BUILDING A LABORATORY MODEL AND IMPLEMENTATION OF EXPERIMENTS TO FORECAST THE NATURE OF SILT TRAVEL IN THE RION RIVER ESTUARY

P.BALJYAN, A.SARUKHANYAN, N.HOVUMYAN

National University of Architecture and Construction of Armenia

This paper was prepared within the framework of the "Integrated Coastal Monitoring of Environmental Problems in Sea Region and the Ways of their Solution" -- ICME Project

Be received 30.03. 2016

This paper is intended for carrying out theoretical and experimental study silt and sediment propagation at of the Rion River mouth. For this reason a mathematical model was developed designed to predict accumulations of silts at the coastal zone and their distribution pattern. At the same time the problem was solved by river modeling. To this end in the hydraulic research laboratory an experimental facility has been built. On the basis of the results obtained due to this two different procedures a comparative analysis was made. The difference of the obtained data is within the acceptable range.

Keywords: ***flow, silt, soil deposition, hydraulic modeling, experiment***

Objectives of experimental studies are:

- **To study physical, natural process of silts and sediments propagation in the coastal zone of rivers,**
- **To check up hypotheses and propositions that have been taken while preparing the mathematical model of the process under study,**
- **To compare results of the experiments with calculation data obtained by using the developed mathematical model.**

To attain the set problems in the hydraulic research laboratory of the Hydroengineering and Water Problems Institute after Academician I.V.Eghizarov an experimental facility has been built. It is a trough of 1.6m width and 32m length (Fig. 1). At its head there is a water feeding assembly, and at outlet there is a water removal assembly equipped with flowmeters.

In the tray of the experimental facility a 1m wide and 25m long ground canal with its raised edges was built (Fig. 2). The head unit enables to provide from 1 to 30 litre per second flow in the experimrimental model.

The obtained results

We have developed a mathematical model designed to forecast regularities of silt propagation. Calculations are carried out in the Rion river costal area using the model.

To check reliability of the model data obtained in the course of laboratory experiments will be compared with data of calculations using the model. In case of necessity some corrections will be

made in the theoretical model. In case of satisfactory coincidence of data obtained by experiments and calculations the foreseen results for determining silt propagation pattern in the Rion river costal area will be presented.

On the basis of jointly solution of three fundamental equation of mechanics of double-phase one-dimensional liquid (equation of nonuniform motion, equation of water balance, and equation of silts) the following differential dimensionless equation describing the process of stabilized stage of channel transformations was obtained [1, 2]

$$\frac{d\bar{z}}{d\bar{x}} + \frac{d\bar{h}}{d\bar{x}} - \frac{Fr_0}{\beta_0 \bar{A}^3}\frac{d\bar{A}}{d\bar{x}} = i_0\, \bar{d}_{OT}^{1/3}\, \bar{A}^{2/3}. \qquad (1)$$

Fig. 1. Benchmarking of the experimental facility

Fig. 2. Construction of the channel laboratory model

The section under consideration has comparatively small longitudinal slope of the bottom. At that, the reasonably large length of the rectangular shape of the channel laboratory model practically remains rectangular. Therefore, the flow at that section can be regarded as uniform. In such sections the suggested mathematical model is simplified. In particular, gradients of the effective cross-section's depth and area (second and third summands of the first part) is equaled to zero. At the same time because of uniform distribution of river bed ground along the current, its dimensionless diameter will be a unity. Then Eq.1 for the section under study we get

$$\frac{d\bar{z}}{d\bar{x}} = i_0\, \bar{A}^{2/3}, \qquad (2)$$

where $\frac{d\bar{z}}{d\bar{x}}$ **is the forecast of the supposed slope of the bottom of the water course section under study,** $\frac{d\bar{z}}{d\bar{x}} = \frac{dz}{dx} = i_0$ **,** i_0 **is the natural slope of the bottom of the water course at transition section**

of silts motion, $\overline{A}$ is forecast cross-section area of the river at the section under study and is equal to $\overline{A} = A/A_0$.

Before starting key experiments a whole number of preliminary guiding experiments have been carried out (Fig.3). At that possibility of using the values of flow and channel parameters was clarified which are too near to similar parameters of the Rioni River modeled by Frud criteria [3]. Preliminary experiments have shown that when at the outlet estuary section the flow pattern and the base level of erosion are not changed, then silts and sediments flowing from upstream water leave the "conditional river" wholly and poured into the "conditional sea". In case the estuary mark rises due to high waves or other reasons, the main mass of silts are deposited upstream.

After preliminary experiments another two groups of key experiments have been carried out. Duration of the first group was 15 hours, first two days by 4,5 hrs, the third – 6 hrs.

Fig. 3. Performance of preliminary experiments

Fig. 4. Carrying out of the key experiment

Duration of the second group – 12,5 hrs: the first day by 6 hrs, the second – 6,5 hrs.

Water flow for the first group was taken 10 *l/s*, for the second – 12,5 *l/s*.

The channel features were not changed.

In parallel to the laboratory model initial values, analytical method was used to calculate the slope of silt deposition.

The section of under consideration has comparatively small longitudinal slope of the bottom. In that, the reasonably large length of the cross shape of the river practically remain rectangular. Therefore, the flow at that section can be regarded as uniform. In such sections the suggested mathematical model is simplified. In particular, gradients of the effective cross-section's depth and area (second and third summands of the first part) is equaled to zero. At the same time because of uniform distribution of river bed ground along the current its dimensionless diameter will be unity. Then Eq.1 for the section under study we get

$$\frac{d\overline{z}}{d\overline{x}} = i_0 \, \overline{A}^{2/3} , \qquad (3)$$

where $\frac{d\bar{z}}{d\bar{x}}$ is forecast, supposed slope of the bottom of the water course section under study, $\frac{d\bar{z}}{d\bar{x}} = \frac{dz}{dx} = i$, i_0 is natural slope of the bottom of the water course at transition section of silts motion, $\bar{A}$ is forecast cross-section area of the river at the section under study and is equal to $\bar{A} = A/A_0$.

On the basis of the obtained regularity Eq.3 calculation is made for determination of the predicted slope of the surface of soil deposition on the model's bottom.

The results of experiments

For the first group the base level of erosion was raised by 20mm (Fig.4), for the second group – 30mm. At that periodic observations of deposition propagation process were performed. In Figs 5 and 6 shapes of arrangement of deposition surfaces are shown.

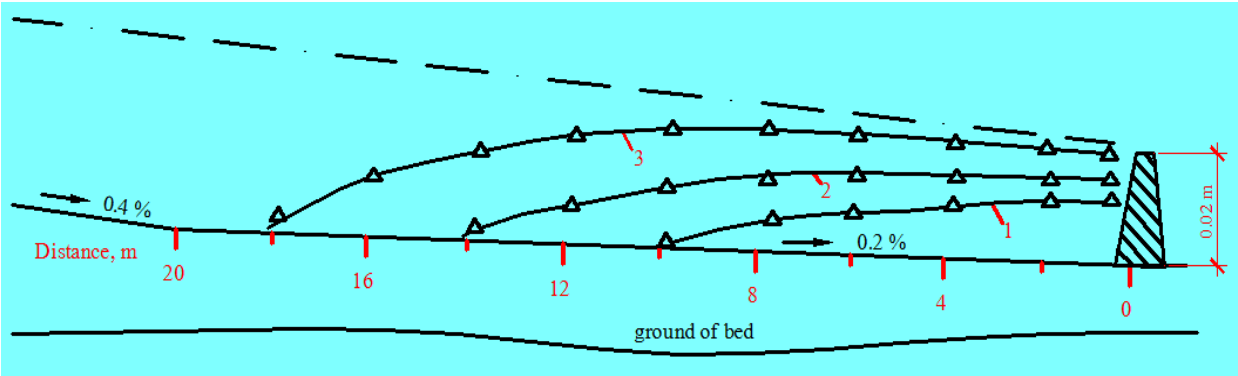

Fig. 5. Silts propagation in the first group of experiments
– – – surface of depositions coinciding with the mathematical model,
curve 1 - the result of the experiment, duration of the experiment was 4,5 hrs,
curve 2 - the result of the experiment, duration of the experiment was 4,5 hrs,
curve 3 - the result of the experiment, duration of the experiment was 6,0 hrs.

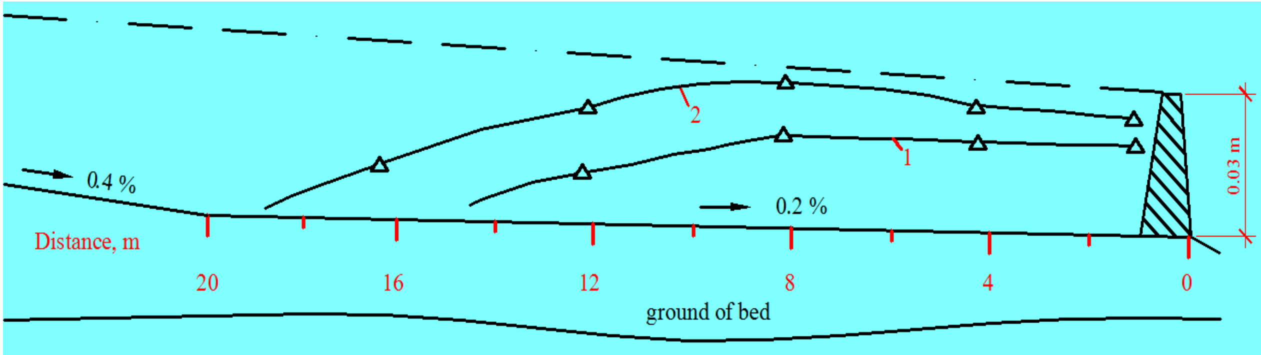

Fig. 6. Silts propagation in the second group of experiments
– – – surface of depositions coinciding with the mathematical model,
curve 1 - the result of the experiment, duration of the experiment was 6,0 hrs,
curve 2 - the result of the experiment, duration of the experiment was 6,5 hrs,

Comparison of calculated and experimental results shows that the suggested mathematical model describes quite well hydrodynamic process of sedimentation regime at the coastal zone of rivers. Therefore, the developed model can be used for natural conditions.

R E F E R E N C E S

1. **Baljyan P.O., Karapetyan H.I. The Universal Theory of Stabilized Channel Formation. Proceedings of State Engineering University of Armenia//Hydrology and Hydraulic Engineering. 2014. №1. Yerevan.**
2. **Baljyan P.O.,Karapetyan H.I.,Sarukhanyan A.A., Hovumyan N.G. Theoretical method of silt propagation form prediction in estuaries at Unsteady Base Erosion Level//Energia #2(74). 2015.Tbilisi.**
3. **Ресурсы поверхностных вод СССР. Т. 9. Вып. 1. Западное Закавказье. Л:Гидрометеоиздат. 1974.**

Professor Pargev Baljyan

E-mail: baljyan-1951@list.ru