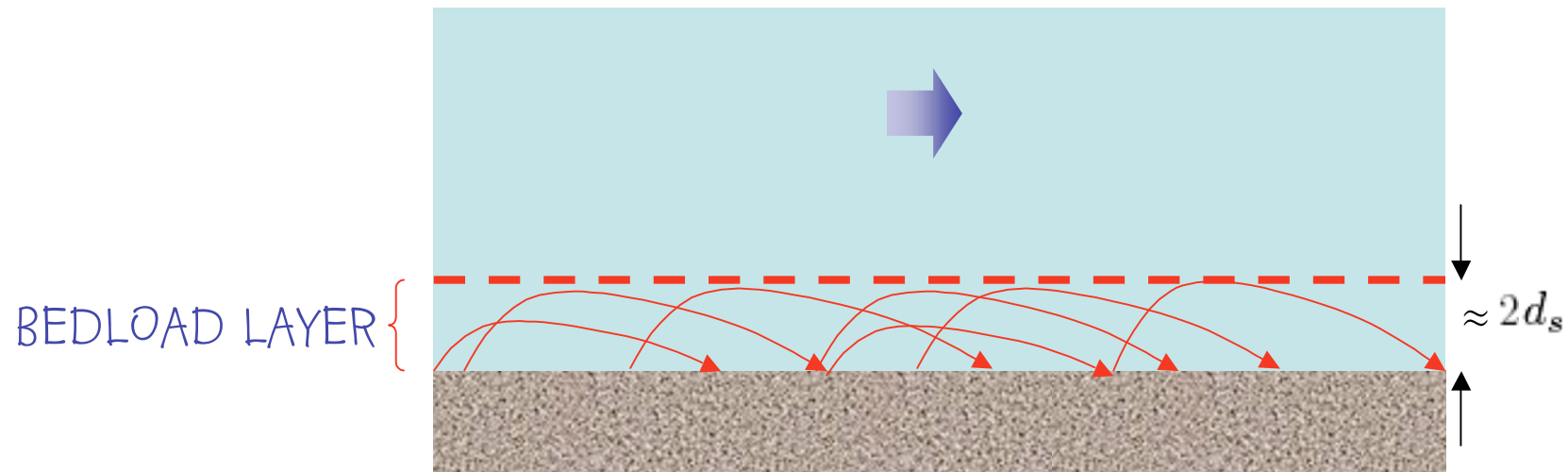


## 6.2 Gasto sólido de fondo

Gasto sólido de fondo para sedimento de tamaño uniforme

ENFOQUE TIPO BAGNOLD



## GASTO SOLIDO DE FONDO

$$i_b = W_b u_b$$

PESO SOLIDO SUMERGIDO POR UNIDAD DE ANCHO Y TIEMPO

PESO SUMERGIDO CAPA GASTO SOLIDO POR UNIDAD DE AREA

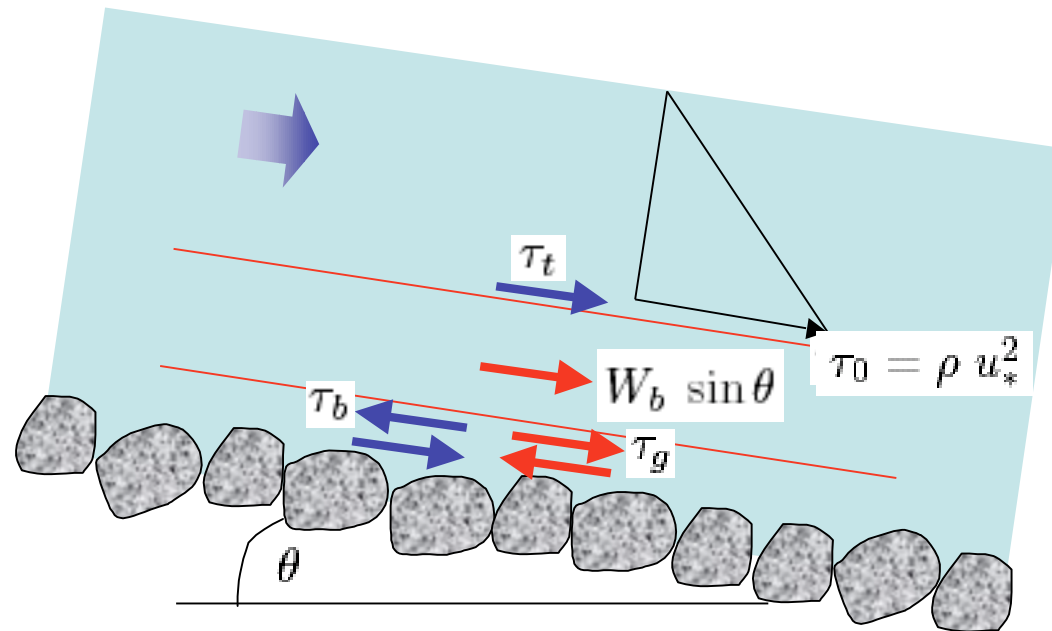
VELOCIDAD MEDIA DE LAS PARTICULAS SOLIDAS

$$W_b = \tau_g / \mu_d$$

ESFUERZO CORTE EN EL LECHO

COEFICIENTE DE FRICCION DINAMICA

## GASTO SOLIDO DE FONDO



$$\tau_0 = \rho u_*^2 \quad \rightarrow \quad \tau_t + W_b \sin \theta = \tau_g + \tau_b \quad \leftarrow \tau_c$$

$\approx 0$

$$\tau_g = \tau_0 - \tau_c$$

$$i_b = W_b u_b$$

$$\tau_g / \mu_d$$

$$\tau_0 - \tau_c$$

$$i_b = \frac{1}{\mu_d} (\tau_0 - \tau_c) u_b$$

DEF.: GASTO SÓLIDO ADIMENSIONAL

$$q_s^* = \frac{i_b}{\sqrt{\rho^2 (R g d_s)^3}} = \frac{q_s}{\sqrt{g R d_s^3}}$$

GASTO SÓLIDO VOLUMETRICO POR UNIDAD DE ANCHO (m<sup>3</sup>/s/m)

$$q_s^* = \frac{1}{\mu_d} \tau_*^{1/2} (\tau_* - \tau_{*c}) \frac{u_b}{u_*}$$

## VELOCIDAD MEDIA DE SALTACION

$$\frac{u_b}{u_*} = a \left( 1 - b \left( \frac{\tau_*}{\tau_{*c}} \right)^{-1/2} \right)$$

11.5

0.7

$$q_s^* = \frac{1}{\mu_d} \tau_*^{1/2} (\tau_* - \tau_{*c}) \frac{u_b}{u_*}$$

$$q_s^* = \frac{a}{\mu_d} (\tau_* - \tau_{*c}) (\tau_*^{1/2} - b \tau_{*c}^{1/2})$$

## EC. DE GASTO SÓLIDO ADIMENSIONAL

## ECUACIONES EMPIRICAS Y SEMIEMPIRICAS

$$q_s^* = 18.74 (\tau_* - \tau_{*c}) (\tau_*^{1/2} - 0.7 \tau_{*c}^{1/2})$$

ENGELUND & FREDSE

0.05

$$q_s^* = 8 (\tau_* - \tau_{*c})^{3/2}$$

MEYER-PETER & MULLER

0.048

$$q_s^* = 17 (\tau_* - \tau_{*c}) (\tau_*^{1/2} - \tau_{*c}^{1/2})$$

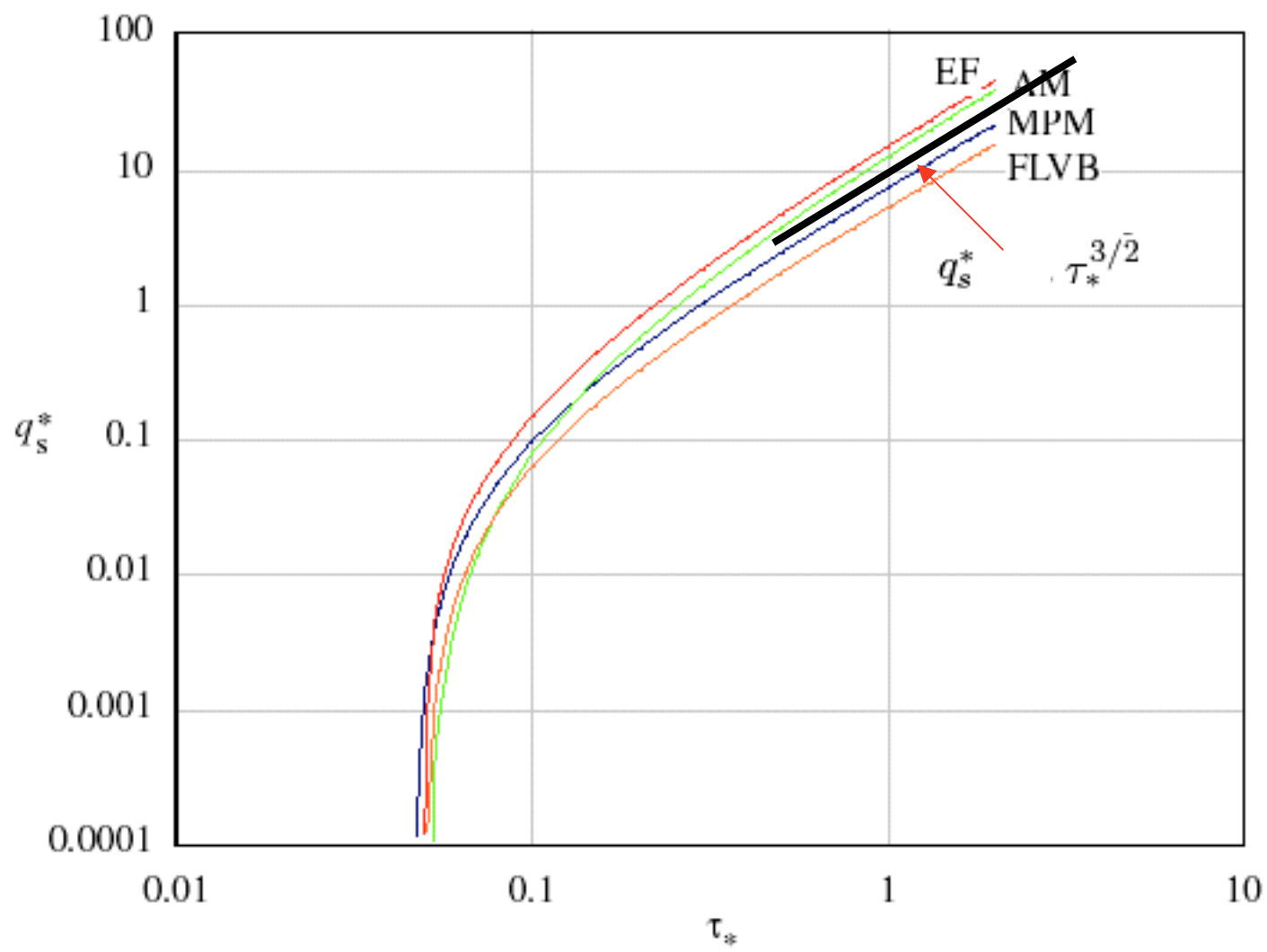
ASHIDA & MICHIE

0.05

$$q_s^* = 5.7 (\tau_* - \tau_{*c})^{3/2}$$

FERNANDEZ-LUQUE & VAN BEEK

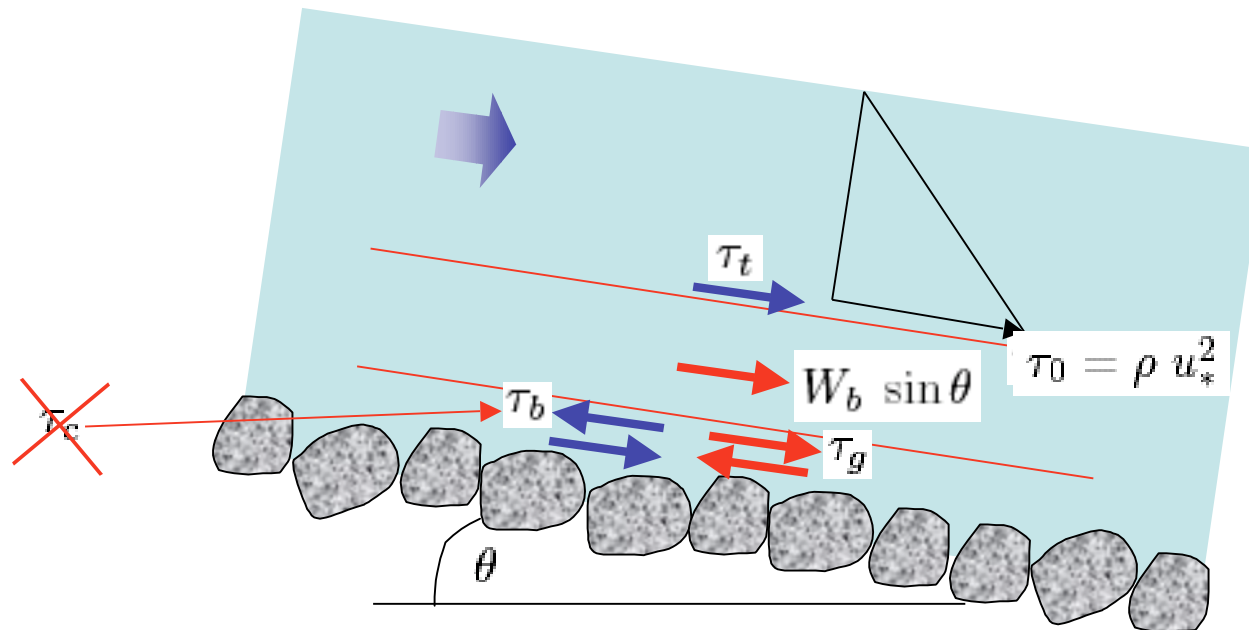
0.05 a 0.058



## RELACION TEORICA CON COEFS EMPIRICOS

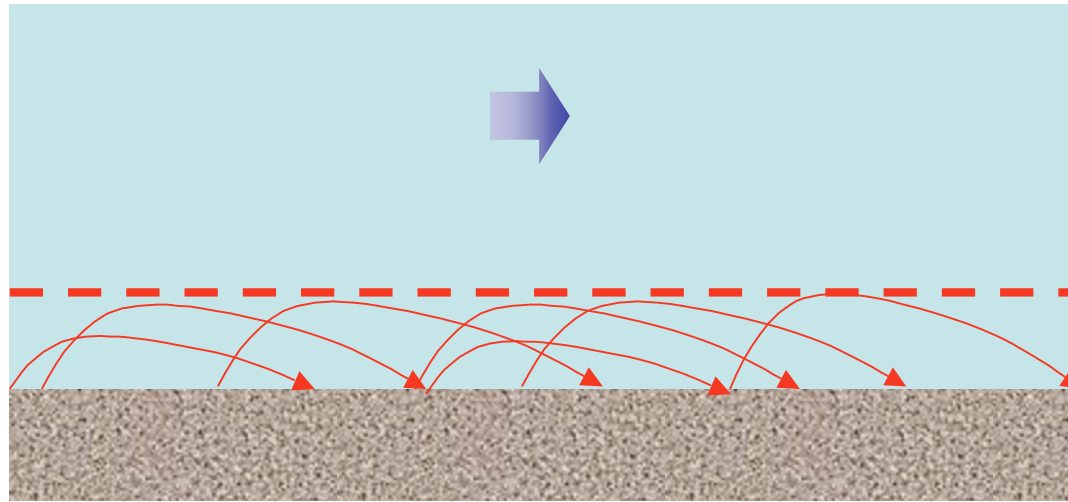
$$q_s^* = 38.3 (\tau_* - \tau_{*c}) (\tau_*^{1/2} - 0.7 \tau_{*c}^{1/2})$$

$$\frac{a}{\mu_d} = 18.74$$

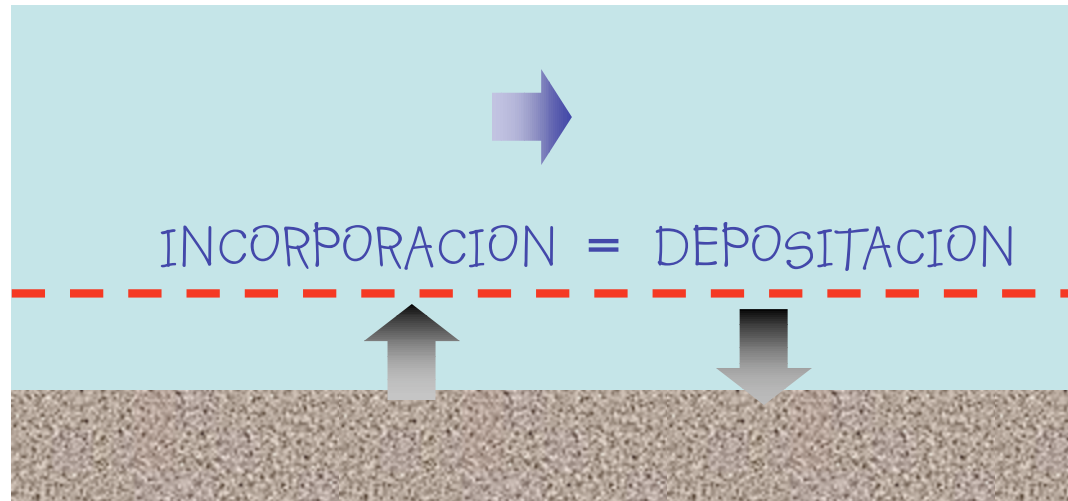




SEMINARA et al. (2002) & PARKER et al. (2003)

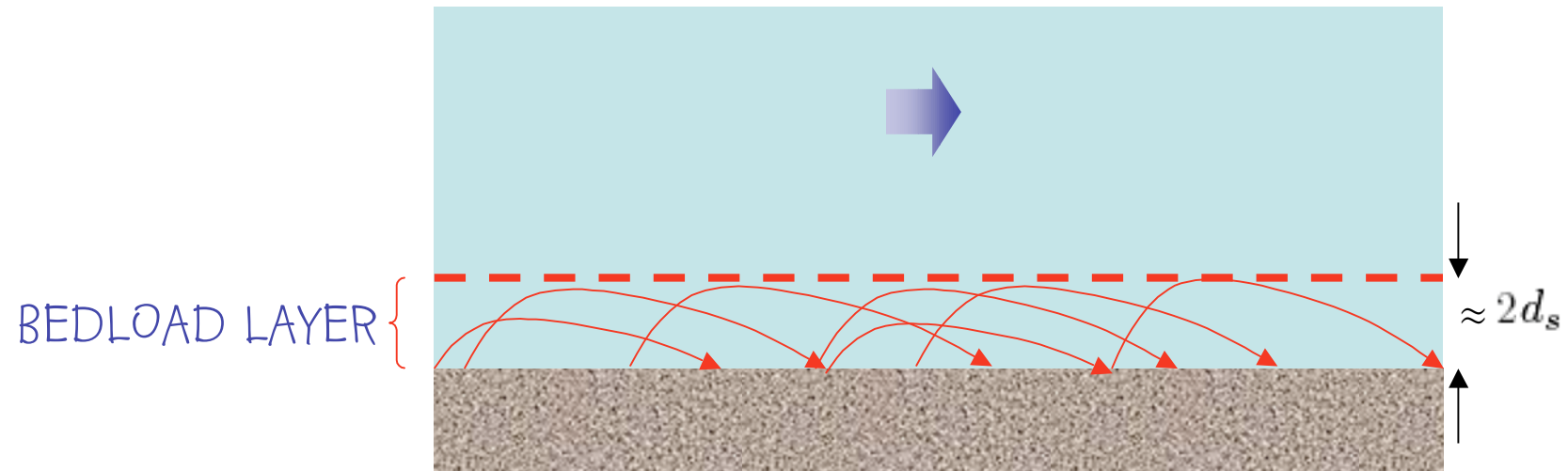


SEMINARA et al. (2002) & PARKER et al. (2003)

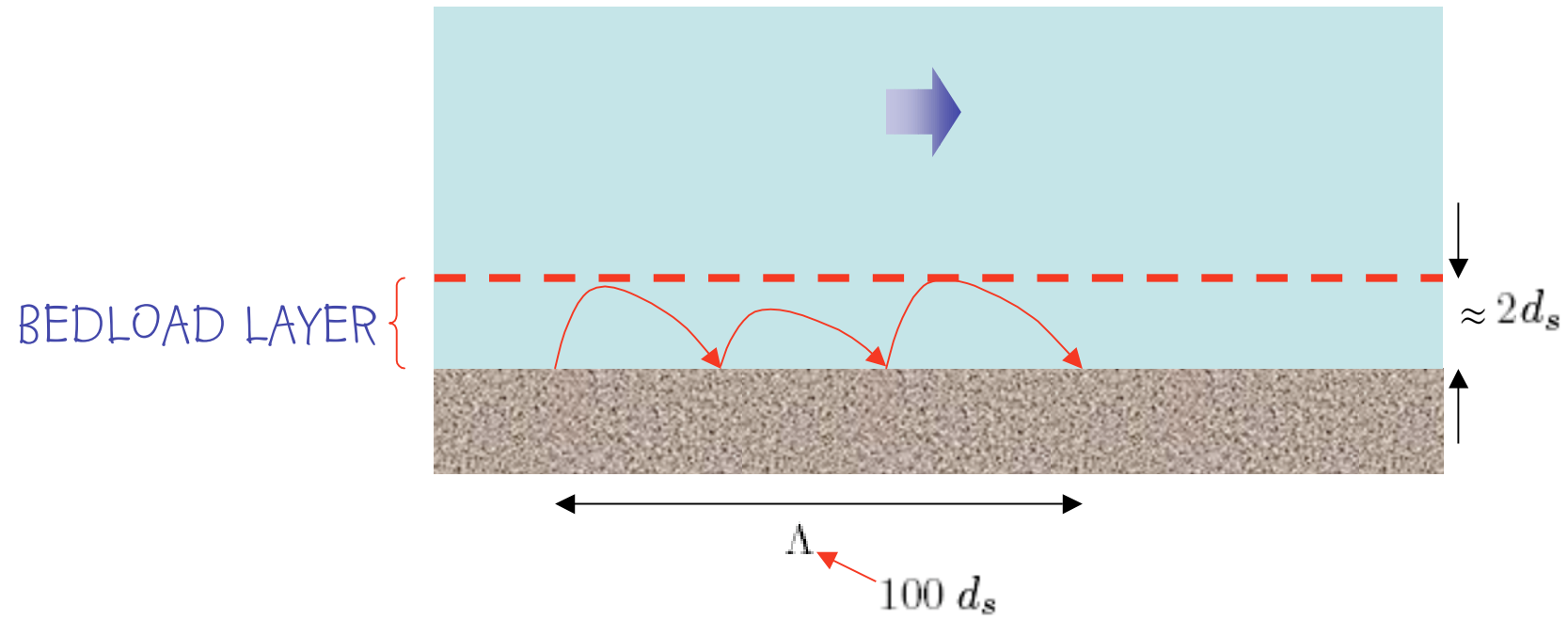


$$q_s^* = A (\tau_* - \tau_{*c}) (\tau_*^{1/2} - b \tau_{*c}^{1/2})$$

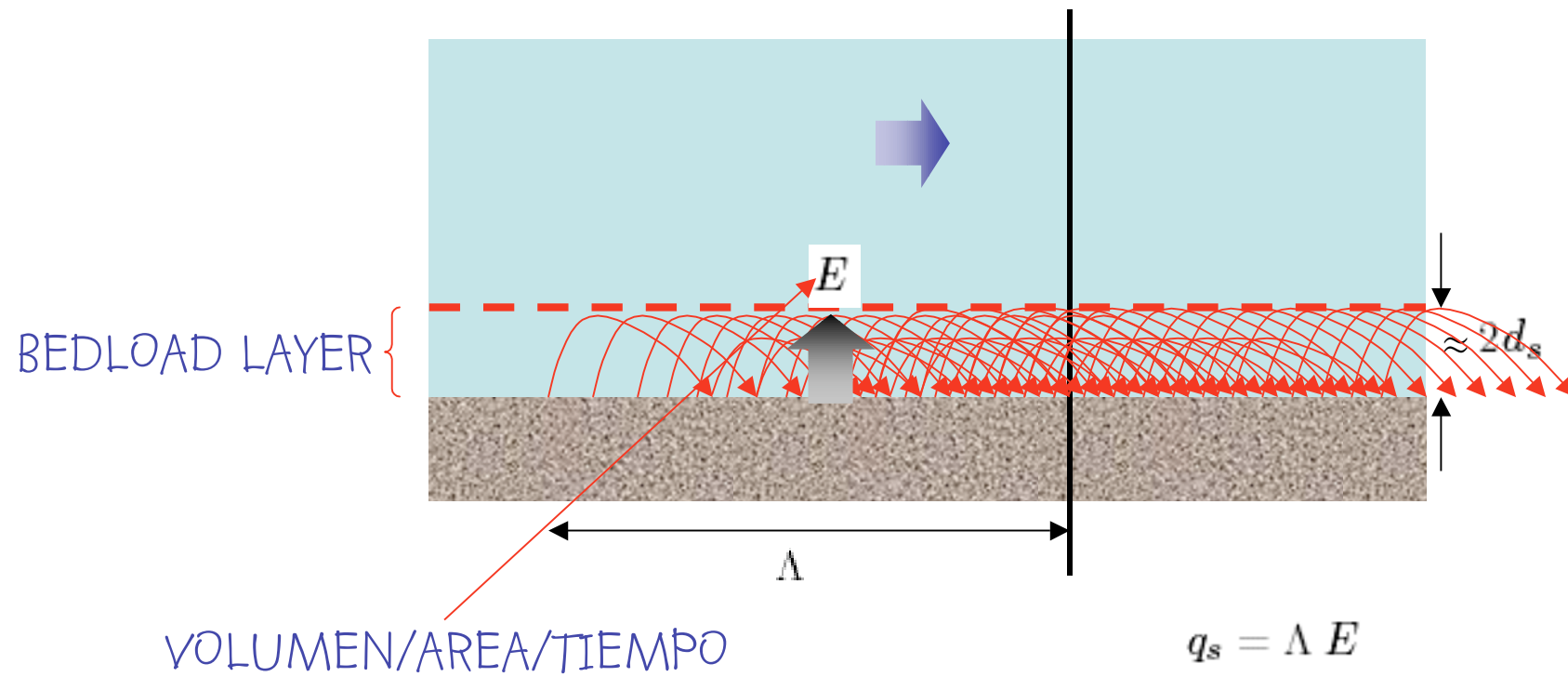
## ENFOQUE TIPO EINSTEIN



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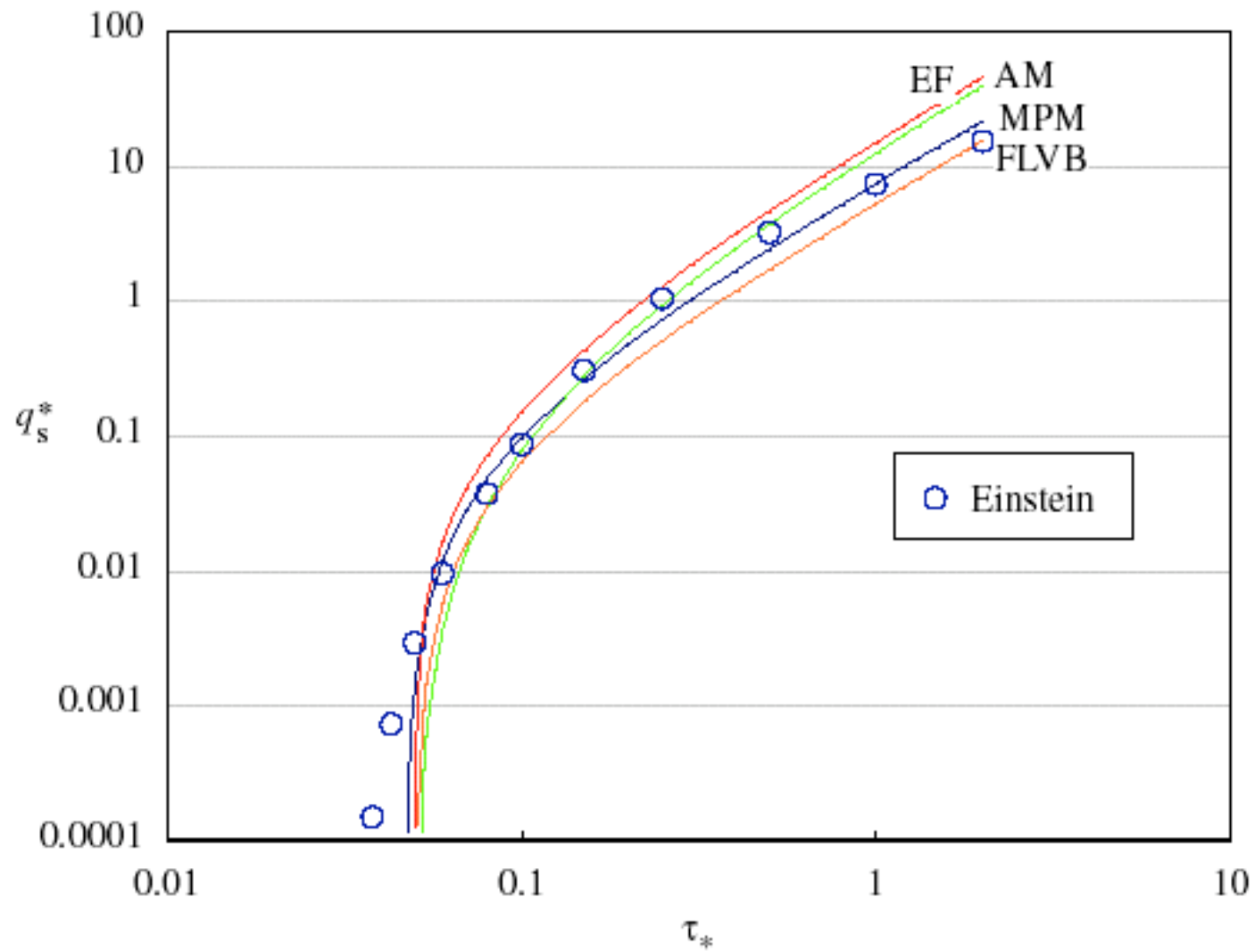


## ECUACION DE GASTO SOLIDO DE EINSTEIN

$$\frac{43.5 \, q_s^*}{1 + 43.5 \, q_s^*} = 1 - \frac{1}{\sqrt{\pi}} \int_{\xi_0}^{\xi_1} \exp(-t^2) \, dt$$


$$\xi_0 = -\frac{0.143}{\tau_*} - 2 \quad ; \quad \xi_1 = \frac{0.143}{\tau_*} - 2$$


## ECUACION DE GASTO SOLIDO DE EINSTEIN



## ECUACION DE GASTO SOLIDO DE ACKERS & WHITE

EFICIENCIA DE TRANSPORTE


$$G_{gr} = \frac{q_s u_*^n}{d_s U^{1+n}}$$


$$F_{gr} = \frac{u_*^n}{\sqrt{g} R d_s} \left( \frac{U}{\sqrt{32} \log_{10}(10 \frac{h}{d_s})} \right)^{1-n}$$

FACTOR DE MOVILIDAD

$$G_{gr} = C \left( \frac{F_{gr}}{A} - 1 \right)^m$$



## ECUACION DE GASTO SOLIDO DE ACKERS & WHITE

$$D_{gr} = d_s \left( \frac{g R}{\nu^2} \right)^{1/3} = R_p^{2/3}$$

$$D_{gr} > 1$$

$$1 < D_{gr} < 60$$

$$A = \frac{0.23}{\sqrt{D_{gr}}} + 0.14$$

$$C = 10^{(2.86 \log_{10}(D_{gr}) - (\log_{10}(D_{gr}))^2 - 3.53)}$$

$$m = \frac{9.66}{D_{gr}} + 1.34$$

$$n = 1 - 0.56 \log_{10}(D_{gr})$$

## ECUACION DE GASTO SOLIDO DE ACKERS & WHITE

$$D_{gr} = d_s \left( \frac{g R}{\nu^2} \right)^{1/3} = R_p^{2/3}$$

$$D_{gr} > 1$$

$$D_{gr} > 60$$

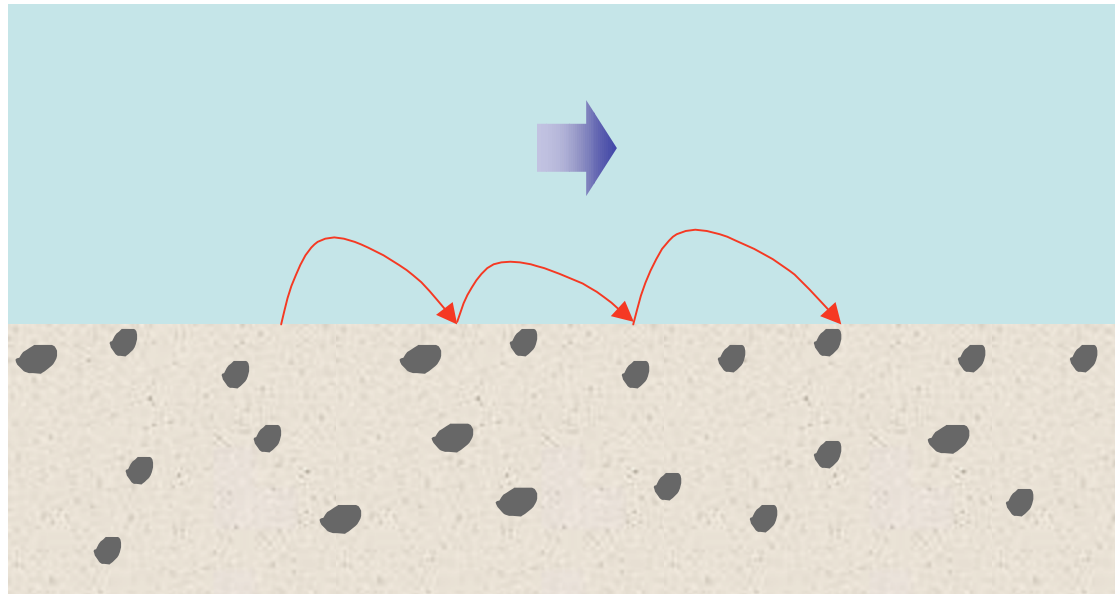
$$A = 0.17$$

$$C = 0.025$$

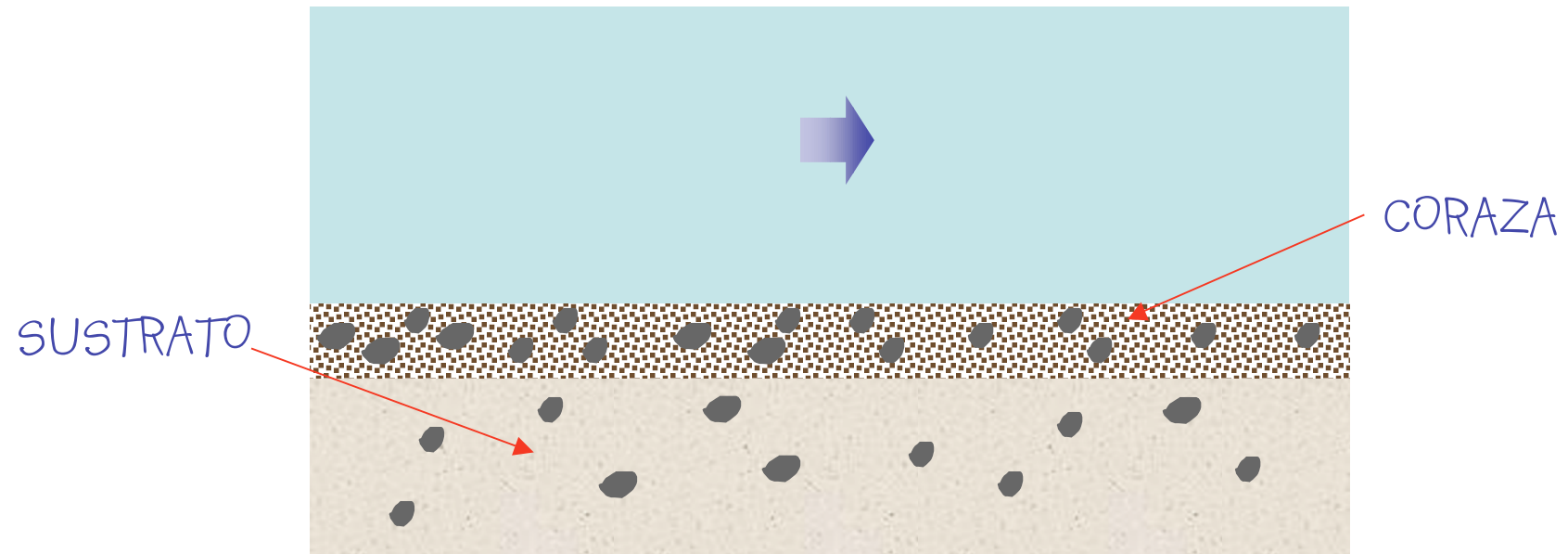
$$m = 1.5$$

$$n = 0$$

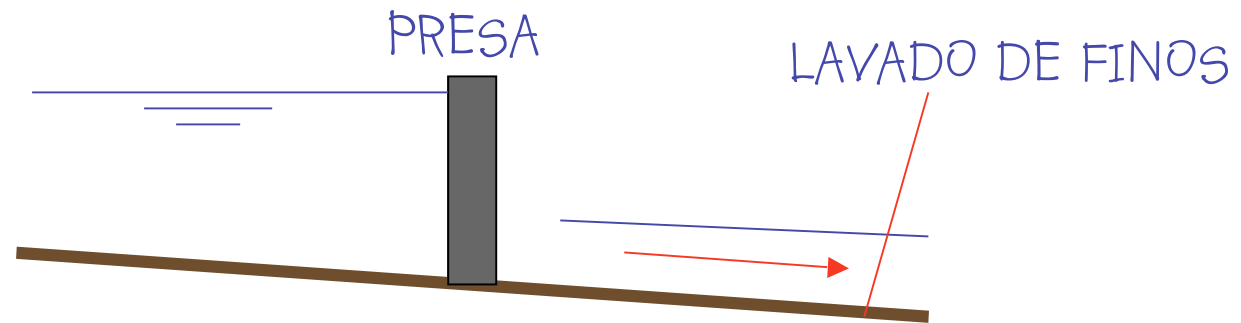
#### 6.2.4 Gasto sólido de fondo para sedimento de granulometría extendida



#### 6.2.4 Gasto sólido de fondo para sedimento de granulometría extendida



CORAZA ESTATICA

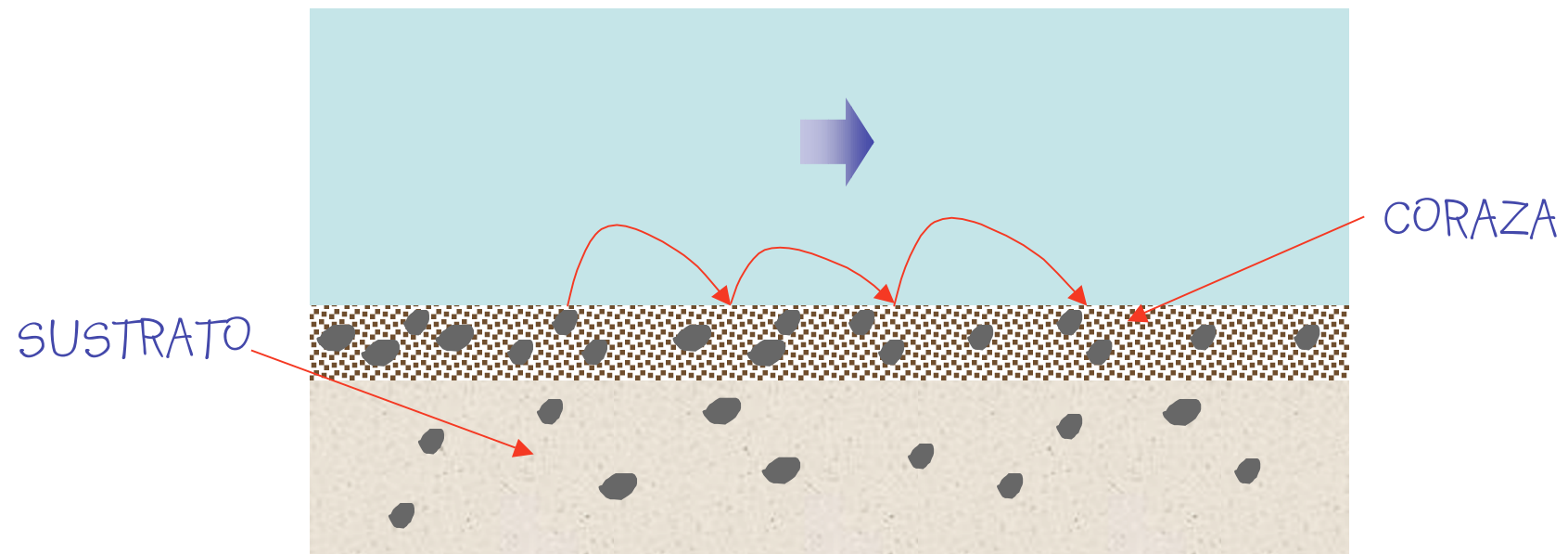


CORAZA DINAMICA

## HIPOTESIS DE IGUAL MOVILIDAD

FORMA DEBIL

FORMA FUERTE



## ECUACIONES DE GASTO SÓLIDO PARA SEDIMENTO GRADUADO

MEYER-PETER & MULLER: USAR  $D_m$

ACKERS & WHITE: USAR  $D_{35}$

EINSTEIN: EFECTO DE ESCONDIMIENTO

$$\frac{43.5 \, q_s^*}{1 + 43.5 \, q_s^*} = 1 - \frac{1}{\sqrt{\pi}} \int_{\xi_0}^{\xi_1} \exp(-t^2) \, dt$$

$$\xi_0 = -\frac{0.143}{\tau_*} - 2 \quad ; \quad \xi_1 = \frac{0.143}{\tau_*} - 2$$

$$0.143 \frac{\sigma_Y (\sigma^2 / \sigma_x^2)}{\sigma_*}$$

FACTOR ESCONDIMIENTO



## METODO DE PARKER (1990)

BASADO EN MEDICIONES DE CAMPO:  
CANTERBURY, NZ  
OAK CREEK, CA

BASADO EN LA GRANULOMETRIA DE LA CORAZA

ENTREGA GRANULOMETRIA DEL GASTO SOLIDO  
(Y DEL SUSTRATO)

VALIDO PARA FRACCIONES  $d_{s_i} > 2 \text{ mm}$

## METODO DE PARKER (1990)

CURVA GRANULOMETRICA:  $\{(d_{si}, F_i), i = 1, N\}$

GASTO SOLIDO TOTAL:  $q_s = \sum_{i=1}^N q_{si}$

GASTO SOLIDO FRACCION i:  $q_{si} = q_i F_i$

FRACCION TRANSPORTADA:  $p_i = \frac{q_{si}}{q_s} = (q_i F_i) / (\sum_{i=1}^N q_i F_i)$

GASTO SÓLIDO ADIMENSIONAL

$$W_{si}^* = \frac{R \, g \, q_i}{u_*^3 \, F_i}$$

ESFUERZO DE CORTE ADIMENSIONAL

$$\tau_{*sg} = \frac{u_*^2}{g \, R \, d_{sg}}$$

ESFUERZO DE CORTE ADIMENSIONAL  
NORMALIZADO

$$\phi_{sg0} = \frac{\tau_{*sg}}{\tau_{*rsg}}$$

LEY DE GASTO SÓLIDO

$$W_{si}^* = 0.00218 G(X_i)$$

ESFUERZO DE CORTE ADIMENSIONAL  
NORMALIZADO MODIFICADO

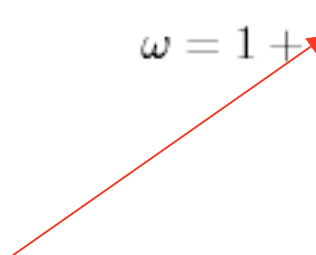
$$X_i = \omega g_{0i} \phi_{sg0}$$

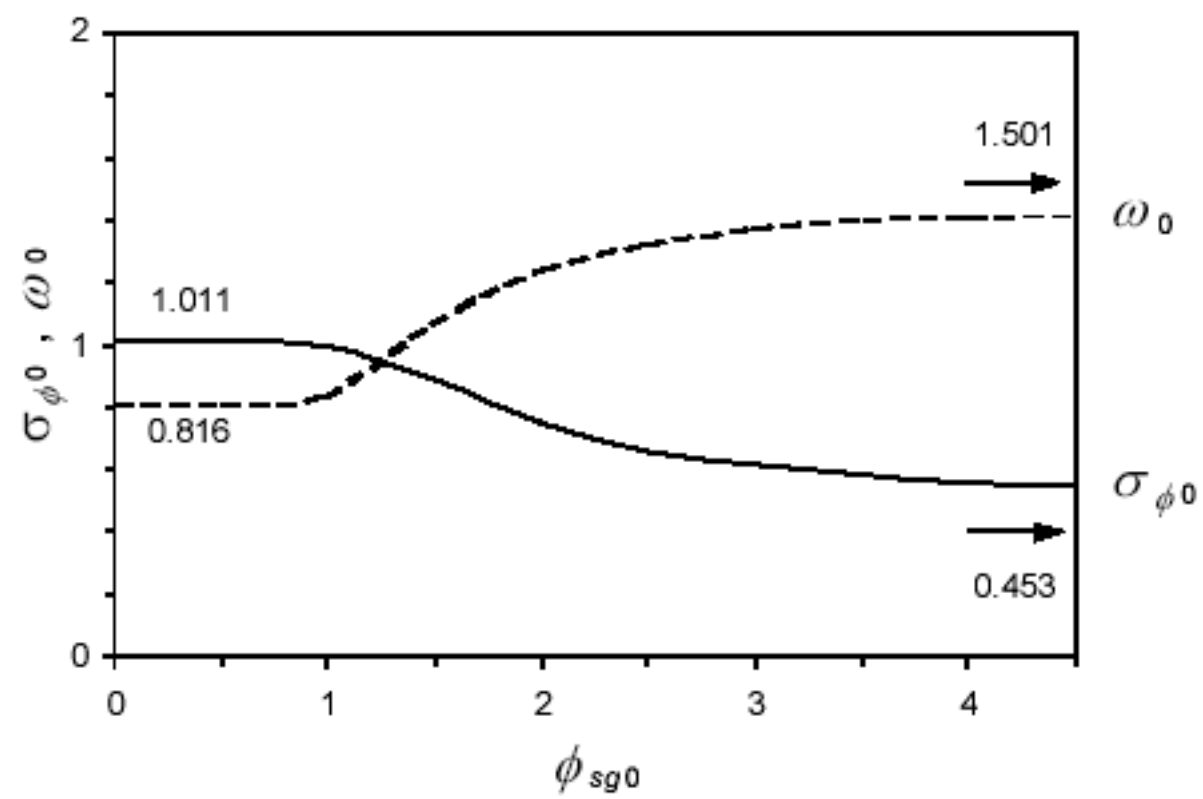
FACTOR DE ESCONDIMIENTO

$$g_{0i} = \left( \frac{d_{si}}{d_{sg}} \right)^{-0.0951}$$

FACTOR DE ESTIRAMIENTO

$$\omega = 1 + \frac{\sigma_\phi}{\sigma_{\phi 0}} (\omega_0 - 1)$$

$$\sigma_\phi = \log_2(\sigma_{sg})$$




METODO DE PARKER (1990)

LEY DE GASTO SOLIDO

$$G(\xi) = \begin{cases} 5474 (1 - 0.853/\xi)^{4.5} & \xi \geq 1.65 \\ \exp(14.2 (\xi - 1) - 9.28 (\xi - 1)^2) & 1 \leq \xi < 1.65 \\ \xi^{M_0} & \xi \leq 1 \end{cases}$$

$$M_0 = 14.2$$

## METODO DE WILCOCK & CROWE (2003)

$$W_i^* = f(\tau/\tau_{ri})$$

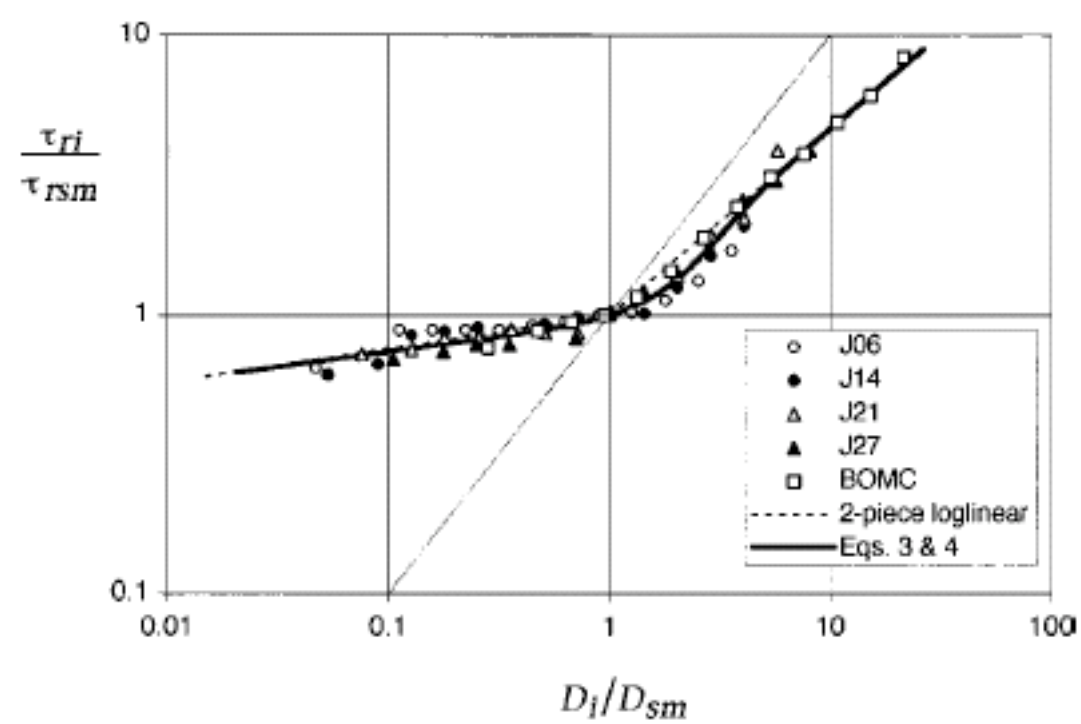
$$W_r^* = 0.002$$

$$W_i^* = \frac{R \ g q_{bi}}{F_i u_*^3}$$

ID. PARKER

$$\frac{\tau_{ri}}{\tau_{rsm}} = \left( \frac{D_i}{D_{s50}} \right)^b$$

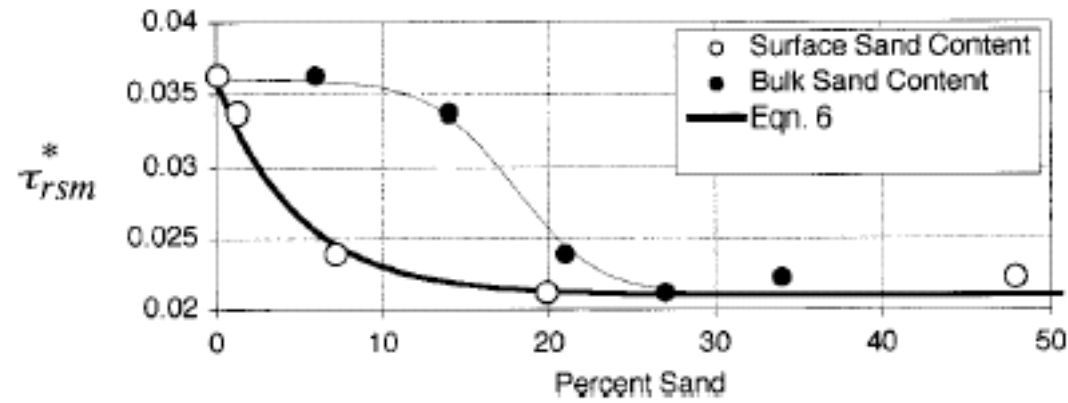
$$b = \frac{0.67}{1 + \exp\left(1.5 - \frac{D_i}{D_{sm}}\right)}$$





$$\tau_{rm}^* = \frac{\tau_{rm}}{(s-1)\rho g D_{sm}}$$

$$\tau_{rm}^* = 0.021 + 0.015 \exp[-20F_s]$$



**Fig. 5.** Variation of Shields number for reference shear stress at  $D_{sm}$ , as function of surface sand content  $F_s$ . Also shown are same values of  $\tau_{rm}^*$  plotted as function of sand content of bulk sediment.

## LEY DE GASTO SOLIDO

$$W_i^* = \begin{cases} 0.002\phi^{7.5} & \text{for } \phi < 1.35 \\ 14\left(1 - \frac{0.894}{\phi^{0.5}}\right)^{4.5} & \text{for } \phi \geq 1.35 \end{cases}$$

$$\phi = \tau / \tau_n$$

