

Prevention And Control of Mass Concrete Cracks in Building Construction Engineering

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Abstract. As a kind of building material, mass concrete plays an important role in building construction. It is widely used in engineering projects and needs to be controlled in many aspects, otherwise cracks may appear and affect the safety and performance of the project. In this paper, the crack problems of mass concrete structures are studied and analyzed, such as cracks caused by mix ratio, temperature change, foundation deformation. Firstly, by understanding the internal and external causes of cracks in mass concrete, the key issues were suggested. Then, the method to prevent and control the crack of mass concrete is put forward from the selection of reasonable raw materials and mix ratio, pouring method, temperature control and other aspects. The research results can be used as reference to reduce the negative impact of cracks in building construction engineering. While improving the safety and service life of housing construction projects, it also improves the economic value and reduces the time cost of rework.

Keywords: Mass concrete; crack prevention; construction.

1. Introduction

As the national economy grows with high speed and quality, China has strengthened its investment and construction of infrastructure since the 21st century [1]. Various bridges, high-rise buildings and large-scale complex projects are constantly emerging, which makes the application of large volume in practical engineering more and more widely used [1]. Crack phenomenon prevalent in mass concrete construction. After the formation of cracks, the integrity, durability and waterproofing of buildings can be affected, so that the building unsafe [2]. This paper is devoted to discussing the causes of cracks in mass concrete, and puts forward preventive measures against cracks in mass concrete. Although it is impossible to completely eradicate the issue of mass concrete cracks, there are still many prevention and control measures that can be taken to lessen the problem. In these ways, the safety of mass concrete projects has been improved, and the prevention and control of mass concrete cracks in housing construction projects have also been promoted.

2. Causes of Cracks in Mass Concrete

2.1. Raw Materials and Mix Proportion

Most Chinese construction projects employ mass concrete. Because mass concrete has a unique mix ratio and raw material composition, cracks are simple to form throughout the construction process. There are numerous basic ingredients needed to produce vast quantities of concrete. Compared to small volume concrete, the water cement and sand gravel ratios are frequently more challenging to understand. The use of some admixtures with a low water reduction rate and poor water retention will also result in cracks in mass concrete constructions due to the high slurry content of aggregates in raw materials and the ease with which their instability might result in concrete cracking [3].

2.2. Change of Outside Temperature

The temperature at which mass concrete is poured varies depending on the ambient temperature. It is especially undesirable for mass concrete since the abrupt drop in temperature would significantly widen the temperature gap between the inner and exterior layers of concrete. Temperature deformation brought on by temperature differential results in temperature stress. The temperature stress increases with temperature differential.

2.3. Cracks Caused by Foundation Deformation

Due to the uneven vertical settlement or horizontal displacement of the foundation, the structure experiences additional stresses that exceed the tensile strength of the concrete structure, resulting in cracking of the structure. The foundation can safeguard the project's stability in a building information engineering construction project. The vertical settlement or uneven horizontal displacement of the foundation will cause additional stress in its main structure [1]. In this case, the tensile strength of mass concrete will change, which is also the reason for cracks in mass concrete [3].

3. Selection of Reasonable Raw Materials and Mix Ratio

In order to reduce the impact of crack on mass concrete, it is necessary to choose reasonable raw materials and design reasonable mix ratio. The aim is to improve the cracking resistance of the concrete.

3.1. The Right Cement Selection

In the composition of mass concrete, cement is the main reason that leads to the temperature difference between mass concrete and the outside environment and thus cracking.

Therefore, it is necessary to choose early cement with low hydration heat to prepare concrete. The higher the content of C3A and C3S in cement, the higher the heat of hydration. In order to reduce the content of C3A and C3S in cement, medium heat Portland cement or low heat slag cement is generally used. In addition, the heat release of cement hydration is related to the fineness of cement particles, so the fineness of cement should be increased as much as possible without affecting the activity of cement [4]. In the construction, various environmental factors should be considered comprehensively, according to the performance of concrete select appropriate cement brand for concrete preparation.

3.2. The Appropriate Aggregate Selection

Aggregate is one of the important materials for supporting and filling concrete and it is the granular loose material accounting for 80%~83% of the total volume of large concrete. Therefore, when preparing mass concrete, the qualified aggregate should be selected strictly [5].

3.3. Appropriate Admixtures Selection

The performance of mass concrete can be improved by increasing the use of various admixtures, including water reducing agent, retarding agent, expansion agent. This method can effectively reduce the crack occurrence rate of large volume concrete. The mass concrete admixture is generally composed of micro expansion agent and high efficiency retarding and water reducing agent [6]. It increases setting time, reduces cement use and reduces water use. Thus, the heat peak period of mass concrete can be slowed down, the temperature tensile stress can be reduced, the water resistance can be improved and the expansion force can be reduced [6].

4. Pouring Mode

Compared with ordinary concrete, mass concrete has larger structure, greater difficulty and larger pouring area. In order to avoid cracking caused by excessive temperature stress due to excessive temperature difference, it is generally necessary to choose a reasonable pouring method.

4.1. Layered Concrete Pouring

In the conventional concrete placement, many projects will choose the concrete placement method as shown in Fig. 1. In this method, after the first layer of concrete is fully poured, the second layer is poured before the first layer of concrete is first set, and so on until the completion. The second method is to pour the first layer from the ground floor to a certain distance and then pour the second layer. The builders continued to use this method all the way to the top floor. At the same time, ensure that each layer is effectively poured and the first layer of concrete has not reached the initial setting, so the construction personnel can judge whether to pour from the second layer according to the state of the lowest layer. In the final method, the concrete is gradually poured from the bottom to the top, and the slope is less than one-third and suitable for the structure with a ratio of three to one. When the concrete is shaken again, the relevant personnel should pay attention to the placement of vibrators above and below each inclined layer. As the inclined layer advances, the vibrator will follow [7].

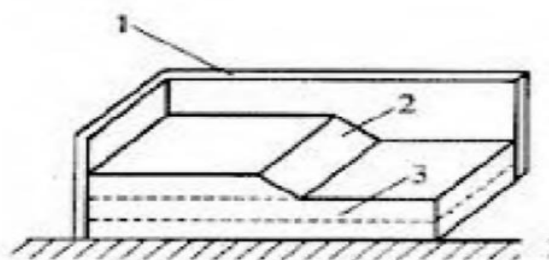


Fig. 1 Full pouring [7]

4.2. Alternative Bay Construction Method

In today's mass concrete construction, alternative bay construction method is widely selected. The alternative bay construction method was proposed by Professor Tiemeng Wang, which divides large areas of concrete into small pieces in actual construction. Through the principle of "put both, put first and then resist", with the "resistance based" method, let the concrete fully shrink, reduce the internal tensile stress of concrete, so as to control the generation of cracks [8]. Scholars from Harbin Institute of Technology calculated the temperature stress of concrete at different ages of single pouring, layered pouring and alternative bay construction method by temperature gradient, and obtained Table 1. It can be seen from Table 1 that, compared with the other two methods, the internal temperature stress of mass concrete is reduced by 14.3% at each age in alternative bay construction method [8]. Therefore, it is of great help to control the temperature stress of mass concrete and reduce the crack.

Table 1. Temperature stress table of concrete at different ages with the three methods [8]

Age	Single pouring	Layered pouring	Alternative bay construction method	Ultimate tensile strength
2	0.247	0.238	0.22	0.789
4	0.485	0.414	0.356	1.13
5	0.525	0.479	0.389	1.36
8	0.63	0.618	0.577	1.59
10	0.741	0.725	0.697	1.66
15	0.75	0.717	0.695	1.73

5. Control of Temperature

After the mass concrete is poured, the hydration heat generated by the cement hydration reaction causes the internal temperature of the concrete to rise continuously and then be cooled. In the meantime, if the heat of hydration cannot be effectively dispersed, the temperature difference between the inside and outside of the mass concrete is too large, will form too large temperature stress, resulting in damage or cracking of the concrete structure. Therefore, how to control the temperature

difference between the inside and outside of the concrete mass concrete is very important for its crack prevention.

5.1. BIM Technology

The monitoring of mass concrete is an important point in the whole project. With the development of technology, BIM technology gradually emerges. In order to monitor the internal temperature in mass concrete, it is generally necessary to bury many temperature measuring points and require technical personnel to monitor them. The error will be greatly affected by the measurement time difference, and the process is complicated. If BIM technology is used, it can reduce the tedious process and labor cost, and reduce the error caused by time. In the construction of mass concrete for Beijing intercity Railway, Wang Xiaoguang established a mass muddy concrete model based on BIM technology, carried out temperature calculation and scheme design, monitored the temperature inside and outside the concrete and the temperature inside the cooling water pipe, and automatically controlled the valve discharge of cooling water, thus greatly reducing the manpower time [9].

5.2. Embedded Cooling Water Pipe

In general engineering, the circulating water is introduced and the heat is taken out by embedded cooling pipes, during which the temperature is monitored in real time. In the actual large volume concrete building, circulation pipes can be set up before pouring, and cooling water can be injected after pouring to take away the heat inside the concrete through heat exchange. Each pipe has a valve, and a number of temperature points are embedded before pouring, so the construction personnel can flexibly adjust the internal temperature according to the actual situation, thus effectively reducing the temperature stress.

The commonly used embedded cooling water pipes include steel pipe, steel wire mesh plastic composite pipe and HDPE composite pipe [10]. Guo from Henan University, through the analysis of the cooling and cracking prevention effect of three kinds of water pipes in practical engineering, concluded that under the same insulation conditions, the cooling effect of iron pipe and steel wire mesh plastic composite pipe is good, but iron pipe is easy to cool too fast and cause cracking, HDPE composite pipe is the worst [11]. In the actual project, reasonable and accurate calculation should be made to determine which kind of water pipe to use.

5.3. Heat of Hydration Inhibitor

As an additive to control the heat release rate of concrete, the thinner the concrete structure, the more obvious the peak cutting range and rate of the heat of hydration inhibitor. Compared with embedded cooling water pipes, the construction method is simpler, with lower technical requirements, but slightly higher cost. There are few engineering examples and studies, most of which are numerical analysis [12].

6. Conclusion

In this paper, the mechanism by which large-scale concrete fractures develop during building construction is addressed, and the mitigation strategies are suggested. Cracks in mass concrete can be minimized by implementing a number of preventative measures. In the management of mass concrete construction, good mass concrete construction quality can not only guarantee the stability and safety of buildings but also lessen the number of fatalities and financial losses brought on by negligent construction practices, as well as guarantee the overall quality of the construction. In more and more contemporary projects, mass concrete crack prevention and control measures will be adopted.

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