RESEARCH ON 3D AERATION INFRASTRUCTURE SHAPE OF HIGH-HEAD, LARGE- DISCHARGE SPILLWAY TUNNEL

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Because the river course is narrow, the slopes of both banks are steep, the hydraulic power engineering in alpine valley area usually applies spillway tunnel as the main flood-discharging infrastructure. Both layouts---"Dragon Head" and "Dragon Tail" have a common feature of shape that is the floor elevation falls rapidly in the section of ogee vertical curve, making use of ogee to make water flow smoothly down to join downstream gentle slope free-flow tunnel. The elevation of ogee connection is normally low that leads to great fall and high speed. Additionally, the flow turns direction from time to time, the pressure changes accordingly functioned by centrifugal force, which causes the bigness of pressure gradient. From the running of the projects built, cavitations in high-head spillway mostly start from ogee end, such as Hoover Dam spillway tunnel, Yellow Tail Dam tunnel, Grand Valley tunnel in the United States, Liujixia Engineering right-bank tunnel, Ertan Engineering 1# spillway tunnel in China. Cativation to a certain degree can cause the high speed scouring, thus making the hydraulic structures suffered from cavitation damage, influenced their smooth functioning. The united force of erosion and scouring often lead to large-scale destruction of slop, floor, and bed rock. Therefore, great concerns are paid to the study on the cavitation of ogee end of high-head spillway tunnel all the time.

Aeration relief erosion is the most efficient technique to prevent the cavitation damage of high-head spillway buildings. Since the air trough is adopted in USA Yellow Tail tunnel to solve the defense of ogee section and downstream section, aeration relief erosion began to be applied widely in high-head spillway buildings. The first domestic engineering used aeration relief erosion is Fengjiashan project, which carried on the systematic model experiment and prototype observation, and pre-designed various convex bodies, further verified the excellent erosion-relief effect by aeration flow. Later, spillway tunnels in many projects like Wujiangdu, Lubuge, Dongjiang and Ertan adopted corresponding aeration infrastructure. Meanwhile, study on mechanism of aeration relief erosion and

shape of aeration infrastructure goes deeper and deeper. To sum up, the shape of aeration infrastructure is of two types: two-dimensional and three-dimensional. Aeration karaz, trough and the combination are of typical 2D shape. It effectively solves the problem of bottom flow aeration. The 3D shape infrastructure is aeration karaz of sudden enlargement and sudden drop. This shape is to meet the need of water stop by eccentricity hinge curved gate. Owing to the fairly high position of control gate, the water velocity off gate is relatively low, and the air carrying capacity of lateral stream is limited. Through experimentation, a broom-shape clear water area is found to exist near the lateral wall behind lateral cavitation, which area can not get the protection of aeration relief erosion.

The cavitation erosion of high-head "Dragon Head" free-flow tunnel usually takes place on downstream lateral wall of ogee end and bed floor, thus it's extremely meaningful to study the aeration infrastructure of that part. This paper introduces the simulation result of four types of aeration infrastructure shape of ogee end (sudden drop +lateral contraction aeration karaz), from the aspects of flow pattern, air cavity form, wind velocity of ventilating shaft, flux and water low aeration concentration demonstrates that after optimization on shape size, this 3D aeration infrastructure can acquire satisfying aeration effect on maintaining flow pattern. The 3D aeration infrastructure laid at high-head large discharge spillway tunnel ogee end can form stable lateral and bottom cavities and eliminate aeration blind zone between lateral walls behind karez, so is better than 2D aeration infrastructure in that the latter has a weak point that clear water zone emerges near lateral wall behind karez when the water is deep. The 3D aeration infrastructure is an efficient measure to strengthen the protection for lateral wall, which makes it one of the most effective structures to prevent the destruction of cavitation erosion at ogee end lateral wall and base plate in high-flow- velocity, large-depth spillway tunnels.

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