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Experimental Study on Flow Turbulence Distribution around a Spur Dike with Different Structure

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Abstract

The spur dike is an important building in river guiding and bank protection. In the present paper, the turbulence intensity distribution around spur dikes with different structures under the same flow condition is studied through model experiment and it gives the turbulence contours. Combining with theoretical analysis, it can be calculated that the turbulence intensity in the arc-like spur dike and fan-like are relatively weaker than that of the hook-like spur dike, and the strongest turbulence intensity occurs around the trapezoidal spur dike. The conclusion will provide a scientific basis for a reasonable choice of the structure of a spur dike, which provides the references for a better structure of a spur dike.

Keywords: Spur dike; turbulence ; distribution; flume; structure

1. Introduction

The spur dike is an important building in river guiding and bank protection. So far, there have been a lot of researches about it. Some [1-3] are about the erosion and microscopic turbulence around the tip of a spur dike and its downstream, and some [4-5] are about the numerical simulation of flow around the spur dike combining with the mathematical analysis .But these are based on a single type of spur dike[6]. Since the flow around the spur dike is not the same under different structure of spur dike, and the turbulence kinetic energy distribution are not the same. The flow turbulence plays an important role in the starting up velocity and the erosion of the bed sediment. In order to further study the erosion and sediment movement, it is necessary to research the turbulence intensity around the spur dike.

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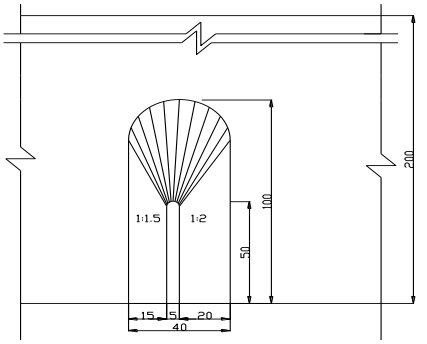
2. Model description

The experiment was carried out in a flume in the Water-Marine Major Laboratory at the ChongqingJiaotong University. The rectangle flume has a length of 30m, width of 3m and height of 0.6m. With undistorted model of scale of 1/40,The model spur dike is designed according to the common spur dikes of the Yangtze River and "Technical Code of Regulation works for Navigation Channel(JTJ312-99).It is 50cm long and 10cm high, and its front slope is 1:1.5, its back slope is 1:2, its slope to river is 1:5(shown in Fig.1).There are four types of the tip of the spur dike, one is a arc-like groin, one is a fan-like groin, the other is a hook-like groin and a trapezoidal groin. The experimental discharge is 51l/s, and depth of water is 10cm.Flow rate is measured by the flow collection system designed by the laboratory, and its sampling frequency is 100HZ.



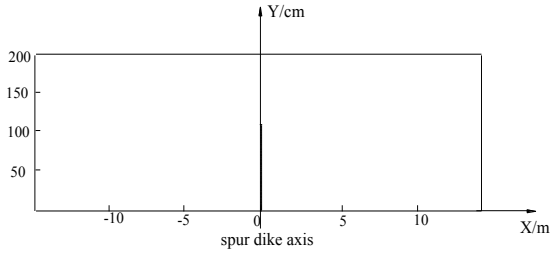


Fig.1. Top view of model spur dike (left)
Fig.2. Coordinate system (right)

3. Results and analysis

A coordinate system is established in order to express conveniently (shown in Fig.2).The *X*-axis is the flow direction, *Y*-axis is the horizontal direction, and *Z*-axis is vertical direction. The model groin is placed in the section *X*=0, and the coordinate *Y*=100cm is the head of groin.*U* is the instantaneous velocity of flow, and $\overline{U}$ is the mean square value of *U*, U' is the fluctuating velocity. The flow turbulence intensity *T* is the mean square value of U'.

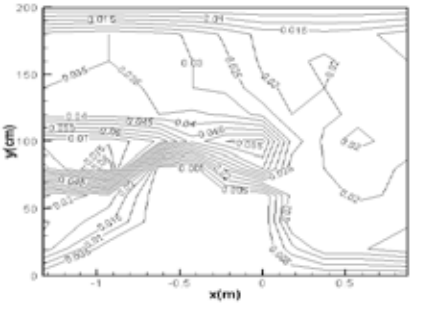
3.1. Plane turbulence distribution of different structure spur dikes

Most of the spur dikes in the natural rivers are made of granular materials. It is not the same that different structure effects the velocity distribution, especially effects flow turbulence greatly. Here is the turbulence distribution contour of four spur dikes.

From the figures we can see that the turbulence contour distribution of the four structure spur dikes are similar because the stronger turbulence almost concentrates along the region 0.4m<$X \leq$ 1.2m and 80cm<*Y*<140cm,and the extreme is nearly in the point *X*=1cm and *Y*=100cm.

But there are many differences between them. The turbulence contour of the trapezoidal spur dike is densest than the others (shown in Fig.3), which is because the trapezoidal cross-section is angular and interferes the flow severely. The turbulence contour of arc-like spur dike(shown in Fig.4)、fan-like spur dike (shown in Fig.5) and hook-like spur dike (shown in Fig.6) are relatively sparse and uniform. Which

is the reason that these spur dikes adjust the flow more gently. From above charts we can see that the best is the fan-like spur dike.



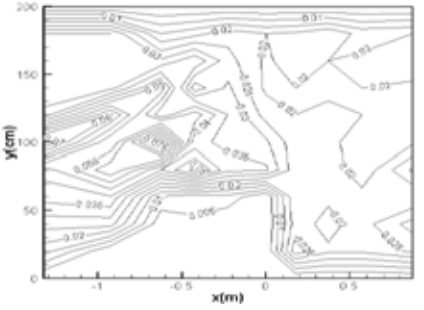
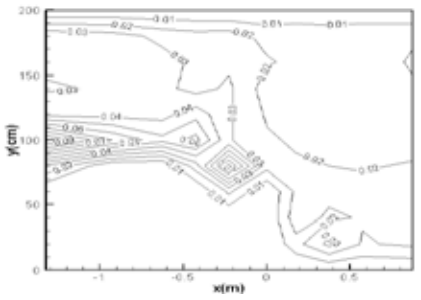


Fig.3 Turbulence T(m.s-1) of trapezoidal spur dike (left)
Fig.4 Turbulence T(m.s-1) of arc-like spur dike (right)



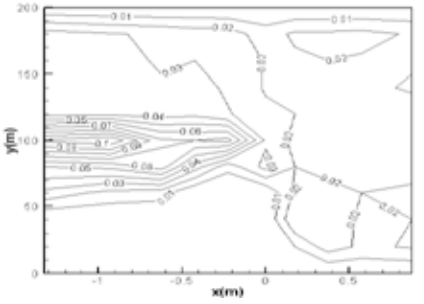
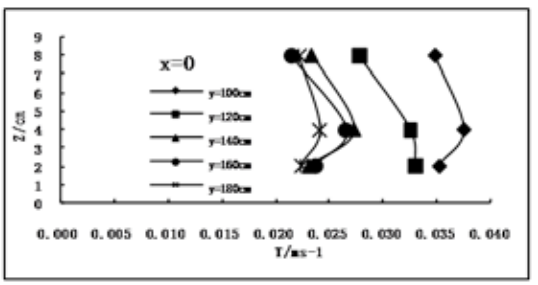


Fig.5 Turbulence T(m.s^{-1}) of fan-like spur dike (left)
Fig.6 Turbulence T(m.s^{-1}) of hook-like spur dike (right)

3.2. Vertical turbulence distribution

The vertical turbulences are also analyzed between different types spur dikes. From the Fig.7 to Fig.10 we can see the turbulence change shown in the same cross-section(x=0) but of different spur dikes. The vertical turbulence maximum mostly occurs in the local 0.6 times the water depth H except the trapezoidal spur dike occurring in the local 0.2 times and 0.8 times the water depth H. Overall, the turbulence of the trapezoidal spur dike is the greatest and followed in order by the hook-like spur dike, the fan-like spur dike and the are-like spur dike.



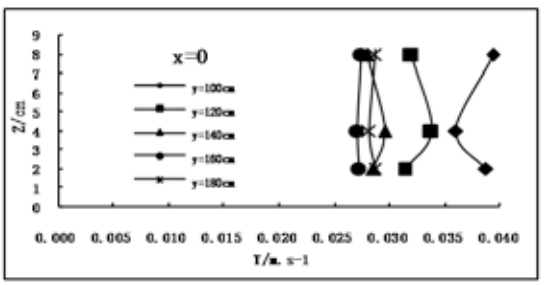
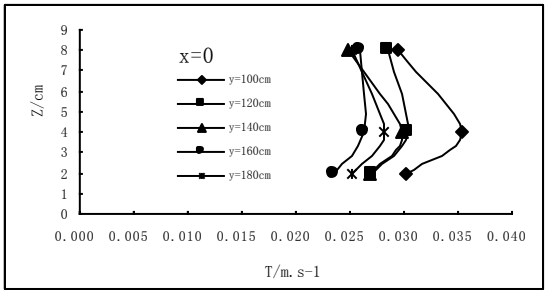


Fig.7 Vertical turbulence T(m.s^{-1}) of arc-like spur dike (left)
Fig.8 Vertical turbulence T(m.s^{-1}) of trapezoidal spur dike(right)



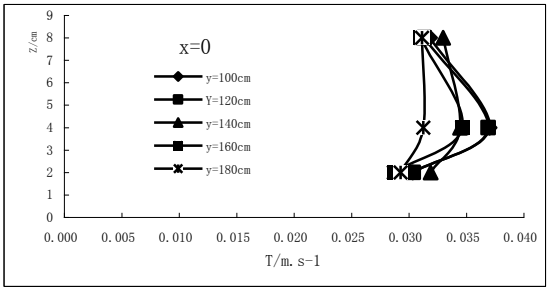


Fig.9 Vertical turbulence T(m.s^{-1}) of fan-like spur dike (left)
Fig.10 Vertical turbulence T(m.s^{-1}) of hook-like spur dike (right)

4. Conclusion

The turbulence plane contours of different structures spur dikes are similar that is the flow turbulence maximum occurs in the region where the *X* coordinate $0<x<1.2$m and *Y* coordinate $70\text{cm}<y<120\text{cm}$ downstream the spur dike tip. However, because the trapezoidal cross-section will disturb the flow more strongly, its turbulence contour is denser than the other three spur dikes, so its turbulence gradient is also larger.

The vertical turbulence maximum mostly occurs in the local 0.6 times the water depth H except the trapezoidal spur dike occurring in the local 0.2 times and 0.8 times the water depth H. There is not much difference on the turbulence value in the same local of different spur dikes, overall, the turbulence of the trapezoidal spur dike is the greatest and followed in order by the hook-like spur dike, the fan-like spur dike and the arc-like spur dike.

Acknowledgements

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References

[1] CAO YM et al. The experimental research of the flow field and turbulence characteristics in the scour and backflow region around a groin. *Chinese Journal of Hydrodynamics*.2008;9:560-569.

[2] CHEN ZC et al. Turbulence intensity measurement in the backflow region around a spur dike. *J Tsinghua Univ(Sci&Tech)*.2008;12:2053-2056.

[3] ZHANG HQ et al. Experimental study on turbulence characteristics of spur dike. *Journal of Waterway and Harbor*.2008;6:185-192.

[4] PENG J et al. Numerical model of local scour around spur dikes. *Journal of Sediment Research*.2002;2:25-28.

[5] LING JM et al. Numerical simulation of flow in the vicinity of a circumfluent spur dike. *Journal of Highway and Transportation Research and Development.*2006;11:10-14.

[6] ZHANG BS et al. Experimental study on flow construction over spur-dikes. *Journal of Beijing University of Aeronautics and Astronautics.*2002;10:580-585.