Research on Anti-Crack Design of Super-Long Concrete Structure

Huihui Jiang*

School of Management, Tianjin University of Technology, Tianjin, 300384, China
*Corresponding author’s e-mail: 279642639@qq.com

Abstract. There are many reasons for cracks at super-long concrete, which may be due to factors such as tensile stress and temperature shrinkage. Combined with the existing research and in-depth analysis from multiple angles, the causes of mass concrete cracks and the design method of temperature post-casting zone are described. Finally, related technical suggestions and supplementary measures were also put forward. At present, the anti-crack design of super-long concrete structures is mainly based on experience. Structural measures are used. The comprehensive effect lacks check and review. Even if the maximum crack width is checked, the load effect of concrete forming and cool shrinkage is basically not combined. For different requirements, an appropriate crack controlled standard is selected, and the maximum crack width limit of concrete specifications is generally used as the upper limit.

1. Introduction
At this stage, with the progress of China's society and the continuous improvement of the economic level, people's living standards have also been rapidly improved. At the same time, they have higher requirements for the construction level of civil engineering of buildings and structures. However, for large volumes as far as the concrete structure is concerned, the quality of the finished product will not only affect the overall quality of the project, but will also have a great impact on future daily use. In terms of the construction technology of large-volume concrete at this stage, due to the differences in different monomer structures, there are different concrete construction pouring schemes for the size, shape and volume of different monomer structures. For super high-rise concrete structures, the pile foundation, underground structure and above-ground structure concrete have large volume, complex structure, and high technical requirements, even higher than the general construction standards. Therefore, the construction technicians of the construction unit should use practical and effective construction techniques. The process is controlled to ensure that the concrete structure are more efficient and safe For ultra-long concrete underground structures, wide cracks and their amplitudes may cause damage to the local waterproof layer, forming leakage channels through the wall panels, and then leakage will affect the normal use of the structure and reduce the durability of the structure. At present, the actual service life of common polymer membrane waterproofing layers is obviously shorter than the service life of the structural design, and the design usually does not reserve or cannot reserve the conditions for updating and reforming such waterproofing layers. For this reason, the anti-leakage and durability designed of ultra-long concrete underground structures of anti-leakage requirements should not be relaxed due to the conventional waterproof layer on the outside.
2. Main causes and influencing factors of cracks in mass concrete

2.1. Cracks caused by construction
Adding water or adding excessive admixtures to the on-site mixing concrete increases the water-cement ratio, which not only reduces the strength of the concrete, but also easily causes dense bleeding, leaving a lot of bleeding channels and forming a weakened layer on the surface. Capillary shrinkage occurs after water loss, causing cracks to appear. Whether the maintenance after construction is timely is the key to quality assurance, and it will affect the shrinkage of the concrete and cause cracks. If the bearing time of the concrete is too early, it will cause the concrete to partially collapse and stress concentration, which will cause the concrete to crack[1].

2.2. Causes and influencing factors of plastic shrinkage cracks
Concrete is a mixture of sand, stone, water, and cement. During the hardening process of the mixed concrete, the total shrinkage are 0.04% to 0.06%[2]. At the same time, as the strength level of cement increases, the fineness increases. As the volume increases, the concrete shrinks further. If the newly-cast concrete structure is not covered with water retention measures in time before hardening, the surface water evaporation rate exceeds the rate of internal water surface migration and replenishment, especially in dry areas, where the air humidity is small, resulting in a large amount of water evaporation in the plastic stage of the concrete. The crack speed are accelerated, and this plastic shrinkage crack will have serious consequences of the safety of the concrete retaining wall, waterproof permeability and structural durability. Factors affecting the plastic shrinkage of concrete: too much cement, too much mud in the sand or cement with a large shrinkage rate; the concrete water-cement ratio is too large, the formwork is too dry; adding a retarder to delay the set time will increase Plastic shrinkage; the concrete is excessively vibrated, and more mortar layers are formed on the surface; after the concrete is poured, the surface is not covered in time, the water evaporates, and the volume shrinks sharply, resulting in cracking[3].

2.3. Influence of temperature
Generally, when the construction technology of mass concrete structure is applied for civil engineering, its quality is easily affected by temperature. Based on this status quo, during construction, if the temperature difference between the outside world is large, then a large temperature stress will be generated, so that cracks are prone to occur[4].

3. Post-Temperature Design

3.1. Effect of concrete shrinkage
In the process of civil engineering application of large-volume concrete construction, in order to ensure the quality of concrete hardening after pouring, at this time, it should be ensured that it has about 20% of water[5]. After the concrete construction, the evaporation of water during curing can not be effectively controlled to increase the shrinkage of the concrete. In this way, it is easy to crack, which will affect the quality of the construction. In addition, in the process of construction, usually large volumes of concrete will be used. Based on this situation, in order to ensuring the quality of concrete, in general, the construction personnel will add appropriate additives, etc. This imposes higher requirements on the construction personnel, requiring them to effectively control the evaporation of concrete moisture, which will affect the entire construction process. Therefore, the construction personnel needed to pay attention to reducing the occurrence of unnecessary problems and reducing Crack phenomenon to ensure the efficiency and rationality of the construction process.

3.2. Cross reinforcement
With the increase of the number and strength of the structural reinforcement of the cast-in-place strip after the crossing temperature, tensile stress of the concrete molding also increases accordingly.
Therefore, there is a limit to the reinforcement ratio of these crossing rebars. \( \left[ p_s \right] \), \( \left[ p_s \right] = \left[ A_s \right] / A_c \), \( \left[ A_s \right] \) and \( A_c \) are the continuous crossing steel bars area and concrete cross section within the unit length of the post-casting belt. When \( p_s \geq \left[ p_s \right] \), the post-casting belt is completely ineffective at the visible temperature, where \( p_s \) is the reinforcement ratio of the steel bar casted across the temperature, \( \left[ p_s \right] = A_s / A_c \), and \( A_s \) is the post-casted belt at temperature After the oblique penetration of the temperature, the \( A_s \) with the reinforcement needs to be multiplied by the reduction coefficient \( \zeta \), \( 0 \leq \alpha \leq \pi \), \( \zeta = \alpha / \pi \). The elastic analytical formula for determining \( \left[ p_s \right] \) can be derived as follows[1]:

\[
\rho_s = \frac{l}{\alpha_s (b_{pc} - 1)} + \frac{b_{pc}}{\alpha_s l_{pc}}
\]

(1)

In the formula: \( E_s / E_c \) and \( E_c \) are the modulus of elasticity of concrete and steel bar respectively; \( l_{pc} \) is the spacing of the post-cast strip; \( b_{pc} \) is the width of the post-cast strip.width of the post-cast strip.

3.3. Reasonable width range

If the actual project requires or restricts the continuous reinforcement of the cross-reinforcement at the post-belt position (not temporarily cut off), you can reduce the number of these cross-reinforcements by increasing the number of post-reinforcement (reducing the spacing) or increasing its width. Elastic analytical formula to determine the reasonable range of \( b_{pc} \) can be derived as follows[1]:

\[
b_{pc} = (\xi_i \lambda_i \eta_i + \xi_r \lambda_r \eta_r) \alpha_s E_s / \rho s l_{pc}
\]

(2)

In the formula: \( \xi_i \) and \( \xi_r \) are the constraint influence coefficients of the forming vertical members on the shrinkage and deformation of the concrete on the left and right sides of the cast-in-place belt, respectively. \( l \) and \( r \) are greater than 0 and decrease as the constraint increases. Constraints, \( \xi_i = \xi_r = 1 \), 0; \( \lambda_i \) and \( \lambda_r \) are the constraint influence coefficients of the crossing steel bar on the shrinkage and deformation of the concrete on the left and right sides of the cast-in-place belt. \( \lambda_i \) and \( \lambda_r \) are greater than 0 and vary with \( s \) increases and decreases. If all \( A_i \) are overlapped or ignored, \( \lambda_i = \lambda_r = 1 \); \( \eta_i = l_{pc} / l_{pc} \), \( \eta_r = l_{pc} / l_{pc} \), \( l_i \) and \( l_r \) are post-pouring, respectively. Calculate the length of the shrinkage area of the concrete with left and right sides, \( l_{pc} = l_i + l_r \).

Obviously, when the constraints on the shrinkage and deformation of the concrete on both sides of the cast-in-situ strip have been increased by the formed vertical members and crossing steel bars, there is \( \xi_i \lambda_i \eta_i + \xi_r \lambda_r \eta_r \rightarrow 0 \), otherwise, \( \xi_i \lambda_i \eta_i + \xi_r \lambda_r \eta_r \rightarrow 1 \). It can be known from this that \( 0 < \xi_i \lambda_i \eta_i + \xi_r \lambda_r \eta_r < 1.0 \), taking into account the current status of construction, \( 800 \sim 1000 \text{ mm} \leq b_{pc} < \alpha_s \rho s l_{pc} \). That is, the lower limit of the normal width of \( b_{pc} \) is \( 800 \sim 1000 \text{ mm} \), and the corresponding upper limit is \( \alpha_s \rho s l_{pc} \) after neglecting the influence of the formed vertical members and the crossbar reinforcement. In this case, just take an integer value between the two limits.

4. conclusion and suggestion

(1) It can be known from the above analysis that in actual construction, the quality of mass concrete will affect the overall project quality. Therefore, in order to ensure the construction efficiency, the relevant staff should effectively control and manage from the aspects of preparation and pouring, and at the same time, the cracks generated by the structure should be dealt with in time. The relevant training department
of the construction unit shall regularly provide construction management personnel with mass concrete placement technology training, so as to popularize the professional knowledge and skills related to mass concrete to ensure the safety and smooth operation of the entire project.

(2) The anti-cracking design of super-long concrete structures should be carefully selected with expansion reinforcement belts or expanded concrete. If these measures are adopted, the validity should be checked and rechecked based on the overall structural model and actual working conditions.

(3) Calculate according to the method in Section 3.2. If it is confirmed that \( p_i \geq \left[ p_i \right] \) of the reinforcement of the cast strip after continuous crossing temperature, it is necessary to cooperate with the combined stress analysis to increase the number or width of the cast strip after temperature, or correspondingly increase other structural cracking measures.

(4) The existence of cracks in the concrete structure not only affects the bearing capacity of components, but also affects the durability and safety of the structure. Therefore, the construction of concrete must be in accordance with national standards in order to effectively control various cracks in concrete and carry out effective prevention and control to ensure the quality of concrete. Due to the effective crack control measures adopted in the retaining wall project, the construction quality of the concrete is ensured, and the occurrence of harmful cracks is avoided.

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