Study on the protective effect on the front end of the triangular stone cage pier damaged mode

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Abstract

As a new type bridge pier structure, gabion structure have an characteristics of environmentally and cost. But there are many flood damages happening in real engineering applications. This paper taking a mountain gabion bridge for example, starting from the river sand scour and flow field, investigating the influence of protection on the front end of the triangular stone cage pier damaged mode by using model test.The results show as follows: Change of lateral displacement along the vertical direction of the water flow and emptied of sand along the horizontal direction is the main form of piers forward destruction. The model is better than the original model and anti scour time increased by 94.4%, the offset is reduced by 48.3%, the settlement is reduced by 80%, welcoming the maximum scour range of about 86.4% of the original model.

Keywords

Gabion pier, triangle protection, scour depth, model test.

1. Introduction

With the gradual maturity of the modern gabion material technology, the stone cage structure instead of traditional concrete structure used to the construction of small bridge and culvert pier.This structure has the characteristics of green environmental protection, low construction cost, low construction difficulty and so on.The stone cage bridge in poor area of China, Yunnan, Guizhou, Chongqing and other village has built more than 20, in use there is still a certain proportion of damage events.Such damage caused great inconvenience to the local logistics and transportation, especially in the mountainous areas.

many scholars have made their research in area of anting erosion performance of stone cage and pier flood damage model.Fu Xuhui et al. [1] have researched on characteristics of protection gabion structures at high angles of water erosion used the self-similar model movable bed method in the experiment and getting protection width is the conclusion based protection key indicators. Jiang Tao etc. [2] think when research bridge pier position damaged or destroyed by flood reason, the existing in of bridge pier compressed the current discharge section area with the time to have caused bridge location both sides flow to increase be the most important reason that causes that bridge pier washes away. Because the line effect of pier has caused its local scour on every side to make the pier basis phenomenon occur emptying, Tian Xingcan [3] thinks that basic pier buried depth deficiency also is the major reason of bridge disaster by flood.

This paper is example with certain mountain area gabion bridge, and to this type of gabion bridge pier model commonly used, performance model experiment discussion front end triangle is protected the effect that influences for the damaged or destroyed by flood of gabion bridge pier antiscour, and its structural shape and engineering parameter etc. are proposed related advisory. Bridge appearance such as Fig. 1-2.

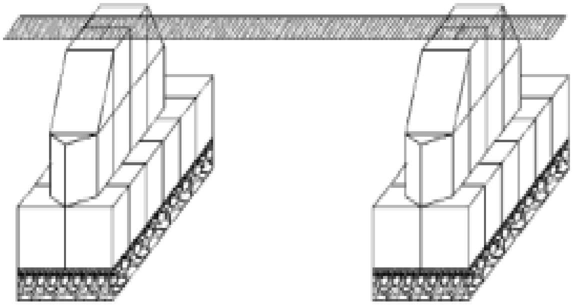

Fig.1 gabion schematic pier

Fig.2 gabion bridge

2. Gabion bridge pier model test

2.1 The net cage physical model

This physical experiments is mainly studied the difference of front end triangle protection foundation structure and conventional model damaged or destroyed by flood pattern. Experimental design of geometry scale of 1:10, according to the original single stone cage cage structure size of $1m\times1m\times1m$, the experimental model of a single cube stone cage cage size set of $0.1m\times0.1m\times0.1m$ .The design model is determined according to the gravity similarity criterion. Geometric scale and other than the size of the size will be determined. Wherein, test model speed guide is following

$$\lambda_v = v_p / v_m = \left[\left(g_p * \Delta p * l_p \right) / \left(g_m * \Delta m * l_m \right) \right]^{1/2} \quad (1)$$

In the formula: v_p, Δp and l_p refer to the critical flow velocity in the prototype, the density and the former molded dimension of the relative water of gabion filler respectively;, v_m, l_m and Δm are respectively the density of critical flow velocity in the model, size, the relative water of filler; The acceleration of gravity of g_m and g_p representative models, prototype.

Table 1 model scale size

名称	比尺大小
水平，竖直比尺（λ_l ，λ_h ）	1:10
粒径比尺（λ_D ）	1:10
流速比尺（λ_v ）	1:3.3
输沙率比尺（λ_G ）	1:33
时间比尺（λ_t ）	1:3.9

This test water flute length 25m , wide by 1m , high by 1m can move maximum stream flow $800m^3/h$;Flow rate of water flow is fixed by the water level instrumentation by electronic scale mensuration, height of water level by the quality of propeller type current meter mensuration, stone in this test. The prototype net cage adopts the steel wire that coats the PVC material to make, and according to the similarity principle, the Physical Experiment model adopts 2mm rugosity steel wire to make. Be to guarantee similarity, in the test in the gabion cobble-stone diameter size be controlled between $2cm-3cm$, density is $3t/m^3$.Net cage whole body porosity control 25% to 30 % scope. According to the design of the testing regulations of hydraulic model with made the physical model of ecological graticule mesh, confirmed the feature dimension and the guide parameter of grid model.

The bridge washout test proof body of a bridge when the bridge floor height is identical with water level is in precarious position in the condition of flooding [3].Before the akhet arriving, water level is in the scope of ground floor net cage; Under flood regime, current possibly reach second layer net cage even cover the net cage top. Therefore, in order to reach the scouring effect of infrastest, the test depth of water is controlled to be 20cm.Movable bed model length is 2.3m, test bed material by 2-3 mm particle size sand, both sides laying bricks, pier model front distance brick 30cm, tail distance brick 130cm, model buried at a depth of 10cm exposed part is 20cm.The experimental flow rate is controlled by the computer as 0.8m/s.

3. Model Test and Data Analysis

The experiment set-point by positioning the axis intersection, where the horizontal plane perpendicular to the direction of flow is arranged 15 lateral positioning axis, respectively, in the front axle 1 cm, 4cm, 9cm, 19cm, bridge position every 10cm arranged a bridge tail 2cm, 7cm, 17cm, the horizontal plane is arranged along the flow direction of the positioning axis 9, respectively, in the axis of the bridge, the bridge left 1cm, 4cm, 9cm, 19cm, bridge right 1cm, 4cm, 9cm, 19cm. Set the coordinates (Y-axis, X-axis, Z-axis), respectively, along the flow direction of the horizontal plane perpendicular to the flow direction, a vertical plane perpendicular to the direction of flow prevail. Depth measuring point by comparing the depth of the probe measured before and after taking flush. Experimental model piers dot chart as detailed in Figure 3-5.Coordinate is provided with (Y axle, X axle, Z axle) respectively to be as the criterion perpendicular to water (flow) direction perpendicular to water (flow) direction, vertical plane along water (flow) direction, horizontal plane. The measuring point degree of depth measures through probe washes away the front and back contrast degree of depth. Motor initial frequency electric machine frequency 28Hz, the current flow rate of water flow is 0.4m/s, treats that water level reaches 20cm and makes flow velocity reach 0.8m/s through regulating tail-gate and electric machine frequency.

Current around the bridge pier mainly comprise the turbulent system of back-water at pier, upstream face incision stream and relatively large scope; Wherein, As an integrated water flow structure, the turbulent region comprises the downward current of the preceding upstream face of pier, the tail end whirlpool that the shunting of pier shaft side forms, and streams the horse-hof shape whirlpool and the pier tail place whirlpool of formation. Cage by wire PVC coated woven material, texture is easy to plastic but is soft, so in practical use for protection of bridge piers of the pier head is not destroyed in lower pier in front of package live "V" shape iron sheet. This protection pier money flow rate decreased, increasing the pier backwater before and under shear flow, the formation of stagnation pressure. Stagnation pressure caused by water cut and formed on both sides of the flow acceleration, increasing erosion on both sides of the river sand. The pier on both sides of swirling flow separation, vortex induced lift force in Z direction leads to the formation of negative pressure sand floating loss. This loss is often irreversible, caused by tunneling the overturning cage pier bottom.

3.1 Comparison of Scouring Time

Scouring the original model time 54min, the model of Scouring Time 105min.

3.2 Pier slope, skew and sedimentation contrast

The original model: the left side of the piers along the flow direction of a larger shift occurred and Settlement, the average deviation amounted to 11.6cm, the average settlement 7.5cm, the largest settlement of about 9cm.

Fig3 Front end triangle basis protecting bridge pier

Fig4 The original model

The Model: left side piers along the flow direction of the overall lateral occurred, the average offset + 5.6cm, maximum offset + 7.9cm; overall uneven subsidence phenomenon occurs, the settlement ends meet water significantly, the average settlement + 4.8cm maximum settlement + 7.2cm; tails uniform settlement, the average settlement 1.2cm; overall average settlement + 3.4cm.

3.3 Comparison of sediment scour the riverbed

The original model: riverbed scour shape is substantially elliptical, pier-side welcome water scour depth reached a maximum of 19.9cm; scour both sides of the pier faded from front to back, the maximum scour depth on both sides of the cage about 17.1cm;

The Model: meet the water-side shape of parabolic approximation, the largest positive side pier scour 17.2cm, 14.2 average erosion; the left side of the pier scouring average 16.7cm, the right of the average erosion 17.2cm, maximum erosion of about 20cm.

4. Conclusion

Can get through above contrast:

(1). aspect flushing time, this time model has a distinct increment than master mould, improves about 94.4%;

(2). aspect side-play amount, this time model is compared with master mould, and side-play amount reduces greatly, is merely 48.3% of master mould, and resistance to capsizing promotes greatly;

(3). aspect settling amount, this time model is compared with master mould, and it is original 45.3% that the bulk settling amount is merely, and the maximum settlement amount is merely 80%, and settling amount obviously reduces;

(4). aspect the degradation degree in riverbed, this time model is compared with master mould, and upstream face maximum erosion journey is about 86.4% of master mould, has slightly to promote;Bridge pier both sides maximum erosion amount is 117.0% of a master mould, to the protective effect of both sides riverbed silt not as master mould.

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