Drag coefficient of unsubmerged rigid vegetation stems in open channel flows

Manoochehr Fathi-Moghadam\textsuperscript{a}; Samad Emamgholizadeh\textsuperscript{b}

\textsuperscript{a} School of Water Sciences and Engineering, Shahid Chamran University, Ahwaz, Iran
\textsuperscript{b} Shahrud University of Technology, Shahrud, Iran

Online publication date: 13 December 2010

To cite this Article Fathi-Moghadam, Manoochehr and Emamgholizadeh, Samad(2010) 'Drag coefficient of unsubmerged rigid vegetation stems in open channel flows', Journal of Hydraulic Research, 48: 6, 829 — 830

To link to this Article DOI: 10.1080/00221686.2010.529303

URL: http://dx.doi.org/10.1080/00221686.2010.529303

PLEASE SCROLL DOWN FOR ARTICLE

Full terms and conditions of use: http://www.informaworld.com/terms-and-conditions-of-access.pdf

This article may be used for research, teaching and private study purposes. Any substantial or systematic reproduction, re-distribution, re-selling, loan or sub-licensing, systematic supply or distribution in any form to anyone is expressly forbidden.

The publisher does not give any warranty express or implied or make any representation that the contents will be complete or accurate or up to date. The accuracy of any instructions, formulae and drug doses should be independently verified with primary sources. The publisher shall not be liable for any loss, actions, claims, proceedings, demand or costs or damages whatsoever or howsoever caused arising directly or indirectly in connection with or arising out of the use of this material.
Discussion

Drag coefficient of unsubmerged rigid vegetation stems in open channel flows


Discussers:
MANOOCHEHR FATHI-MOGHADAM (IAHR Member), School of Water Sciences and Engineering, Shahid Chamran University, Ahwaz, Iran.
Email: mfathi@scu.ac.ir (author for correspondence)

SAMAD EMAMGHOLIZADEH, Assistant Professor, Shahrud University of Technology, Shahrud, Iran.
Email: S.Emamgholizadeh@sharoodut.ac.ir

Based on the momentum approach, the authors have conducted extensive flume experiments to measure the drag force $F_D$ on a smooth surface single stem in an array of stems. A dimensional analysis was conducted to develop equations to estimate $C_D$ in the regular-square staggering and triangle-staggering stem patterns. The paper provides also an overview of the history of previous works for drag force estimation on single elements in a roughness array. However, the following comments should be considered regarding experimentation and the related assumptions in developing the equations:

(a) Total drag includes the pressure drag (or form drag, less sensitive to the Reynolds number $R$) and the friction drag (or viscous drag, highly sensitive to $R$; Munson et al. 2002). There is a considerable variation in the surface drag as the flow velocity increases, yet this cannot be measured if a smooth cylinder is employed. A smooth-surface cylinder stem may not represent the prototype rigid stem which has considerable surface roughness. Otherwise, effects of $R$ in the proposed Eqs. (8)–(11) for calculating $C_D$ become significant.

(b) The authors assumed an additive property for the momentum absorbed by the flume bed and the cylinder elements. Despite considerable attention to the form drag, there is nothing in the analysis to account for the effect of bed shear on drag force measurements. Using momentum and energy approaches by measuring smooth surface shear with a Preston tube and a system of load cells, Lashkarara and Fathi-Moghadam (2010) in agreement with Knight (1981) observed considerable bed shear, pointing at the non-uniform velocity distribution in the vertical direction for smooth bed flow. Figure D1 shows the increase of bed shear stress $\tau_b$ or the velocity profile variation with average flow velocity $V_c$. The differences of data presented by Knight (1981) and Lashkarara and Fathi-Moghadam (2010) are due to differences in flume scale and slope, as well as by laboratory experimentation.

(c) The drag force on cylinders was determined by measuring the bending moment located at its top. This requires the centre of water pressure on the cylinder to be correctly known for any $V_c$. The authors assumed a uniform velocity distribution to determine the centre of pressure force (while it is stated non-uniform at bottom of p. 694, left column) and an average depth velocity $V_c$ for calculating $C_D$. These assumptions affect their results as discussed in (b). In addition, river bank and flood plain flows are shallow and the protruded rigid stems do not appear close enough in nature to assume negligible bed shear and a uniform velocity profile.

In conclusion, the experimental uncertainties and the assumption of a uniform velocity profile deteriorate the results and the
application of the proposed equations to naturally sparse rigid stems in shallow flood plains and river banks. Fathi-Moghadam and Kouwen (1997) used a frictionless knife edge table attached to a system of the load cell beneath a smooth flume to measure the direct drag force on flexible samples of real coniferous trees. The correct arrangement of the drag force measuring system and the application of the mean velocity measurements in front of flexible tree samples have supported their results and the application of their proposed equation in practice.

Acknowledgement

The discussers would like to acknowledge the financial support of Chamran University of Ahwaz and the Centre of Excellence on Operation Management of Irrigation and Drainage Networks of Iran.

References


Reply by the authors

The authors wish to thank the discussers for their interest in our paper. We would like to submit pointwise the discussion as below:

(a) The drag due to flow on tall rigid vegetation stems was mainly studied by the authors. The results are directly applicable for vegetation like bamboo plantations, which are tall, thin, rigid and of smooth surface. Typical flood plains, the like of Sandai River, Kagoshima, Japan have this pattern. However, note that even for smooth thin stems $C_D$ values weakly depend on $R_d$. Thus, its effects on drag cannot be significant for rough surface stems of large diameter.

(b) Note that the stem used for our measurement of stem drag is not connected to the channel bottom (Fig. 3) and the observed velocity distribution for subcritical flow is relatively uniform over the flow depth, except obviously close to the channel bed (Fig. 9). This confirms that our measurements on the stem drag are accurate. For supercritical flow, only literature data on stem drag were used by us.

(c) Prototype examples were already given in (a) above for applications of the present approach. The mechanics for measurement of stem drag is defined under (b) above. Note that our relationship is applicable for a large range of $0 \leq \lambda \leq 0.011$ thus it is useful to determine the stem drag even in isolated rigid tall stems.

As explained above, the present stem drag relationship is applicable to a large range of $\lambda$ values. Also the technique of partitioning the total drag into stem drag and bed particle resistance (Eq. 4) was validated by Kothyari et al. (2009), wherein the proposed methodology was applied to determine the sediment transport rate through vegetated flows and in which the stem drag was computed by using Eq. (11). Note that our data and literature data as well confirmed the applicability of this methodology to determine sediment transport by vegetated flows.

Reference