ANNEX 11

BED SOLID CONSUMPTION RELATION USED

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The calculation relation used in the study of Meyer-Peter and Müller (1948), Ackers and White (1973), Parker (1990) and Wilcock and Crowe (2003). The origin of them, as well as their characteristics, general conditions of use, and applicability were described in point 7 of the Report.

Meyer-Peter and Müller relation (1948)

The Meyer-Peter and Müller relation is one of the mostly used in the forecast of bed solids consumption. It was developed out of 251 experiments, with sediments of uniform size and granulometry mixtures with low extension, several ratios of specific density, and cases with and without shapes of bed. One of the reasons of its popularity is, besides its extensive empiric base, its simplicity.

According to Meyer and Müller, the dimensionless solid consumption, q^* is given by:

$$q_s^* = 8\left(\tau_{50}^* - 0.047\right)^{3/2} \qquad \text{(A5.1)}$$

Where $q_s^* = \dfrac{q_s}{\sqrt{RgD_{50}^3}}$ being q_s the solid consumption per width unit , D_{50} the size considered as typical from the sediment, g the gravity acceleration and R the specific density immersed in the sediment, given by $R = \dfrac{\rho_s - \rho}{\rho}$ where ρ_s is the density of the sediment and ρ the one of the liquid.

being t the cut effort.

Ackers and White relation (1973)

Ackers and White distinguish the mechanism of movement of the sediments according to its sizes. The movement of the coarse is associated with the effective cut effort acting over them and the finest ones depend on the intensity of turbulence. The solids consumption, which includes both types of sediments is determined from:

$$\tau_{50}^* = \frac{\tau}{gRD_{50}}$$

$$G_{gr} = C_a\left(\frac{F_{gr}}{A_a} - 1\right)^{m_a} \qquad \text{(A5.2)}$$

where F_{gr} is the movement number, given by:

$$F_{gr} = \frac{u_*^{n_a}}{\sqrt{RgD_s}}\left[\frac{V}{\sqrt{32}\log\left(\alpha h_W / D_s\right)}\right]^{1-n_a} \qquad \text{(A5.3)}$$

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In the previous expression *Ds* is the characteristic size of the sediments, which the authors recommend to be equal to *D*35. V, u^* y h_w are the mean speed, frictional and the flow height respectively. *a* = 10 y n_a are parameters obtained experimentally. This last one would depend on the dimensionless diameter

$D_{gr} = D_{35}\left(\frac{gR}{\nu^2}\right)^{1/3}$, where v is the kinematic viscosity of the water. The relation binding n_a with D_{gr} is presented ahead.

The function proposed by Ackers and White to determine the solids consumption of the bed is:

$$G_{gr} = C_a\left(\frac{F_{gr}}{A_a} - 1\right)^{m_a} \qquad \text{(A5.4)}$$

Where C_a, A_a and m_a depend on D_{gr}, as well as n_a, as per the following relations:

$$1 \le D_{gr} \le 60 \qquad \begin{cases} n_a = 1.0 - 0.56 \log D_{gr} \\ A_a = \dfrac{0.23}{\sqrt{D_{gr}}} + 0.14 \\ m_a = \dfrac{9.66}{D_{gr}} + 1.34 \\ \log C_a = 2.86 \log D_{gr} - (\log D_{gr})^2 - 3.53 \end{cases} \qquad \text{(A5.5)}$$

$$D_{gr} > 60 \qquad \begin{cases} n_a = 0.0 \\ A_a = 0.17 \\ m_a = 1.50 \\ C_a = 0.025 \end{cases} \qquad \text{(A5.6)}$$

The solid dimensionless consumption is presented as the quotient between the mass flow of the sediment and the mass flow of liquid $X = \frac{\rho_S Q_S}{\rho Q}$ and it is included in the definition of *Ggr* :

$$G_{gr} = \frac{X h_w}{(R+1) D_S}\left(\frac{u_*}{V}\right)^{n_a} \qquad \text{(A5.7)}$$

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Parker relation (1990)

The Parker relation of 1990 is based on the one presented previously by Parker, Klingeman and McLean (1982). The relation considers that the gravel course distinguishes a superficial layer, called active layer (and corresponds to the crust when sediments comprised in it, are not in movement) and an inferior one, the substratum.

The solid consumption according to Parker is given by:

$$Qs = b_w \frac{0.00218 u_*^3}{Rg} \sum_i G\left[\omega g_0\left(\frac{D_i}{D_{sg}}\right)\phi_{sg0}\right] F_i \qquad \text{(A5.8)}$$

where b_w is the width of the course, Fi is the granulometric fraction associated to the size Di of the active layer.

$$\phi_{sg0} = \frac{\tau_{sg}^*}{\tau_{rsg}^*} \quad ; \quad \tau_{sg}^* = \frac{\tau}{\rho g R D_{sg}} \qquad \text{(A5.9)}$$

τ is the cut effort acting on the bed and D_{sg} the geometric diameter of the superficial layer, given by

$$ln(D_{sg}) = \sum F_i \, ln(D_i) \, . \; \tau_{rsg}^* = 0{,}0386 \, .$$

$$g_0\left(\frac{D_i}{D_{sg}}\right) = \left(\frac{D_i}{D_{sg}}\right)^{-0.0951}$$

(A5.10)

$$\omega = 1 + \frac{\sigma_\phi}{\sigma_{\phi 0}}(\omega_0 - 1) \qquad \text{(A5.11)}$$

The standard geometric deviation is given by $\sigma_\phi^2 = \sum_i \left[\frac{ln(D_i/D_{sg})}{ln(2)}\right]^2 F_i$.

ω_0 and $\sigma_{\phi 0}$ depend on ϕ_{sg0} according to the graphic relation of Fig. A5.1.

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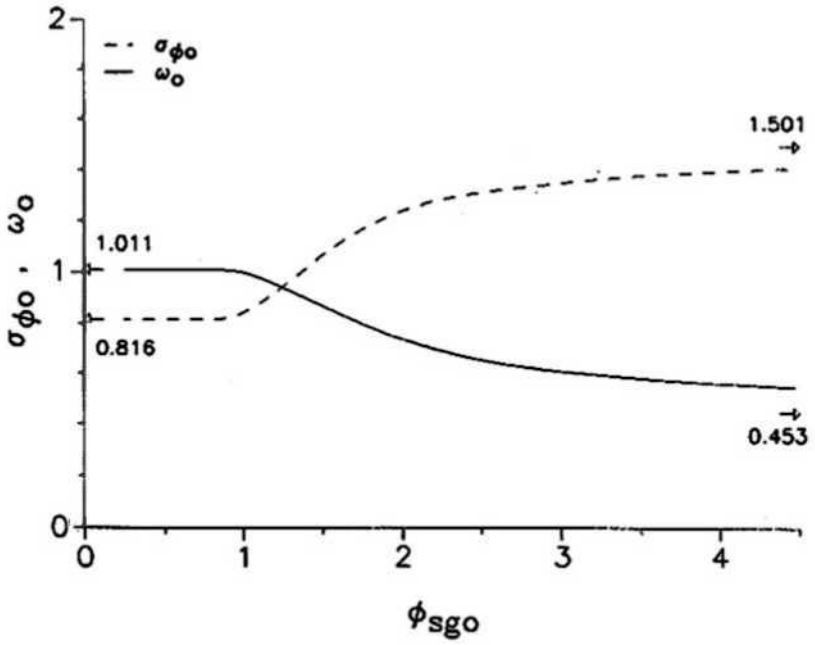

Fig. A5.1. Parker Method. Functions ω0 and σφ0

Wilcock and Crowe (2003) relation

According to Wilcock and Crowe, the sand content in a mixture plays an important non-lineal effect in the magnitude of gravel transport, therefore its effect is incorporated in the calculation of its relation, having the solid consumption given by:

$$Qs = b_w \frac{u_*^3}{Rg} \sum_i G(\phi_i) F_i$$

(A5.12)

$$G(\phi_i) = \begin{cases} 0.002\phi_i^{7.5} & \phi_i < 1.35 \\ 14\left(1 - \dfrac{0.894}{\sqrt{\phi_i}}\right)^{4.5} & \phi_i \geq 1.35 \end{cases}$$

(A5.13)

$$\phi_i = \frac{\tau_g^*}{\tau_{rg}^*}\left(\frac{D_i}{D_{sg}}\right)^{-\theta}$$

(A5.14)

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$$\theta = \frac{0.67}{1 + exp\left(1.5 - D_i / D_{sg}\right)} \qquad \text{(A5.15)}$$

$$\tau_g^* = \frac{\tau}{\rho R g D_{sg}} \quad ; \quad \tau_{rg}^* = 0{,}021 + 0{,}015\, exp\left(-20 F_s\right) \qquad \text{(A5.16)}$$

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