SELECTED PAPERS ON SEDIMENTATION AND RIVER ENGINEERING 2010

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SUMMARY

Totally 53 papers are collected in this symposium. They are important part of the achievements of scientific and technical workers in River Research Department, Changjiang River Scientific Research Institute. The main subjects are fundamental theory of sediment movement, flow and sediment in river basin, river ecology, river evolution and regulation, sediment issues in hydraulic engineering, physical modeling techniques, numerical Simulation of flow and sediment transport.

This symposium will be provided as a reference for those scientific and technical workers and improve their abilities in international communications. Moreover, we hope it will do a good favor to young researchers.

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PREFACE

The River Research Department, Changjiang River Scientific Research Institute, was founded in 1953. During the past 60 years, the River Research Department has been devoted to the water conservancy researches for the public welfares. In the practice and study of many important hydraulic engineering projects, such as Gezhouba Dam, Three Georges project, South to north water diversion project, cascade hydropower development in the upper Yangtze River, the Yangtze River regulation projects, the River Research Department carried out valuable scientific investigations. Great achievements has been obtained in fundamental theory of flow and sediment transport, river channel evolution and regulation, flood control and disaster relief, sediment issues in hydro-junction, water and sediment transport process in river basin and ecological environment, river modeling, etc..

Recently, our researchers and engineers are becoming active in the international communications and cooperation in the form of abroad investigation / training / consultation, and also by exhibition of our scientific achievements in the form of international journal publication and international conferences, etc.. In this symposium, up to 45 papers are collected which are mainly concerned in the following 6 aspects:

(1) Fundamental Theory of Sediment Movement;

(2) Flow and Sediment in River Basin, River Ecology;

(3) River Evolution and Regulation;

(4) Sediment Issues in Hydraulic Engineering;

(5) Physical Modeling Techniques;

(6) Numerical Simulation of Flow and Sediment Transport.

The international communication of water conservancy science and technology becomes more and more important nowadays. It's a "going out-introduced in-going out again" process. We hope that the collected and reprinted papers in this symposium will provide as a reference for relative scientific workers and improve their abilities in international communications. Also we hope it will promote more high-quality achievements and do a good favor to the young scientific workers.

CONTENTS

Ⅲ River Evolution and Regulation

Ⅳ Sediment Issue of Hydraulic Engineering

Ⅴ Physical Modeling

Ⅵ Water and Sediment Numerical Modeling

I Fundamental Theory of Sediment Movement

Experiment Study on Local Scouring Depth Around Pile Permeable Spur Dikes

Zhou Yinjun, Fan Beilin, Liu Huanfang, Wang Jun

Abstract: In case of the law of local scour and calculation of the maximal scouring depth associated with permeable pile groin, the mobile bed experiment of clear water scouring with different operating conditions was carried on. In the experiment, the groin models were angled from 30°to 135°to the downstream channel sidewall with six pervious rates between 0 and 40%. Based on the experiment and previous research, the shape of the scouring hole, the influential factors and mechanism of local scour depth about the permeable groin were researched. The conclusions of this research can show that the local scour hole was a channel which looked like a "V", the scouring depth nearby the pile root was maximal, and in the whole local scour channel, the maximal scouring depth was situated at head of spur dike and caused by circumferential motion around piles. The depth was augmented with the contraction ratio increasing, and also with the pervious rate decreasing, especially when the angel was 90°the depth was maximal, which also related with Fr and sediments gradation. At last, dimensional analysis was used to derive the calculated formula about local scour depth of permeable pile spur dike, the formula connected the depth and its influential factors directly, and it can reflect the influencing law quantitatively. The calculated result fitted the experiment data well, which can supply reference to the project design.

Key Words: permeable pile spur dike; local scour channel; scouring depth; pervious rate

1 Introduction

Pile permeable spur dike was a sort of new prevailing river regulation building, which was on probation in the 1970s and gradually generalized. Its primary function was to deposit falling with tranquil flow and protect dikes and flats purposefully (Chen, X. G. and Li, P. W., 1997). Because of certain pervious rate within the permeable spur dikes (pervious rate: the ratio of clear distance and center distance between every piles, it reflects the structural waterproofing characteristic of permeable spur dikes, by Chen, X. G. and Li, P. W., 1997), it can, comparing with traditional impermeable spur dikes, not only divert the major current, but also make the partial current pass through the spur body. So in the actual works, it was able to get velocity of flow gentleness behind the dikes, as well as bring little effect to the main stream current structure. Intensity of current moving around the spur was reduced, so the scour depth of jetty head is less than solid spur dikes, and the interaction between the current which passed through permeable spur and circumfluence procreated by the main stream caused a relative quiet water region which was appearing behind the permeable spur dikes. In addition, there were some merits: simply structure, high degree mechanization of building operation, handle safety, adapting to

flood of different standard, occupying few farm and protecting ecology and lower compensation cost. It showed that the pile permeable spur dikes have much predominance in the aspect of strengthening engineer safety and reducing the investment. Currently, the permeable spur dikes are broadly applied in river and navigation channel control, as well as estuary regulation of each major river valley in China (Zhao, W. J. and Yan, S., 2006; Zhou Y. J. and Liu H. F., 2007). Especially, reinforced concrete pile permeable spur dikes, besides applied in Yellow River regulation engineers in 1970s, gradually generalized from seawall reinforcement in QianTang River (east of China) to Tarim River (west of china) regulation projects.

The maximal scour depth around pile permeable spur dikes was directly related to the security of the engineer. It was very important for the engineering's design and protection to predict the scouring depth accurately. Predecessor had already done some research in this problem, such as Copeland, R. R. (1983), Feng H. Ch., Shi Z. T. (2002). They all derived empirical formula that can calculate scouring depth associated with 90° permeable spur dikes after in-house experiment. However, there was some difference between the stream structure of permeable spur dikes and solid spur dikes. The mechanism of local scour associated with permeable spur dikes wasn't known clearly enough, and the previous research was limited at 90° permeable spur dikes, so current calculated methods can't satisfy the needs of engineering design, especially lacked of a dependable method of calculated (different angles) maximal scouring depth around pile permeable spur dikes, the present condition also restrict pile permeable spur dikes to be generalized extensively. To resolve this problem, after analyzed the mobile bed experimental results of clear water scouring around permeable spur dikes with different operating conditions, the calculated method of maximal scouring depth around pile permeable spur dikes was discussed in this thesis.

2 Experiments

All of the experiment were conducted in a flume at State Key Lab of Water Resources and Hydropower Engineering Science, Wuhan. The flume channel was 10m long, 1m wide, 0.5m deep, and the channel slope was 1/5000. The channel was filled with sediments to allow for unimpeded development of the scour hole. The bed sediments had a median size of 0.5mm and a geometric standard deviation of 1.3. For reflecting the influence of permeable spur dikes to fluent and bed more explicitly, the clear scouring experiment was carried on, $v/v_c<1$, where v_c was initial scour velocity of the sediments. The fluent Fr was 0.23 - 0.37. Model pile permeable spur dikes were circular-shape rebar pile spur dikes. The model spur dikes were vertical to the bed; their height was equal to the depth of the flume. The pervious rate scope of the actual project was consulted, the pervious rate of experiment was 0, 16%, 20%, 25%, 30%, 40%. The purpose of the experiment was to study law of local scouring around the pile permeable spur dikes with different work conditions.

Before every experiment runs, the bed slope would be adjusted to 1/5000, and then the model was set. Based on Roger A. K. and Carlos V. A. ' research (2002) about local scour of solid spur dike, the scour experiment was continued for 30h, the scour hole was stabilized. So after 30h, the experiment was stopped, water in the flume was drained by valve which was on the bottom of bed. To reflect the local scour result of permeable spur dikes, the bed nearby permeable spur dikes was divided into a lot of grids, and after scouring the height survey of each point was carried on. Fig. 1 and Fig. 2 were respectively actual measured contour map (initial height was 23cm) of district nearby solid spur dikes and permeable spur dikes (pervious rate was 20%) had been scoured in the same flow and sediments condition, and the projective length of spur dikes along the width direction were 20cm, the angle was 60°.

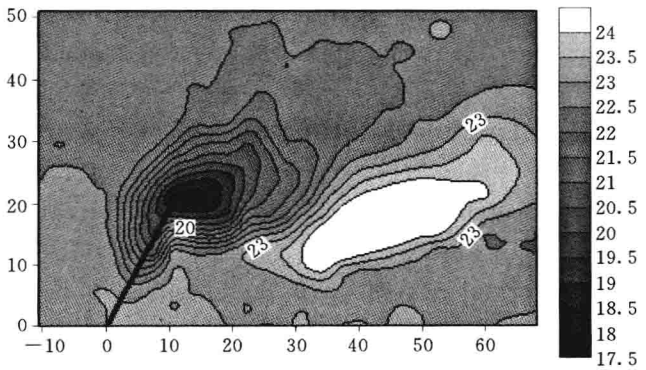

Fig. 1 Actual measured contour map of district nearby spur dike has been scoured

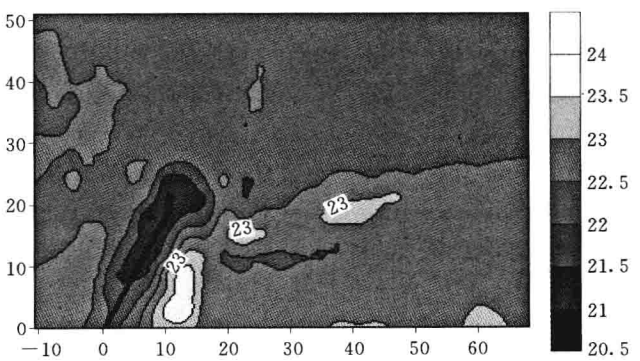

Fig. 2 Actual measured contour map of district nearby permeable spur has been scoured

3 Results

Compared Fig. 1 with the Fig. 2, there were several difference about local scour geometry between pile permeable spur dikes and solid ones.

1) After scouring, the pile permeable spur dikes didn't format a scour holes like horse's hooves as solid spur dikes, replaced of a scour slot as "V" along the length direction of dikes. The slot was wide, and there were local scour existing both before and behind of pile permeable spur dikes. The scouring depth increased from dikes root to head with little variation;

2) The position of maximal scouring depth was outside of permeable spur dike's head, and the depth was less than the one of solid spur dikes. This result certificated that ability about preventing from water destruction of permeable spur dikes was better than solid spur dikes again;

3) From the degree and range of local bed deformation, it can be showed that the permeable spur dikes influence to master channel deformation more slightly, the master channel can be avoided to excessive scouring. When permeable spur dikes were using to regulate one region of river, other parts of river were not influenced seriously.

4 Mechanism and Influence Factors of Local Scour

There were lots of research about local scour associated solid spur dikes already (Sheng H. R. and Cheng Q. H., 2001; Zhang, B. Sh. and Ma J, Y., 2002), each researcher derived different formula based on different physical model. In summary, the common viewpoint about mechanism of local scour is that the velocity of flow around dikes increasing and caused large scale eddy flow structure including circumferential motion vortices as horse's hooves and dissociation vortices, which reinforced the ability of fluent scour. It can be point out that the basic reason for local scour is the action of circumferential motion around dikes. Spur dikes would influence flow field distribution at cross section to compress flow section area, the velocity of upstream of dikes' head would increase, in addition, because of the action of circumferential motion around dikes' head, the velocity of flow around dikes' head increased further. When this velocity was greater than the initial scour velocity of the sediments, the sediments nearby dikes' head continued threshold to move out, the depth of water didn't increase until the scour holes attained limit and became stable. This theory can be used to analyze the law of local scour associated with watercourse modification building like spur dikes, and expand mechanism of local scour associated with pile permeable spur dikes. There were special points about the flow of pile permeable spur dikes. Based on observation in experiment, it can both directed and permeated flow, when the master fluent round the dikes' head, the circumferential motion of fluent upstream transmitted to downstream passed through the interspaces among piles, the flow which passed through the permeable spur dikes was influenced by fluent upstream. The flow directed to bottom of bed, and produced another sort of horizontal axis spiral flow, which ran parallel with axis of permeable spur dikes and the intensity was weaker. The horizontal axis spiral flow was reason for formation of scour slot as "V" at piles' root.

4.1 Influence of Effective Length of Dikes to Scour Depth

Because the local scour of permeable spur dikes was related with the velocity increasing of fluent outside dikes' head, the velocity was decided by the active intensity of water-stop. The effective length of dikes (the projective length of spur dikes along the width direction) was an important factor to reflect the ability of water-stop, so the effective length was used to express the geometry index when the influence of length to local scour was considered in this thesis. Fig. 3 was comparison of several experiment data with the same angels and other conditions.

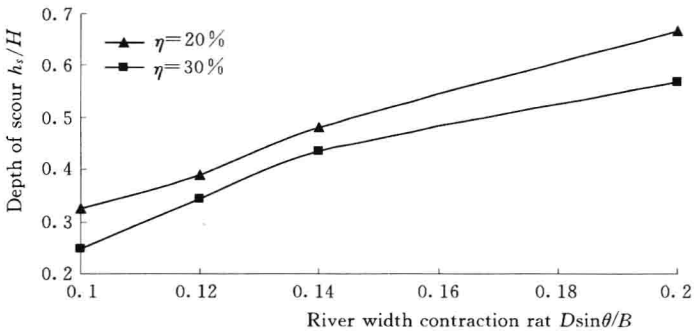

Fig. 3 Influence of river width contraction rat to the scour depth

From the Fig. 3, the scour depth was related with effective length obviously. Because of the variety of length reflected the degree of river width contraction, which influenced the fluent structure nearby dikes' head and the depth of scour.

4.2 Influence of Pervious Rate to the Scour Depth

The important difference between permeable spur dikes and solid spur dikes was that the permeable spur dikes have a certain pervious rate. So it was necessary to research the influence of the pervious rate in the scour depth. Fig. 4 was comparison of several experiment data with same effective length and other conditions.

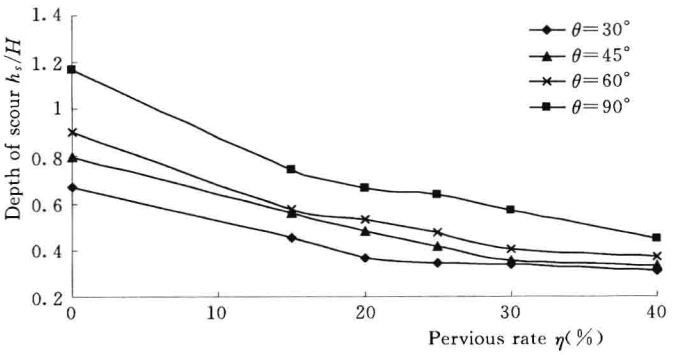

Fig. 4 Influence of pervious rate to the scour depth

Because pervious rate was also an important factor to reflect the intensity of water-stop, along with the increasing of pervious rate, the intensity of water-stop became weaker, the depth of local scour was smaller. This phenomenon can be reflected on the Fig. 4, meanwhile it can be seen that the solid spur dike was a special condition of permeable spur dike in pervious rate of 0, so the depth of scour associated solid spur dikes was biggest.

4.3 Influence of Spur Angles to the Scour Depth

From Fig. 4 we can see that the different scour depth was with different angels in this experiment, in spite of the effective length and other conditions were same. It was to say that the effective length can't reflect the influence of permeable spur angels completely, so several experiment data with different angels but same effective length and other conditions could be used to research the law about influence of angels to the scour depth.

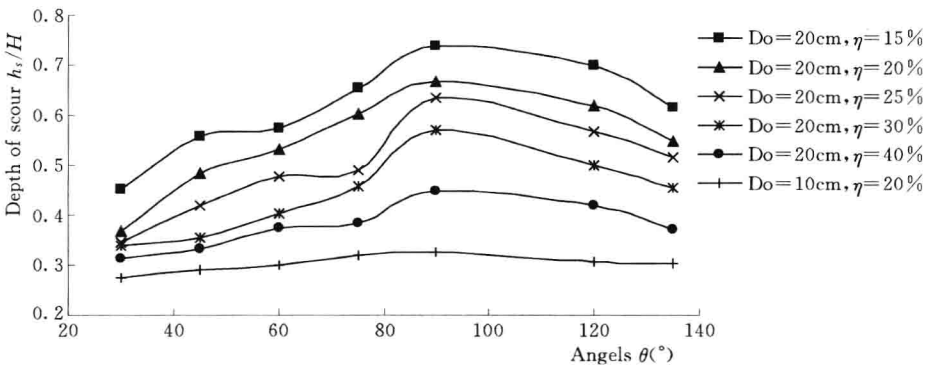

Fig. 5 Influence of spur angles to the scour depth

The Fig. 5 showed that the scour depth was maximal when the angel was 90°, the scour depth increased along with the increasing of angel from 0° to 90°. When the angels were greater than 90°, the scour depth decreased gradually; therefore, the variety rate was smaller.

Both *Fr* of fluent and sediments gradation had much influence to depth of scour associated with permeable spur dikes. It can be known that local scour was related with fluent condition closely after lots of research about local scour associated with solid spur dikes had been consulted. Even though there were only fluent factor in some previous formula structure (Roger A. K. and Carlos V. A., 1999). Currently, the common viewpoint about influence of fluent condition to local scour was that the velocity of fluent depended the sediments threshold motion and was the master condition of scour depth, the depth of scour increased with the *Fr* when other conditions were consistent. Therefore, it was a complicated to research the influence of the bed sediments characters to local scour. But if only non-cohesive uniform sediments were involved, there were some researches. From the angel of sediments incipient motion, major researcher figured that depth of scour decreasing with the sediment particles size increasing (Lim S. Y. and Cheng N. Sh., 1998). In the