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Prediction of Sediment Transport in National Waterway-I (River Ganga) around the region of Patna, Bihar

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Abstract: **During the monsoons, materials are dislodged and these materials are transported on the land surface, streams and rivers act as passage for the movement of sediments. When there is not enough energy to transport the sediments, deposition occurs. Rivers and streams carry sediment as they flow depending on the sediment supply along their course. Depending on the settling velocity, drag and lift force, these sediments are carried along the river in either suspended form or bed load. The bed load and suspended load are calculated using the formulae developed for alluvial rivers. Sediment load depends upon surface run off, which in turn depends upon rainfall.**

Keywords: **Bed Load, Suspended Load, Total Sediment Transportation, Grain size, Current Velocity, NW-1.**

1. INTRODUCTION

The site is located in region of Mohkama, Bihar (90kms from Patna city) where the water depth maintained at 3 meters. The measured current velocity is U=0.8m/s to 1m/s (in accordance with the float used in hydrographic survey). It is estimated form the previous data that sand ripple height is approximately 10cm.

The river Ganga transports sand and clay with it and considering the above site, the average grain size is kept variable with course of discharge. As in river Ganga, sediment movements form a part of the long-term pattern of geological processes. Sediment transport may be understood as occurring in one of the two modes:

- By rolling or sliding along the floor/bed of the rivers; sediment thus transported constitutes the bed load.
- By suspension in the moving fluid (finer particles) which is the suspended load.

2. OBJECTIVE AND METHODOLOGY

In this research work, the total sediment transport done by the river Ganga at a site named Mohkama is calculated considering different grain sizes been deposited by the river in past. For the said calculation to be done, there was a necessity to Calculate bottom shear stress, Chezy coefficient, frictional Velocity and bed shear stress. The effective Shear stress is then calculated.

Calculation of bottom shear stress:

The bottom shear stress τ_b when there are sand ripples with height of approximately 10cm on bed will be:

$$\tau_b = \rho\, u_*^2$$

The bed roughness is taken as:

K_s=0.75 X Height of sand ripple

=0.075m

Chezy coefficient is calculated as:

$$C = 18log\left(\frac{12h}{k_s}\right)$$

$$=18log\left(\frac{12*3}{0.075}\right)$$
$$= 48.26\sqrt{m}/s$$

The friction Velocity is Calculated as:

Bed Shear stress is calculated as:

$$u_* = \frac{U}{C}\sqrt{g}$$

$$=\frac{0.9}{48.2}\sqrt{9.8} = 0.0584 \text{ m/s}$$

$$\tau_b = \rho\, u_*^2$$

$$=1000*0.0584^2 = 3.410 \text{ N/m}^2$$

Effective Shear Stress:

$$\tau_b' = \frac{1}{2}\rho\left(\frac{0.06}{\left(log\left(\frac{12h}{H_r}\right)\right)^2}\right)U^2$$

Where h is water depth and U is current Velocity. Since River Ganga has a rippled bed, H_r is taken into consideration.

3. CALCULATIONS

Bed Load Transportation q_B

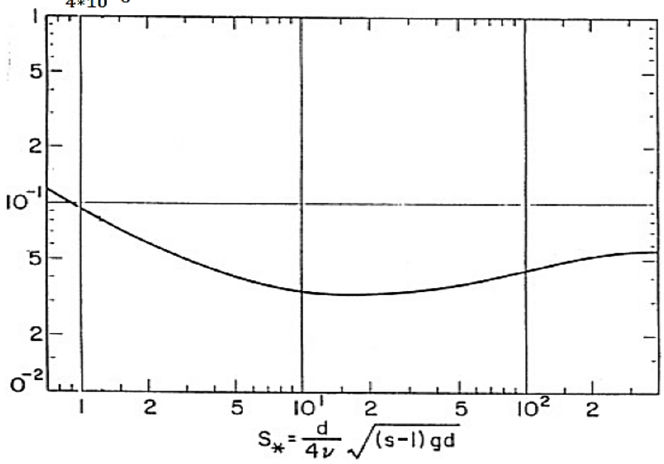
The relative density

$$s = \frac{\rho_s}{\rho} = 2.59$$

The shield's parameter is

$$S_* = \frac{d_{50}\sqrt{(s-1)gd_{50}}}{4\mu}$$

$$S_* = \frac{0.0002\sqrt{(2.59-1)9.8*0.0002}}{4*10^{-6}} = 2.79$$



Shield's parameter

From the graph we found that critical shield's parameter is 0.052

Bed Load q_B is calculated as:

$$\emptyset_B = \frac{q_B}{d\sqrt{(s-1)gd}}$$

Using Meyer Peter Formula:

$$\emptyset_{B=} 8\left(\theta' - \theta_c\right)^{1.5}$$

4. RESULTS

Since Sand and Clay prevails on riverbed of Ganga river, thus by varying the grain size diameter, current velocity and depth of channel, following Calculations are made:

Size of Grain(d_{50})m	Water Depth(m)	Current Velocity(U)m/s	Bed Load(m^3/s)	Current Velocity	Bed Load
0.0004	1.4	0.8	0.0000132	1	0.00000290
0.0006	1.6	0.8	0.0000170	1	0.00000370
0.0008	1.8	0.8	0.0000115	1	0.00000337
0.001	2	0.8	0.00001	1	0.00000342
0.0012	2.2	0.8	0.0000077	1	0.00000330
0.0014	2.4	0.8	0.000000051	1	0.00000307
0.0016	2.6	0.8	0.000000026	1	0.00000275
0.0018	2.8	0.8	0.000000496	1	0.00000970
0.002	3	0.8	0.0000530	1	0.00001035

The average bed load carried by river with current velocity 0.8m/s is 39580 m^3/year

And with current velocity 1m/s is 14880 m^3/year

The suspended Load transported as

$$q_s = 1.83 q_B \left(I_1 ln\left(\frac{h}{0.033k_s}\right) + I_2\right)$$

Size of Grain(d_{50})m	Water Depth(m)	Current Velocity(U)m/s	Bed Load(m^3/s)	Current Velocity	Bed Load
0.0004	1.4	0.8	0.0000118	1	0.0000073
0.0006	1.6	0.8	0.0001486	1	0.0000072
0.0008	1.8	0.8	0.0000102	1	0.00000642
0.001	2	0.8	0.0000915	1	0.00000904
0.0012	2.2	0.8	0.0000718	1	0.000001233
0.0014	2.4	0.8	0.0000486	1	0.00001598
0.0016	2.6	0.8	0.0000249	1	0.0000159
0.0018	2.8	0.8	0.0000485	1	0.00002000
0.002	3	0.8	0.0000525	1	0.00002348

The average bed load carried by river with current velocity 0.8m/s is 178110m^3/year and with current velocity 1m/s is 3730m3/year

Total Sediment Transport

TST = $q_t = q_s + q_b$

The Total Sediment Transported by the river is calculated as 236300 m^3/year

5. CONCLUSIONS

1. The Bed Load Transported is more than the suspended load
2. The total Load at current velocity 1m/s is less than that carried by current velocity of 0.8m/s
3. Results show that a huge volume of approximately $3.7X10^3$ $m^{3\ gets}$ deposited in the region which could be needed to dredge.

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