Traditional calculation methods

For a composite cross-section the values of the hydraulic roughness for the various zones usually differ. Early publications on the approach used the Manning-Strickler method for irregular river cross-sections. In such cases, which are very common, the effects of banks and channels on the current distribution have to be considered. An irregular cross-section should be schematised using one of the following approaches.

1 A general method is to divide the cross-section into vertical slices parallel to the river axis, each with a more or less constant water depth, as shown in Figure 4.58a.

For the determination of the equivalent roughness, the water area is divided into N parts with the wetted perimeters P_1, P_2, …, P_N (m) and the Manning coefficients of roughness n_1, n_2, .., n_N (s/m$^{1/3}$) are known.

By assuming that each part of the area has the same mean velocity, the equivalent coefficient of roughness may be obtained by Equation 4.137 (Einstein, 1934; Yassin, 1954; Horton, 1933).

$$n = \left(P_1 n_1^{3/2} + P_2 n_2^{3/2} + \ldots + P_N n_N^{3/2}\right)^{2/3} \Big/ P^{2/3} \tag{4.137}$$

By assuming that the total force resisting the flow is equal to the sum of the forces resisting the flow developed in the subdivided areas (Pavlovski, 1931; Mülhofer, 1933; Einstein and Banks, 1950), the equivalent roughness coefficient is given by Equation 4.138.

$$n = \left(P_1 n_1^{2} + P_2 n_2^{2} + \ldots + P_N n_N^{2}\right)^{1/2} \Big/ P^{1/2} \tag{4.138}$$

Lotter (1933) assumed that the total discharge of the flow is equal to the sum of discharges of the subdivided areas (see Figure 4.58a). Thus the equivalent roughness coefficient can be computed from Equation 4.139.

$$n = P\, R^{5/3} / \left(P_1\, R_1^{5/3} / n_1 + P_2\, R_2^{5/3} / n_2 + \ldots + P_N\, R_N^{5/3} / n_N\right) \tag{4.139}$$

2 Where a main channel and a floodplain can be clearly distinguished, the cross-section should be divided into two separate parts (see Figure 4.58b). Then, using the Chézy formulation, the conditions of equal water surface gradient i and continuity yield to Equations 4.140 and 4.141.

$$i = U_1^2 / \left(R_1 C_1^2\right) = U_2^2 / \left(R_2 C_2^2\right) = U^2 / \left(R\, C^2\right) \tag{4.140}$$

$$U A_c = U_1 A_{c1} + U_2 A_{c2} \tag{4.141}$$

This results in Equations 4.142 and 4.143.

$$U A_c = U A_{c1}\left(\sqrt{\frac{R_1}{R}}\,\frac{C_1}{C}\right) + U A_{c2}\left(\sqrt{\frac{R_2}{R}}\,\frac{C_2}{C}\right) \tag{4.142}$$

$$\sqrt{R} = \left(A_{c1}\sqrt{R_1}\,C_1 + A_{c2}\sqrt{R_2}\,C_2\right) / \left(A_c C\right) \tag{4.143}$$

The overall C-value can be computed from Equation 4.144.

$$C = (b_1 C_1 + b_2 C_2) / b \tag{4.144}$$

where $b = b_1 + b_2$ (see Figure 4.58b).

3 If the area of the cross-sections (A_{c1} and A_{c2}) cannot be estimated accurately, as in Figure 4.58c, then the application of the hypothesis of Einstein is recommended. Einstein assumed $U_1 = U_2 = U$, resulting in Equation 4.145.

$$1/(R_1 C_1^2) = 1/(R_2 C_2^2) = 1/(R\, C^2) \tag{4.145}$$