Engel

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EQUIVALENT ROUGHNESS OF ALLUVIAL BED

Discussion by

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Discussion by Peter Engel[b]

The author has analyzed a large set of flume and field data for flows with plane bed conditions to obtain an expression for k_s/D_{90} as well as for flows in the presence of sand waves to obtain his Equation 12 which gives k_s/Δ in terms of Δ/Λ. The writer wishes to comment on both of these aspects of the paper.

In the case of the plane bed considerations, the data show considerable scatter with the bulk of the data giving an equivalent sand grain roughness ratio in the range $0.2 < k_s/D_{90} < 6$. The large scatter in k_s/D_{90} is attributed by the author as being due to small irregularities in the bed and therefore he claims a completely plane bed does not exist. The writer feels that there may be another reason for this scatter. Consider the plot of k_s/D_{90} vs $(\theta - \theta_{cr})$ in the author's Fig. 1. All the data are for values of $(\theta - \theta_{cr})$ between about 0.2 and 2.4. This means that for a large part of the data sand waves must be present. For these cases considerations of a plane bed do not apply. The writer suggests that the large values of k_s/D_{90} are due to the presence of sand waves. The writer has recently examined some data from experiments on the beginning of

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a October, 1982, Leo, C. Van Rign

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sediment transport of uniform granular bed material (14, 15, 16). These data are plotted in Fig. 3 as $\rho U^2_{cr}/\gamma_s D_{50}$ vs h_{cr}/D_{50} where ρ = density of fluid, U_{cr} = critical mean flow velocity, γ_s = submerged unit weight of sediment, D_{50} = median grain size and h_{cr} = critical flow depth. The scatter in the plotted data is due only to experimental error (i.e. subjective determination of U_{cr}, etc.). Using the author's Equation 7, one can obtain a theoretical relationship for $\rho U^2_{cr}/\gamma_s D_{50}$ in the form:

$$\frac{\rho U_{cr}^2}{\gamma_s D_{50}} = 6.25 \theta_{cr} \ell n^2 \left[12.1 \frac{h}{k_s} \right] \text{ for } h \sim R \quad (13)$$

in which θ_{cr} = 0.045 for all values of $U_* k_s/\nu > 70$ (18). Considering $k_s/D_{50} = n$, curves were then obtained for values of n = 1, 2.5 and 5.0 and these are also shown on Figure 3. The spacing between the curves shows the effect that k_s/D_{50} has on the $\rho U^2_{cr}/\gamma_s D_{50}$ vs h_{cr}/D_{50} relationship. The plot also shows that the curve for n = 2.5 provides a good average fit to the data in the range $5 < h_{cr}/D_{50} < 100$ with the data following the theoretical curve quite well when $h_{cr}/D_{50} > 10$. This value of $k_s/D_{50} = 2.5$ agrees quite well with the data from Kamphuis (6) by taking $D_{50} \approx D_{90}$ because of uniform grain size distribution. Finally, the theoretical curve for the author's value of n = 3.0 was also added to Fig. 3. It can be seen that there is not a great deal of difference between the curve for n = 2.5 and n = 3.0. However, considering the results of Kamphuis (6), the writer would prefer $k_s/D_{50} = 2.5$ to $k_s/D_{50} = 3.0$.

In determining his value of k_s/Δ for sand waves, the author feels that the sand grain roughness can be neglected, in the range of Δ/Λ values shown in his Fig. 2. The writer agrees that the effect of sand grain roughness, which can be acounted for by the dimensionless parameter D_{50}/Δ, becomes negligible when Δ/Λ is large. However, it has been shown by Engel and Lau (17) that the effect D_{50}/Δ is only negligible when $\Delta/\Lambda > 0.05$. This is shown in Fig. 4, in which the Darcy-Weisbach friction factor f is plotted as a function of D_{50}/Δ with Δ/Λ as a parameter. Values of k_s/Δ can be obtained from values of f vs D_{50}/Δ in Figure 4 by forming the relationship

$$\frac{k_s}{\Delta} = 12.1 \frac{h}{\Delta} \exp^{(-0.4\sqrt{8/f})} \qquad (14)$$

from the author's Equation 7. As an example, values of k_s/Δ were computed for different values of D_{50}/Δ for the case of $\Delta/\Lambda = 0.02$. The results are plotted in Fig. 5 which clearly show the effect of D_{50}/Δ. The value of k_s/Δ for $D_{50}/\Delta \approx 0$ is in close agreement with that obtained by the author. As the value of D_{50}/Δ increases the values of k_s/Δ become considerably larger than those predicted by the author's equation. The writer is therefore of the opinion that the author's equation for the prediction of k_s/Δ is only valid for very small values of D_{50}/Δ.

APPENDIX I. - REFERENCES

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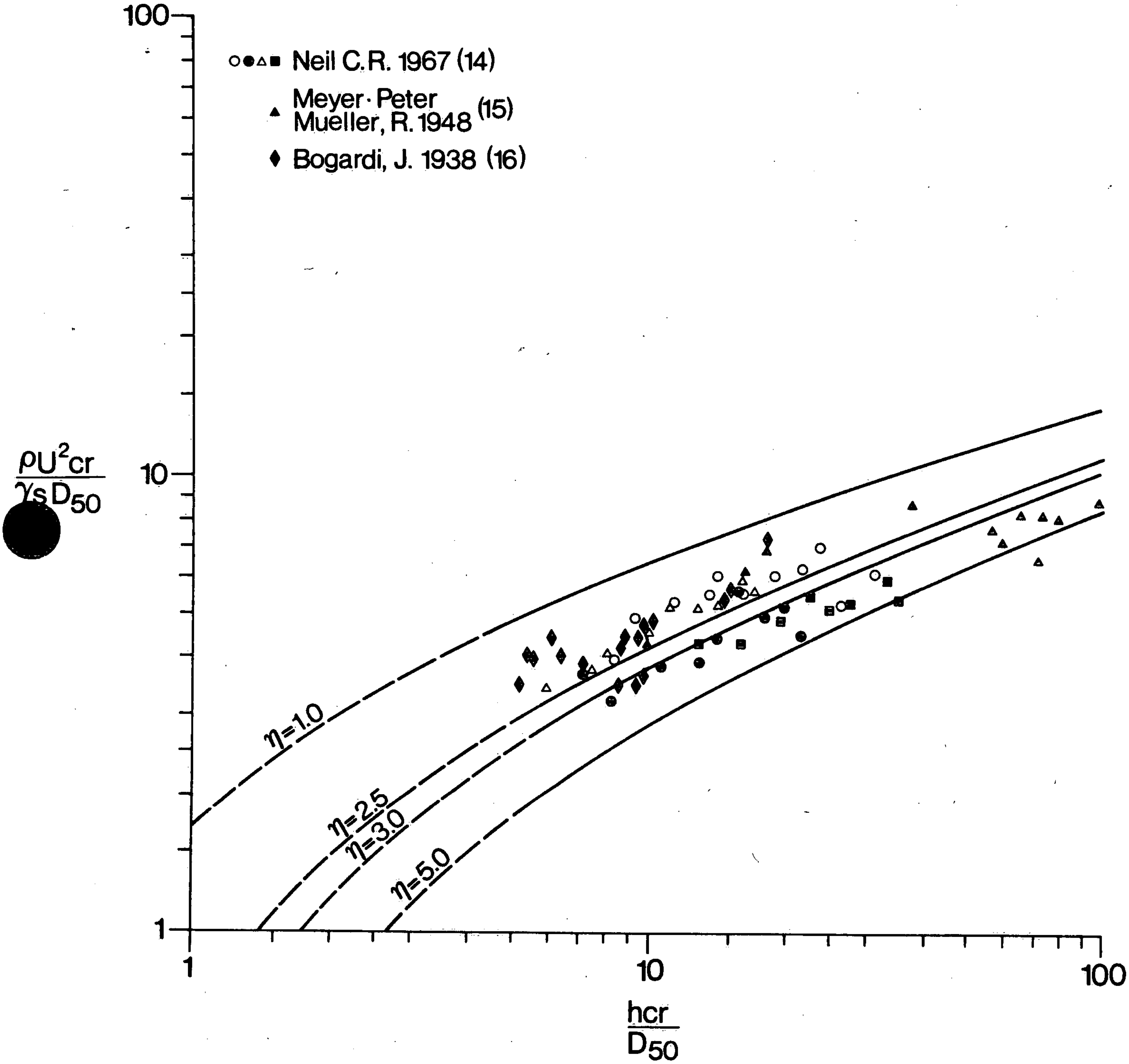

Figure 3 DETERMINATION OF η FROM $\frac{\rho U^2_{cr}}{\gamma_s D_{50}}$ versus $\frac{h_{cr}}{D_{50}}$ RELATIONSHIP

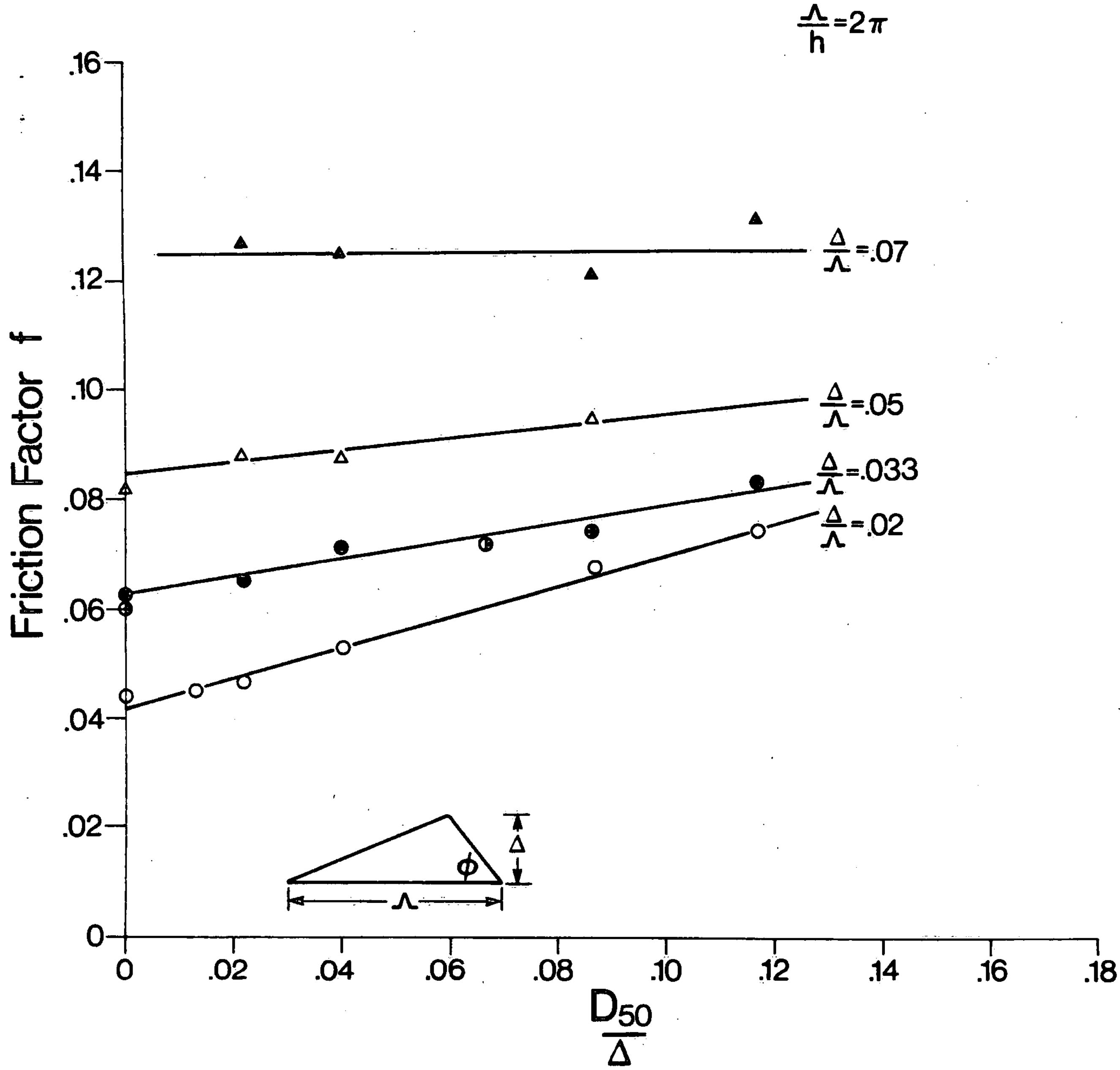

Figure 4 EFFECT OF SAND GRAIN ROUGHNESS ON FRICTION FACTOR IN PRESENCE OF DUNES. (17)

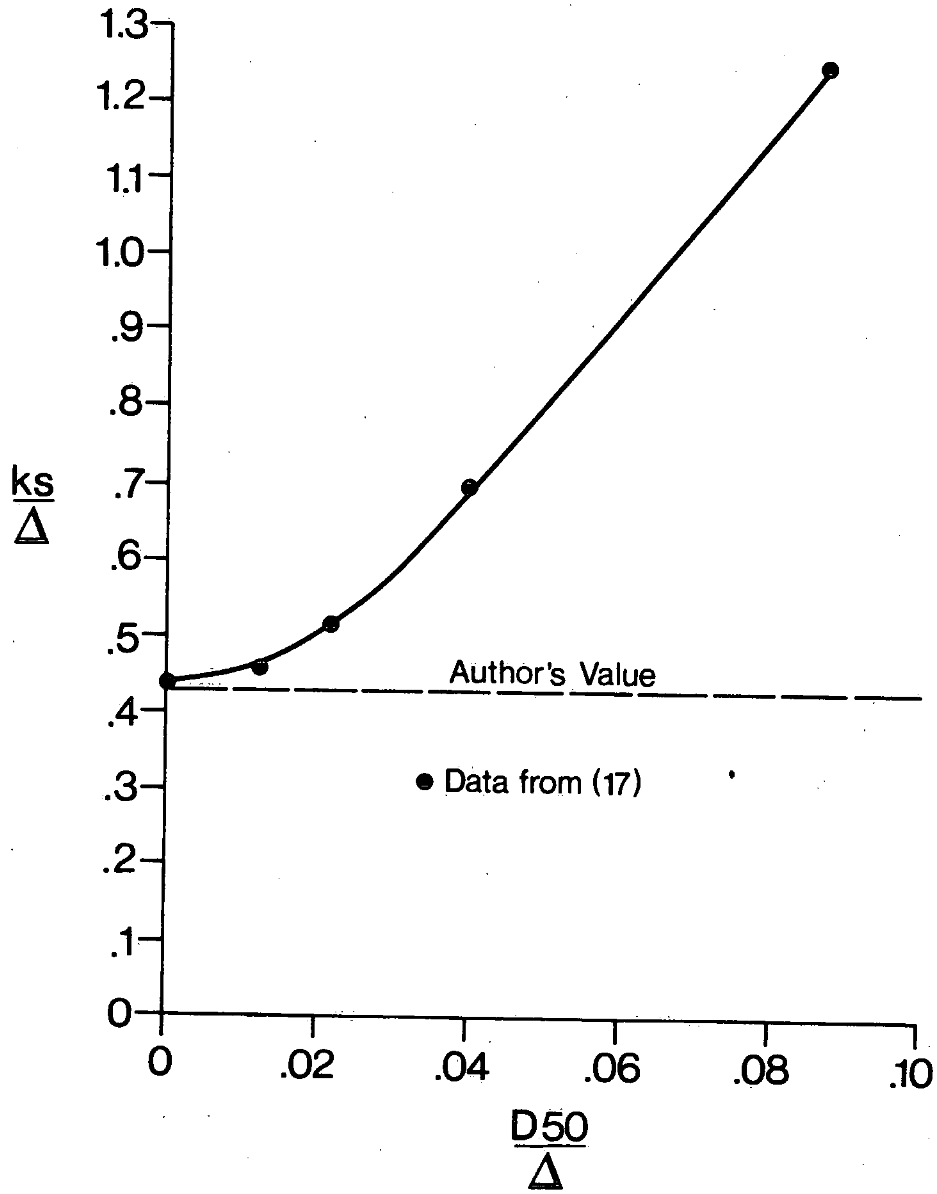

Figure 5 EFFECT OF GRAIN SIZE ROUGHNESS ON $\frac{ks}{\Delta}$