 Inside and outside temperature difference

According to the specification requirements, the difference between mass concrete surface temperature and the center temperature should be less than 25℃. As mentioned above, the core temperature of mass concrete may reach 90℃, while the surface temperature at least should be higher than 65℃. Generally in the hottest season when the temperature reaches 40℃, the surface of the concrete is still difficult to achieve such a high temperature. So the internal temperature of concrete falls from 90℃to the concrete surface temperature with range from 60℃to70℃. The resulting shrinkage reaches 6×10-1 mm/m which greatly exceeds the ultimate tensile strain value of the concrete. The crack then inevitably occurs.[8]

3.3 The climate problem

The climatic conditions of the northwest arid areas are important causes leading to the cracks of mass concrete in roadbed, which are mainly manifested in the following aspects:

(1) During roadbed construction, in most of the time the mass concrete structures are exposed to dry air and windy, dusty environment, so if they are improperly maintained and the structure doesn't keep moist state, which will make concrete shrink and produce stress. At this time, the strength of concrete

increases slowly and when the tensile stress is greater than the strength of extension, the concrete cracks will occur.

(2) In the northwest region, insolation intensity is high and temperature in the morning and evening is low. If not timely backfill after the completion of the mass concrete of roadbed construction, temperature deference crack will be produced for effect of heat bilges cold shrink on the exposed part of the structure by the outdoor temperature.

4. Prevention measures for mass concrete crack in roadbed

According to the above reasons of crack of roadbed mass concrete in the northwest arid region, there are two main ways to prevent roadbed cracks of mass concrete construction. First one is to adjust the proportions of concrete mix, so as to reduce shrinkage as far as possible in the process of hydration and hardening of concrete, and make mass concrete have certain micro expansion performance;[8]second is to take the appropriate process measures to reduce the interior temperature rise of the mass concrete and the temperature difference between inside and outside, in order to minimize the shrinkage value and the internal and external differential temperature stress of concrete.

Therefore, prevention measures of mass concrete cracks in roadbed in northwest arid region are as follows:

4.1 To mix expansion agent

This is one of the most effective way. The mixed expansion agent can replace the same amount of cement., which will cause micro expansion in the hardening process, thereby it reduces the cement dosage and the hydration heat. This is mainly due to the expansion agent hydration with almost no hydration heat. At the same time it can also offset most of the chilling shrink and air shrinkage and chemical reduction effect. If the mixed expansive agent and set retarding superplasticizer are used in the construction, high lowing concrete with good pumpability will be got.

4.2 To choose low heat of hydration of concrete

For super thick mass concrete, it should give preference to low grade cement, because with the same varieties of cement, low grade cement generally is 15 ~ 25% lower than the high grade cement in hydration heat. For the same grade cement, it should give preference to the cement that is mixed with slag, tephros, coal ash, because of depending on the different amount of mix, this kind of cement is 10 ~ 40% lower than ordinary Portland cement in hydration heat.

4.3 To improve the mixture ratio

On the premise of guaranteeing the strength and performance of concrete, dosage of cement should be reduced.

4.4 To incorporate retarding admixtures

The use of retarding admixtures will delay hydration reaction, and make cement hydration speed in early stage slow and hydration heat slowly release, which will delay the peak time of hydration heat and then reduce the temperature rise.

4.5 To strengthen maintenance

All exposed surface of mass concrete of the roadbed should be covered, in order to reduce the surface cooling speed, reduce the temperature difference between inside and outside, and prevent excessive temperature stress. According to different construction technology, different methods for maintenance should be applied. The main methods are as follows:

(1) for completing concrete pouring by one time, a more effective maintenance method is to use waterproof thermal insulation material;

(2) for layered concrete pouring and few reinforcement of mass concrete in roadbed, it should use reusable PVC foam heat preservation mat that is difficult to stick on the surface of the concrete;

(3) for more reinforcement of mass concrete in roadbed, it should first spray curing agent to form a membrane, and then scatter polystyrene foam to preserve temperature.

4.6 To use heat transfer water pipe to derive hydration heat

Commonly used embedded cooling water pipes adopt single circuit, two-way double circuit, layered double circuit and other methods to accelerate the internal heat emission of concrete.

5. Conclusion

In northwest arid region, the key to mass concrete cracks is to control the cracks caused by temperature stress. To do this, first of all it should control the internal highest temperature rise and the temperature difference between inside and outside, to reduce the temperature stress; second, in order to control the highest concrete temperature rise, it is better to use slag and other low thermal cement and it is appropriate to adopt double admixing technology to reduce the dosage of cement and reduce the hydration heat. Corresponding measures should be taken to reduce concrete pouring temperature; finally, another way to control concrete temperature difference between inside and outside and improve the early strength of concrete is moisture-retention and heat-insulation. In short, as long as the construction measures are appropriate and construction methods are reasonable, for the mass concrete construction of roadbed, the cracking caused by temperature can completely be avoided under strict management and then the quality of the concrete body also can be guaranteed.

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