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Missouri River Vertical Sediment Concentration Distribution for Different Sediment Sizes

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IV. SUMMARY AND CONCLUSIONS

Due to the presence of dunes and fluid turbulence, the point flow velocities and the point suspended sediment concentrations fluctuate greatly with time. In theory, a large amount of data should be taken to establish a meaningful time average value at each point. Since the available data is insufficient to establish the mean values, an alternative data grouping procedure was used to obtain the average velocity, depth, and temperature, and the representative velocity and concentration profiles for each group. Based on these grouped data at Omaha, Nebraska City, and Sioux City, a sediment transport relationship for evaluating the bed load and total load was developed and the following conclusions can be drawn:

A. VERTICAL VELOCITY DISTRIBUTIONS

1. Several types of vertical velocity distributions were tried, most of which produced similar results. Due to its simplicity, the power law type of relationship, such as that used by Toffaleti (1969), was selected.

2. The linear relationship between n_1 and n_2 derived from regression analysis by Shen and Wang (1979) had been checked with the grouped data and was adopted for the present study.

3. The regression equation for n_2 (Equation [17]) derived in the present study is slightly different from the regression equation for n_1 (Equation [12]) obtained previously by Shen and Wang (1979) due to the following three reasons: i) In the present study, averaged flow conditions in each group were used rather than all individual flow conditions (1979); ii) In the present study, the unit of D_{50} is measured in units of feet rather than in millimeters (1979) ; and iii) In the present study, the flow depth was found to be significant rather than the temperature being

slightly significant (1979).

B. VERTICAL SUSPENDED SEDIMENT CONCENTRATION DISTRIBUTION

1. The suspended sediment concentration profile developed by Rouse (1979), Equation (3), was adopted in this study. However, the exponent [Equation (4)] was modified to become Equation (19), i.e. a correction factor C_Z , Equation (21) times the theoretical Z value, Equation (4), with $\beta = 1$.

2. Since the mean flow velocity and the shear velocity are directly proportional to each other, the exponent Z was found to be approximately proportional to $u_*^{0.17}$. This seems to contradict the generally adopted form of Z_t as shown in Equation (20). A great deal of analysis was undertaken to investigate this point. It was found that, in fact, Z values are not highly dependent on u_* in the studied reach of the Missouri River. More data are needed to clarify the contradiction between Equations (20) and (23).

C. SEDIMENT CONCENTRATION IN THE BED LAYER

A reference bed layer of 2 sediment diameters in thickness was proposed to describe the sediment concentration near the bed. Within this layer, the sediment load is assumed to be uniform. The magnitude of the sediment load in the bed layer was determined by extending the vertical suspended sediment distribution into this layer.

D. BED LOAD

Since bed load measurements are not available, Equations (40) and (41) were used to calculate the bed loads. The bed loads were assumed to be that part of the suspended loads within a thickness of two sediment diameters from the bed. Based on this assumption, a regression equation was developed

for the bed load transport rate. It was found that these bed load rates are quite different from those predicted by any available formula.

E. COMPARISON OF THE TOTAL BED LOAD WITH OTHER SEDIMENT TRANSPORT RELATIONSHIPS

1. RMS Values

Quantitative comparison of the results from different sediment transport relationships based on the $(RMS)_{log}$ values calculated from Equation (37) is shown in Figure 53. It can be seen that the Remodified Einstein Method (Shen and Hung, 1981) gives the closest results compared with the true values in Omaha and Nebraska City. However, it should be pointed out that both the Remodified Einstein method (Shen and Hung, 1981) and the Modified Einstein Method (Colby and Hembree, 1955) are based on actual measurements and cannot be used as sediment transport rate prediction equations. Without considering these two methods, the present method gives the best predictions for the data compared. It should be noted that the Toffaleti method also gives fairly good agreement with the observed sediment loads in the Missouri River for both 0.125 mm and 0.177 mm sediment sizes. For 0.250 mm, the amount of data may not be sufficient to define the relative merits of these formulas.

2. Weighted RSM Values

To consider the variation of flow, one may use the "flow duration" as a weighting factor in calculating the RMS values. The results based on Equation (39) are plotted in Figure 56. It can be seen from this figure and from Figure 53, that, in general, the results are similar other than the fact that Shen and Hung's method (1971) gives relatively better results when the flow duration is considered in calculating the RMS value.