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ESTIMATION OF HYDRAULIC PARAMETERS IN A PROPOSED BARRAGE BY USING MATHEMATICAL MODEL.

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Abstract: **Ajansara Barrage Project was proposed by M/s.Vidarbha Irrigation Development Corporation (VIDC), Nagpur under Water Resource Department, Government of Maharashtra, for Lifting Irrigation to irrigate an area of 30004 Ha of Culturable Command Area (CCA) by utilizing the water from the Wardha River in Village Ajansara, Hinganghat Taluka of Wardha District of Maharashtra State. The scheme involves a masonry barrage across Wardha River at village Ajansara with a flanked by earthen bunds on both the sides. The barrage site has a gross catchment area of 11.605 Sq. km with interception of 2618 Sq. Km. The masonry barrage has a length of 267 m with 15 nos. of vertical lifting gates of size 15 X 9.50 m. The length of earthen dam on both flanks is 3765 m. The storage is proposed against gates only, while the earthen bunds are proposed to take care of outflanking due to high floods and approach to barrage in flood period. In the present paper an attempt has been made to evaluate back water, rise in water level at barrage and effect of barrage on flood plain by using Hecras software. After taking the run of the model with and without structure and comparing, it is observed that the rise in water level is 8.73 and its backwater length is 41km.**

Keywords: **Backwater, Hecras, Flanks, Barrage, Earthen embankment.**

I. INTRODUCTION

Water is an important parameter for water resource engineers. In the Indian River, the study of water level is an important part for surface water discharge, flood etc. For applications of most of the hydrological design, it is necessary to have records of water level for a long period, especially for flood monitoring, discharge measurement etc.

A barrage is a structure constructed across the river which diverts flow into man-made channels where maximum quantity of water is allowed to store by gates and small portion or nil portion of water allowed to store by crest. It is designed based on surface and subsurface flow considerations. It forms an important structure to divert river water through a canal system for irrigation and other useful purposes.

Barrages offer better control than weirs. However, barrages are costlier than weirs (Modi PN, 1988). The characteristics of surface and subsurface flows are taken into considerations while designing a barrage. The crest level, downstream floor length, and minimum depths of upstream and downstream sheet piles/cutoffs are mainly governed by surface flow considerations. However, for a given surface flow condition the cost of a barrage largely depends upon the depth of sheet-piles and the length of the floor and its thickness which is governed by subsurface flow conditions. In fact, change in depth of sheet pile affects the floor length and uplift pressure distribution beneath the floor, and hence thickness of the floor. Thus, cost function has nonlinear variation with the variation in depth of sheet piles. The exit gradient, which is considered the most appropriate criterion to ensure safety against piping (IS6966, 1966, S. K. Garg, 2013 and Module- IV, 2019) on permeable foundations, exhibits non -linear variation in floor length with variation in depth of downstream sheet pile. These facts complicate the problem and increase the non-linearity of the problem. However, an optimization problem may be formulated to obtain the optimum structural dimensions that minimize the cost as well as satisfy the exit gradient criteria.

This research study is conducted by using HEC-RAS Model, free of charge software while some flood models are commercial ones. Moreover, HEC-RAS requires less time for simulation. These are sufficient reasons why HEC-RAS is selected to be used to primarily understand flood parameters and characteristics. At present in computer technology and research in numerical techniques, various 1-D hydrodynamic models HEC-RAS have been developed (Robert et al., 2012). This software contains four one-dimensional hydraulic components for: steady flow computations; unsteady flow simulation; movable boundary sediment transport computations and water quality analysis using a common geometric data representation and common geometric and

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hydraulic computation routines. (Karim, S. et al., 2009 and Amir et al., 2012). In this paper, we focus on the unsteady flow component of HEC-RAS for maximum discharge of 15168.5 cumecs which is given by M/s.Vidarbha Irrigation Development Corporation (VIDC), Nagpur under Water Resource Department, Government of Maharashtra to perform and analyze flow parameters of the Wardha River. The basic data requirements for simulation are included: geometric data, cross section geometry, reach lengths, Manning's roughness coefficients, contraction and expansion coefficients, steady flow data, boundary condition, flow regime (Karim, S. et al., 2009).

II. MATERIALS AND METHODS

2.1 Study Area

This research was conducted along Wardha River in Village Ajansara, Hinganghat Taluka of Wardha District of Maharashtra State. Wardha River is one of the major rivers in Vidarbha area of Maharashtra. It originally arose at altitude of 777m in Satpura Range in Betul district of Madhya Pradesh for a flow of 32 Km. and then after traveling of 528 Km it enters in Maharashtra and joins Wainganga at Seoni in Chandrapur District. This study was based on the 1D mathematical model HEC-RAS 6.2 version to get an idea about hydraulic aspects of the river. The river has been provided with an inline structure of spillway gates (i.e Barrage). Figure 1 shows the study area.

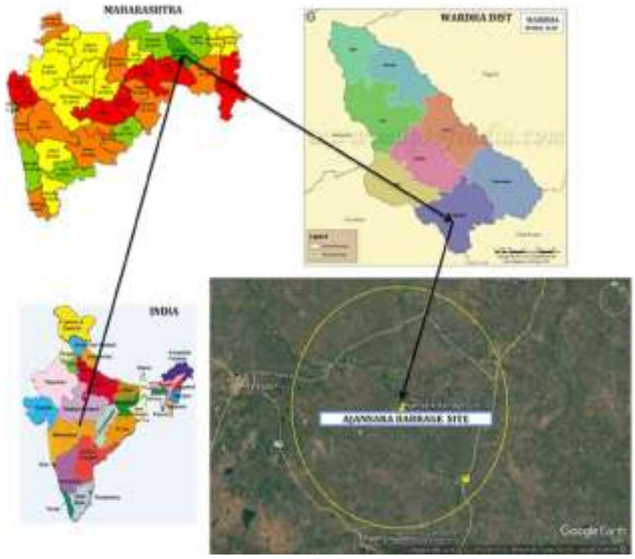

Figure 1: Map of Study Area.

2.2 Model setup

Hydraulic model of Wardha River is covering the total river reach of 25.56 km and cross-sections used for an interval of 0.5 Km. In order to study the flood situation, flood hydrographs of flood events having maximum discharge of 15168.5 cumecs which is given by M/s.Vidarbha Irrigation Development Corporation (VIDC), Nagpur under Water Resource Department, Government of Maharashtra were taken into consideration. The data were entered in HEC-RAS software. The study reach includes 52 cross sections on the Main River.

2.3 Numerical Model

As per St. Venant Equation

Continuity equation

$$\frac{\partial Q}{\partial x} + T\frac{\partial y}{\partial t} = 0$$

Momentum equation

$$\frac{\partial Q}{\partial t} + \frac{\partial}{\partial x}\left[\frac{Q2}{A}\right] + gA\,\frac{\partial y}{\partial x} + gA\,(S_0 - S_f) = 0$$

Friction slope S_f

$$S_f = \frac{Q2.n2}{A2.R(4/3)}$$

Where, A= flow depth, Q= discharge, x = distance along the channel, y = bed elevation.

2.4 Model Proving Studies

For validating the study, relation between mathematical model and observed data can be confirmed by Manning value 'n' of Wardha River. So, we use the actual site for this study. In monsoon year 2021 the discharge and water level were recorded for high discharge 15168.5 cumec. For these discharges of Wardha river water level at Babapur, Kapsi, Rohini and Hirapur were 220.90 m, 216.40 m, 212.13 m and 211.97 m respectively. The cross-section of Babapur, Kapsi, Rohini and Hirapur are c/s No.1, c/s No.22, c/s No.48 and c/s No.51 respectively. Were Babapur, Kapsi are upstream and Rohini, Hirapur are downstream of barrage. For manning value 'n' the value taken is 0.028 which is best after comparing the mathematical model at discharge 15168.5 cumec. The result is shown below in Table no. 1. Figure 3 shows that the Proto gauge water level and observed water levels are fairly matching.

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Table No. 1 Table showing comparison between observed and computed water level.

Gauge station	**Gauge levels**		
	Observed water level during 2021 (m)	**Mathematical model (Hecras) (m)**	
		n = 0.028	**n = 0.03**
Babapur	220.96	221.00	222.05
Kapsi	216.40	216.44	216.51
Rohini	212.13	212.15	212.18
Hirapur	211.97	212.00	212.01

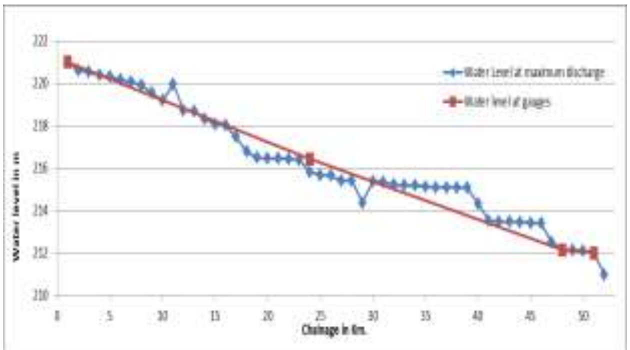

Figure 3.Plan comparing the water level taken on four gauge site with water level in mathematical model.

III. BOUNDARY CONDITION

a) Upstream Boundary condition:
Daily average inflows were established on the basis of daily discharge data available for the month mid-June-July of year 2021 on the basis hydrograph was prepared.

b) Downstream Boundary condition
Slope of the river is used as a downstream boundary condition.

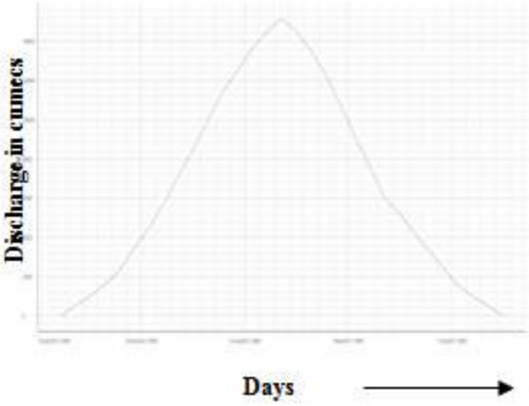

Figure 4: Hydrograph

IV. RESULTS AND DISCUSSIONS

Using discharge Hydrograph as upstream boundary condition for the month mid-June-July of year 2021 cross section for the year May 2020 and slope as downstream condition. Mathematical model (HEC-RAS) was run with input date of discharge of 15168.5 cumec for three cases were taken.The Mathematical model run was taken for

a) Without structure (Refer Figure No.5)
b) With structure:-
1. Fully opened gate (Refer Figure No.6)
2. Fully closed gate (Refer Figure No.7)
3. Partially open gate (Refer Figure No.8)

A figure 9 graph shows the comparison of water level without structure, with structure and partial opened structure with various gate operations.

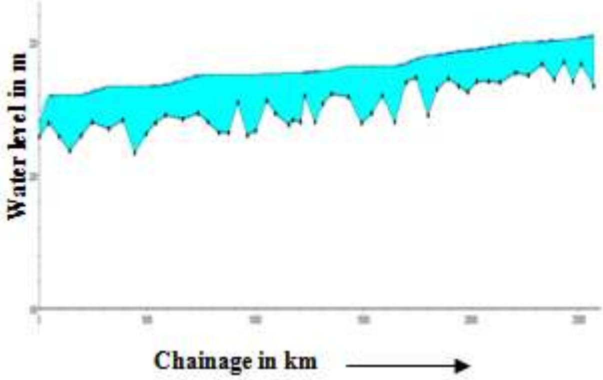

Figure 5: Longitudinal section showing water surface and bed profile (without Structure).

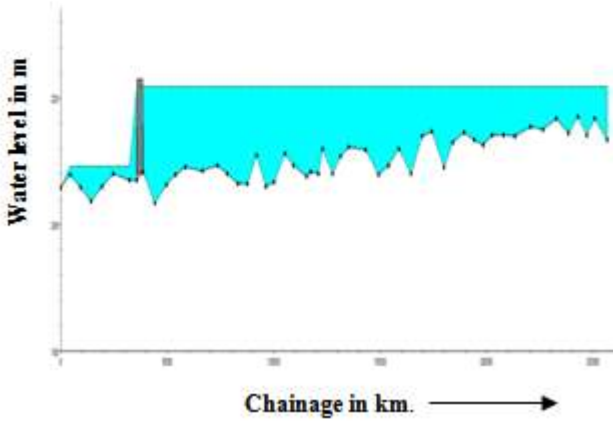

Figure 6: Longitudinal section showing water surface and bed profile with structure (Barrage) fully closed gate.

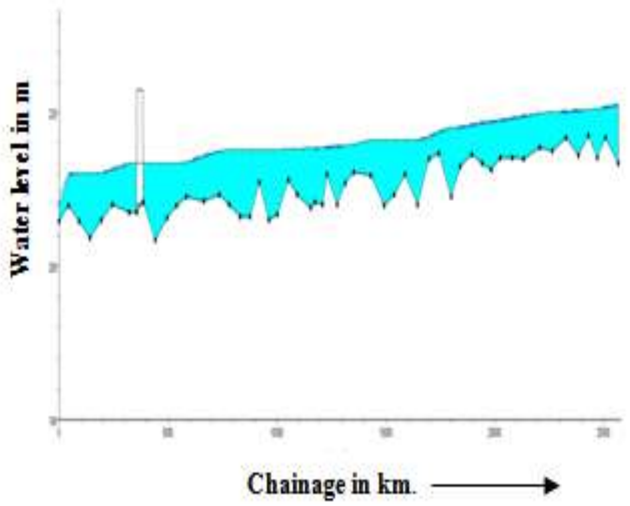

Figure 7: Longitudinal section showing water surface and bed profile with structure (Barrage) fully opened gate.

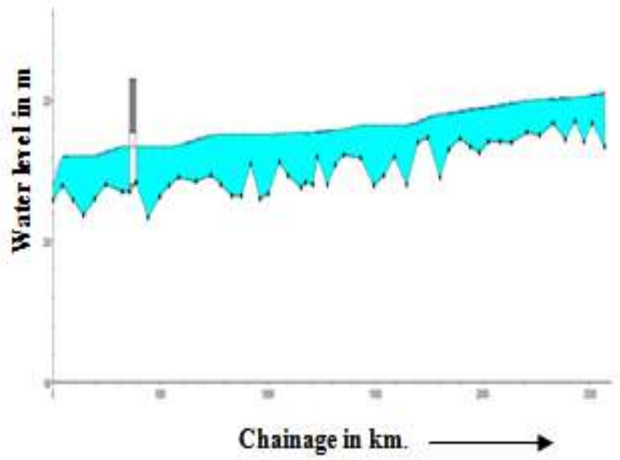

Figure 8: Longitudinal section showing water surface and bed profile with structure (Barrage) partially opened gate.

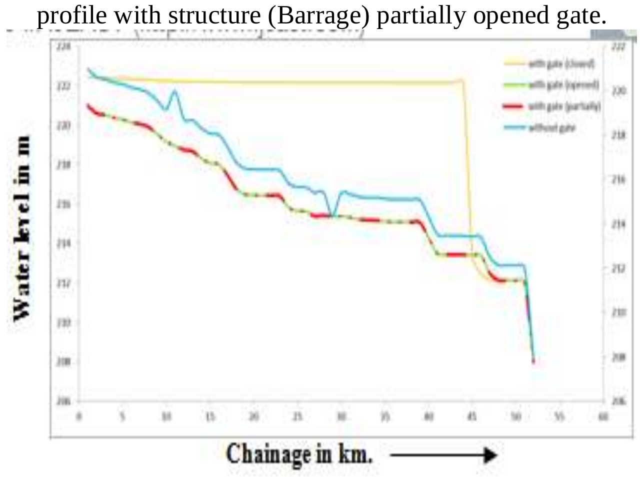

Figure 9: Comparison of water level a) Gate opened, b) partially gate opened & c) fully gate opened.

V. CONCLUSION

Hecras 6.2 was used for evaluating waterway, backwater and the design parameter and was compared with hydraulic values taken by project authority. For discharge of 15168.5 cumec at the alignment of structure, the water level recorded in 2021 at Babapur, Kapsi, Rohini and Hirapur have fairly matched the mathematical model water level for n = 0.028. After running the model without structure the water level observed at alignment of structure 213.42 m is compared with project authority of water level. A run was taken after providing a structure gate the water level observed was 1.74 m (free board) below the TBL (i.e. 223.9 m), hence satisfactory.

VI. ACKNOWLEDGMENT

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