Isfahan University of Technology (IUT) **Department of Civil Engineering**
RIVER ENGINEERING **1403-1404** **Term II**
Assignment #2 **Sediment Properties and Flow Resistance** **Due: 18/12/1403**

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1 Prepare a sample from one of the drainages reaches located in the Isfahan University of Technology. Fill out the form below and draw the sediment distribution curve. Determine d_{90}, d_{65}, d_{50}, d_g, σ_g.

Class No.	Class Range (mm)	d_i (mm)	i_b

2 Having the sediment distribution obtained in problem #1 and assuming an average velocity of 1 m/s, calculate the fall velocity and the critical shear stress using different methods. Explain the reasons behind the differences.

3 As you know, it is difficult to define experimentally (by visualization) the incipient motion of the bed particles. Use the materials available in books, internet, etc., write a summary about the experimental criteria used by different investigators to outline the incipient motion. Comment on the engineering applicability of the proposed criteria.

4 Given the following data,
$y = 1$ m ; $S_0 = 0.0008$; $B = 5$ m ; $d_{35} = 0.3$ mm
$d_{65} = 0.9$ mm ; $\upsilon = 10^{-6}$ m^2/s ; $S_s = 2.65$; $m_s = 2$
Obtain the discharge for the upper flow regime, using the method proposed by Engelund and Hanson.

2 Fall Velocity

1) From C_D

$$W_s = \frac{\gamma \pi d^3}{6}(S_s - 1) = \frac{(9810\,N/m^3)\pi(0.00021m)}{6}(2.65-1) = 1.8\,N$$

$$\frac{W_s}{\rho \upsilon^2} = \frac{(1.8\,N)}{(1000\,kg/m^3)(1.12\times10^{-6}\,m^2/s)} = 1600 \quad ; \quad Fig.(2.1) \rightarrow \begin{cases} C_D = 2 \\ Re = \dfrac{wd_s}{\upsilon} = 30 \end{cases}$$

$$\begin{cases} w^2 = \dfrac{4}{3}\dfrac{gd}{C_D}(S_s - 1) \\ \dfrac{wd_s}{\upsilon} = 30 \end{cases} \; ; \; \begin{cases} w^2 = \dfrac{4}{3}\dfrac{(9.81m/s^2)(0.00021m)}{2}(1.65) \\ \dfrac{w(0.00021m)}{(1.12\times10^{-6}\,m^2/s)} = 30 \end{cases} \; ; \; \begin{cases} w = 0.05\,m/s \\ w = 0.16\,m/s \end{cases}$$

Now a new value of shear stress will be set at w = 0.027 m/s.

$$Re = \frac{(0.05m/s)(0.00021m)}{(1.12\times10^{-6}\,m^2/s)} = 9 \quad ; \quad C_D = 9 \quad ; \quad w^2 = \frac{4}{3}\frac{(9.81m/s^2)(0.00021m)}{9}(1.65)$$

$$w = 0.022\,m/s$$

2) Fig. (2.2)

w = 0.022 m/s

3) Fig. (2.3)

$$SF = 0.7 \xrightarrow{Fig.\,(2.3)} w = 0.022\,m/s$$

Critical Shear Stress

1) Shields

$$\frac{d_g}{\upsilon}\sqrt{0.1(S_s - 1)gd_g} = \frac{(0.00021m)}{(1.12\times10^{-6}\,m^2/s)}\sqrt{0.1(2.65-1)(9.81m^2/s)(0.00021m)} = 3.45$$

$$Shield \quad Diagram \rightarrow \begin{cases} \tau_* = \dfrac{\rho u_*^2}{(\gamma_s - \gamma)d_s} = 0.035 \\ R_* = \dfrac{u_* d_s}{\upsilon} = 20 \end{cases} \; ; \; \begin{cases} \dfrac{(1000\,kg/m^3)u_*^2}{[(2.65-1)(9810\,N/m^3)](0.00021m)} = 0.035 \\ \dfrac{u_*(0.00021m)}{(1.12\times10^{-6}\,m^2/s)} = 20 \end{cases}$$

$$\begin{cases} u_* = 0.01\,m/s \\ u_* = 0.11\,m/s \end{cases}$$

Now a new value of shear stress will be set at u_* = 0.027 m/s.

$$R_* = \frac{(0.01m/s)(0.00021m)}{(1.12\times10^{-6}\,m^2/s)} = 1.9 \quad ; \quad \tau_* = 0.06 = \frac{(1000\,kg/m^3)u_*^2}{[(2.65-1)(9810\,N/m^3)](0.00021m)}$$

$$u_* = 0.011\,m/s \quad ; \quad \tau_{c_{Shields}} = \rho u_*^2 = (1000\,kg/m^3)(0.011\,m/s)^2 \quad ; \quad \underline{\underline{\tau_{c_{Shields}} = 0.12 \quad Pa}}$$

2) Henderson

$\boldsymbol{u_*} = 0.013\,\boldsymbol{m/s}$; $\tau_{c_{Hend}} = \rho u_*^2 = (1000\,\boldsymbol{kg/m^3})(0.013\,\boldsymbol{m/s})^2$; $\underline{\underline{\tau_{c_{Hend}} = 0.17 \quad \boldsymbol{Pa}}}$

3) USBR

$\tau_{c_{USBR_{average}}} = 70\,\boldsymbol{g/m^2}$; $\underline{\underline{\tau_{c_{USBR_{average}}} = 0.70 \quad \boldsymbol{Pa}}}$

4 The hydraulic radius and the parameter χ are calculated as

$$R = \frac{(B + m_s y)\,y}{B + 2y\left(1 + m_s^2\right)^{1/2}} = \frac{\left[5m + 2(1m)\right](1m)}{5m + 2(1m)\left(1 + 2^2\right)^{1/2}} = 0.74\,m$$

$$d = \frac{1}{2}(0.3\,mm + 0.9\,mm) = 0.6\,mm \quad ; \quad \chi = \frac{RS_0}{[SG - 1]\,d} = \frac{(0.74\,m)(0.0008)}{\left[(2.65/1) - 1\right](0.0006\,m)}$$

$$\chi = 0.60$$

From Fig. (2.32) and for the upper flow regime (antidune), $\chi' = 0.60$. The hydraulic radius due to grain roughness and the shear velocity are determined as

$$R' = \frac{\chi'\left[(\rho_s/\rho) - 1\right]d}{S_0} = \frac{\chi'}{\chi}R = \frac{0.60}{0.60}(0.74\,m) = 0.74\,m$$

$$u'_* = \sqrt{gR'S_0} = \sqrt{\left(9.81\,m/s^2\right)(0.74\,m)(0.0008)} \quad ; \quad u'_* = 0.076\,m/s$$

From Fig. (2.32) the parameter x and the average velocity are

$$\frac{k_s}{\delta} = \frac{d_{65}}{11.6\upsilon/u'_*} = \frac{(0.0009\,m)}{11.6\left(10^{-6}\,m^2/s\right)/(0.076\,m/s)} = 5.90 \quad ; \quad x = 1.03$$

$$V = 5.75u'_*\log\left(12.27\frac{R'}{k_s}x\right) = 5.75(0.076\,m/s)\log\left[12.27\frac{(0.74\,m)}{(0.0009\,m)}(1.03)\right] = 1.76\,m/s$$

And finally, the cross-section and the discharge are computed as

$$A = (B + m_s y)\,y = \left[(5m) + 2(1m)\right](1m) = 7\,m^2 \quad ; \quad Q = \left(7\,m^2\right)(1.76\,m/s) = \underline{\underline{12.3\,m^3/s}}$$