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Design criteria for sediment transport in sewers based on self-cleansing concept

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Razi University

Department of Civil Engineering, Razi University, Kermanshah, Iran

Razi University

Self-cleansing design concept

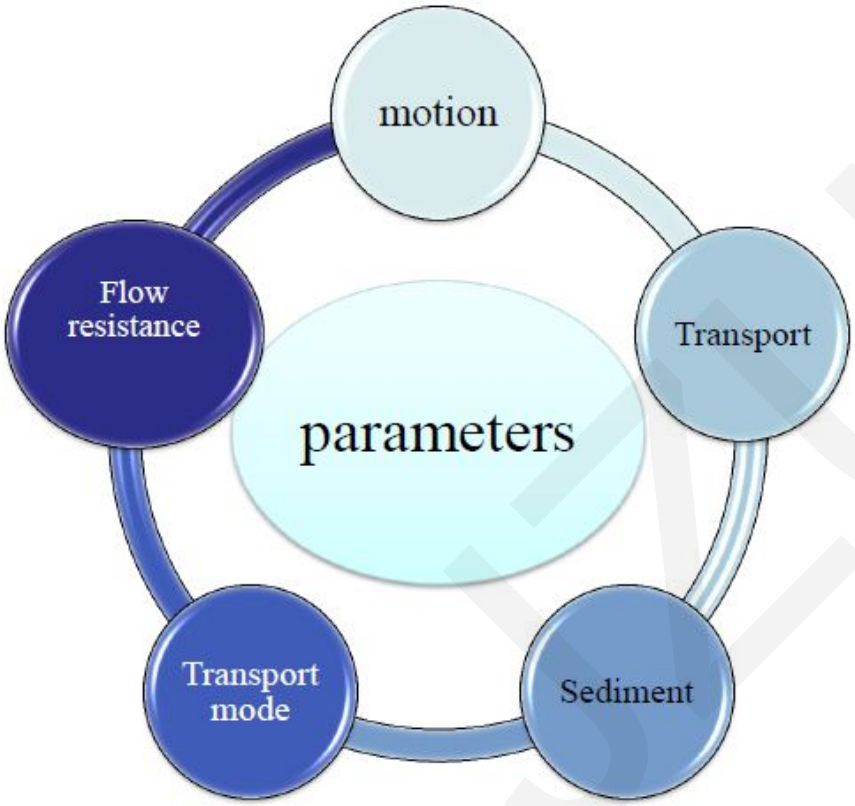
The self-cleansing process in the wastewater system must establish a balance between the amount of sediment and the rate of erosion during the sediment transport and, in a specific period of time, minimize the combined costs of construction, operation and maintenance of the system.

1- Design criteria for non-deposited sediment transport

2- Design criteria for limited deposit sediment transport

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Dimensionless parameters of sediment transport in clean pipe



Non-deposited sediment transport:

$$F_r = \frac{V}{\sqrt{gd(s-1)}} = f(\frac{d}{y} or \frac{d}{R}, C_V)$$

Limited deposit sediment transport:

$$F_r = \frac{V}{\sqrt{gd(s-1)}} = f(\frac{d}{y} or \frac{d}{R}, C_V, \frac{y_s}{D})$$

Non-deposited bed load

May *et al.* (1996): $$C_V = 3.03\times10^{-2}\left(\frac{D^2}{A}\right)\left(\frac{d}{D}\right)^{0.6}\left[1-\frac{V_t}{V}\right]^4\left[\frac{V^2}{gD(s-1)}\right]^{1.5} \qquad Eq.3$$

$$V_t = 0.125[g(s-1)d]^{0.5}\left[\frac{y}{d}\right]^{0.47} \qquad Eq.4$$

Vongvisessomjai *et al.* (2010): $$\frac{V}{\sqrt{g(s-1)d}} = 4.31C_V^{0.226}\left(\frac{d}{R}\right)^{-0.616} \qquad Eq.5$$

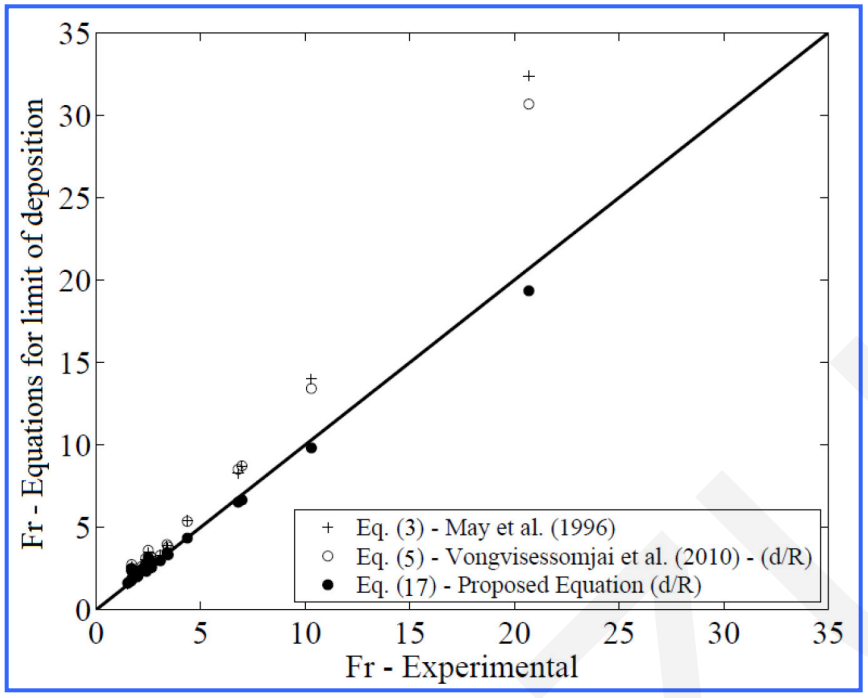
$$\frac{V}{\sqrt{g(s-1)d}} = 3.57C_V^{0.21}\left(\frac{d}{y}\right)^{-0.542} \qquad Eq.6$$

Proposed equation: $$F_r = 4.49C_V^{0.21}\left(\frac{d}{R}\right)^{-0.54} \qquad Eq.17$$

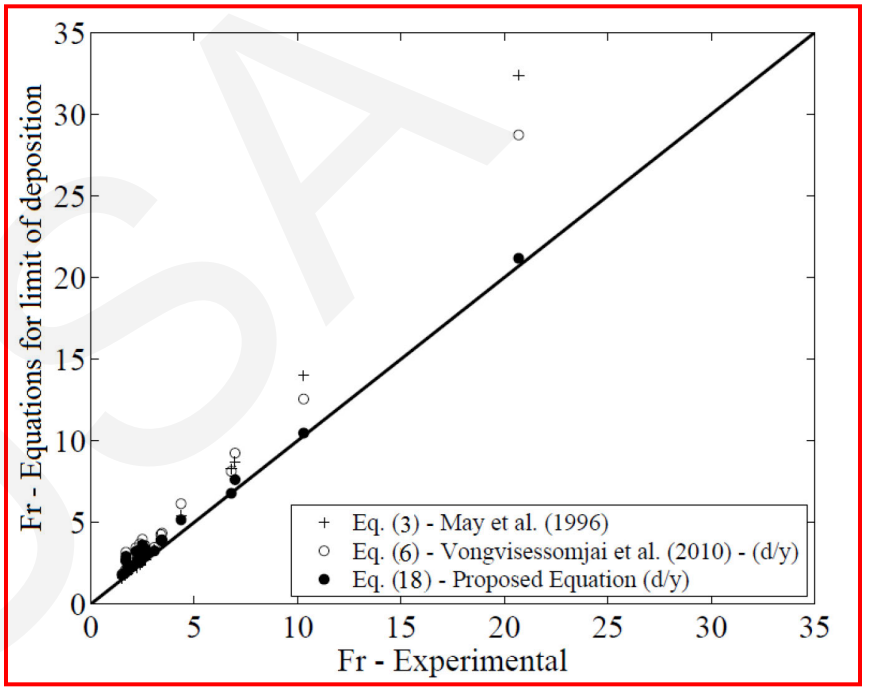
$$F_r = 3.59C_V^{0.22}\left(\frac{d}{y}\right)^{-0.51} \qquad Eq.18$$

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Non-deposited bed load: Results



Comparison of the proposed equation (17) for *d/R* with the equations of Vongvisessomjai *et al*. (2010) and May *et al*. (1996)



Comparison of equation (18) for *d/y* with equations of Vongvisessomjai *et al*. (2010) and May *et al*. (1996).

Bed-load in deposited bed state

Ab. Ghani (1993): $$\frac{V}{\sqrt{g(s-1)d}} = 3.08 C_V^{\,0.21} D_{gr}^{\,-0.09} \left(\frac{R}{d}\right)^{0.53} \lambda_s^{\,-0.21} \qquad Eq.7$$

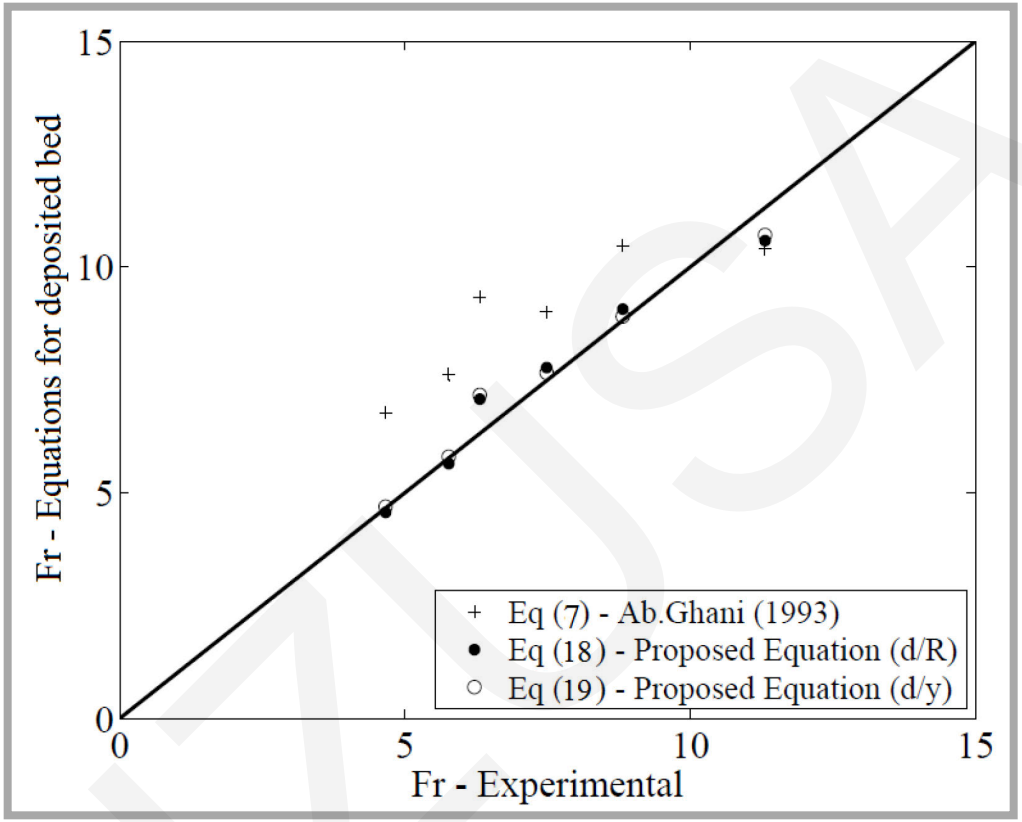
$$\lambda_s = 1.13 \lambda_0^{\,0.98} C_V^{\,0.02} D_{gr}^{\,0.01} \qquad Eq.8$$

Proposed equation: $$F_r = 2.5 C_V^{\,0.375} \left(\frac{d}{R}\right)^{-0.766} \left(\frac{y_s}{D}\right)^{-0.258} \qquad Eq.18$$

$$F_r = 2.8 C_V^{\,0.335} \left(\frac{d}{y}\right)^{-0.482} \left(\frac{y_s}{D}\right)^{-0.463} \qquad Eq.19$$

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Bed-load in deposited bed state: Results



Comparison of the Froude numbers from equations (18) and (19) and Ab. Ghani with the actual Froude number