

Experimental Study on Stress Performance of New Pre-stressed Gate Pier Structure

Abstracts: The design of gate pier structure is usually constrained by the stress state at the neck, so pre-stressing techniques are an important measure for improving the stress performance of large radial gate pier structures. The structure features of anchor blocks and their influence on neck stress are key problems which should be considered during the design of large radial gate piers. By using structural simulation model tests and taking the pre-stressed gate pier of the sediment release gate at Pushihe Power Station as an example, the changes in crack resistance and stress distribution in anchor blocks caused by their reserving cavities are analyzed. The influences on the stress performance of pre-stressed gate pier structures by anchor blocks with cavities are discussed. The results show that the design scheme of new, cavity type, anchor blocks can effectively improve the preloading effect at the neck of gate piers as well as improve the crack resistance of gate pier necks.

Keywords: Pre-stressed gate pier; Model test; Cavity type anchor block; Stress performance; Pre-stressed anchor ties

CLC: TV32+1

Document code: A

1. Background

In recent years, with the increasing of flood discharge at hydro-junctions, the working head increases continuously, the thrust on radial gates is becoming greater and greater larger, and the stress performance of gate piers becoming more complex. Adequate attention has been paid to the influences on the stress performance of gate piers by the thrust of large tonnage from radial gates during the design and analysis of many large radial gate pier structures^[1]. The enormous thrust on the radial gate is passed to the gate pier through the support structure. Most support structures of gate piers use anchor blocks. There is no large volume, concrete structure, to share the thrust at the downstream of the anchor block. The stress is concentrated on the connection part (gate pier neck) between the anchor block and gate pier. A high tensile stress area will be formed at this location which may lead to cracking in the concrete^[2]. For the support structure of these types of large radial gates, the crack prevention or crack control requirements of gate pier structures during normal operation period can only be satisfied by adopting prestressed anchorage technology^[3].

Many domestic scholars have studied the structural type of pre-stressed gate piers and their stress mechanisms. Chuancai Li, Caixu He, et al. discussed the structural types and design methods of pre-stressed gate piers. They proposed the slotting anchor block structure type of prestressed gate piers. They thought that this type of anchor would change the transmission path of pre-applied force, increase the compressive pre-stressing at the neck, and improve the effectiveness of pre-stressing^[4, 5]. On the basis of analyzing the stress distribution on the large thrust pre-stressed gate pier necks by the finite element method, Tun Zhu, et al. proposed the structural type of neck slot^[6].

To optimize the stress distribution in the anchor blocks and at the gate pier neck, cavities can be reserved in the anchor block of the gate pier to improve the effect of pre-stressing. The selection of the size and the position of cavities in the anchor block, and the influences of stress at the gate pier neck and in the anchor block, have been the concern of both theorists and engineers. By taking the prestressed gate piers on the sediment release gate at Pushihe Power Station as an example, simulation model tests and studies of the cavity type anchor block gate pier structure are

conducted. The stress performances of new gate piers under three kinds of design conditions are analyzed.

2. Overview of the Project

The sediment release gate in the pump storage power station at Pushihe utilizes a large radial working gate to retain water. The dimension of the orifice is 14m × 20m. The thrust of the radial gate reaches 34,000kN, and the thickness of the gate pier is 4m. It has the characteristics of large thrust and long moment arm. Pre-stressed anchor ties should be used to improve the crack resistance at key parts of the gate pier. The pre-stressed anchor ties are composed of main anchor ties and secondary anchor ties. The main anchor ties are usually arranged along the thrust direction of the radial gate. Certain quantities of horizontal, secondary anchor ties, perpendicular to the main anchor ties are installed in the anchor block to reduce the tensile stress on the anchor block caused by the bending effect of radial gate thrust. This also helps to improve the stress conditions in the anchor block. To improve the pre-stressing effectiveness of main anchor ties, the technical scheme of cavity type anchor blocks is adopted in the design. Its structural arrangement is shown in Fig.1.

In this structural type, cavities are reserved in the anchor block, and the pre-stressing of the main anchor ties are transferred to the adjacent of the action line of radial gate thrust. Compressive stress will be concentrated on the external surface at the cross section of the gate pier neck. The problems of insufficient compressive stress on the external surface and an overabundance of compressive stress at the middle section, which appeared on the cross section of the simple anchor block type pre-stressed gate pier neck during its operation, can be improved. The number of anchor ties required can also be greatly reduced. The length of the cavity can be adjusted according to the amplitude of radial gate thrust, the tonnage, quantities and the construction technique of prestressed anchor ties. After the stretching of anchor ties, the cavity is refilled. This will not affect the integrity of the anchor block, and it will protect the refilled concrete from secondary tensile stress during the stretching of the main anchor ties. The refilled concrete will only be affected by the compressive stress generated by the radial gate thrust.