Suspended Load

For small particles, the particle velocity can be approximated by

$$\frac{\partial C}{\partial t} + \nabla \cdot \vec{F}_s = 0 \qquad (1)$$

where

$$\vec{F}_s = \left(\vec{u} - w_s \hat{k}\right) C \qquad (2)$$

For a unidirectional open channel, (2) can be Reynolds averaged; $C = \overline{C} + C'$, $u = \overline{u} + u'$, to solve for the mean flux

$$\frac{\partial \overline{C}}{\partial t} + \nabla \cdot \overline{\vec{F}}_s = 0 \qquad (3)$$

where

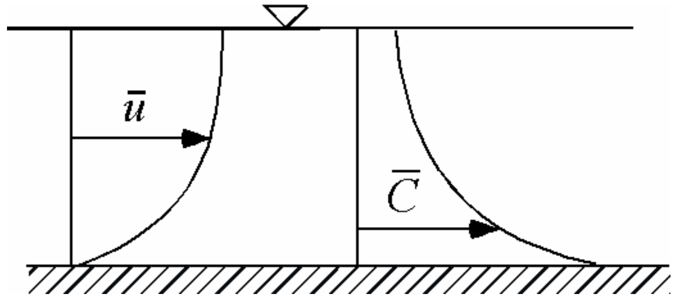
$$\overline{\vec{F}}_s = \left(\overline{\vec{u}} - w_s \hat{k}\right) \overline{C} + \overline{\vec{u}' \cdot C'} \qquad (4)$$

One can assume that

$$\overline{\vec{u}' \cdot C'} = -D_d \nabla \overline{C} \qquad (5)$$

This is known as a **Fickian** assumption, where D_d is the "kinematic eddy diffusivity".

Suspended Load in a Channel

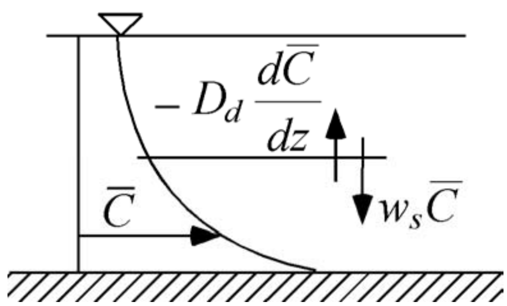


If we are at equilibrium, then the balance of flux in the vertical *z* is

$$\overline{w'C'} - w_s\overline{C} = 0 \tag{6}$$

which combined with a Fickian approximation and a uniform flow assumption yields –

$$-D_d \frac{d\overline{C}}{dz} - w_s\overline{C} = 0 \tag{7}$$



Rousean Distribution of Suspended Load

In order to calculate the concentration profile, we need to know what vertical distribution of D_d is. We assume –

$$D_d = \kappa u_* z\left(1 - \frac{z}{H}\right) \tag{8}$$

This is an estimation of the distribution of the eddy diffusivity coefficient in the vertical. When applied to the velocity profile (as in the case of generating a total flux of sediment), it is often called the **Rousean** relation for the distribution of eddy viscosity in the vertical.

We now use the concepts of Fickian diffusion of sediment to estimate the concentration in the vertical. Substituting (8) into (7) and integrating…

$$\int_b^z \frac{d\overline{C}}{\overline{C}} = -\xi \int_b^z \frac{H dz}{z(H-z)} = \ln\left[\left(\frac{H-z}{z}\right)^{\xi}\Bigg|_b^z\right] \tag{9}$$

where ξ is the Rouse number, defined by

$$\xi = \frac{w_s}{\kappa u_*} \tag{10}$$

and we choose b to very close to the bed, that is:

$$\frac{b}{H} << 1 \tag{11}$$

It is essentially the ratio of turbulent fluctuations to the settling velocity of the sediment. You can further reduce (9) to

$$\overline{C} = \overline{C}_b \left[\frac{(H - z)/z}{(H - b)/b} \right]^{\xi} \tag{12}$$