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FLUVIAL STAGE AND SEDIMENT DISHCHARGE RATING WITH POSSIBLE MAXIMUM SCOUR DEPTH PREDICTION OF A SELECTED REACH OF THE JAMUNA RIVER

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ABSTRACT

A study has been undertaken to develop a fluvial stage-discharge rating curve for Jamuna River. Past Cross-sectional survey of Jamuna River reach within Sirajgonj and Tangail has been analyzed. The analysis includes the estimation of discharge carrying capacity, possible maximum scour depth and sediment transport capacity of the selected reaches. To predict the discharge and sediment carrying capacity, stream flow data which include cross-sectional area, top width, water surface slope and median diameter of the bed material of selected stations have been collected and some are calculated from reduced level data. A well-known resistance equation has been adopted and modified to a simple form in order to be used in the present analysis. The modified resistance equation has been used to calculate the mean velocity through the channel sections. In addition, a sediment transport equation has been applied for the prediction of transport capacity of the various sections. Results show that the existing drainage sections of Jamuna channel reach under study have adequate carrying capacity under existing bank-full conditions, but these reaches are subject to bed erosion even in low flow situations. Regarding sediment transport rate, it can be estimated that the channel flow has a relatively high range of bed material concentration. Finally, stage- discharge curves for various sections have been developed. Based on stage-discharge rating data of various sections, water surface profile and sediment-rating curve of Jamuna River have been developed and also the flooding conditions have been analyzed from predicted water surface profile.

Keywords: *Fluvial; Stage-discharge rating curve; Sediment rating curve; Water surface profile; Scour depth.*

1. INTRODUCTION

In Bangladesh, most of the river courses are of alluvial in nature. Due to their great tendency to change course, large rivers have been subject to investigation and studies. Stage, discharge and sediment transport change daily and seasonally. Changes in stage continuously influence scour and fill patterns along the channel bed as well as the magnitude of hydraulic resistance. In dealing with natural rivers with movable beds, the engineer is confronted with the problem of unavailability of stream flow data. Unless adequate discharge and sediment transport capacity data are available for performing practical engineering works, evaluation of frictional effects can be based almost upon the modified equations and developed rating relationships. Also, it is not feasible to measure the discharge everyday due to economic consideration. Thus stream flow data is not recorded regularly, instead water levels are recorded and the stream flow is deduced by means of rating curves. A rating curve is used to convert records of water level into flow rate. The flow boundary of an alluvial river is not fixed, but undergoes changes in characteristic geometry and dimensions through mutual interaction between the flow and the bed. When the discharge in an alluvial channel is low, the velocities as well as the shear stresses are small, the sediment particles remain at rest and the flow is similar to that over a rigid boundary. If the discharge is gradually increased, the velocity and shear stress also increase and a critical stage (threshold condition) is reached when the particles on bed begins move. At still higher values of shear stress, the particles comprising the channel bed are set in motion and the bed deforms from its initial plane condition. The use of rating curve of a river channel has long been of interest to hydraulic engineers and modelers. A numerical model requires a logical scheme, where stage and velocity can be predicted for a given channel characteristics including bed material, bed slope and discharge. Engineers are often faced with problems of designing a channel to accommodate a given discharge with a given bed slope and an unknown sediment discharge.

In the light of the above, this study attempts to explore the possible application of flow resistance equation in order to develop a stage-discharge and sediment discharge rating curve. Prior to the application of a flow resistance equation, a well-known predictor developed by Garde and Ranga Raju has been adopted and modified to a relatively simple form for easy application in alluvial channels. Finally, water surface profile for the study section is developed from the prepared rating curves. Also the possible maximum scour depth is calculated by using regime equation.

Here, the study reach is selected within the district of Sirajganj and Tangail from E894018.91 to E894912.29 and N240310.89 to N242415.08 (BTM coordinate) and covers about 40 km reach of the Jamuna River. We choose eight cross-section stations in the downstream of Jamuna bridge for our analysis purposes. The average longitudinal slopes of the study reach ranges between 0.000055m/m to 0.00025 m/m. The reach length is selected for its nearly straight topography in maximum cross sections for the simplicity in analysis.

2. METHODOLOGY

Stage-discharge predictors can be proposed by using some techniques. There are different methods for predicting fluvial discharge. Here we are considering the bed materials size in establishing a mean velocity equation thus the study is related to the fluvial process. In this study, the Grade and Ranga Raju equation has been adopted to calculate the mean velocity through the channel sections and total sediment transport capacity prediction is done by applying Ackers-White equation. Here, we have also used Sheilds diagram to predict erosion and deposition characteristics of selected river reach of Jamuna and Lacey's Regime equation is also used for clear water scour depth calculation for our analysis purposes.

2.1 Stage-Discharge Predictor

Based on the analysis of large number of data from canals, rivers and laboratory flume, Garde and Ranga Raju (1993) obtained a relationship and later Ranga Raju graphically presented a function of the form

$$K_1 \frac{U}{\sqrt{g(\Delta\rho_s/\rho)R}} = f\left[K_2\left(\frac{R}{d}\right)^{1/3}\left(\frac{S}{\Delta\rho_s/\rho}\right)\right] \tag{1}$$

Were U is the mean velocity, R is the hydraulic radius, S is the channel longitudinal slope, d is the sediment size and $\Delta\rho_s/\rho$ is the relative sediment density. The empirical coefficients K_1 and K_2 are functions of sediment size.The data used for development of Eq. (1) cover a wide range of sediment sizes and flow conditions. Comparing their procedure with observed data, Garde and Ranga Raju stated that the mean velocity can be predicted within ± 30 percent accuracy. However, the functional form was only presented graphically, but if the relationship is to be adapted to other computer applications, it is worth to fit a function to this relationship.

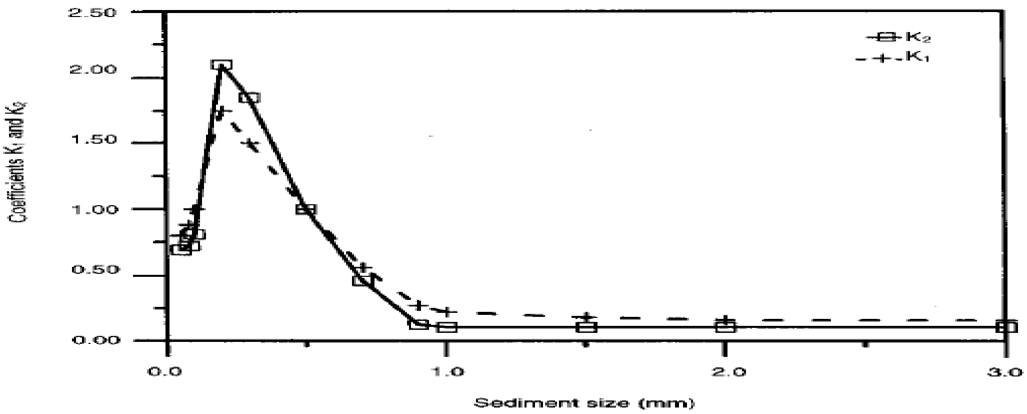

Figure 1: Coefficients K_1 and K_2 versus sediment size (**Abdulaziz A. A. and Matin M.A., "**Fluvial Stage-discharge Rating of Wadi Hanifa Main Channel", Journal of King Saud University, Engineering Sciences: 12(1); 45-63.)

The graphical relation derived from the functional form Eq. (1) can be very closely approximated, after rearranging, by the following expression:

$$\frac{U}{U_*} = \lambda(K_2^x / K_1)(\frac{\Delta\rho_s}{\rho})^{(1/2-x)}(\frac{R}{d})^{x/3}S^{(x-1/2)} \qquad (2)$$

Where U_* is the shear velocity [= $\sqrt{(gRS)}$], is the empirical coefficient and x is an exponent and need to be evaluated using the observed data. In this study, the values of λ and x for three different regimes have been evaluated further by fitting observed data from Ranga Raju for median condition.

Expressing the entire coefficient term $\boldsymbol{\lambda}(K_2*/K_1)$ of Eq. (22) by an inverse of a single resistance F_f**,** Eq. (2) can be rewritten as:

$$\frac{U}{U_*} = \frac{1}{F_f}\left(\frac{S}{\Delta\rho_s / \rho}\right)^{(x-1/2)}\left(\frac{R}{d}\right)^{x/3} \qquad (3)$$

In which the values of F_f are function of sediment size and can be obtained from Figure 2. Values F_f of have been calculated using coefficients K_1, K_2 (Figure 1). Venoni reported a similar form of Eq. (3), which was another version of Garde and Ranga Raju equation. Also, Eq. (2.3) has a similar form of the dimensionless Manning-Strider type equation for exponent x =1/2. However, for movable bed alluvial channels the value of x varies for three different regimes due to variation of resistance occur from various bed formations.

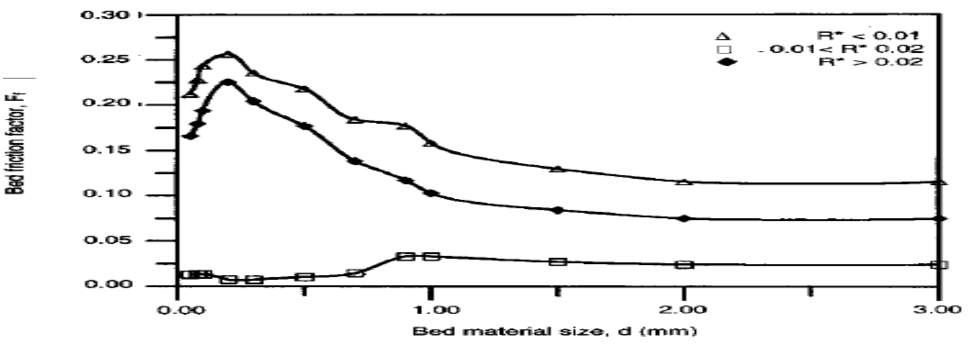

Figure 2: Alluvial resistance factor as a function of sediment size. (Abdulaziz A. A. and Matin M.A., "Fluvial Stage-discharge Rating of Wadi Hanifa Main Channel", Journal of King Saud University, Engineering Sciences: 12(1); 45-63.)

Bathymetric survey data (2013) of eight sections in Jamuna river reach have been collected from Bangladesh Water Development Board (BWDB) and used in the present analysis. Location of the present study and cross-sections details is shown in previous chapters. The actual cross sections are analyzed for different flow depths, increasing from the bed level to the bank-full level. The procedure includes the computation of hydraulic mean depth (D) at different water levels. For each cross cross-sections the hydraulic mean depth at each water level is computed conventionally using the following relation:

$$D_i = \frac{1}{T_i}\left(\sum A_{i-1} + \frac{1}{2}(T_{i+1} + T_i)(h_{i+1} - h_i)\right) \quad (4)$$

where A is the flow area, T is the top width and h is the water level at level i ,i=1,2,3…up to number of division, from lowest bed level to bank full level. However, sections associated with floodplain are analyzed by using flow division procedure. In this procedure, the main channel and side channel velocities are calculated separately with the assumption that small amount of exchange of shear stress at the interface of water between main and side channel is accounted. Therefore, in calculating the hydraulic mean depths of two channel portions, wetted perimeter of entire main channel including this interface is considered, while for the side channels only the wetted perimeter for bed and banks are considered. For Jamuna river reach, sediment characteristics do not vary significantly. Typical grain size distribution curve of bed materials of Jamuna is shown in Fig. 2.3. It can be seen from the shape of grain-size distribution curve of Jamuna, the median sediment size is close to.22mm. This sediment size can be considered as representative size of the selected river reach of Jamuna.

Thus for bed material size d_{50}=0.22 mm, relative density, $\Delta\rho_s/\rho$ =1.65, the parameter R* found to be within 0.01 to 0.02 for transition flow regime. Therefore, using the F_f value as obtained from lower regime curve of Figure 2, and with R = D, Eq. (3) becomes;

$$\frac{U}{U_*} = 75.4275(S)^{0.692}\left(\frac{D}{d_{50}}\right)^{0.3973} \quad (5)$$

For given bed slope, S and median sediment size, d_{50} Eq. (4) and Eq. (5) have been used to calculate the mean velocity for any given stage. Accordingly, discharge may be computed by multiplying the mean velocity with the corresponding flow area.

2.2 Shear stress calculation using Sheild's Diagram

The average shear stress on the bed of an open channel at which the sediment particles just begin to move is called the critical shear stress. Shield was the first to give a semi-theoretical analysis for determination of critical shear stress and his analysis is commonly used. He expressed a graphical relation between dimensionless critical shear stress $\tau_*=\tau_c/(\Delta\rho_s g d_{50})$ and boundary Reynolds number, $R_e=U_*d/\upsilon$), for incipient motion of bed particles. Here τ_c is the critical shear stress, υ is the kinematic viscosity of water and g is the acceleration due to gravity. In the turbulent region, it was shown in Shields diagram (after Chang) that range between 0.047 and 0.06 for Reynolds number 100< R_e* <500. Thus, for known values of flow depth, slope and sediment size, the shear stress difference can be computed. We can then calculate the difference between computed shear stress and critical shear stress. Positive sign of shear stress difference means beds and banks are subject to erosion while negative sign means they are subject to deposition.

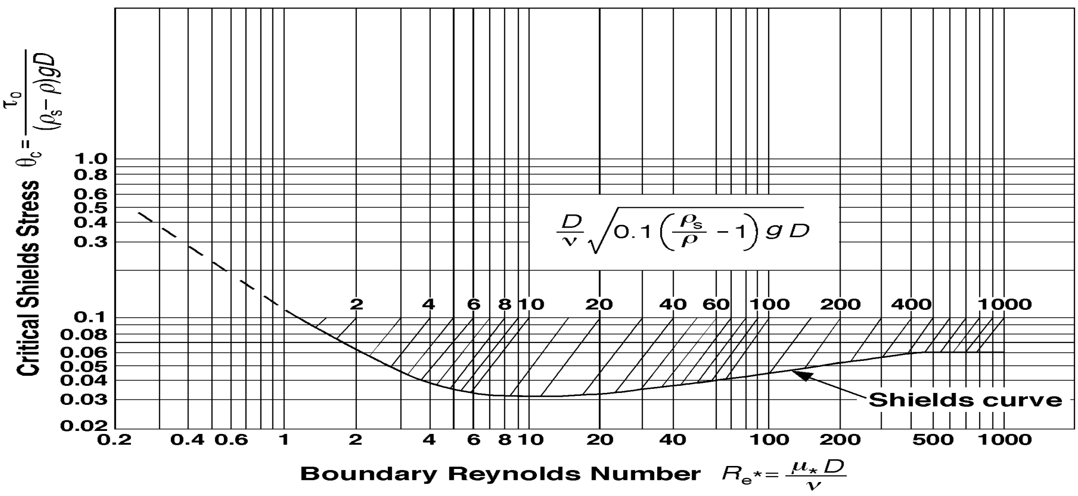

Figure 3: Sheild's diagram for shear stress calculation (Shields, A.,1936. "Application of similitude mechanics and the research on turbulence to bedload movement." Mitteilungen der Preussischer Versuchsanstalt f¨ur Wasserbau und Schiffbau 26. In German (Anwendung der A¨ hnlichkeitsmechanik und der Turbulenzforschung auf di Geschiebebewegung**)."**

2.3 Estimation of scour depth

During floods, the channel bed may undergo scour due to flowing of water. This general scour of the river bed may cause several problems such as bank instability. Although the bed levels may be restored by deposition as the floods recedes, it is necessary for the hydraulic engineers to estimate maximum bed scour depth adjacent to the banks. This is particularly important when a hydraulic structure like culvert or bridge abutments need to be constructed in the channel bed.

Predicting a general scour can be dealt with as a problem of determining equilibrium boundary shear stress responsible for resistance of grains to motion. The grain at the surface of a stationary bed must be subject to $\tau \leq \tau_c$. Hence a depth can be estimated to satisfy this threshold requirement. No suitable theoretical method has yet been available in literature for proper estimation of general scour depth in natural channels. However, many empirical equations are proposed. Here for our analysis purposes, we use Lacey's regime formula. This is widely used in this sub-continent to find out scour depth in unconsolidated alluvial rivers. This empirical regime formula is:

$R = 0.47\ (Q/f)^{1/3}$ (6)

With, $D_s = XR\text{-}h$ (7)

Where, D_s	(m)	Scour depth at design discharge
Q	(m^3/s)	Design discharge
h	(m)	Depth of flow, may be calculated as (HFL-LWL)
f	(-)	Lacey's silt factor = 1.76 $(d_{50})^{1/2}$
d_{50}	(mm)	Median diameter of sediment particle
X	(-)	Multiplying factor for design scour depth

2.4 Total sediment transport capacity

The total sediment transport rate is an integral part of any problem involving alluvial channels, because these channels do not just carry water, but water and sediment. The sediment flow in a channel is partly responsible for its instability, such as erosion and deposition, silting of reservoirs etc. Therefore, the sediment transport rate must be known to the hydraulic engineers for designing a new channel on the same plain.

The total sediment load in nature is the sum of bed load, suspended load and wash load. However, excluding wash load, sum of bed and suspended load is often called total load. Bed material load also sometimes referred as total load. Several total load prediction formulas are available in related literatures. For instance,the Colby equation, Engelund-Hansen formula, Yang equation and Ackers and White equation which are well known and widely used as sediment discharge predictors. White *et al.* compared eight different formulae using 1000 flume and 260 field measurements.

It was shown that Ackers-White equation predicts 68% of data within discrepancy ratio range 0.5 to 2 compared to 63% by Enge!und-Hansen equation. The laboratory data include 0.04 to 4.494 mm and field data from 0.095 to 68 mm. Lau and Krishnappan (1994) tested eight different formulae using their laboratory sediment discharge data. They found that the prediction by Ackers-White equation agrees reasonably well with observed data. Using sediment data of Sacramento river, Nakata also tested eleven sediment discharge formula. He showed that the overall prediction by Ackers-White equation looks excellent. Based on the evidences from these literatures, Ackers-White equation has been selected for prediction of sediment transport rate through the selected river reach of Jamuna. Moreover, this equation can be applicable to wide range of sediment sizes.

3.4.1 Ackers-White formula

Based on Bagnold's stream power concept, Ackers and White (1973) related the concentration of bed-material load as a function of the mobility number F_{gr}:

$$C_s = cs\frac{d}{R}\left(\frac{U}{U_*}\right)^n\left(\frac{F_{gr}}{A}-1\right)^m \qquad (8)$$

Where n, c, A, and m are coefficients. The mobility number F_{gr} is given by

$$F_{gr} = \frac{U_*{}^n}{[gd(s-1)]^{1/2}}\left[\frac{U}{(32)^{1/2}log\left(\frac{10R}{d}\right)}\right]^{1-n} \qquad (9)$$

They also expressed the sediment size by a dimensionless grain diameter d_g:

$$d_g = d\left[\frac{g(s-1)}{\upsilon^2}\right]^{1/3} \qquad (10)$$

Where, υ is the kinematic viscosity of water.

In deriving the mobility factor for sediment transport, they distinguished bed load and suspended load. The transport of coarse sediments in the form of bed load is attributed to the stream power that generates the grain shear stress which is reflected in the second part of F_{gr} in Eq. (9). For fine sediments, which travel mainly in suspension, the turbulent intensity that sustains the suspension is assumed to be a function of the total bed shear; thus the stream power is $\tau_o U$. The first part of F_g reflects the power expenditure associated with turbulent intensity of the flow. The coefficient n is the transition exponent, which depends on the sediment size; it is used when both modes of transport are present and it is zero for coarse sediments with bed load only. The coefficient A may be interpreted as the critical value for F_{gr}

For application in the Jamuna river reach, the Ackers-White equation can be expressed as:

$$C_s = 0.0295\left(\frac{d_{50}}{D}\right)\left(\frac{U}{U_*}\right)^{0.583}\left(\frac{F_{gr}}{0.2375}-1\right)^{3.076} \qquad (11)$$

in which, the particle mobility number F_{gr} is given by

$$F_{gr} = 16.758(U_*)^{0.583}\left[\frac{U}{5.657 log\left(\frac{10R}{d_{50}}\right)}\right]^{0.417} \quad (12)$$

Here, calculated values of coefficients for Jamuna river are as follows:
c = 0.0111256
n = 0.583
A = 0.238
m = 3.076
In Eq. (11), C_s is the total load concentration by weight and it is expressed in ppm by multiplying the calculated value with 10^6. For known sediment size, channel slope, flow depth and mean velocity, Eq. (12) is used for the computation of F_{gr}.

3. ILLUSTRATIONS

3.1 Figures and Graphs

Predicted mean velocity equation has been applied to generate stage discharge data for each cross-section. A typical stage-discharge curve has been generated for each of the eight cross-sections. Stage-discharge curves for upstream station RMJ 6.1 and downstream station RMJ 3.0 are shown in Figure 4 ad Figure 5. These can be used as discharge predictor by knowing water level of the flow. This water level can be measured in the field by installing water level recorder at suitable location of the channel reach. The two curves have very good correlation coefficient values.

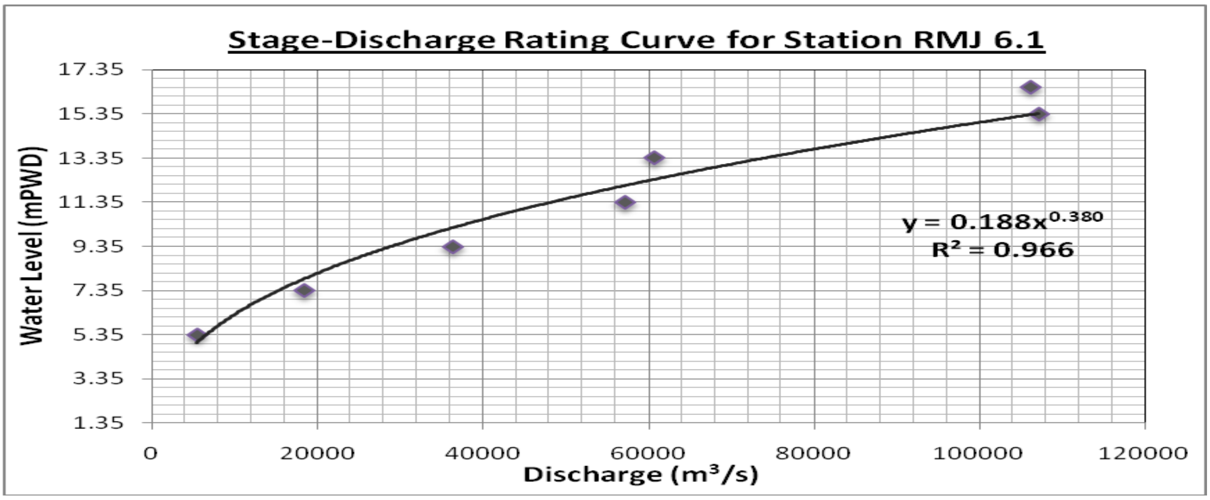

Figure 4: Typical stage-discharge rating curve for station RMJ 6.1.

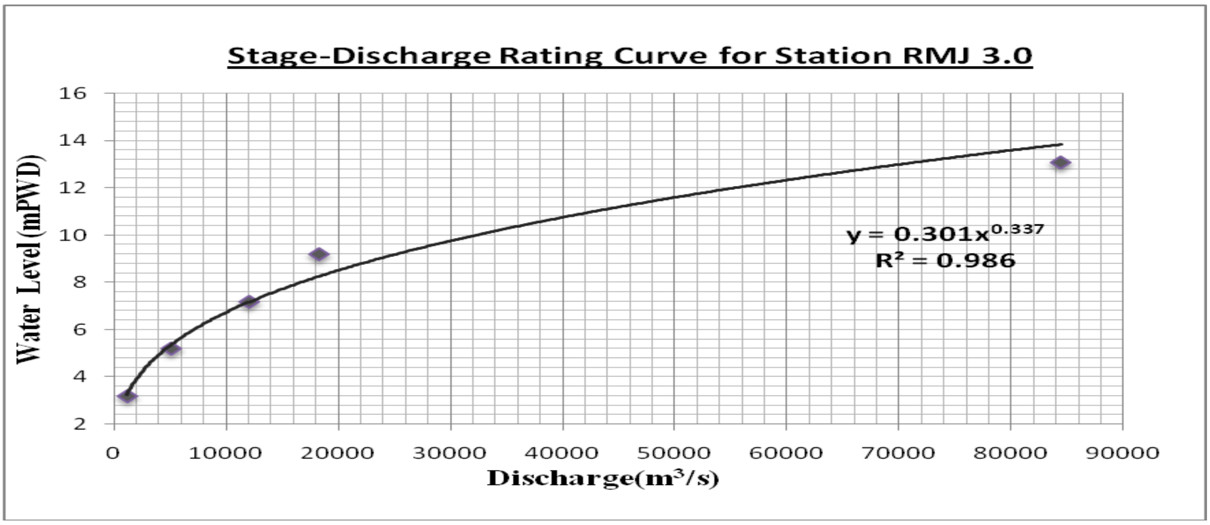

Figure 5: Typical stage-discharge rating curve for station RMJ 3.0

Based on stage-discharge data, water surface profiles of the entire reach have been drawn for different discharges. Here, water surface profiles for two discharges such as Q = 10000 m^3/s and Q = 30000 m^3/s are shown in Figure 6 and Figure 7. Bank full ad bed levels of the reach are also shown in the figures. From these profiles, it is seen that the selected Jamuna river reach can carry discharge up to about 10000 m^3/s without flooding the banks. The reach can carry discharge up to about 30000 m^3/s but flooding occurs at stations RMJ 4.0 and RMJ 3.0.Their combined water surface profiles is shown in Figure 3.3.

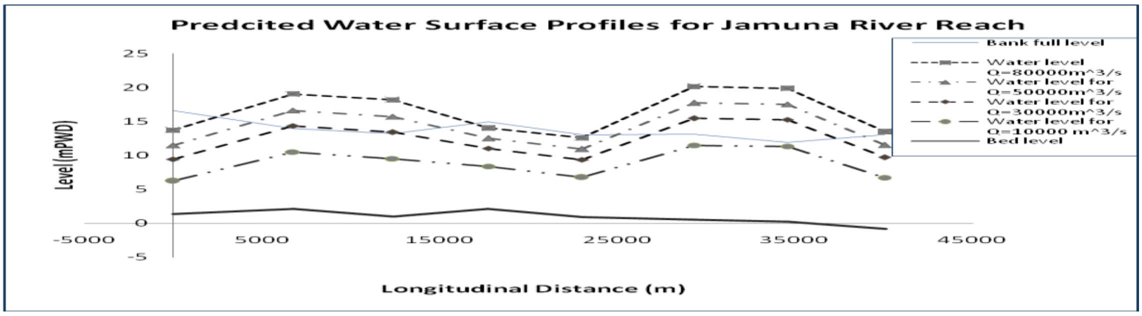

Figure 6: Predicted water surface profiles for Jamuna River reach for different discharges

Using estimated values from Acker's-White equation, a set of sediment rating curve is prepared for different flow depth conditions. For highest flow depth at bank-full condition, the sediment rating curve is drawn. Also, rating cures have been generated here for three different longitudinal slopes in order to observe the variations with slopes. A mean sediment curve in terms of total sediment concentration versus discharge intensity (discharge per unit width) has been constructed as shown in Figure 3.4. This figure can be used to predict the total load concentration for given longitudinal slope and discharge intensity.

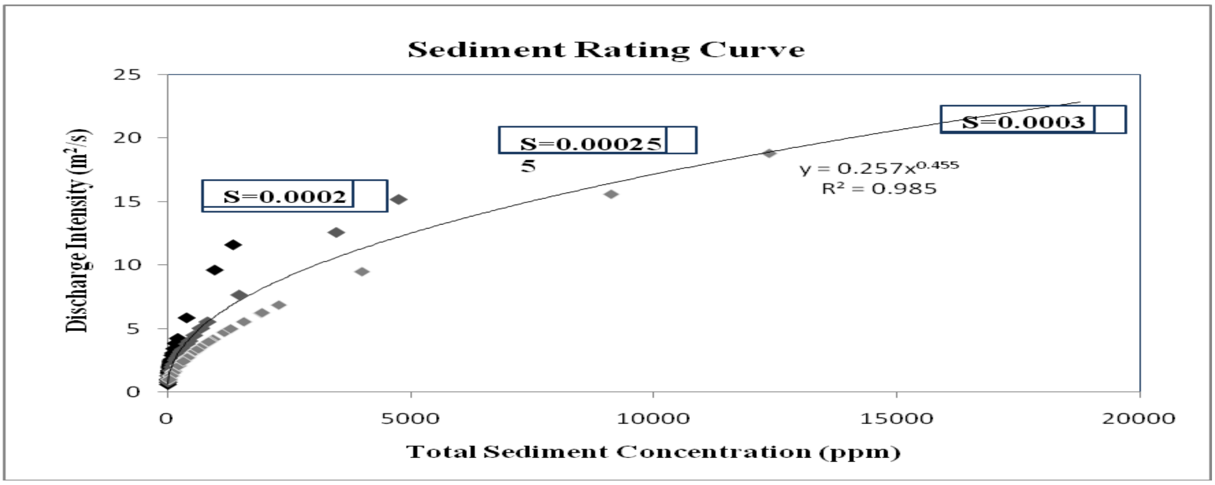

Figure 7: Sediment rating curves in terms of discharge intensities for different bed slopes versus total load concentration.

3.2 Tables

Eight cross-sections over 40 km length of Jamuna river reach have been used to determine flow and sediment transporting capacity. The geometric dimensions of these sections are shown in Table 3.1. It can be seen that the selected reach are becoming flared towards the downstream side.

Table 3.1: Geometric dimensions of selected cross-sections along study reach at bank-full condition

Station No.	Distance (d/s) (m)	Max. depth (m)	Bank-full width (m)	Flow Area (m^2)	Hydraulic Mean depth (m)	Average bed slope*10^{-4}
RMJ 6.1	0	15.23	11187	64391.56	5.76	2.51
RMJ 6.0	6755.96	11.82	16400	65584.69	4.00	1.14
RMJ 5.1	5607	12.22	14300	41830.49	2.93	2.00
RMJ 5.0	5378.46	12.80	16615	89610.01	5.39	2.14
RMJ 4.1	5274	12.18	21100	86405.72	4.10	2.37
RMJ 4.0	6269.95	12.57	13000	71649.20	5.51	5.58
RMJ 3.1	5288.3	11.65	12100	56334.30	4.66	5.86
RMJ 3.0	5466.28	13.07	15160	78432.04	5.17	1.90

Estimated discharge capacity, shear stresses, maximum erosion depth and sediment concentration have been estimated for various existing cross-sections under bank full conditions and under constant flow depth of 6 m. Results are shown in Table 1 and Table 2.

Table 1: Discharge capacity, shear stress differences and depth of scour through the eight cross-sections of Jamuna river reach for bank-full condition

Cross Section Station No.	Depth at Bank-Full Level (m)	Shear Stress Difference ($\tau-\tau_c$) (N/m^2)	Discharge Capacity (m^3/s)	Depth of Scour (m)
RMJ 6.1	15.23	+14.01	106216.35	23.73
RMJ 6.0	11.82	+4.30	30420.73	15.64
RMJ 5.1	12.22	+5.56	28607.26	15.32
RMJ 5.0	12.8	+11.14	115074.29	24.37
RMJ 4.1	12.18	+9.35	97987.07	23.10
RMJ 4.0	12.57	+2.84	18926.10	13.35
RMJ 3.1	11.65	+2.50	13557.77	11.95
RMJ 3.0	13.07	+9.48	84425.93	21.98

***($\tau-\tau_c$)=$\rho gDS- \tau_*(\Delta\rho gd)$**

*(+) ve sign means bed and banks are subjected to erosion

Table 2: Discharge capacity, shear stress differences and max. depth of scour through the eight cross-sections of Jamuna river reach for 6m flow depth**.**

Cross Section Station No.	Shear Stress Difference ($\tau-\tau c$) (N/m^2)	Discharge Capacity (m^3/s)	Depth of Scour R (m)
RMJ 6.1	+12.50	18511.34	13.25
RMJ 6.0	+4.16	4883.47	8.50
RMJ 5.1	+6.79	4457.36	8.25
RMJ 5.0	+6.01	9450.02	10.59
RMJ 4.1	+6.97	12351.12	11.58
RMJ 4.0	+1.09	1052.60	5.10
RMJ 3.1	+1.50	1108.61	5.19
RMJ 3.0	+4.79	5145.74	8.65

As computed and shown in Table 1, the discharge capacity of cross-section RMJ 6.1 is found to be 106216.35 m^3/s when the flow depth is 15.23 m. Maximum discharge capacity of cross-sections RMJ 6.0, RMJ 5.1, RMJ 4 and RMJ 3.1 are found less compared to other cross sections in the reach. Reason is that, these four cross sections are relatively shallower or narrower under bank-full condition and have less flow area as well as less bank full width listed in Table 3.1.Consequently, higher carrying capacity is envisaged for station RMJ 5.0 which is 115074.29 m^3/s for a flow depth of 12.8 m. Obviously, may other branch channels are linked to the reach along the sides of station RMJ 5.0, providing higher flow capacity of the main river channel itself. Otherwise, the downstream banks of RMJ 5.0 are subjected to heavy flooding as downstream station after RMJ 5.0 have lower discharge carrying capacity. However, for constant flow depth of 6 m, the corresponding discharge through the sections RMJ 6.1 and RMJ 4.1 are estimated as 18511.34 m^3/s and 12351.12 m^3/s respectively which are the higher as shown in Table 5.2. For sections, RMJ 4.0 and RMJ 3.1, the estimated discharges are found to be 1052.60 m^3/s and 1108.61 m^3/s respectively, which are obviously very low compared to those discharges at bank-full levels. This is due to the fact that, these sections have a narrow deep cut at a depth close to 6 m, which provides less flow area in discharge computation. It is worth mentioning here that, the discharge close to bank-full stages increases at a higher magnitude when compared with that of low stages.

The higher rate of discharge increment is due to wider water conveying area associated with flood plain. Foregoing results are obtained based on constant sediment size. However, it can be estimated that for a constant longitudinal slope, the maximum discharge through the reach in bank-full condition will give upto 22% change in values and for ±20% change in longitudinal slope will give a ±50% change in discharge. On the other hand, for a specific bed slope, 10% decrease of sediment size will give only 5% increase in predicted discharge.

Table 3: Discharge intensity and erosion depth from bed level for RMJ 6.1

Cross Section Station No.	Various Flow Depths (m)	Discharge Intensity (m2/s)	Depth of Scour from WL. (m)	Erosion Depth from Bed Level (m)
RMJ 6.1	4m	2.5	8.84	4.84
	6m	7.67	13.25	7.25
	8m	12.59	16.6	8.6
	10m	15.2	19.31	9.31
	Bank full	9.49	23.73	8.5

Maximum possible erosion depths for various sections have also been computed. It is observed that for discharge intensity 15.2 m^2/s and d_{50} = 0.22 mm, erosion depth can reaches up to 9.31 m from the lowest bed level for the case of cross-section RMJ 6.1. For station RMJ 4.0 and RMJ 3.1 erosion depth from lowest bed levels are negligible. In these cases, depositions are suspected along the irregular cross-sections.

Table 4: Estimated sediment concentration for bank-full condition.

For Bank Full condition		
Cross Section Station No.	**Discharge Intensity (m^2/s)**	**Total Sediment Conc.(ppm)**
RMJ 6.1	9.49	2147.86
RMJ 6.0	4.76	615.44
RMJ 5.1	2.63	185.94
RMJ 5.0	8.39	1731.73
RMJ 4.1	4.98	670.21
RMJ 4.0	8.74	1861.10
RMJ 3.1	6.35	1051.97
RMJ 3.0	7.76	1506.67

The total sediment transporting capacity of the channel reach is calculated from Ackers-White's equation in which the mean velocity is computed using predicted mean velocity equation. Total sediment concentration is computed using constant sediment size and constant longitudinal slope. Thus, using different longitudinal slopes, variations are illustrated in the last portion of this chapter. Here, estimated sediment concentrations along with discharge intensities for selected stations under bank-full condition are shown in Table 3.5. For all the cross-sections under bank-full condition, predicted sediment concentration is found to range between 185.94 ppm to 2147.86 ppm. However, these concentrations are very close to clear water flow except RMJ 6.1 and RMJ 4.1 and don not produced any significant impact on the overall flow regime of the river reach. For increasing discharge intensity, total sediment concentration is also increasing.

4. CONCLUSIONS

Fluvial stage-discharge rating has been done by using modified resistance equation for various cross-sections of the Jamuna river reach. Computed water surface profile shows that the channel reach can carry discharge up to 30000m^3/s, without causing over bank spills for a considerable portion of the reach. Further computation shows that serious flooding is occurs under bank-full discharge 50000 m^3/s and 80000 m^3/s respectively. From computed shear stress differences, it is observed that severe bed and bank erosion occur at bank-full condition. From computed erosion depth, it can be predicted that erosion from bed level increases with increasing flow depth for selected stations. Combined with proposed mean velocity equation, sediment transport rate is also predicted using modified Ackers-White equation for selected Jamuna river reach. It is seen that for constant bed material size and longitudinal slope, total sediment concentration is increasing with increasing discharge intensity. For higher slopes, the predicted total sediment concentration is also increasing.The river reach has high range of bed material concentration (within the range 7 ppm to 4766 ppm) for different flow depth condition. Higher the flow depth, higher the total sediment concentration.It is concluded from our analysis that the predicted equations may not be valid for other reach along the Jamuna river. But is shows a satisfactory performance for the river reach under study. Verification of our proposed equations using observed water level, water discharge and total sediment concentration data of Bahadurabad station doesn't fully satisfy our prediction. Dissimilarity in bed slope, bed and bank materials sizes, long distance from selected river reach, location upstream of Bharmaputra-Jamuna basin system may be the reasons behind those anomalies.

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