Study on Reasonable Pipe Section Length of Large Inverted Siphon

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Objectives

The determination of a reasonable length of pipe section is one of the key issues in the design， construction and operation of a large inverted siphon structure． Taking a large inverted siphon to be built as the research object， and considering the influences of pipe-soil interaction， backfill material consolidation， foundation deformation and other factors， the threedimensional finite element models of inverted siphon with pipe section lengths of 15 m， 20 m and 25 m are established respectively， and the nonlinear mechanical analyses are carried out considering the load condition combination during the operation period． The overall settlement of the inverted siphon， the vertical deformation of the pipe body， the stress and the opening amount of the pipe section of the three kinds of pipe section lengths are compared and analyzed， and on this basis， the reasonable pipe section length is proposed． Simultaneously， the stress analysis is also carried out with the proposed length of the pipe section， and the location where it is prone to damage is pointed out and the corresponding structural measures are put forward to provide reference for the design and construction of the inverted siphon to be built and similar engineering practices．

Methods

In order to reasonably consider the influence of boundary effects, the soil on both sides is taken as twice the width of the pipe body from the outside of the side wall, and the depth of the bottom foundation is taken as four times the height of the pipe body. The equivalent composite foundation model is used for the calculation and analysis of the lower vibroflotation gravel pile foundation, and the reinforcement area is treated as an isotropic composite material for calculation and analysis. When defining the interaction contact surface between pipes and soil, the surroundings of the concrete inverted siphon body are used as the main control contact surface, and the surrounding soil is used as the subordinate contact surface. In the analysis, the concrete and cushion parts of the inverted siphon body adopt an isotropic elastic model. Due to the complex reinforcement of the inverted siphon body to be built, a holistic modeling is used to simulate the pipe body. In order to better reflect the stress-strain situation of the foundation soil, this article uses the Mohr Coulomb elastic-plastic model to model the soil. This article comprehensively considers the influence of the geometric size of the inverted siphon body on the structural stress, and uses solid elements to simulate the backfill soil on the upper part of the pipe body, in order to objectively reflect the soil pressure on the upper soil of the buried pipe. When adding loads on the basis of self weight, it is necessary to perform initial geostress balance on the foundation, in order to obtain an initial stress field that meets both the equilibrium conditions and does not violate the yield criterion, thereby ensuring that the initial displacement of each node is approximately zero.

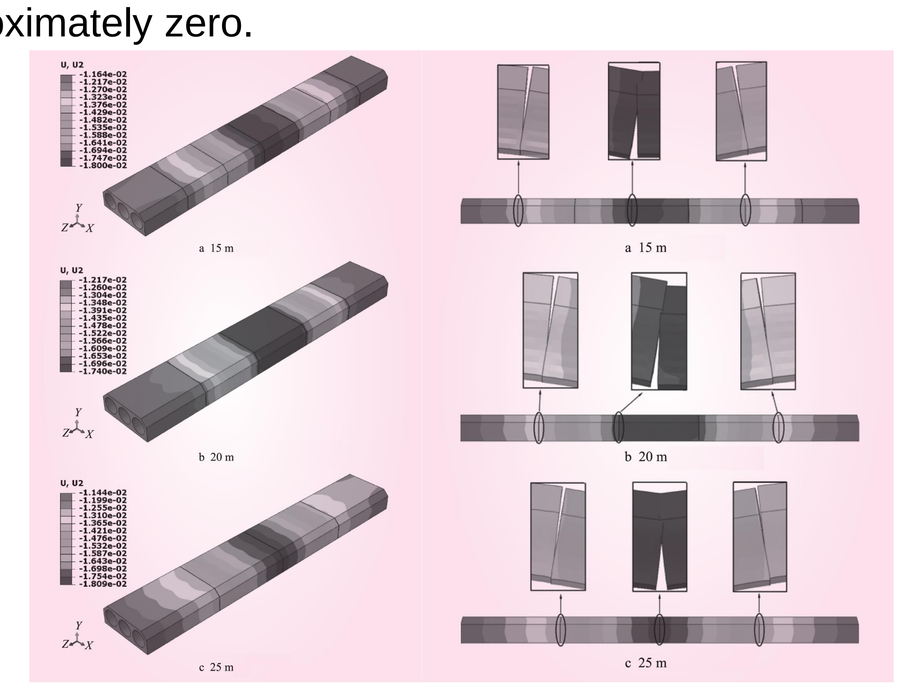

Figure 1 Vertical displacement and deformation of the pipe body

Results

Using the above three-dimensional finite element model, under the combined load of operating conditions, the overall settlement of three types of inverted siphon structures with different pipe joint lengths, the vertical displacement of concrete pipe structure, the size of pipe joint opening, the first principal stress, and the third principal stress were calculated and analyzed. The vertical displacement and deformation are shown in Figure 1, and the first principal stress of the middle section with a length of 20m is shown in Figure 2. Through comprehensive comparison, it can be seen that the length of 20m pipe joint has the smallest settlement difference, The opening amount, turning angle, and other deformations between pipe joints are the smallest, and the tensile stress generated is the smallest. From this, in addition to improving its overall tensile strength along the longitudinal direction, it is also necessary to take into account the large tensile stress at both ends of the pipe mouth and tail; In the horizontal direction, the tensile strength of the partition between the three water holes should be strengthened, as well as the concrete tensile stress strength of the left and right side plates of the pipe body.

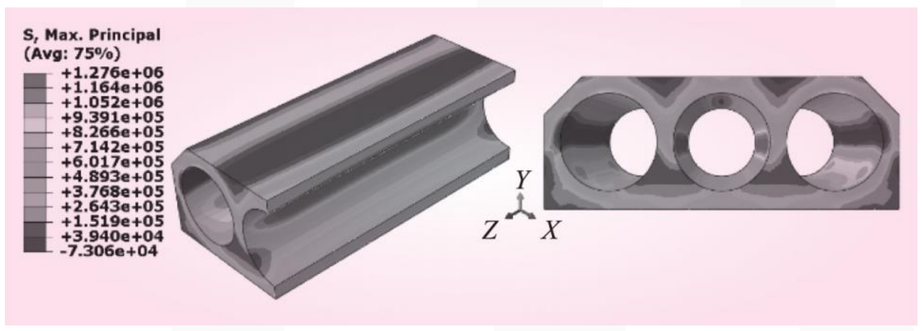

Figure 2 first principal stress of the middle section with a length of 20m

Conclusions

This article establishes a nonlinear three-dimensional finite element model for the interaction between pipes and soil. From the perspectives of settlement, deformation, and stress, it explores the reasonable pipe joint length and stress distribution state of a large inverted siphon structure to be built in a certain area. The main conclusions are as follows: (1) It is appropriate to choose a reasonable pipe joint length of 20m for the inverted. (2) The vertical settlement of the pipe section directly below the river is relatively large, and the opening and deformation of the water stop connections on both sides are the greatest, which is prone to damage. Therefore, it is advisable to replace the water-tight seal. (3) The concrete inside the water hole of the pipe section is subjected to significant tensile stress. Therefore, the partition, side wall, and bottom plate of the inverted siphon pipe structure should be appropriately reinforced to avoid cracking of the pipe concrete.