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

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## ABSTRACT

The paper presents the methodology and results of research conducted on the physical model in the stretch of the Neman [Polish: Niemen] River at Kaunas. The study comprised an assessment of hydraulic conditions in the river bed in the bridge profile at 214+200 km. Additionally analyses were conducted for two river bed reconstruction variants. The aim of the planned reconstruction is to adapt the Neman river bed to the parameters required for the E41 International Waterway. These studies were commissioned by a Lithuanian design office in view of the planned reconstruction and modernisation of the river fragment in accordance with the provisions of the AGN agreement concerning the network of international waterways. The river stretch in Kaunas is of key importance, as it holds a large river port, while bridge profiles are the bottlenecks due to the insufficient minimum waterway depth for safe navigation.

The experimental part of the study consisted in the construction of a physical model for a 1100m river stretch including two bridge profiles (a road bridge and a railway bridge) at 214+200 km (**fig. 1**). The model in the 1:50/200 scale was constructed at the water laboratory of the Department of Hydraulic and Sanitary Engineering, the Poznan University of Life Sciences. The initial step was to construct a box, in which the model was made. Model geometry was recreated using the profiles/cross-sections made based on a numerical model of the area. The distance between the profiles was 50 cm. The model was supplemented with bridge piers and the existing river regulation structures (groynes and longitudinal training dams). The total dimensions of the model were 10 x 3.5 m, of which the modelled river stretch accounted for 5.5 m.

**Fig. 1.** Physical model with the bridges and elements of the river regulation

Measurements were taken for 3 variants including the current status and two reconstruction variants (dredging and development of regulation struc- tures). Each variant was scanned in the 3D technology. The aim was to facilitate further verification of model representation accuracy with results obtained from numerical models. Hydraulic analyses were performed for four selected discharge values Q95%=1.01 dm3/s, Q50%=15.03 dm3/s, Q5%=30.31 dm3/s and Q1%=43.54 dm3/s, corresponding to actual discharges of Q95%=71.6 m3/s, Q50%=1212 m3/s, Q5%=2143 m3/s and Q1%=3079 m3/s, respectively. In order to determine conditions in the river bed for each variant in selected constant measurement profiles the distributions of water flow velocity was measured using an ADV probe. Water table gradients were measured using hydrometric gauge pins, while discharge was recorded with the use of an electromagnetic flow meter. The results were analysed with the application of e.g. the Surfer software, which was used to determine velocity distribution in the profiles above and below the bridge piers. These distributions show a considerable effect of bridge piers on velocity values and the concentration of discharges between the bridge piers (**fig. 2**). A similar effect on river conditions was found for the hydraulic structures strongly concentrating and directing the current within the established waterway(**fig. 3**). In order to provide spatial visualisation of velocity distributions tests were also conducted using a pigment. The recorded image of the pigment distribution constituted additional material facilitating qualitative evaluation of the tested variants.

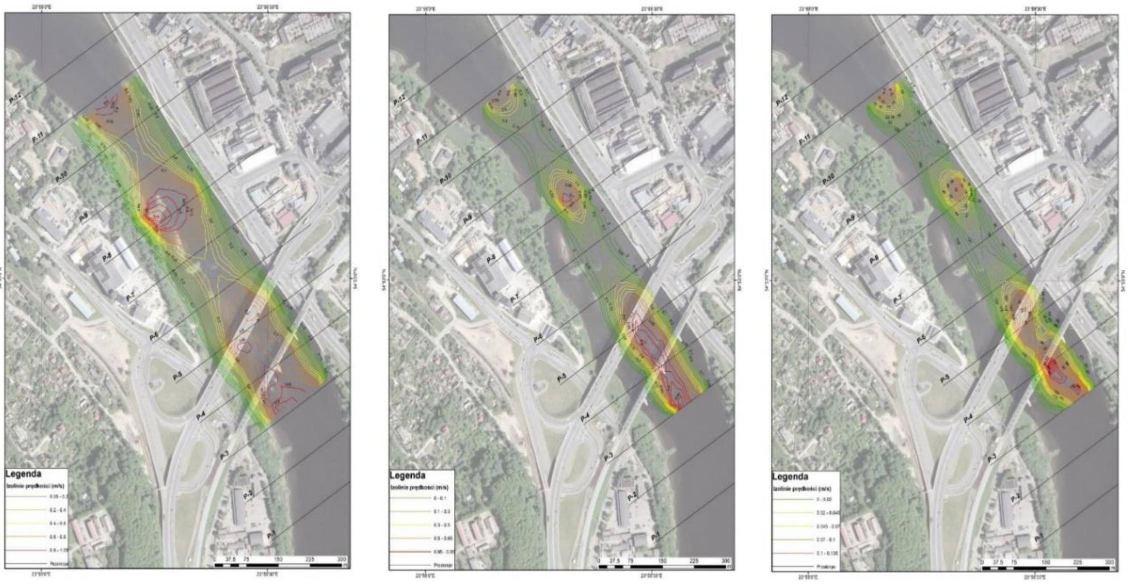


**Fig. 2.** Spatial distribution of velocities

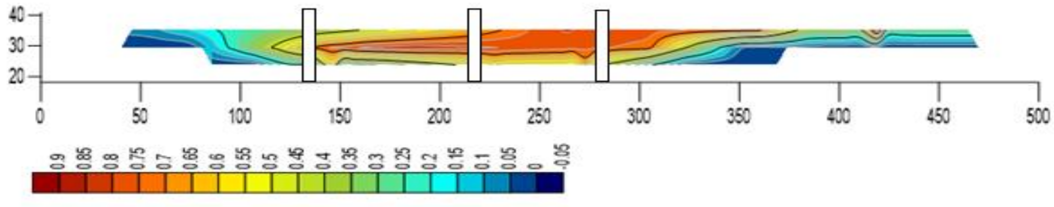


**Fig. 3.** Magnitudes of the flow velocities in bridge cross section

The aim of the measurements was to investigate distributions of velocity and filling for all the analysed reconstruction and discharge variants. On this basis the accuracy of planned investments was verified and a slightly different location and parameters of the river regulation structures were proposed. These included two elements, i.e. the construction of groynes and training dams, and dredging of the river bed in locations identified as the shallowest. Analyses confirmed the applicability of physical modelling techniques for complex hydraulic systems and their results, next to the results of hydrodynamic modelling, may constitute a source of data for the verification of adopted design assumptions.