Local Scour Development at Engineering Structures during Multiple Floods”

Gints Jaudzems, Boriss Gjunsburgs (*Riga Technical University*)

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I. Introduction

The equilibrium, or temporal, stage of scour near hydraulic structures was studied by many authors, and for computing the equilibrium or temporal depth of scour, the discharge on the peak of the flood was used; it is not restricted in time for the whole maintenance period of engineering structures, but is time-restricted for temporal scour estimation. In field conditions, the scour is formed by multiple floods of different probability, duration, frequency, and sequence. The scour hole parameters (depth, width, and volume) during floods under clear-water conditions in the floodplain are summed up and increase from flood to flood.

Using the differential equation of equilibrium of the bed sediment movement in clear water, a method for calculating the scour development in time at engineering structures in river flow during floods has been elaborated. The agreement between the experimental and calculated results (Gjunsburgs & Neilands, 2004) allows us to use this method for computer modeling of the scour process in nature during floods with different probability, duration, frequency, and sequence.

II. Method

The differential equation of equilibrium for the bed sediment movement in clear water conditions was used and the method for computing the scour development with time was elaborated. According to the method, the relative scour depth at the hydraulic structures depends on the following dimensionless parameters: the contraction rate of the flow, kinetic parameter of the open flow, kinetic flow parameter under the bridge, Froude number of open flow, Froude number/slope ratio, relative grain size of the bed material, relative depth of flow, relative local velocity, steady or unsteady flow conditions, relative depth of scour developed during the previous time, stratified bed conditions, as well as the time, probability, duration, frequency, and sequence of the multiple floods, sediment transport conditions, shape of the structures, slope of the wall side, and the angle of the flow crossing.

To determine the scour depth development during the multiple floods, the hydrograph was divided into time steps with different duration, and each time step was divided into smaller time intervals. For each time step, the following parameters must be determined: the water depth in the floodplain h_f; contraction flow rate Q/Q_b, where Q is the discharge of flow and Q_b is the discharge in the bridge opening under open-flow conditions; the maximum backwater Δh, grain size d_i; thickness H of the bed layer with d_i; the specific weight γ of the bed material. As a result, we have local velocity V_l, local velocity V_{lt} at calculated scour depth h_s, critical velocity V_0, and critical velocity V_{0t} at calculated scour depth h_s, and h_s at the end of time intervals and finally at the end of the time step. For the next time step, the flow parameters were changed because of the flood and because of the scour developed during the previous time step.

III. Results

A computer modeling of the time-dependent scour during multiple floods with different probability, duration, frequency, and sequence was performed. Results are presented in figures and tables.

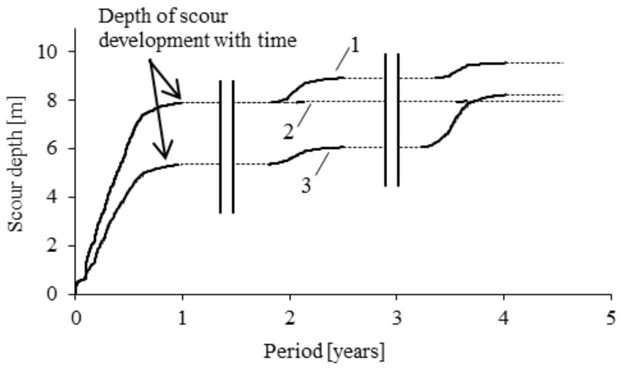

Fig. 7. Scour development with time for floods of different sequences

As seen from Fig. 7, scour development varies for floods with different sequence. Curve 1 presents scour development of the sequence of three floods of the same probability. Scour depth increases from flood to flood and sums up. Scour develops insignificant after the first high flood, if it is followed by two lower floods (Curve 2). However scour depth achieves higher value if two lower floods are followed by the high flood (Curve 3).

Modeling of multiple floods with different duration, probability and frequency shows the influence of them to the scour development with time.

IV. Conclusions

The differential equation of equilibrium of the bed sediment movement in clear water was used to elaborate a method for calculating the scour development in time at engineering structures during multiple floods. It was found that, with a less probability, increased duration and frequency of the floods, and certain sequences of different probability, the scour depth at the abutments increases. Proposed method allows computing the development of scour during expected usual or extreme flood events varying with flood probability, frequency, sequence, and duration at the stage of design or in maintenance period of the river engineering structures. Thus the most dangerous scenario of expected floods for engineering structures can be found in advance, to take necessary protection measures.

V. References

[1] B.Gjunsburgs and R.Neilands, “Local velocity at bridge abutments on plain rivers”, Proc. River Flow 2004, in Greco, Carravetta & Della Morte (eds), Napoli, Italy, Vol.1, pp. 443-448.