Physical modeling for the improvement of the sailing conditions in the Nemunas River in the city of Kaunas, Lithuania

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Fig. 1. Physical model during construction

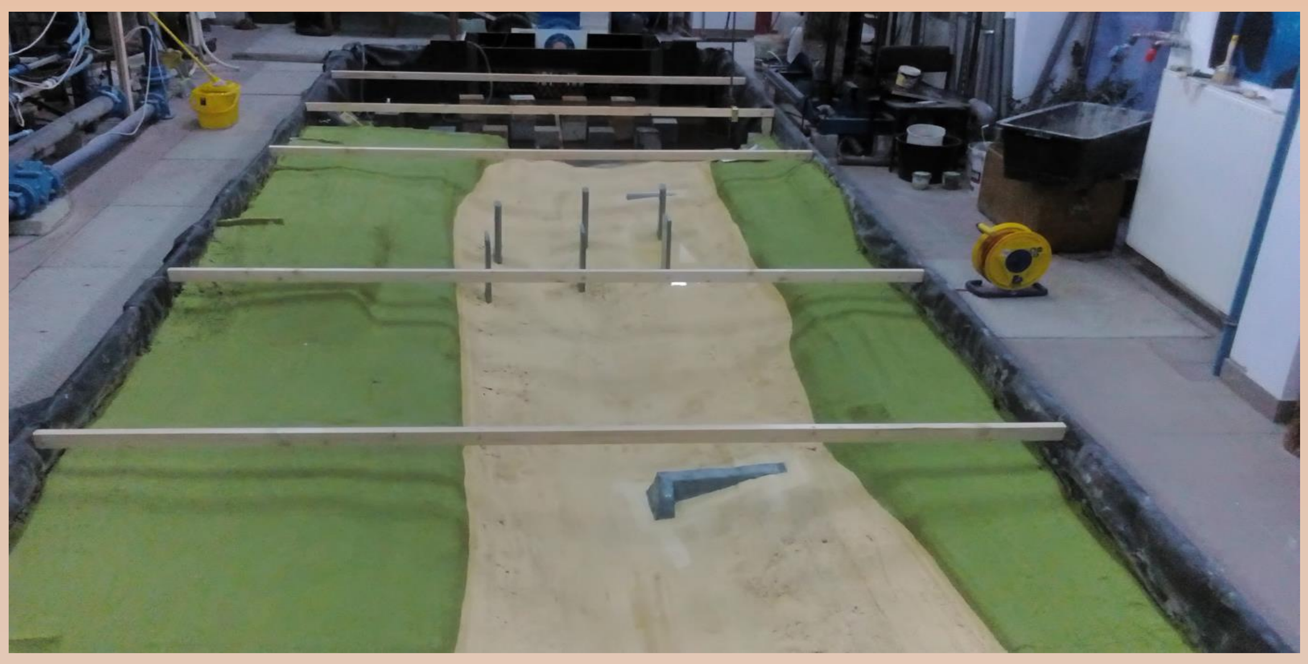

Fig. 2. Physical model with the bridges and elements of the river regulation

Fig. 3. Physical model during experiment

The purpose of the research is the analysis of the hydraulic conditions in reach of the Nemunas River located in the city of Kaunas, Lithuania. The current state of the reach was compared with the planned modifications aimed at improvement of the sailing conditions. The Nemunas River is the part of the International Waterway E 41. This waterway is being reconstructed to increase the parameters of sailing to the class Va according to the regulations of AGN Agreement. The reach in the city of Kaunas is crucial because of two bridges located there.

The research work consists of construction of the physical model for the reach including the bridge cross-section at kilometerage 214+200. The length of investigated reach equals 1100 m. The hydraulic experiments were made for four selected discharges reflecting $Q_{95\%}$ = 1,01 dm^3/s, $Q_{50\%}$ = 15,03 dm^3/s, $Q_{5\%}$ = 30,31 dm^3/s and $Q_{1\%}$ = 43,54 dm^3/s, witch corenspod to real discharge $Q_{95\%}$ = 71,6 m^3/s, $Q_{50\%}$ = 1212 m^3/s, $Q_{5\%}$ = 2143 m^3/s and $Q_{1\%}$ = 3079 m^3/s. These flows were tested with the model of current bed geometry and two variants of modifications. The physical model was built in the hydraulic laboratory of the Department of Hydraulic and Sanitary Engineering at the Poznan University of Life Sciences. The geometrical scale of the model is 1:50/200. The construction of the model started with the box presented in Figure 1. The geometry was reconstructed on the basis of rigid profiles modeled on the basis of the digital terrain model including the river bathymetry. The entire construction was completed with the bridges and elements of the river regulation.

The element of the research was also scanning of the model variants. These data (Fig. 4) will be enable comparison of the created physical model with digital terrain model and verification of the geometrical consistency with GIS data.

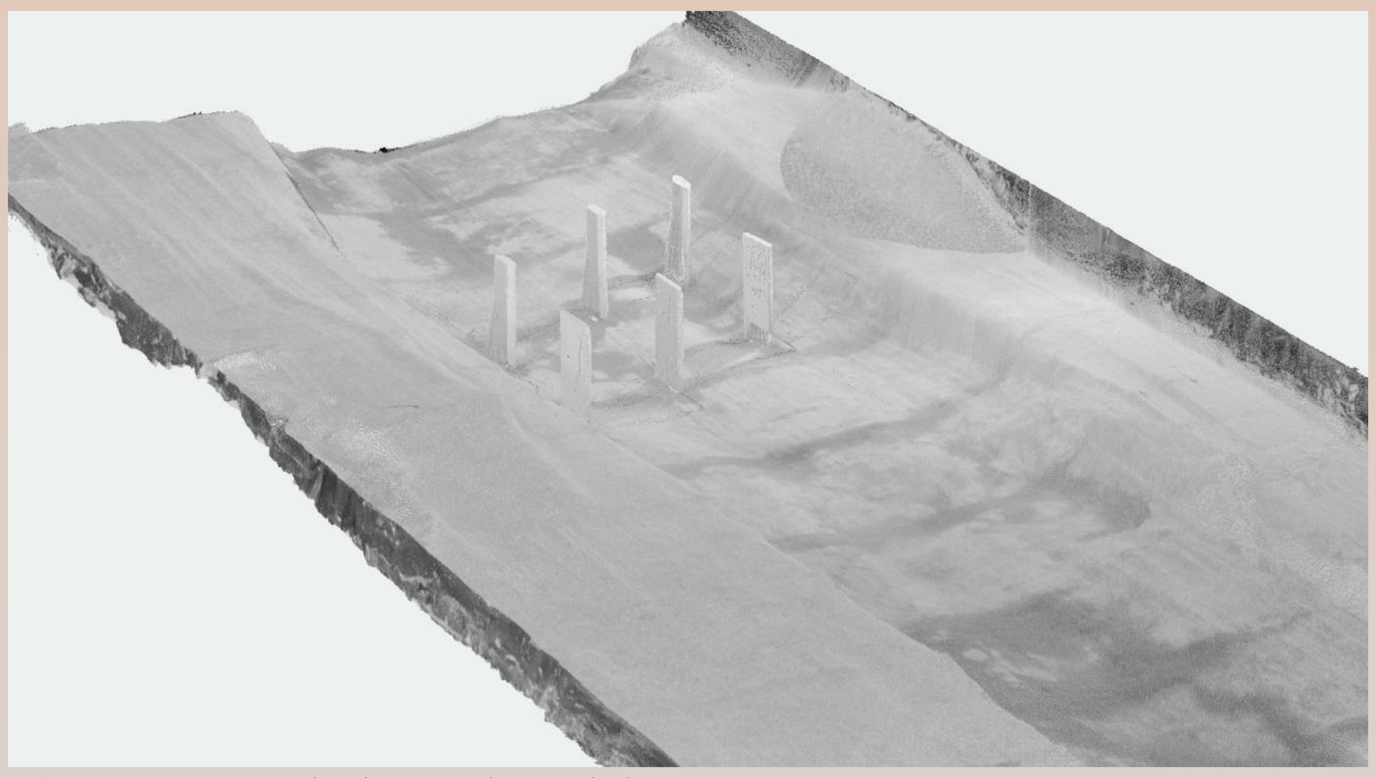

Fig. 4. Scanned physical model

Results. The measurements were aimed at investigation of velocity distributions taking into account the flow processes in the river. The correctness of the planned modifications were verified on this basis. During measurements the ADV device and marker were applied for observation of the processes in the river bed.

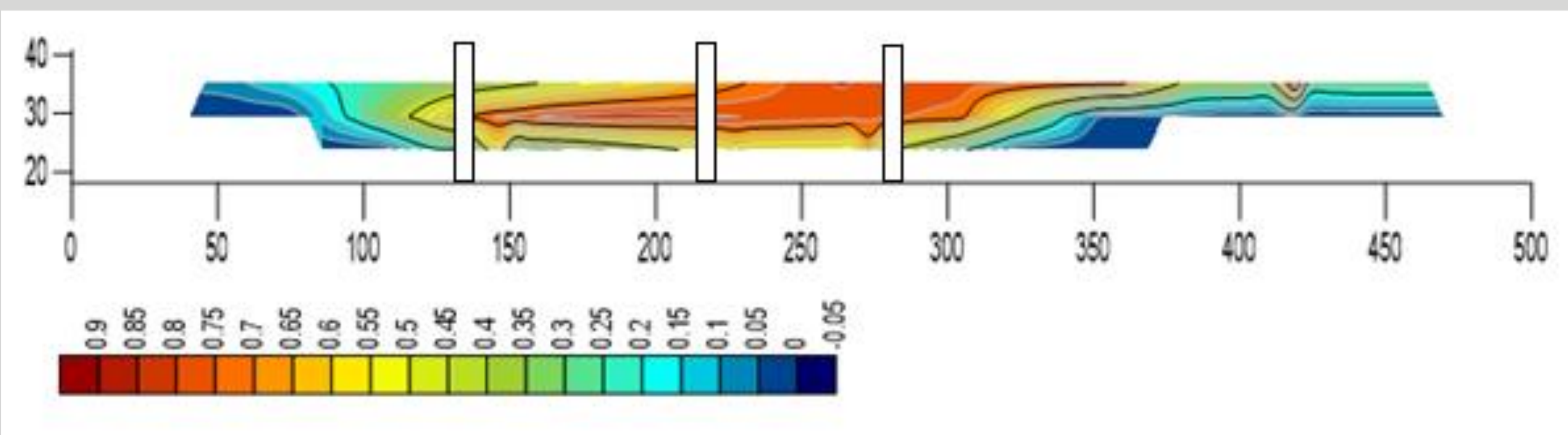

Fig. 5. Magnitudes of the flow velocities in bridge cross section

Additionally the Surfer software was applied to determine the velocities in the head and tail of the bridge piers. These distributions also present significant influence of the bridge piers on the magnitudes of the flow velocities. The increase of the velocities over the bed between the piers is shown there (Fig. 5).

The figures above (Fig. 6) present the spatial distribution of velocities compared with natural conditions reflecting discharges (from the left): $Q_{1\%}$, $Q_{5\%}$, $Q_{95\%}$. The shapes of the isolines show significant impact of the regulating structures in the magnitudes of velocities in the river bed.

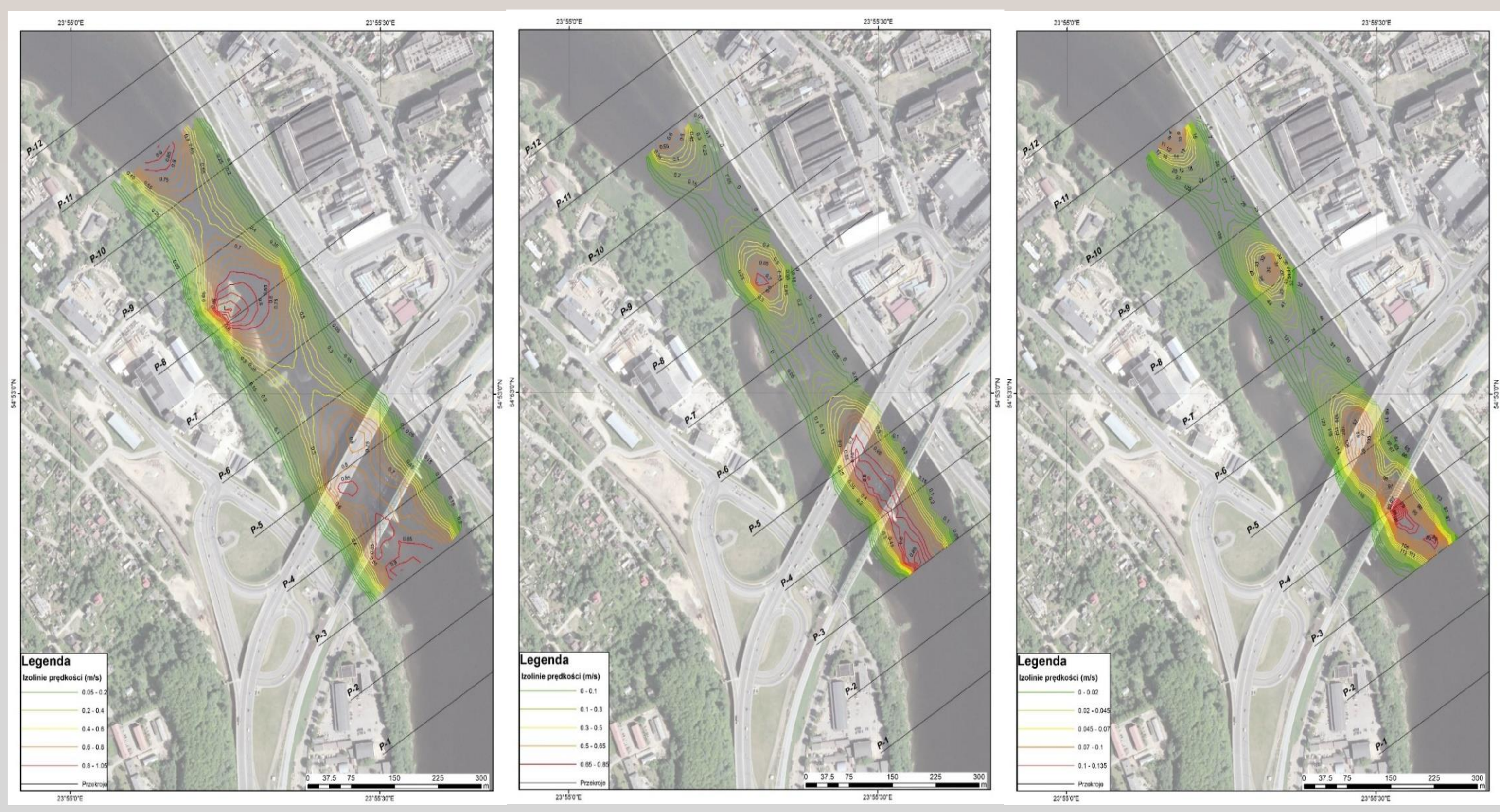

Fig. 6. Spatial distribution of velocities

Conclusion. The analysis of the obtained results enabled choice of the optimal hydraulic conditions. The necessary modifications to the river bed are taken into account. These include two elements: the construction of regulating structures (Fig. 2) and dredging works in the locations identified as the most shallow (Fig. 3). It has been proven that the most optimal option is first variant, which with the dredging of the channel meets the assumptions of the planned waterway. There was confirmed Influence of the designed elements on the river direction and concentration within waterway flow. Lower importance of trough channel was noticed while higher value of flows occured.