SHAPE DEPENDANT MANNING ROUGHNESS

WITOLD G. STRUPCZEWSKI
Institute of Geophysics, Polish Academy of Sciences,
Ksiecia Janusza 64, 01-452 Warsaw, Poland
ROMUALD SZYMKIEWICZ
Department of Hydrotechnics, Technical University of Gdansk,
Majakowskiego 11/12, 80-952 Gdansk, Poland

To get a general assessment of the model's applicability, it is not sufficient to check whether each underlying physical assumption sounds conclusive and has been tested empirically, but it is necessary to confront the model's output for various realistic initial and boundary conditions with our knowledge of the nature of the modelled process. Unfortunately, our understanding of the majority of natural processes may be too poor for such confrontation. The only hope, then, is to make such an assessment by analysing the results obtained by applying the model in different natural conditions. As, usually, there are several factors which may influence the values of the parameters of the model, it is not an easy task to derive them physically if only a passive type of experiment is available. The steady state flow process in an open channel modelled by the Chezy Uniform Flow Formula, with Manning friction, may serve as an example where both active and passive experiments are possible for verification and improvement of the formula. Hydraulic techniques and numerical models used in mountain-river studies are generally unverified for high gradient rivers because they have been developed for lower gradient rivers.

The Chezy model is the element of the majority of 1-D models of processes in a river network. Since unsteady flow friction is assumed to be the same as the friction for steady flow, all 1-D models of flood-routing are based on the Chezy model. Apart from hydrology and hydraulic engineering, there are many other water-related disciplines such as water quality, fluvial geomorphology, and sediment transport, which require an accurate determination of the hydraulic characteristics of rivers, e.g. shear stress, flow resistance, velocity distribution, velocity, and discharge. The longitudinal dispersion of both active and passive pollutants, either conservative or nonconservative, in the flowing aquatic environment of a prismatic channel

under both steady and unsteady flow conditions is described by the 1-D model built on a flow model. There is a need for hydraulic engineers and scientists in related disciplines to apply sound hydraulic methods; hydraulic research during last three decades has been limited. Funding has been diverted to more complex studies on a catchment, regional, or global scale. For a proper orientation of research programmes in hydrology, the present aspiration needs to be put into action with necessary research tools at disposal.

In spite of incorporating theoretical fluid-mechanics for better flow resistance, the Manning formula has not been superseded by a theoretically-based formula developed from modern fluid mechanics. Yen (1989) indicated that the Manning formula's longevity was a mixed blessing. He questioned whether the formula was fundamentally sound and practical or if it merely reflected lack of progress.

Chow (1959) named several factors affecting the variability of the Manning n, stating that *"there is no evidence about the size and shape of a channel as an important factor affecting the value of n"*. Here, based exclusively on the analysis of the Manning equation ,it will be demonstrated that the Manning n is dependant on the channel shape and n varies with flow depth. It will be done by determination of the channel shape above an initial level for given

(1) depth-discharge curve and
(2) area-discharge curve.

By solving the inverse problems of the Manning equation it will be shown that neither of two steady flow axioms, i.e.

(1) increase of flow depth causes increase in flow discharge and
(2) a widening of a channel increases its flow capacity,

is fulfilled by Manning formula with constant n.

The idea for this came directly from practice when the senior author tried to apply the Manning formula on deep and narrow channels of Liberian rivers for depth-discharge rating curves estimation with a few measurements only.

The paper is addressed to research and practising hydraulic engineers, mathematical modellers, scientists, and students in water-related disciplines to show them the deficiency of one of the basic research tools. It provides guidelines for a research programme on the shape dependant n. The computer