New Structure of Impervious Steel Sheet Pile in Foundation Slab

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Abstract. In view of the poor seepage control effect, slow construction progress and high investment cost of the existing sluice vertical impervious core structure, a new type of anti-seepage steel sheet pile structure for foundation slab is proposed in this paper. The new structure is formed by connecting multiple steel sheet piles, the steel sheet pile is in "U" shape, the steel sheet pile body forms horizontal extension edges on both sides, the two extended edges form two reverse hooks at the end, and the clasp forms an inward inclined plane at the connection opening. The steel sheet pile is used as the vertical anti-seepage body, and the structure of the steel sheet pile is optimized. The connection end is connected by the reverse hook. The gap between the connection end faces is small and the anti-seepage performance is good. The structure reduces the seepage head, reduces the saturation line, and improves the stability of sluice foundation and sluice.

1. Preface

Sluice is widely used in water conservancy projects and plays the role of flood discharge and waterlogging drainage. Huang mu-shun[1] systematically analyzed and emphasized the importance of sluice drainage and anti-seepage design, and its anti-seepage quality directly affected the overall function and structural safety of sluice. Cement, mortar, clay, concrete and other materials are often used in the vertical impervious body of foundation, but the anti-seepage effect is not ideal. Li Yan-song[2] made a comprehensive comparison between plastic concrete and high-pressure spiral spray technology for the anti-seepage design of Westlake sluice foundation, and pointed out that the plastic concrete with good anti-seepage effect also has the disadvantages of large construction amount, easy hole collapse during trenching and long construction period. High pressure jet grouting cutoff wall is also used for anti-seepage treatment. Wen Hai-jia et al[3] took the anti-seepage wall project of Linhuaigang Water Control Project as an example, and analyzed the technical difficulties encountered in the use of high-pressure jet grouting method, such as complex construction technology, slow construction progress and high investment cost. Yue Juan et al[4] made a comprehensive comparison between the composite geomembrane and plastic concrete in the seepage control of the Yellow River Diversion Sluice, and found that even if the permeability coefficient of the composite geomembrane is better than that of the plastic concrete and the cost is low, the uneven settlement of the sluice chamber cannot be reduced. Then, Larsen steel sheet pile as a new material with high strength, light weight, good water resistance, reusable and short construction period, breaks the bottleneck of anti-seepage technology. Zhou Yuan-yuan[5] introduced in detail the wonderful use of Larsen steel sheet pile material in seepage control. But how to adjust measures to local conditions and combine with water conservancy projects is a difficult problem. In addition, Xia Wei [6] made a comprehensive analysis on
the advantages and disadvantages of the steel sheet pile structure which has been applied in the water conservancy dike project. Even though the construction technology of the steel sheet pile structure has been quite mature after years of improvement, there are still some situations, such as moving forward when the force is unbalanced, and the anti-seepage effect of the lock is not ideal in some cases. Aiming at the problems existing in the existing technology, this paper studies the new structure of anti-seepage steel sheet pile in foundation slab.

2. New structural features
Steel sheet pile is a kind of high-strength steel with lock mouth in seepage prevention of steel sheet pile. The closed steel sheet pile wall is formed by locking and occluding. It can be used to cover part of water and soil engineering, and more suitable for underground seepage control and groundwater level. Its shape is generally U-shaped. Its characteristics are high strength, high bending strength, especially high joint, not easy to leak. And its construction technology is relatively simple, continuous operation is simple and fast, suitable for weak strata and rich groundwater areas. Because of the close connection of the lock joint, the problem of easy opening in the construction of the waterproof wall can be solved and the large-scale leakage of groundwater can be prevented. As shown in the Fig.1, it is the structural schematic diagram of a new type of steel sheet pile structure with anti-seepage of foundation slab, which can be applied to the anti-seepage of lock chamber bottom plate. The new structure is made up of several steel sheet piles 1. The number of steel sheet piles is increased. Instead of using only one layer of steel sheet piles, the new structure is "U" shaped and has a certain angle outward expansion. The purpose is to expand the support range and area of the structure, and to be more fixed and reliable. Secondly, the surface of steel sheet pile 1 is also coated with waterproof coating 2. The waterproof coating can better isolate the water penetration and effectively improve the impermeability by using the compactness of the material. In addition, an anti-seepage membrane is set outside the steel sheet pile to further isolate the water penetration and further prevent seepage. Then, along the "U" shaped steel sheet pile body, horizontal extension edges are formed on both sides, and the two extended edges form two reverse hooks 3 at the end. The reverse hook has more advantages in connection and closure, which is convenient for construction, has small connection end clearance and good anti-seepage performance. The hook 3 forms an inward inclined slope 5 at the connection opening, which further strengthens the fixation and tightness of the connection. Moreover, a waterproof rubber pad is set inside the hook 3, which improves the anti-seepage effect of the connection port, effectively improves the anti-seepage property of the connection end, and ensures the safety of the structure. In addition, the steel sheet pile in the structure also forms a V-shaped support frame 4 inside the two sides, which ensures the stable support of the steel sheet pile and prevents the soil around the steel sheet pile from showing obvious inclination angle due to insufficient resistance of the soil around the steel sheet pile during construction, thus causing potential safety hazard. The concrete strength grade is C25, the impermeability grade is W6, the frost resistance grade is F50, and the minimum cement content of reinforced concrete is $300 \text{ kg/m}^3$.

3. Innovation of new structural features
Firstly, compared with the traditional high-pressure jet grouting anti-seepage wall, the steel sheet pile has the advantages of large treatment depth, good anti-seepage effect, small impact on adjacent
buildings and fast construction speed. Secondly, due to the difference of the project, the geological and environmental conditions of the sluice will also have its particularity. Compared with the traditional seepage control measures, the steel sheet pile structure has more advantages. Moreover, from the structural point of view, the new structure has also done a lot of new details. If the number of steel sheet piles is increased, the structure will have stronger firmness and impermeability than using a single steel sheet pile. The increase of the number will also cause the increase of weight, and the greater weight will produce greater resistance, which will make the steel sheet pile structure more stable and not easy to tilt. Then, the new structure of anti-seepage steel sheet pile is not only equipped with anti-seepage membrane outside the steel sheet pile, but also coated with waterproof coating on the surface. It also has waterproof rubber pad at the end hook of connection function, which has stronger anti-seepage effect, reduces seepage head, reduces infiltration line, and improves the stability of sluice foundation and sluice. Then, the optimal design of the hook is also refreshing. The structure adopts reverse hook connection at the connection end, which is different from the previous hook symmetrical design form. Such design of the structure will make the connection more firm and closer, weaken the influence of penetration at the end of the connection, improve the construction efficiency, and better adapt to the construction conditions in the actual construction. In addition, the greater innovation is that the V-shaped support frame is formed inside the two sides, and the former steel sheet pile structure may move forward due to the unbalanced force, thus affecting the stability of the structure or the anti-seepage effect. The V-shaped support frame is added to the structure, which not only alleviates the problem of force imbalance to a certain extent, but also makes the structure more difficult to deform.

4. Conclusion
The anti-seepage steel sheet pile structure of foundation slab described in this paper is a new structure optimized and designed after optimizing the existing steel sheet pile structure and combining with the actual seepage control problem of sluice, which can better play the anti-seepage role in the sluice floor and improve the engineering quality level.

Compared with the previous steel sheet pile structure, the structure is almost the same except that the direction of the hook is changed to the reverse direction and the V-shaped support frame is added. Moreover, because the structure combines with the actual situation of water conservancy project, anti-seepage measures are added in each detail, which is also a new breakthrough in applying steel sheet pile structure to the vertical anti-seepage body of sluice. The structure uses steel sheet pile structure to prevent seepage, which not only improves the anti-seepage effect of cement, mortar, clay, concrete and other common materials, but also simplifies the construction technology of steel sheet pile, improves the construction progress and reduces the construction cost. It also has more advantages than other anti-seepage measures in terms of safety and environmental protection effects, and its development potential and market space are also large.

The new structure of anti-seepage steel sheet pile in foundation slab is suitable for the steel sheet pile structure with anti-seepage of lock chamber floor, but it is not limited to this structure, and more deformation can be put into use in other examples.

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