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Influence of Core Wall Type on Crack Resistance of Core Wall

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Abstract

The hydraulic fracturing resistance of asphalt concrete core wall mainly depends on physical and mechanical factors such as the material of the core wall and the geometric size of the core wall. Three types of core wall types, such as equal thickness type, gradient type and stepped type, are often used in practical engineering. In order to study the influence of core wall types on the cracking resistance of the core wall, Duncan Zhang E-B model is used to conduct finite element numerical simulation of five different core wall types. By analyzing the stress deformation of the center wall of different schemes, it is concluded that the equal thickness core wall has the best anti-hydraulic splitting performance without considering the engineering cost.

Keywords

Asphalt Concrete Core Wall; Hydraulic Splitting; Core Wall Dimensions.

1. Introduction

The geometric size of the core wall has a direct influence on the stress and strain of the core wall. For example, Ge Lili [1] points out through numerical simulation that the arch effect of the core wall of the inclined core dam is relatively weaker than that of the straight core dam, and the hydraulic splitting resistance of the inclined core wall is better than that of the straight core wall. Chu Fuyong [2] pointed out that the hydraulic fracturing resistance of curved core wall of curved dam is better than that of straight core wall of straight dam. Dang Faning [3] points out that the tensile stress is lower and the behavior of the core wall is better than that of the straight core wall. All of the above studies focus on the overall slope curvature of the core wall, and the influence of the inner structure of the core wall on its cracking resistance will be discussed in this paper. In addition, when selecting the core wall, no matter how the type and thickness of the core wall change, the minimum construction width requirements should be met when minimizing the amount of asphalt concrete to ensure that the core wall can operate normally under various working conditions.

2. Research Program

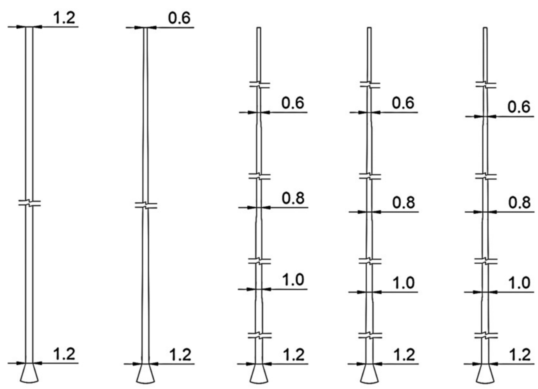

Figure 1. Diagram of different core wall types

This paper will study the influence of five different core wall types on the cracking resistance of the core wall, namely, equal thickness type, gradient type, stepped type, upstream gradient type, downstream gradient type, upstream gradient type, downstream gradient type, and the five types of core wall can ensure the constant position of the center line of the core wall, see Figure 1.

3. Core Wall Stress Analysis

3.1. Core Wall Deformation Analysis

Figure 2 shows the cloud diagram of core wall settlement during the completion period and the water storage period of the equal thickness core wall scheme. The maximum core wall settlement under both conditions occurs at about 1/2 of the dam height. As the upstream rockfill in the water storage period is driven by the floating force of water body to move the core wall towards the dam top, the core wall settlement during the water storage period is smaller than that during the completion period, and the maximum settlement value during the completion period is 55.54cm. It accounts for 0.52% of the dam height. The settlement law of other core wall types is basically the same as that of the equal thickness type, and the maximum settlement values are 55.54cm, 56.74cm, 55.57cm and 55.53cm, respectively, which are all less than 1% of the dam height. According to the calculation results of each scheme, the change of core wall type has almost no influence on the settlement of core wall. The maximum settlement of stepped core wall is slightly larger than that of other types, and the settlement value of upstream stepped and downstream gradient core wall at the height of 63m is larger than that of other types. This is because the thickness of stepped core wall changes too fast within a certain elevation, and the tribological effect of transition material on the settlement of core wall is weakened. Causing the core wall to produce bad stress deformation, will increase the possibility of the core wall cracking.

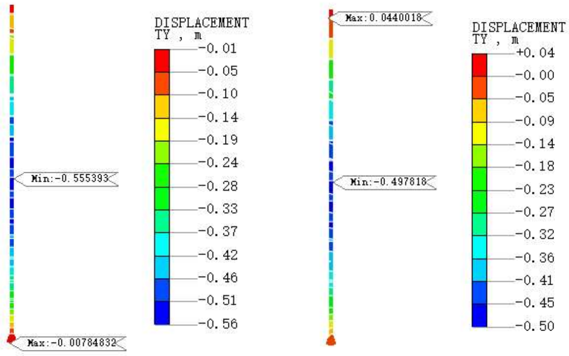

Figure 2. Settlement diagram of equal thickness core wall

The maximum along-river displacement occurs at the top of the core wall during the water storage period of each scheme, and deforms downstream, which are 23.51cm, 23.60cm, 23.47cm, 23.65cm and 23.85cm respectively. The maximum along-river displacement of the core wall during the water storage period of each scheme has little difference, which is far less than the deformation capacity of asphalt concrete. The maximum flexural span ratio is about 0.24%, and the risk of flexural cracking is small. Among them, the stepped core wall is the smallest, the dam shell material has the strongest limiting effect on the horizontal displacement of the core wall, but the height of the core wall is about 30m. The upstream and downstream gradient core wall is the largest, and the height of the core wall is 63m. This is because the thickness of the core wall changes too fast in a certain elevation upstream, the control and

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constraint effect of the transition material on the core wall is weakened, and the deformation trend of the core wall to the downstream is increased, which increases the possibility of the core wall cracking, which is unfavorable to the work of the core wall.

3.2. Core Wall Stress Analysis

When the same thickness core wall is adopted, the asphalt concrete core wall is basically compressed under two working conditions, there is no tension stress distribution, and the compressive stress increases with the decrease of elevation. The asphalt concrete core wall has no tensile stress under the two conditions, and the possibility of tensile cracking is not very high. The main stress of the core wall size in the completion period of the five schemes is greater than that in the impounding period, because the upstream shell material of the dam body is affected by the floating force of the water body. During the completion period, the core wall is subjected to the maximum compressive stress at the junction of the core wall and the base, with the maximum principal stress of 2300.27kPa, and the minimum compressive stress at the dam top, with the minimum principal stress of 7.25kPa. During the water storage period, the core wall is subjected to the maximum compressive stress (1628.57kPa) at the junction of the core wall and the base, and the minimum compressive stress (6.07kPa) at the dam top. The stress law of other core wall types is basically the same as that of equal thickness type.

3.3. Hydraulic Splitting Analysis

The calculation results show that the vertical stress in the core wall during the storage period is compressive stress, without tensile stress distribution, and the difference between the vertical stress and the water pressure gradually increases with the decrease of the elevation during the storage period. The average vertical stress of the core wall element at the same elevation of each scheme is greater than the water pressure when the reservoir is full, and the hydraulic splitting risk is small. The position of the core wall near the base of each scheme suddenly becomes smaller, which is caused by the strong arch effect at the bottom of the core wall.

The vertical stress of the stepped core wall fluctuates significantly up and down 30m above the core wall, while that of the stepped and down gradient core wall 63m above the core wall. This is due to the sudden change in the thickness of the core wall. When the shear stress of the core wall increases, the large difference between the modulus of the transition material and the core wall leads to the intensified restraint and control effect on the deformation of the core wall, and the stress arch effect of the core wall is enhanced accordingly. The vertical stress is weakened.

The crack safety ratio coefficient K_n is used as the standard to characterize the crack safety performance of asphalt core wall, and the difference of the influence of core wall type on the crack resistance of the core wall is quantified to make the influence law more clear.

$$K_n = \frac{\overline{\sigma_z} + \triangle\sigma_z}{\overline{\sigma_z}} \tag{1}$$

Where $\overline{\sigma_z}$ is the water pressure value at the same elevation at the tangential point between the vertical stress line and the doubled water pressure line when the dam is fully stored. $\triangle \sigma_z$ is the difference between the mean value of vertical stress and the water pressure at the same elevation core wall element at the tangent point of the vertical stress line and the multiplied water pressure line when the dam is fully stored. When $K_n < 1$, hydraulic splitting of the core wall is very likely to occur, when $K_n > 1$, the hydraulic splitting risk of the core wall is small, the higher the K_n value, the weaker the arch effect, the smaller the cracking risk of the core wall, and the greater the vice versa.

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Table 1 shows the calculated proportional coefficients of anti-cracking safety of different core wall types. It can be seen that the anti-cracking safety indices of the five schemes are all greater than 1, indicating that the hydraulic splitting risk is small when the five core wall types are adopted. Among them, the equal thickness core wall has the highest K_n value (1.535), and the most likely position for the first crack is the bottom of the core wall, which has better hydraulic fracturing resistance and safer core wall form than other core wall types. The second is the gradient type and the upstream gradient downstream step type, and the safety coefficients of crack resistance are 1.526, which also indicates that the geometric shape of the downstream core wall has little influence on the crack resistance of the core wall, and the main influencing factor is the upstream core wall shape. The crack resistance of the upstream and downstream gradient core wall is the worst, and the crack resistance coefficient is 1.348. This is because the uneven stress of the asphalt concrete core wall produces a large arch effect at the height of 60m, and the vertical stress of the core wall decreases abruptly. The most likely crack location is also on this elevation.

Table 1. Safety ratio coefficient of crack resistance of different core wall types

Core wall type	K_n
isopach	1.535
tapered	1.526
stepped	1.498
Upstream gradient downstream step type	1.526
Upstream cascade downstream gradient	1.348

Each of the five schemes has advantages and disadvantages. Although the equal thickness core wall has the best crack resistance, the structure size remains unchanged, the construction is simple, and it is widely used in low DAMS. For example, the bituminous concrete core wall of the cave with a dam height of 47m is arranged with a dam core wall of 50cm width and equal thickness, more bituminous concrete is required in high DAMS than other schemes, which will cause certain waste and high project cost. When other core wall types can also meet the engineering requirements, other types will be preferred in order to save the project economy. The structure size of the gradual core wall is gradual, the structure is relatively reasonable, the stress state of asphalt concrete is better, and the stress concentration will not be caused by the gradual change of structure size. However, because the structure size is gradual, the horizontal width of each layer is different, and the size of each layer needs to be adjusted during the construction process, and the construction process is more difficult. The stepped core wall is developed on the previous several structural dimensions, although the crack resistance is poor, it changes the difficult problem of construction control to a certain extent, and reduces the construction waste. If the structural difference size control is reasonable, it is a more reasonable structure type. For example, the asphalt concrete core walls of the main dam of Nierji, the Three Gorges Maopingxi and the Yele Dam in Sichuan are all terraced.

4. Conclusion

The change of core wall type has little effect on the settlement of core wall. There is little difference in the maximum along-river displacement of the core wall during the storage period. The shear stress of each scheme fluctuates obviously at the bottom of the core wall. The shear stress of the core wall during the water storage period is greater than that during the completion period, but the maximum shear stress is less than the shear strength of the asphalt concrete core wall. The average vertical stress of the core wall element of the same elevation is

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greater than the water pressure when the reservoir is full, and the hydraulic splitting risk is small. The Kn value of equal thickness core wall is the highest, which is 1.535, and the most likely position for the first crack is the bottom of the core wall, which has better hydraulic splitting resistance than other core wall types.

Acknowledgments

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