Critical-Flow Diagram for Trapezoidal Channels

A diagram is presented for all critical-flow computations in a trapezoidal channel section

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IN a recent article Jenkner[1] extended the well-known critical flow computations for circular sections to include the minimum specific energy. In this article a diagram is introduced for all critical-flow computations in a trapezoidal channel section.

The author and A. Thiruvengadam[2] have developed a two-parameter solution for the critical depth in trapezoidal sections. It was shown that:

$$\frac{Q_c\ m^{3/2}}{\sqrt{g}\left(\frac{b}{2}\right)^{5/2}} = 4\sqrt{2}\,\frac{(X_c+X_c^2)^{3/2}}{(1+2X_c)^{1/2}} \qquad \dots (1)$$

where Q_c is the critical discharge
m is the side slope
g is the acceleration due to gravity
b is the bed width of the channel

and $X_c = \frac{m\,Y_c}{b}$, Y_c being the critical depth (see Fig. 1).

Now, $\frac{Q_c\ m^{3/2}}{\sqrt{g}\left(\frac{b}{2}\right)^{5/2}}$ can be plotted against X_c as shown by curve *1* in Fig. 1. So, when Q_c is given, Y_c can easily be obtained and vice versa. For more accurate calculations, use can be made of the tables evolved by the author[3].

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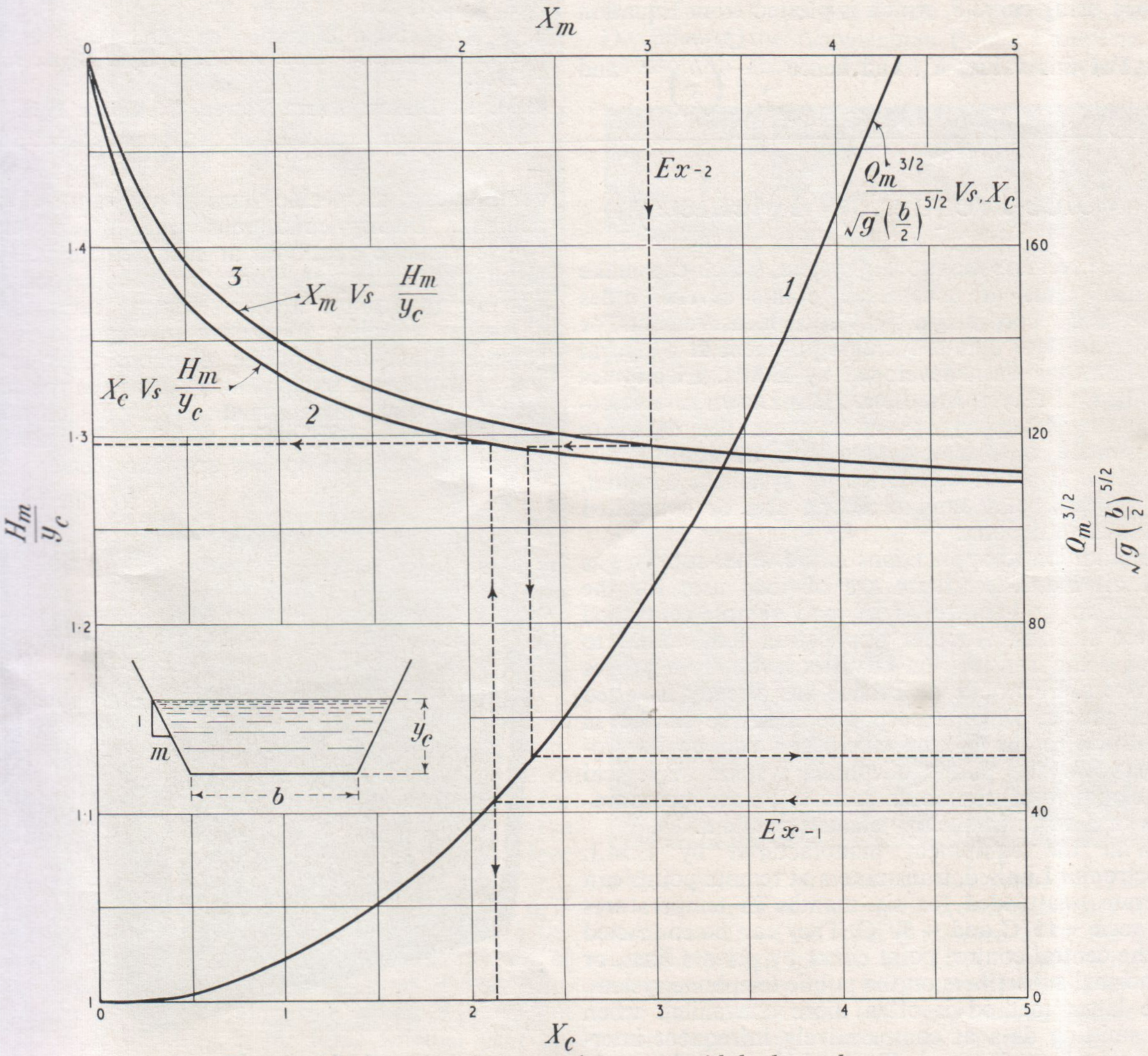


Fig. 1. Critical-flow diagram for trapezoidal channels

If H_m is the minimum specific energy, it can be shown that

$$\frac{H_m}{Y_c}=1+\frac{1}{2}\,\frac{1+X_c}{1+2X_c} \quad \dots (2)$$

So, once Y_c and hence X_c are known, $\frac{H_m}{Y_c}$ can be calculated or obtained from curve *2*.

But if for a given channel section and given H_m, it is desired to find Y_c and Q_c, then the procedure to be adopted normally is one of trial and error using the equation

$$\frac{Q_c\, m^{3/2}}{\sqrt{g}\left(\frac{b}{2}\right)^{5/2}}=4\sqrt{2}\,\frac{\left\{X_m^2\left(\frac{Y_c}{H_m}\right)^2+X_m\left(\frac{Y_c}{H_m}\right)\right\}^{3/2}}{\left\{1+2X_m\left(\frac{Y_c}{H_m}\right)\right\}^{1/2}} \quad \dots (3)$$

This difficulty can be overcome as follows

$$\text{If } X_m=\frac{H_m\, m}{b}$$

$$=X_c\,\frac{H_m}{Y_c} \quad \dots (4)$$

Equation (2) can be rewritten as

$$\frac{H_m}{Y_c}=1+\frac{1}{2}\,\frac{1+X_m\left(\frac{Y_c}{H_m}\right)}{1+2X_m\left(\frac{Y_c}{H_m}\right)} \quad \dots (5)$$

For a given H_m, and hence X_m, H_m/Y_c can be obtained using curve *3*, which is plotted from Equation (5). For this value, X_c, and hence $\frac{Q_c\, m^{3/2}}{\sqrt{g}\left(\frac{b}{2}\right)^{5/2}}$ and as a result Q_c, can be obtained as shown below.

Example 1: For a trapezoidal channel with $b=0{\cdot}40$ ft, $m=2$ and $Q_c=1{\cdot}5$ ft³/sec. Find Y_c and H_m.

$$\frac{Q_c\, m^{3/2}}{\sqrt{g}\left(\frac{b}{2}\right)^{5/2}}=41{\cdot}7.$$

From curve *1*, $X_c=2{\cdot}12$ and hence $Y_c=0{\cdot}424$ ft. For $X_c=2{\cdot}12$, from curve *2*, $H_m/Y_c=1{\cdot}297$ and $H_m=0{\cdot}55$ ft.

Example 2: For the channel section given in the previous example, given $H_m=0{\cdot}60$ ft, find Q_c.

$$X_m=\frac{H_m\, m}{b}=3{\cdot}0.$$

Following the arrows marked Ex-2, $\frac{Q_c\, m^{3/2}}{\sqrt{g}\left(\frac{b}{2}\right)^{5/2}}$ is found to be 51·6. Hence $Q_c=1{\cdot}85$ ft³/sec.

Following Diskin[4], when it was attempted to give an exponential equation for curve *1*, it was found that for the range of X_c from 0·1 to 10·0, there would be three separate equations, and as such it is not reported here.

REFERENCES

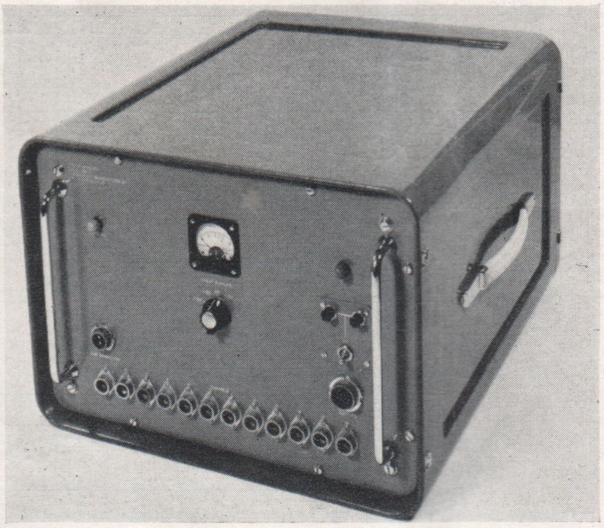
1. W. R. JENKNER. WATER POWER, January 1962.
2. N. RAJARATNAM, and A. THIRUVENGADAM. *J. Instn. of Engrs. (Ind.)*, April 1961. (See also *Ann. Rep. of Civil & Hydraulic Eng. Sec., Indian Institute of Science*, Bangalore, 1959.)
3. N. RAJARATNAM. Discussion on "End Depth in Trapezoidal Channels," *Proc. ASCE. J. Hyd. Divn.*, January 1962.
4. M. H. DISKIN. WATER POWER, September 1958.

Voice-Frequency Telemetry

A new remote-monitoring system, which can make measurements at unattended points several miles apart and record and display such measurements, or feed them into data-reducing equipment at a central location, has been developed by E.M.I. Electronics Limited, of Hayes, Middlesex. It is known as a voice-frequency telemetry system because the data are transmitted over a telephone line at audible frequencies. If a two-way telemetry system is adopted, the process being monitored can also be controlled at the central point.

In addition to applications in the water-supply, gas and oil industries, there are obvious uses for the system in grid-control work and remote-controlled power stations. Another application that comes to mind is the transmission of water levels from gauges on rivers. Electricité de France has already installed level gauges, which incorporate a device similar in operation to the talking clock, and can be interrogated over the public telephone system. A logical development of this would seem to be the incorporation of a voice-frequency telemetry system.

With the equipment manufactured by E.M.I. Electronics Limited, transmitters at remote points can operate unattended for six months in temperatures between −15°C and +50°C. They can be connected to the central control point either by private lines, or as normal subscribers on the public telephone system. The latter method is often more convenient when transmitting data at comparatively infrequent intervals over long distances. Transmissions can be made continuously, at specific times as programmed, or on demand. During continuous transmission, up to twelve variable quantities at each remote point can be sampled in sequence once every 16 seconds. It is possible to arrange higher sampling rates for any particular variable. Operation on demand is most suitable when using public telephone lines or lines shared with other equipment. A call from the central receiving point will automatically switch on the unattended transmitter, which will identify itself by a 15-sec pre-recorded speech announcement.



A typical voice-frequency sender