FLOW-VEGETATION-SEDIMENT INTERACTION

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In the last years, in many reaches of German rivers flood risk increased due to an acceleration of growth of vegetation and the deposition of fine sediment on the flood plains. To handle this problem fundamental knowledge on the resistance of vegetation and the processes which dominate the flow-vegetation-sediment interaction is required. Numerous formulas already exist to calculate the hydraulic resistance of natural rivers with vegetation, whereas only little information is available about the influence of vegetation on erosion and sedimentation processes on flood plains. A summary of the state-of-the-art is given in the paper, main deficits are discussed and possible solutions to solve the problems are pointed out. The latter two points can be summarized as follows (one-dimensional consideration of the complex flow field):

The calculation of the roughness k_T of the fictive separation line at the boundary of the main channel and the banks covered with vegetation requires the estimation of the interactive width $B_{II,m}$ (see Mertens, 1989; Dittrich, 1998; RipFor-report, 2004). However, only pure empirical relationships and no physically based formulas exist to determine $B_{II,m}$. To solve this problem, velocity measurements of high resolution close to the separation line are necessary and the data are recommended to be analyzed on the basis of the double averaged Navier-Stokes equations (DAM). A direct coupling of the turbulent flow field and the roughness texture is possible with these equations. The DAM equations and their application are described in Wilson and Shaw (1977), Nikora et al. (2001) and Koll (2002).

Wilson and Shaw (1977) investigated the turbulent flow field caused by wind over vegetation. Double averaging was carried out in planes parallel to the surface of vegetation. The same procedure is recommended in the case of water flow through emerged and over submerged vegetation and with planes parallel to the separation lines in the cases of bank vegetation. A further improvement of the methodology was achieved by Nikora et al. (2001) and Koll (2002), with experimental data measured over artificial and natural roughness elements of different densities.

In numerous laboratory experiments with flow through emerged vegetation and along bank vegetation, the plants were simulated in almost all cases with rigid cylinders (see e.g. Petryk and Bosmajian, 1975; Lindner, 1982). Thus, experiments should be carried out to determine flow resistance of flexible vegetation with and without leaves under laboratory as well as field conditions. An improvement of the existing formulas should be possible on the basis of the relationship proposed by Järvelä (2004).

As the classical logarithmic velocity distribution is widely used to estimate the resistance of submerged vegetation, its application is limited to high relative submergences. An improvement of the relationship should be possible by applying the DAM methodology on the turbulent flow field and by subdividing the vertical velocity profile in different layers (see Koll, 2002 and Nikora et al., 2002).

As the interaction of flow-vegetation-sediment is very complex and so far not well understood, further research is required. Therefore, fundamental experiments should be conducted under laboratory and field conditions in this research field as well.

REFERENCES

Dittrich, A. 1998. Wechselwirkung Morphologie/Strömung naturnaher Fließgewässer. Mitteilung 198. Institut für Wasserwirtschaft und Kulturtechnik, Universität Karlsruhe.

Järvelä, J. 2004. Determination of flow resistance caused by non-submerged woody vegetation. International Journal of River Basin Management, 2(1), 61-70.

Koll, K. 2002. Feststofftransport und Geschwindigkeitsverteilung in Raugerinnen. Dissertation am Institut für Wasserwirtschaft und Kulturtechnik, Universität Karlsruhe. [online] http://www.ubka.uni-karlsruhe.de/cgi-bin/psview?document=2002/bau-verm/12.

Lindner, K. 1982. Der Strömungswiderstand von Pflanzenbeständen. Mitteilung 75. Leichtweiss-Institut für Wasserbau, Technische Universität Braunschweig.

Mertens, W. 1989. Zur Frage hydraulischer Berechnungen naturnaher Fließgewässer. Wasserwirtschaft 79(4): 170-179.

Nikora, V.I.; Goring, D.G.; McEwan, I. & Griffiths, G. 2001. Spatially-averaged open-channel flow over a rough bed. J. Hydr. Eng., Vol. 127, No. 2, 123-133.

Nikora, V.I.; Koll, K.; McLean, S.; Dittrich, A. & Aberle, J. 2002. Zero-plane displacement for rough-bed open-channel flows. Proc. Int. Conf. on Fluvial Hydraulics, RiverFlow 2002, Belgium, Eds. D. Bousmar & Y. Zech, Balkema Publishers, Vol. 1, 83-91.

Petryk, S. & Bosmajian, G.B. 1975. Analysis of flow through vegetation. J. Hydr. Div. ASCE 101(7): 871-884.

RipFor-report 2004. Hydraulic, sedimentological and ecological problems of multifunctional riparian forest management. Endbericht des EU-Projektes "RipFor", QLRT-1999-1229.

Wilson, N.R.; Shaw, R.H. 1977. A higher closure model for canopy flow. J. Applied Meteorology, Vol. 16, 1197-1205.