Study on the Comprehensive Method of Crack Control in Engineering Structure

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Abstract. It is a very complex and important problem that cracks of engineering structure are caused by deformation (hydration heat, shrinkage, temperature difference). The author in the accumulation of a large number of construction and crack processing experience and theoretical research, on the basis of combination of existing computer network technology, is proposed based on computer technology of the engineering structure crack control synthesis method, including the approximate calculation method of structural mechanics, structure and foundation interaction, construction technology and the optimization of material, environmental conditions, etc.

Keywords: Comprehensive Method, Crack Control, Engineering Structure

1. Introduction

In the past half century, China's construction industry has made brilliant achievements, in which the technology of concrete structure and prestressed concrete structure has made rapid progress and a large number of advanced and mature scientific and technological achievements. At present, a very common problem in the field of engineering structure is the crack problem of buildings, which is increasing in recent years. It has affected the life and production, and troubled a large number of engineering technicians and managers. It is an urgent technical problem to be solved.

2. Comprehensive method of crack control

2.1. Structural design

According to the code for design of concrete structures (GBJ10-89), in order to avoid cracks caused by temperature shrinkage stress, the method of permanent expansion is adopted. The allowable spacing of
expansion joints is 30-55m (indoor or soil medium long wall, shear wall structure and frame structure), and 20-35m in open air. It is also clearly pointed out in the specification notes that the above provisions can be increased or decreased if there is sufficient basis and reliable measures. In other relevant regulations, it is allowed to use post cast strip "instead of expansion joint."

In the current code, the length of expansion joint is regarded as the only factor to control the cracking. According to a large number of field investigations, the causes of structural cracks are comprehensive. The structural length is only one of the comprehensive factors affecting the temperature shrinkage stress, not the only one. As far as the length is concerned, the relationship between the structural length and the stress is nonlinear. For example, if the structural length is less than the specification, it seems that the internal force of the structure has little influence. The expansion joint or post cast strip can effectively control the cracks. However, for the cast-in-place floor, large section beam, shear wall and long wall which bear a large temperature difference and contraction, the probability of the cracks is still very high\[^3\].

The following two problems should be paid attention to when replacing the permanent expansion joint with the post cast strip: ① it is difficult to clean the garbage in the post cast strip, the joint is not dense, the waterproof quality is poor, and two cracks may be formed in the later stage, so the structure of the post cast strip is very important; ② the spacing of the post cast strip should not be too long (30M left and right), and the filling and sealing time should not be too short, so that the total cooling and shrinkage deformation can be carried out for more than half of the time For the best, from the current shrinkage of concrete, it is estimated that 3-6 months can achieve significant results, the shortest is not less than 45 days; in the soft soil area, the filling time is after the structure is capped, then the stress of differential settlement can be effectively released. If the problem of differential settlement is solved by foundation treatment, the post cast strip for this purpose may not be set.

According to the practical experience on site, cracks can be divided into two categories: harmful and harmless\[^4\]. The boundary between harmful and harmless is determined by the use function. When necessary design, construction and material measures are taken to control the occurrence of harmful cracks or due to insufficient estimation and other factors, even if a small number of harmful cracks appear, the chemical grouting treatment can still meet the design and use requirements, the post pouring belt can be cancelled. Practice has proved that from the perspective of long-term normal use, this kind of "anti" based seamless project has a series of advantages over the permanent deformation joint, such as good integrity, water resistance, seismic resistance, construction convenience, etc.

2.2. Structural constraint problem

There are three kinds of structural deformation: free deformation, constrained deformation and actual deformation (apparent deformation), among which only constrained deformation produces constrained stress. When the constraint deformation (constraint stress) exceeds the ultimate tensile strength (tensile strength) of building materials, cracks will be caused.

The force caused by deformation has the maximum value. The designer can design the structure by "resist and release" or "resist and release". The methods of retaining expansion joint and not retaining expansion joint are mainly the methods of releasing or resisting. If they are done properly, the structure will not produce harmful cracks.
The external effect of the structure can be divided into: external load (static and dynamic load), which can be regarded as the first kind of load; the very important external effect is deformation, which means the second kind of load is indirect load, and the deformation includes temperature, humidity and uneven settlement of the foundation\[5\]. In this case, the resistance of the structure depends on the tensile performance of the concrete, that is, tensile strength and tensile deformation.

In the analysis of structural cracks, we should first pay attention to the possibility of cracks caused by the first type of load, especially those structures whose self weight load exceeds about 30% of the ultimate bearing capacity. After formwork removal, it is found that cracks of about 0.1mm are normal structures and stress states. When the ultimate bearing capacity of the structure depends on the tensile, shear and stability conditions, the influence of the cracks caused by deformation on the ultimate bearing capacity of the structure cannot be ignored. It is often said that the temperature shrinkage cracks are not relevant. "It is not comprehensive. Sometimes the penetration cracks of the beam slab structure may reduce the shear and punching bearing capacity. In this paper, the calculation of vertical cracking is introduced.

The approximate calculation formula of the maximum restraint stress of large base plate, long wall, shear wall and floor under the continuous restraint condition is as follows:

\[
\sigma_{s_{\text{max}}}^* = -E\alpha T \left(1 - \frac{1}{\mu ch\beta \frac{L}{2}}\right) H(t, \tau)
\]

Or in time increments:

\[
\sigma_{s_{\text{max}}}^* = \sum_{i=1}^{n} \Delta \sigma_i = -\frac{a}{1-\mu} \sum_{i=1}^{n} \left(1 - \frac{1}{\mu ch\beta \frac{L}{2}}\right) \Delta T E_i(t) H_i(t, \tau_i)
\]

When the stress exceeds the tensile strength, the crack spacing can be calculated:

\[
[L_{\text{max}}] = 2 \sqrt{\frac{EH}{C_s}} \text{arccch} \frac{aT}{aT - \varepsilon_p}
\]

\[
[L] = 1.5 \sqrt{\frac{EH}{C_s}} \text{arccch} \frac{aT}{a - \varepsilon_p}
\]

\[
[L_{\text{min}}] = \frac{1}{2} [L_{\text{max}}]
\]

Among:

T: Including hydration heat, temperature difference and contraction equivalent temperature difference.

\(H(t, \tau)\): relaxation factor;
\( \varepsilon _{p} \): tensile limit of concrete;

H: Thickness of uniform tensile layer (strong restraint zone);

E: Elastic modulus of concrete;

\( C_{x} \): horizontal restraint coefficient;

CH, arech: hyperbolic cosine and hyperbolic cosine inverse function;

a: Coefficient of linear expansion.

Formulas (3), (4) and (5) show that the main factors controlling cracking are restraint, temperature difference, shrinkage and ultimate tensile strength of concrete. We try our best to reduce the first two values and at the same time try our best to improve the ultimate tensile to solve the crack problem effectively. According to the formula, the average crack spacing \([l]\), the maximum crack spacing \([L_{\text{max}}]\), the minimum crack spacing \([L_{\text{min}}]\), \([L_{\text{max}}] = 2[L_{\text{min}}]\), and the average crack width, the maximum and the minimum crack width can be calculated\(^{[6]}\).

It can be seen from formula (3), (4) and (5) that the effect of reducing the degree of constraint (sliding layer, movable node, variable section treatment, etc.) in design, the smaller the difference between temperature difference deformation (including shrinkage) and ultimate tensile, the larger the allowable length, when the temperature difference deformation at equals to ultimate tensile or \(CX \rightarrow 0\), then \(l \rightarrow \infty\). When the ultimate tensile strength \( \rightarrow 0\), and \(l \rightarrow 0\), there is a nonlinear relationship between them. It should be emphasized that not only in design, but also in construction and materials, measures should be taken to reduce the temperature difference (shrinkage difference) as much as possible, improve the ultimate tensile strength, reduce the degree of restraint, and achieve the purpose of comprehensive crack control.

3. Summary

In recent years, due to the change of housing property right system and the improvement of living standards, the requirements for housing quality are more stringent. Although it is identified that there are no harmful cracks affecting the safety, there should be a proper range of permission from the requirements of aesthetics and spiritual function.

Acknowledgements

Youth Science and Technology Innovation Project of Longdong University (XYZK1907).

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