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Not all ancient projects were grandiose. Irrigation undoubtedly started with the first small efforts of some farmer to supplement an inadequate and varying rainfall supply. An extremely interesting account of the development of such irrigation has been given by Adams (1), which indicates that supplemental irrigation was the basis of an expanding civilization shortly after 5000 B.C. and prior to 3500 B.C. in the upper Khuzestan plains of what is now Southwestern Iran (eastern Mesopatamia). The article covers over 7000 years of life in that area, and represents the significant amounts of information which can be produced by archeologists using modern techniques, and in consultation with knowledgeable engineers and agriculturists.

The writer is convinced that our present knowledge of past development only scratches the surface of the vast amounts of information still buried. What further explorations will reveal, only time will tell, but the writer is sure that the engineer of today cannot help but continue to be respectful of the accomplishment of those who did so much, with so little.

Appendix.—Reference.

1. Adams, Robert M., "Agriculture and Urban Life in Early Southwestern Iran," *Science*, Vol. 136, No. 3511, Apr. 13, 1962, pp. 109-122.

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DETERMINATION OF EFFICIENT OPEN CHANNEL SECTIONS[a]

Discussions by R. B. Hickok, and P. N. Modi and S. M. Seth

R. B. HICKOK,[12] F. ASCE.—The author refers to a paper[4] by this writer as an earlier approach to the problem. The paper referred to, presented a scheme differing significantly from that of the author in two respects. First, it is not limited to trapezoidal sections. Its application to parabolic, as well as to trapezoidal sections, was demonstrated. Secondly, it enables simultaneous consideration of capacity and flow velocity criteria, for evaluation of bed scour and sediment transport characteristics of various channels under conditions of nonuniform and unsteady flow. A particular application has been in the selection of channel sections for handling storm runoff, considering also varied gradients and conditions of roughness.

The availability of automatic computers reduces the need for any graphical scheme for design of channels. Such schemes may, however, continue to serve well for small jobs, and for preliminary design and project cost-estimating

[a] November, 1967, by Mohammad Ali Mahdaviani, (Proc. Paper 5567).

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uses. For determining the most hydraulically efficient section, where only a capacity criterion must be satisfied, the scheme presented by the author provides a relatively simple and adequate means for rapid calculation of the optimum channel dimensions.

P. N. MODI,[13] A. M. ASCE AND S. M. SETH.[14]—The author has provided a nomogram and a set of curves developed from the Manning Formula, to

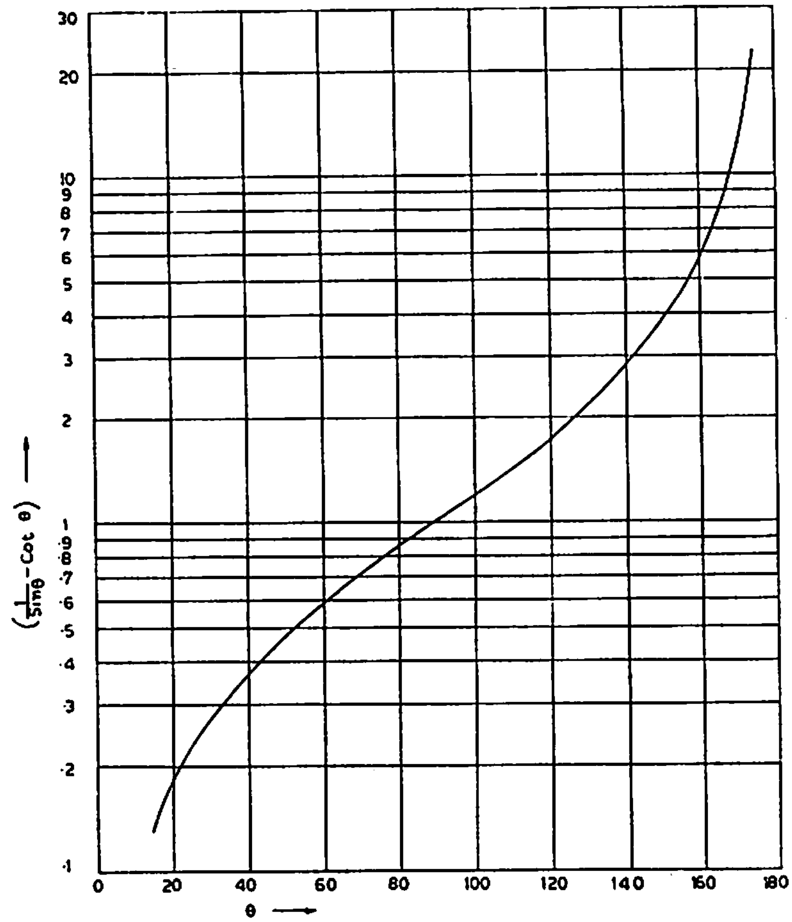

FIG. 10

facilitate the determination of best channel dimensions of a trapezoidal channel. He has also given an example of using the curves and the nomogram, in which for a given set of values of Q = 1000 cfs, n = 0.010, S = 0.001,

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$\alpha = 60°$ and $\beta = 60°$, the depth, y, and bottom width, b, being 10 ft and 11.5 ft respectively. However, if these values of y and b are used and the discharge, Q, is computed using the Manning formula, it comes out to be only 751.9 cfs. On close scrutiny, it has been found that, despite a correct approach to the problem, due to a minor mistake, Eqs. 10b, 12, and 13 given by the author are incorrect. In Eq. 10b, in the denominator $2^{5/3}$ should have been used in place of $2^{3/5}$. Moreover, even with $2^{3/5}$ the constant in Eq. 12 comes as 0.983 and not 1.018 as given by the author. The author's Eqs. 12 and 13 duly corrected are as follows

$$Q = \frac{0.469\ \psi\ S^{1/2}\ y^{8/3}}{n} \qquad (43)$$

or $$y = 1.328 \left(\frac{Q\,n}{\psi\sqrt{S}}\right)^{3/8} \qquad (44)$$

If the noted correct equations are used for a given set of data in author's example, depth, y, and bottom width, b, are found to be 11.12 ft and 12.83 ft

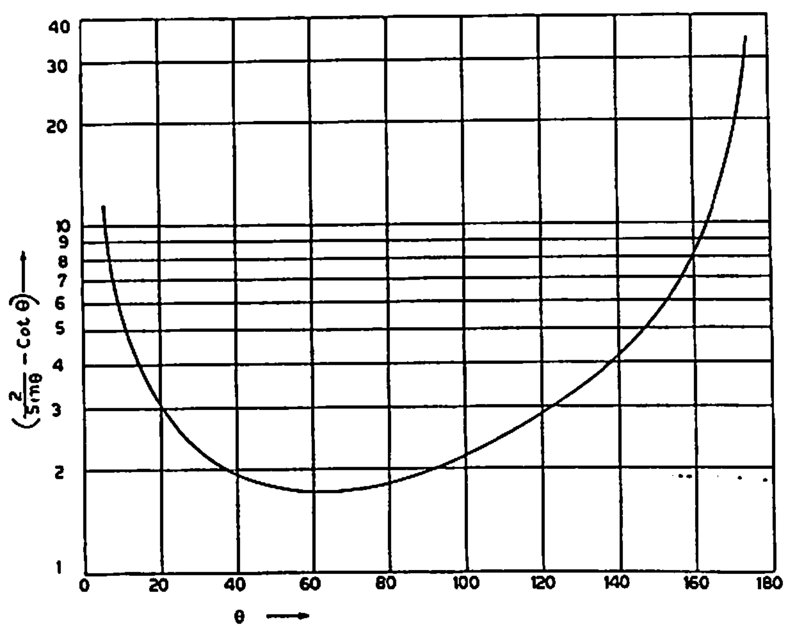

FIG. 11

respectively, which when substituted in Manning equation give the discharge, Q, as 1000 cfs.

Since the nomogram constructed by the author is based on incorrect relationship for y, it is also inaccurate.

Eqs. 8 and 11 have been represented graphically by the author as a set of curves between η and β, and ψ and β for various values of α. In the writers' opinion all these curves are superfluous, since a single curve for each case can be drawn. For η, a single curve can be drawn between $1/\sin\theta - \cot\theta$ and θ and for ψ a single curve can be drawn between $2/\sin\theta - \cot\theta$ and θ. Both these curves have been shown in Fig. 10 and Fig. 11 respectively. For $\theta = \alpha$ and $\theta = \beta$, the values of $1/\sin\alpha - \cot\alpha$ and $1/\sin\beta - \cot\beta$ can be obtained from Fig. 10 and the value of η will be an addition of the two values. By adopting the same method and using Fig. 11 the value of ψ can also be obtained for the various values of α and β. Alternatively the values of $1/\sin\theta - \cot\theta$ and $2/\sin\theta - \cot\theta$ for different values of θ can be tabulated which may be used to obtain the values of η and ψ for the given values of α and β

In conclusion, the writers note that a method for the determination of efficient open channel sections, using dimensionless parameters has been previously presented by them (5).

Appendix.—Reference.

5. Modi, P. N. and Seth, S. M., "Dimensionless Parameters for the Design of Economical Trapezoidal Section of Open Channels," Presented at the December, 1967 Symposium on Hydraulics and its Applications held at M.R. Engineering College, Jaipur, India.

STEADY AND UNSTEADY FLOW TOWARDS GRAVITY WELLS[a]

Discussion by Abdel-Aziz I. Kashef

ABDEL I. KASHEF,[12] F. ASCE.—The author's procedure is a breakthrough in the field of water-well hydraulics since Theis' paper[9] was published. The continuity and motion equations were solved by introducing the constants K and f of the soil structure without referring to the capacity of the soil to store water. However, there are few points that should be clarified to fully understand the limitations of the procedure.

The author states that the recent work of the writer[6] is based on Kirkham's theory. The reference cited was published in 1952, long before the development of that theory and the well problems were treated therein on the basis of the finite-difference equations developed either on the basis of the mathematical equations or directly from first principles. It is apparent that the author meant the writer's procedure published in 1965[7] in which the "exact" free surface was determined on the basis of the analysis of the hydraulic forces within the flow region, a procedure which has a completely different approach than the rigorous mathematical solution given by Kirkham.

It should be pointed out that the last term in Eq. 10 should be H_t rather

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