DESIGN OF SILT EXCLUDER OF NEW KHANKI BARRAGE: A CASE STUDY OF LOWER CHENAB CANAL, PAKISTAN

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ABSTRACT; *Irrigation is the backbone of the agriculture and hence the economy of Pakistan. In order to ensure the efficient working of hydraulic structures like barrages in the irrigation network, it is necessary to safeguard them against the looming problem of sedimentation. The same has been done during the course of this study for efficient design of silt excluder of New Khanki Barrage. In the study of design of silt excluder, losses in different section of silt excluder was calculated by Manning's formula. The optimal size of tunnels was designed by using (Sediment and Hydraulic Analysis of Rehabilitation of Irrigation Canal) SHARC model. The head for free flow was 4.78 m and total loss throughout the tunnels was varies from 0.44 m to 0.54 m against the average inlet velocity of 1.70 m/s as closely to SHARC computed velocity of 1.587 m/s. According to proposed design sediment size of 0.4 mm (i.e. Sand of medium size) is completely excluded by the silt excluder with the settling velocity of 0.0645 m/s. The efficiency of excluder varies from 93.5 % to 95.2% against 90 % of extraction ratio. This indicates that the construction of silt excluder is efficient in reducing the sediment entry into the canal or also economical for cost purpose.*

Keywords: Manning's Formula, SHARC, Sediment, Silt Excluder, New Khanki Barrage

1. INTRODUCTION

Khankibarrage including under sluices constructed on the Chenab River is one of the most important diversion structures amongst 14 large barrages built across the Indus River and its tributaries namely Jhelum, Chenab, Ravi and Sutlej rivers. Khankibarrage is located in Wazirabad Tehsil of Gujranwala District (Latitude, 31°-09' North; and Longitude, 73°-62' East) is at Fig. 1. Khankibarrage irrigates a gross commanded area (GCA) of about 3.6 million acres of fertile land which was almost a desert before construction of Lower Chenab Canal (LCC). Initially LCC was constructed as an inundation canal in 1887 but was later converted to a perennial canal in 1892 to supply irrigation water to the Rachna Doab. The design capacity of LCC is 327 m^3/s (11,538 ft^3/sec).[1]

The Khanki weir was the first weir in the Punjab constructed on the alluvial sandy bed of a river. The silt trouble of the canal started with the first opening of canal and still the pond system was adopted. Due to lack of sufficient attention, the approach was silted up and the control of the river was lost. The working of barrage was not efficient. So, there was a need to construct a device which controls the entry of sediment into the canal. [2]

At present situation new Khanki barrage proposal was proposed at 9 km downstream of existed headwork.A divide wall has been provided to separate the main weir bays from the under sluice bays and to provide a still body of water. A hydro power option of 7.55 MW also added in New Khanki Barrage at LCC (RD0+000). Purpose of this pocket is to minimize the silt charge entering in the off taking canal. Since the intake of the power channel is further upstream of the proposed head regulator of the LCC. So, it was considered necessary to take measures for avoiding the inflow of sediments in to the power channel. Therefore, the Khankibarrage was provided a silt excluder in left under sluice and it was decided to construct eight tunnels in two out of total five bays of left under sluices [3-4].

The bays No's 1 and 2 will serve as excluders. Each bay will be divided into four tunnels of rectangular cross-section. The upstream floor level is proposed 713.00 ft, crest level at 719.00 ft and Soffit level at 724.50 ft (i.e. 5 ft raise crest level). The crest of head regulator 726.00 ft (i.e. 1.5 ft raise from the roof of tunnels) is the recommended levels of new barrage plan. In view of space available there, the width of corresponding tunnels in the bays is so adjusted that no deposition or erosion will be occurring. The tunnel immediately in front of Lower Chenab Canal head regulator is will be the same length as of head regulator while the last one farthest away from the regulator will be smallest [5-6].

Silt excluder is a device construction on the river bed, upstream of the head regulator. The idea of silt excluder must be credited to late Mr. H.V. Elsden (1992). The clearer water enters into the canal and silted water into the silt excluder. Silt excluder consists of silt tunnels or silt plate which is reinforced concrete slab placed horizontally into the parents channel opposite the off-take head and supported by walls and piers is at Fig. 2 [7-8].

The silt excluder is designed for specific hydraulic and sediment condition of the barrage. So, Physical and numerical model study are conducted to observe the behavior of silt excluder. According to physical model study, it has been found that the tunnels should be located at selected positions, rather than distributed uniformly over the entire length of head regulator. It means that the position of tunnels is more important than their number. It was found by experience at Khanki barrage in that three tunnels proved to be more efficient than six. Also, a smaller number of pocket bays covered by the excluder, give better results as do the openings of the tunnels confined to the mouth.[3]

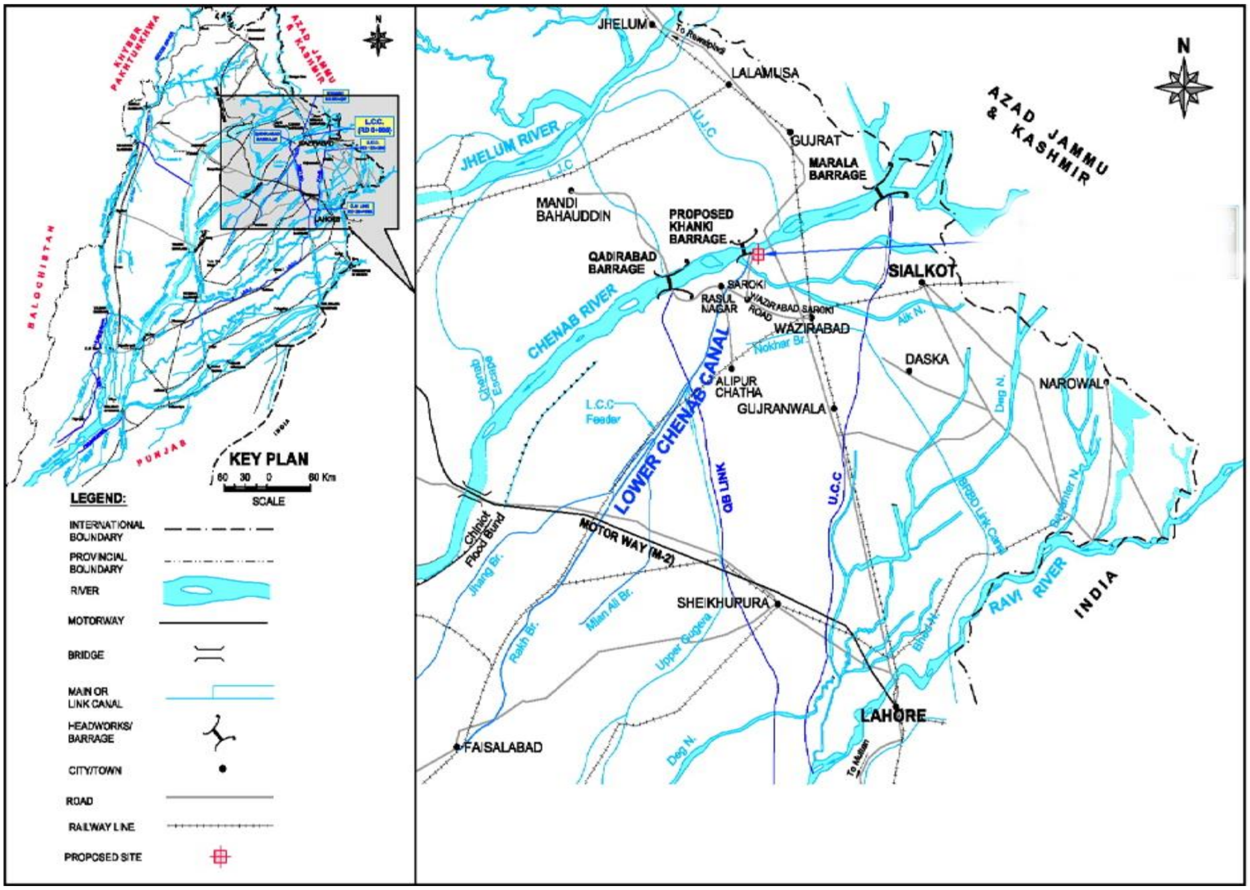

Figure.1 Location of Khanki Headwork

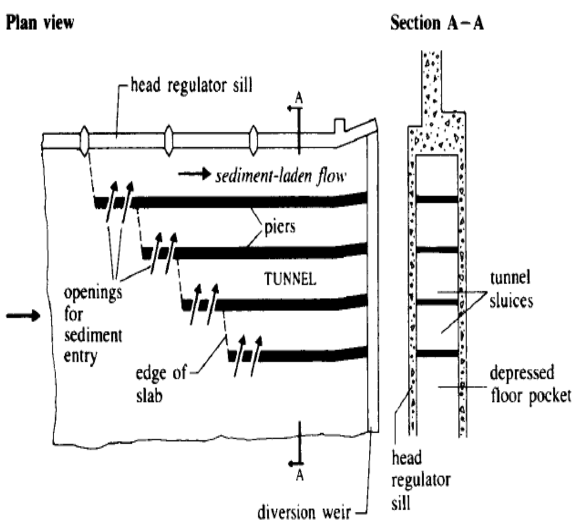

Figure. 2 Plan View of Silt Excluder

SHARC (Sediment & Hydraulic Analysis of Rehabilitation for Irrigation Canal) is a suite of integrated programs designed to assist in the identification and solution of sediment problems at intakes in rivers and canal systems. SHARC module allows access to an Intake model, and three programs supplied with SHARC that are used to design of alluvial canals, (DORC), sediment extractors (DACSE) and settling basins (DOSSBAS). The DACSE software (Design Analysis for Canal Sediment Extractors) provides methods for aiding the design procedure for sediment extractors: vortex tubes and tunnel sediment extractors. These structures function by separating, and then ejecting, the sediment laden bottom layer of flow in a canal. Water and sediment from the region close to the canal bed is diverted by the extractor, and taken out through one canal bank to an escape channel. [4]

2. RELATED WORK

King [5] silt caring capacity of fluid at any point depend difference in velocity of filaments of flow just above and below the point. A small obstruction over the bed keep throwing up the silt which fall backs and thrown up again. This motion of silt particle is terms as siltation, and depends on the bed roughness, velocity and particle size.

Raju and Kothyari[6] explained the design principles of two kinds of sediment withdrawal methods, namely; settling basins, and vortex chambers. They accomplished that the vortex chamber has high efficiency as compared to settling basin and require small flushing discharge. The negative aspect of vortex chamber is that it is suitable for small channels only.

Ahmad et al.[7] discuss different sediment exclusion methods and devices at the intake of canals. It was established by various experiments that an off take from a straight channel draws greater proportion in its water than its due share depending on the discharge extraction ratio and the angle of twist. The excluders were tested for full supply discharge in power tunnel and the river discharge equal to 100,000 cusecs. It was envisaged that an excluder of ejector type or vortex excluder will be efficient for exclusion of coarse silt from power tunnel.

Shakir and Khan[8] indicated that there is a slight difference in sediment intake as a result of raising the crest level of MRL canal, which was considered and supplemented by physical model studies before implementation as one of the most effective measure for controlling the sediment entry in these canals.

Haigh[9] describes different types of silt excluders. According to him different factors affect the Efficiency of silt excluders. Sediment intensity decreases rapidly with depth, additional escapage will increase the efficiency but slowly. The efficiency of silt excluder must be affected by the grade of material carried by the water. The excluder may be accepted to work more efficiently where the proportion of coarser silt is greater than where it is small, but on the other hand, the coarser the heaviest grade of silt carried, the greater the slope and velocity will be, and consequently the less the concentration of silt in the lower layers.

After estimation and analysis of silt excluder efficiency, M. Kaleem[10] explains the impact of silt excluder on the sediment management of the canal which results in significant reduction in sediment entering the D.G. Canal and can be used as an effective tool to overcome the sedimentation problem.

3. DESIGN PARAMETERS FOR SILT EXCLUDER

Bhavan. [11] described the detail of silt excluder parameters and its flushing criteria which is required for efficient design.

3.1 Approach Condition

The curvature of the river flow approaching the canal head regulator plays an effective role in the efficient working of an excluder and as such the locations of the mouths of the tunnels have to be decided, keeping in view the approach conditions. All possible river approach conditions are to be examined carefully while deciding the layout of excluder tunnels. The tunnels are located in front of the canal regulator and their alignment is kept parallel to the axis of the regulator as far as possible. Any deviation in their alignment, found necessary towards their tail ends, should be made on asmooth curve so that kinks are avoided.

3.2 Location of Tunnels

Excluders, tunnels at the inlet end should preferably be bell mouthed by decreasing head loss. Each tunnel has a certain zone of influence which extends upstream to a certain distance in a straight direction as well as sideways up to some distance upstream. The two successive tunnels should be so placed that the zone of suction of the second starts before the zone of suction of the first tunnel ends. To create enough suction in tunnels and carry coarse material like gravel and boulders into the river, a minimum head of 0.9 to 1.2 m is necessary for satisfactory working. A smaller head suffices for finer material.

3.3 Self-Cleaning Velocity

A velocity of 2 to 2.5 m/s is generally treated as self-cleansing velocity inside the tunnels in alluvial reach and 3 to 4 m/s as self-cleansing velocity inside tunnels in shingles and cobbles reach. The velocity at the exit end of the tunnel may be worked out from the working head and throttling affected to attain a velocity higher than 3.0 to 3.5 m/s at the exit in alluvial reach and 4 to 5 m s in shingles and cobbles reach. If the width of the tunnel is kept the same, throttling is done by lowering the underside level of the roof of the tunnels in the case of excluders.

3.4 Roof Level of Tunnels

The roof of a sediment excluder should normally be located at the sill level of the canal. Preferably the height of tunnels should be kept adequate to facilitate inspection and repair work. The tunnels shall be designed to run full bore to secure the maximum efficiency.

3.5 Control Structure

The discharge from sediment excluder is controlled by gated regulation at the downstream end of tunnels. The quantum of discharge to be run through sediment excluder and frequency of its operation would vary in different parts of the year depending on the permissible sediment load in the canal and the sediment load entering in the pocket. This is achieved by operating regulating gate as required. However, in practice, the gates are either fully opened or fully closed.

4. MATERIAL AND METHODS

4.1 Data Collection

For the estimation of design of barrage, the data collected was includes historical sediment and discharge data at head reach, upstream and downstream of barrage or canal and detailed engineering drawing. The bed material sediment data at the upstream of the barrage and geometric data of barrage for computer simulation was collected from Punjab Irrigation & power Department (IPD).

4.2 Data Analysis

In this study 14 years historical sediment and discharge data was analyzed by constructing graphs between average sediment (ppm) and river discharge (ft^3/sec) respectively on monthly or yearly bases and check the impact of sediment entry in low or high flow season.

Bed material sediment data of 20 sites was analyzed by taking average of 20 sites and upstream gradation curve was prepared between Grain diameter (mm) and % passing which is used to find the efficiency of silt excluder.

4.3 Design Calculation of Silt Excluder

In this study of estimation of silt excluder design of Khanki barrage, various design methods were reviewed. It was decided to make use of those methods which provide the better estimation of the geometry of excluder because of different losses has been occurred at different sections of excluder. Keeping in view the suitability of losses Manning's formula was used. Garg.[3]elaborates the design calculation of silt excluder.

I. Losses In Tunnels

By assuming the appropriate dimensions of length, width and height of tunnels losses was calculated as

a) Entrances Losses

Daugherty.[12]defined the different head lose coefficient based upon the pressure difference and convergence of streamlines from the sharp edge orifice so, that maximum velocity and minimum pressure are found.

$$hfe = Le * \left(\frac{V_1^2}{2g}\right) \quad (1)$$

Where,

hf_e = Entrance lose (m)

L_e = Entrance lose coefficient= 0.5 (for Square-edged entrance)

V_1 = Entrance velocity (m/s)

b) Friction Losses

Garg[3]described the different portion of structure where losses were found due to friction. The losses are calculated as,

I. Start of Glacises Portion.
II. Glacises Portion.
III. Losses due to change of velocity in contraction.

I. Start Of Glacises Portion

Daugherty.[12]described the detail of measurement of fluid properties based upon the energy consideration and defined different formulas for computation of energy losses. Based upon Manning's Formula

$$Lc_1 = \frac{n^2 * V_1^2 * L}{R^{1.33}} \quad (2)$$

Where,

n = Manning's roughness

V_1 = Entrance velocity (m/s) = $\sqrt{2gh}$

h = Operating head (m)

L = Length of tunnel (m)

R = Hydraulic radius of tunnel (m)

Lc_1 = Loss coefficient

And, Head lose

$$hf_1 = Lc_1 * \left(\frac{V_1^2}{2g}\right) \quad (3)$$

Where,

hf_1 = Head lose (m)

V_1 = Velocity at entrance (m/s)

II. Glacises Portion

For losses calculation at the glacises portion was same as at the start of glacises portion, but velocity was taken inside the tunnel.

$$hf_2 = Lc_2 * \left(\frac{V_2^2}{2g}\right) \quad (4)$$

Where,

hf_2 = Head lose (m)

Lc_2 = Loss coefficient

V_2 = Velocity in exit (m/s)

III. Losses Due To Change Of Velocity In Contraction

Losses due to change of velocity in contraction was calculated by assuming the appropriate contraction lose coefficient

$$hfc = Lc * \left[\left(\frac{V_2^2}{2g}\right) - \left(\frac{V_1^2}{2g}\right)\right] \quad (5)$$

Where,

hf_c = Head loss in contraction (m)

L_c = Contraction lose coefficient = 0.3 (for conical shape contraction)

V_1 = Velocity at entrance (m/s)

V_2 = Velocity at exit (m/s)

c) Exit Losses

The exit losses was calculated by taking the exit velocity head

$$hex = \left(\frac{V_2^2}{2g}\right) \quad (6)$$

Where,

h_{ex} = Exit lose (m)

V_2=Velocity at exit (m/s)

d) Total Head Lose

Total head lose is sum of all the head lose

$$hft = hfe + hf_1 + hf_2 + hfc + hex \quad (8)$$

e) Head For Submerge Flow

The head for submerge flow is calculated by taking the high flood level both at upstream and downstream

$$H = HFL\ (u/s) - HFL\ (d/s) \quad (9)$$

Where,

HFL (u/s) = High flood level at upstream (m)

HFL (d/s) = High flood level at downstream (m)

f) Working Head For Free Flow

The working head for free flow is calculated by taking high flood level, soffit level and opening at exit.

$$H\ (free\ flow) = HFL\ (u/s) - Soffit\ Level + 0.1*Opening\ at\ Exit \quad (10)$$

Where,

H (free flow) = Head for free flow (m)

HFL (u/s) = High flood level at upstream (m)

Soffit Level = Distance up to roof of tunnel from bed level of river (m)

Opening at exit = Height of tunnel at exit (m)

II. Efficiency Of Silt Excluder

Haigh.[9]defined the efficiency of Silt Excluder in the following manner, which indicates the reduction of silt intensity in the canal water as compared with that of the approach channel.

$$\textbf{Efficiency} = \left(1 - \frac{I_c}{I_f}\right)100 \quad (11)$$

Where,

I_c is the silt intensity in the canal (ppm).

I_f is the silt intensity in the approach channel (ppm).

4.1 Hydraulic Calculation

The hydraulic and sediment simulation by “SHARC” model required geometric, sediment and hydraulic data of the canal and river in an adequate historic time span. This information was used for the model construction, calibration and validation.

The model consists of a flow component, and a sediment component.The flow component determines the origin of the flow diverted to the canal, from the river to the intake. The sediment component, then computed the sediment sizes and concentration transported in the diverted flow pocket, thereby predicting the sediment load entering the intake.

To execute the calculation of SHARC model, save the model and input data file was created by entering the data in required fields. Data network was validated to ensure that necessary data entered correctly. For final results, click on calculation option and results were display below the window.The input data required for model was listed in Table 1.

Table 1 Input Data for Simulation of SHARC model

Discharge of tunnel	172 m^3/s
Bed Width	85m
Sediment concentration	2000 ppm
Manning Roughness	0.012
Mean bed slope of river	0.0001 m/m
Graduation curve of bed material	-
Side Slope	1.5
Total length of tunnels	400 m
Specific gravity of sediment	2.65
Temperature	(30ºC)

5. RESULTS AND DISCUSSIONS

As there is a direct relationship between discharge and sediment load. Analysis of data for the year of 2000 to 2013 regarding discharge and sediment concentration, indicating that sediment load was maximum during the month of July (High flow Season) and minimum in the month of June as discharge is maximum in the month of July and minimum in September (Low flow season). Fig. 3 shows that the monthly average sediment load entering into the canal varies in the range of 7735 ton /day to 31818 ton/day.

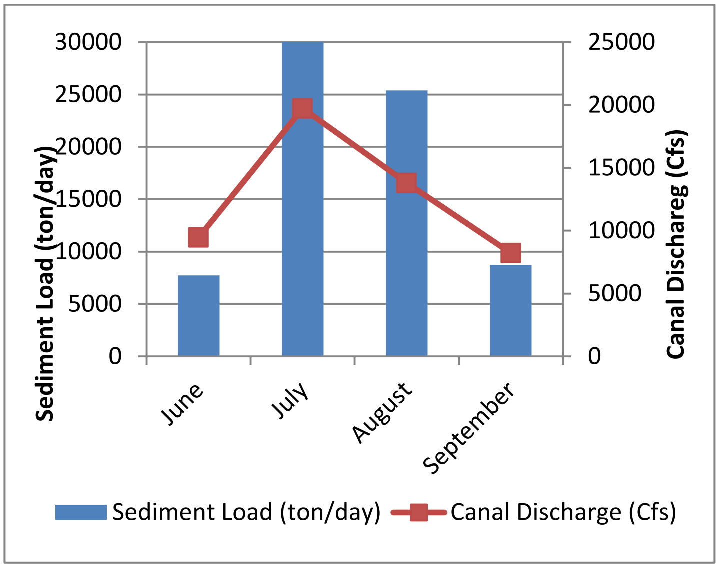

Figure 3 Monthly Avg. Discharges (cfs) Vs. Sediment Load (ton/day) entering in canal

Fig. 4 shows that the average annual discharge (ft^3/sec) vs. Sediment load (ton/day) indicating that the load was maximum during the year of 2005 and minimum in 2003 where as thedischarge was maximum in the year of 2005 and minimum in 2010 respectively. The range of load varies from 1963 ton/day to 7184 ton/day.

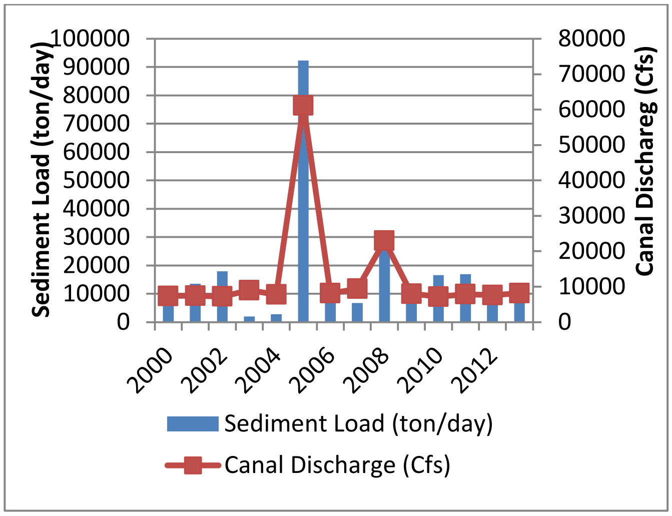

Figure. 4 Avg. Annual Discharge (cfs) Vs. Sediment Load (ton/day) entering in canal

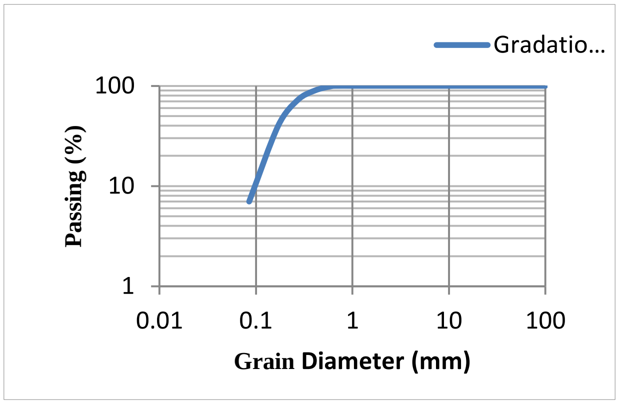

Figure 5 Upstream Gradation Curve of Khanki Barrage

Fig. 5 shows the gradation curve at upstream of barrage. This shows that particle size varies from medium silt to gravel at upstream of barrage. Table 2 shows the efficiency of silt excluder based upon the sediment size computed from the SHARC. It clearly indicates that sediment size of 0.4mm (i.e. Sand of medium size) was completely removed by the excluder against the settling velocity of 0.0645 m/s and cannot enter into the canal regulator. The upstream water depth, velocity and shear velocity computed by the hydraulic simulation of SHARC was 4.125 m, 1.587 m/s and 0.0508 m/s. Keep the extraction ratio of 90 %, the overall trapping efficiency of excluder varies from 93.5 % to 95.2%. The adoption length was 2417m and d_{50} was 0.078 mm.

Table 2 Efficiency of Silt Excluder of New Khanki Barrage

Sand size (mm)	Settling velocity (m/s)	Passing extractor (%)	Trapped (%)
0.063	0.0047	6.96	93.04
0.063	0.0047	6.96	93.04
0.075	0.0064	6.05	93.95
0.085	0.0079	5.31	94.69
0.096	0.0096	4.53	95.47
0.15	0.019	1.75	98.25
0.25	0.0374	0.19	99.81
0.35	0.0556	0.02	99.98
0.4	0.0645	0	100
0.45	0.0732	0	100
0.5	0.0817	0	100
0.55	0.0901	0	100
0.6	0.0983	0	100
0.65	0.1063	0	100

For the optimization of excluder geometry, analytical computation was done on different scenarios as by covering the 3rd bay of under sluices by 4 more tunnels and second was cover the bays No, 1 & 2 by three number of tunnels. It is clear from the table 3 that if No, 3 bay was covered with 4 number of tunnels, the water way for the same discharge was increase. There is inverse relationship between velocity and area. By increasing the water way of 172 m for the same discharge of 172 m^3/s flushing velocity would be decreased to 9.8 m/s which is not recommended for proper flushing or deposition will occurred in front of canal head regulator.

Table 3 Comparison of Velocity by covering 3 bay of Under Sluices

Parameters	2 Bay Covers	3 Bay Covers
Discharge	172 m^3/sec	172 m^3/sec
Water Way	140 m	172 m
Flushing Velocity	13.5 m/s	9.8m/s
Entrance Velocity	1.7 m/s	1.7 m/s

Table 4 shows that if three number of tunnels cover 2 bays of under sluices. The velocity was decreased to 1.02 m/s compared with 1.7 m/s of velocity and causes choking of tunnels by sediment. This also indicates that 1.02 m/s of velocity was not match with physical model studies velocity of 2 m/s and exit velocity also decreased to 1.66 m/s. Table 5 shows the comparison of analytical computation and hydraulic simulation. Taking the analytical approach as a base line percentage difference is finding out by model simulation. This indicates that model simulated results are not as reliable and not compatible with field result as percentage difference goes to negative. As in d_{50} the percentage error goes to very high up to -92.31 %. In actual field condition 0.15 mm values was predicated. Fig. 6 shows the final layout plan of silt excluder.

Table 4 Comparison of Velocity by covering 3 Tunnels of under Sluices Bays

Parameters	3 Tunnels	4 Tunnels
Discharge	172 m^3/sec	172 m^3/sec
Water Way	140 m	140 m
Entrance Velocity	1.02 m/s	1.7 m/s
Exit Velocity	1.66 m/s	3.4 m/s

Table 5 Comparison of Analytical Computation & Hydraulic Simulation

Parameters	Results		
	Analytical Approach	SHARC	%age Difference
Water Depth	4.78 m	4.125 m	-15.88%
Velocity	1.70 m/s	1.587 m/s	-7.12%
Shear Velocity	0.0533 m/s	0.0508 m/s	-4.92%
Trapping Efficiency	91%	93%-95%	-
Adoption Length	-	2417 m	-
d_{50}	0.15 mm	0.078 mm	-92.31%

Table 3 Estimated Design of New Khanki Barrage

Parameters	Symbols	Units	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8
Total Discharge	Q	m^3/s	172							
Tunnel Discharge	Q	m^3/s	22	22	22	19	20	23	23	20
Length of tunnel	L	m	81.25	72.34	63.43	54.42	45.34	36.34	27.33	18.24
Inlet Conditions										
	B_{entr}	m	4.27	4.27	4.27	3.66	3.81	4.42	4.42	3.81
	H_{entr}	m	3.05	3.05	3.05	3.05	3.05	3.05	3.05	3.05
	A_{entr}	m^2	13.01	13.01	13.01	11.15	11.62	13.48	13.48	11.62
	V_1	m/s	1.70	1.70	1.70	1.70	1.71	1.72	1.72	1.72
Exit Conditions										
	B_{exit}	m	4.27	4.27	4.27	3.66	3.81	4.42	4.42	3.81
	H_{exit}	m	1.52	1.52	1.52	1.52	1.52	1.52	1.52	1.52
	A_{exit}	m^2	6.51	6.51	6.51	5.58	5.81	6.74	6.74	5.81
	V_2	m/s	3.39	3.40	3.41	3.41	3.42	3.43	3.44	3.45
a) Enterances Losses										
	L_e	-	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	V_1	m/s	1.70	1.70	1.70	1.70	1.71	1.72	1.72	1.72
	Vh_1	m	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
	hf_e	m	0.07	0.07	0.07	0.07	0.07	0.08	0.08	0.08
b) Friction Losses										
1) Start of Glacies	n	-	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012
	Lc_1	-	0.27	0.36	0.31	0.29	0.24	0.18	0.13	0.10
	V_1	m/s	1.70	1.70	1.70	1.70	1.71	1.72	1.72	1.72
	Vh_1	m	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
	hf_1	m	0.04	0.05	0.05	0.04	0.04	0.03	0.02	0.01
2) Glacies Portion	n	-	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012
	Lc_2	-	0.34	0.30	0.27	0.25	0.20	0.15	0.11	0.08
	V_{avg}	m/s	2.54	2.55	2.56	2.56	2.57	2.57	2.58	2.58
	Vh_1	m	0.33	0.33	0.33	0.33	0.34	0.34	0.34	0.34
	hf_2	ft	0.11	0.10	0.09	0.08	0.07	0.05	0.04	0.03
c) Contraction Losses										
	V_1	m/s	1.70	1.70	1.70	1.70	1.71	1.72	1.72	1.72
	V_2	m/s	3.39	3.40	3.41	3.41	3.42	3.43	3.44	3.45
	Vh_1	m	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
	Vh_2	m	0.59	0.59	0.59	0.59	0.60	0.60	0.60	0.61
	Lc	-	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
	hfc	m	0.13	0.13	0.13	0.13	0.13	0.14	0.14	0.14
d) Exit Losses										
	V_2	m/s	3.39	3.40	3.41	3.41	3.42	3.43	3.44	3.45
	Vh_2	m	0.59	0.59	0.59	0.59	0.60	0.60	0.60	0.61
	h_{ex}	m	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18
Total Head	H	m	0.53	0.54	0.52	0.51	0.49	0.47	0.45	0.44
HFL (u/s)		m	225.2							
HFL (d/s)		m	224.7							
Soffit level		m	220							
Invert level		m	218							
Floor level		m	217							
Head for submergence		m	0.47							
Head for free flow		m	4.78							

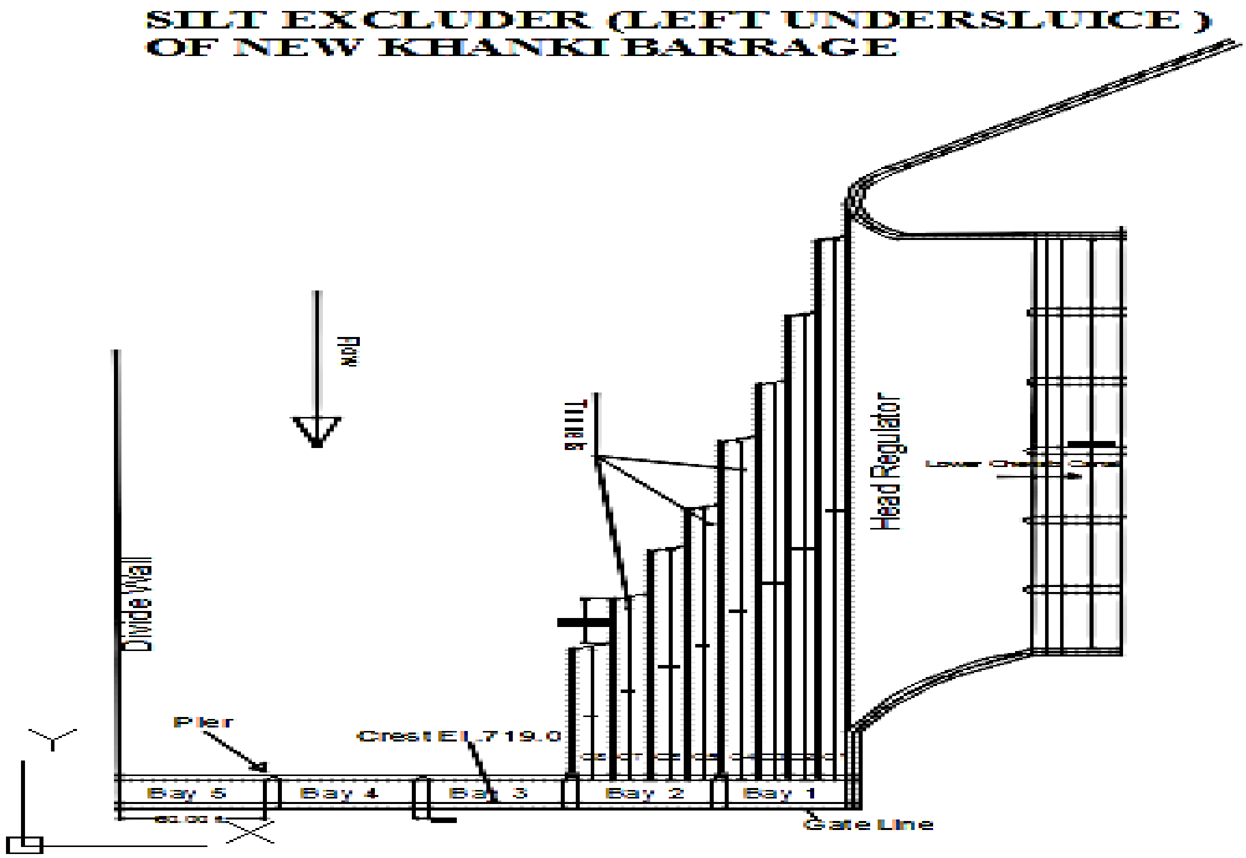

Figure. 6 Final Plan View of New Khanki Barrage

6. CONCLUSION AND RECOMMENDATIONS

In this study, we have attempted to analyze the data regarding sediment in the Khanki barrage for a period of 14 years, which indicates that the construction of silt excluder has reduced the sediment entry into the head regulator of Lowe Chenab Canal and increase the discharge. Selection of more than two bays of under sluice will increase the settling velocity and so deposition will occur in tunnels which are neither suitable nor economical as construction cost will be increased. The normal velocity in the tunnels is 1.5-2 m/s as the bed of the barrage is alluvial. Working head for free flow and minimum head for submergence is 5 m and 1 m respectively should be maintained. To exclude the maximum quantity of sediment load from the canal flows, the the operation authority of barrage should assure no turbulence will occur in the tunnels. The closure of excluder is not suggested in any case expect repair and maintenance and a minimum discharge of 5/3 part of total discharge should always be escape for their positive operation.

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