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BEDLOAD TRANSPORT IN GRAVEL BED STREAMS:

Discussion

by

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MANAGEMENT PERSPECTIVE

An important human resource for proper management of the water resources is a sound understanding of the basic principles. In this discussion, a formulation for bedload transport in gravel bedstreams presented in the open literature is corrected by Mr. Engel, a staff member of National Water Research Institute.

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PERSPECTIVE DE GESTION

Il est essentiel d'obtenir des estimations fiables des conditions nominales pour la construction des pipelines sous-marins dans l'Arctique canadien afin de réduire au minimum les risques de déversement d'hydrocarbures. Les pipelines proposées dans la mer de Beaufort seront probablement enfouis dans des tranchées afin d'éviter le raclage par les floes. Les essais du modèle dont il est question ici révèlent que la pression exercée par les vagues sur un pipeline enfoui dans une tranchée ressemble approximativement à celle exercée sur un pipeline posé sur un fond plat à la même profondeur totale. Cela signifie que pour tenir compte de la force des vagues dans la conception des pipelines enfouis dans des tranchées (ce pourquoi il n'existe aucune information dans la littérature) on peut faire appel à la littérature disponible sur les pipelines sur fond plat.

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ABSTRACT

This discussion points out that the analysis of the author could result in spurious correlation. By a small change in independent variables, a more physically meaningful relation for bedload transport is obtained.

RÉSUMÉ

Ce texte porte sur la mesure de la pression exercée par les vagues sur un pipeline modélisé. Le pipeline est situé dans une tranchée dont la configuration est semblable à celle proposée pour la production d'hydrocarbures et de gaz en mer de Beaufort. Il ressort que les coefficients de traînée et d'inertie sont semblables à ceux qui sont donnés dans la littérature pour les pipelines sur fond plat, en supposant que la profondeur de l'eau équivaut à la colonne d'eau totale, y compris la tranchée. Les essais de visualisation de l'écoulement ont confirmé que les vitesses horizontales étaient à peu près les mêmes que celles que l'on observe sur un fond plat à la même profondeur totale.

BEDLOAD TRANSPORT IN GRAVEL BED STREAMS[a]

Discussion by Peter Engel[b]

The author uses a comprehensive set of field data from Oak Creek to study bed load transport in gravel bed streams. The similarity approach used to delineate the functonal relationships for the bed load transport rate is based on dimensional analysis. The author begins by writing equation (6) and after choosing dimensionless groups arrives at equation (7). The writer is of the opinion that the formulation of equation (7) is not completely compatible with proper dimensional analysis and as a result, the author's equation (7) may result in spurious correlation. In addition, a physically more meaningful formulation for equation (7) could have been obtained by a small change in independent variables of equation (6).

The author begins with his equation (6) which is repeated here for the sake of simplicity as

$$q_{B_i} f[\rho, \mu, D_g, \sigma_g, C_s, D_i, \tau_o, d, g, f_i] \tag{6}$$

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[a] March, 1987 by Pamayistis Diplas (Paper No. 21,302).

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The author goes on to say that for a log-normal grain size distribution f_i can be expressed as a function of D_g and σ_g. If this is true, then equation (6) which contains f_i, σ_g and D_g is over specified. Only two of the three variables are required to determine the third. Considering that the author uses the term f_i to define W_i*, then in order to retain f_i in equation (6) either D_g or σ_g must be dropped.

Suppose that σ_g is selected, then equation (6) becomes

$$q_{B_i} f[\rho, \mu, D_g, \rho_s, D_i, \tau_o, g, f_i] \tag{6a}$$

Now, using the author's chosen dimensionless groups, equation (6a) becomes, after some manipulation of terms,

$$\frac{q_{B_i}}{\sqrt{gR\,D_i}\;\;D_i} = f[\tau_i^*, R_p, \frac{D_i}{D_g}, \frac{d}{d_g}, R, f_i] \tag{6b}$$

The quantity q_{B_i}* can now be obtained by combining f_i and the dependent dimensionless variable in equation (6b) resulting in

$$q_{B_i}^* = q_{B_i}/f_i\sqrt{gR\,D_i}\;\;D_i \tag{6c}$$

However, this operation does not eliminate f_i from the function f in equation (6b). The authors now give legitimate justification for eliminating R_p and d/D_g. The third variable R is eliminated on grounds that the sediment density is virtually constant and thus R does not vary significantly. Although this is true, a reason with more physical significance is that R is not significant for transport en masse, but is important only for single particle trajectories (Yalin, 1977). This is why the condition for the inception of sediment transport can be given by a single curve in the Shields diagram even though materials over a wide range of ρ_s were used. After eliminating R_p, d/D_g and R, equation (6) becomes after the appropriate manipulation

$$w_i^* = \frac{R\, q_{B_i}}{f_i \sqrt{g}\, (ds)^{1.5}} = f[\tau_i^*, \frac{D_i}{D_g}, f_i] \tag{8a}$$

Equation (8a) is the logical form that should have evolved from equation (6) through dimensional analysis. Unfortunately, this form is not very practical because it results in spurious correlation as a result of f_i appearing on both sides of the equation. A more correct form of equation (8a) would be

$$\frac{R\, q_{B_i}}{\sqrt{g}\, (ds)^{1.5}} = f[\tau_i^*, \frac{D_i}{D_g}, f_i] \tag{8b}$$

The dimensional analysis of the author could have resulted in a physically more correct formulation by replacing the variable g in equation 6 by γ_s, the submerged specific weight of the sediment, which can be expressed as $\gamma_s = \rho g \, (\rho_s/\rho - 1)$. The use of γ_s avoids the rather dubious term "submerged specific gravity" and introduces the physically correct quantity of submerged specific weight. Dimensional analysis then results directly in

$$\frac{\gamma_s q_{B_i}}{\rho \, u_*^3} = f[\tau_i^* , \frac{D_i}{D_g} , f_i] \qquad (8a)$$