A

MAJOR PROJECT REPORT

ON

COMPUTER AIDED DESIGN

OF

TUNNEL TYPE SILT EJECTOR

A thesis submitted in partial fulfillment of the Requirement for the degree of

MASTER OF ENGINEERING
IN
HYDRAULICS AND FLOOD CONTROL ENGINEERING

Submitted By

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CERTIFICATE

This is to Certify that the Major Project Work entitled "**COMPUTER AIDED DESIGN OF TUNNEL TYPE SILT EJECTOR**" which is being submitted by **Miss. SUCHITRA RANI GAUTAM,** in partial fulfillment for the award of the degree of **MASTER OF CIVIL ENGINEERING IN HYDRAULICS AND FLOOD CONTROL ENGINEERING** is a record of student's own work carried out by her under my supervision and guidance. The matter of this project has not been submitted by the student for the award of other Degree or Diploma.

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DATE:

(SUCHITRA RANI GAUTAM)

ABSTRACT

A tunnel type silt ejector is commonly used at the downstream of head regulator of the canal to eject the sediments, which has already entered into the canal. In such ejectors, the sediment-laden water, which flows near the bed, is made to flow through the tunnels provided at the canal bed. It is then discharged into the river through outfall channel. Comparatively sediment-free water is obtained at the downstream of silt ejector. The basic hydraulic principle utilized in designing silt ejector is that the energy loss (head loss) is kept minimum and equal in all tunnels carrying equal discharge. In the present project, a silt ejector is designed based on IS-6004 guidelines

Using the guidelines of IS-6004, the present work has been planned to design a silt ejector for a canal based on the recent concept of sediment transport through closed conduit. The present project work has been planned with the following objectives:

(a) To collect the data for designing sediment ejector from the executing agency in the field.

(b) To design the components of silt ejector, particularly tunnels and sub-tunnels, based on the existing sediment transport concept through the closed conduit.

(c) To develop a computer program in C++ language to make the design of sediment ejector easier as several trails are involved for setting the efficient structure

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CHAPTER-1

INTRODUCTION

1.1 GENERAL

The river in erodible valleys carry huge sediment load during the floods. The channel which take off from the source like diversion headworks draw heavy sediments particularly during the flood. These off taking channel cannot carry the sediments in suspension due to their slopes being milder than that of the river. This results in silting of channel in the head reaches. The entry of the coarse particles in the power channel may, in addition, cause wear and tear to turbine blades. The exclusion of these sediments from the canal is utmost important to make the channel cross-section free from silting and turbine with undesirable damage.

A silt ejector is a hydraulic structure constructed in a canal bed (used for many purpose like irrigation, power generation) to eject out the sediment, which has already entered into the canal. The sediment ejector are based on the principle that the concentration of sediment in the flow is maximum in the bottom layers and if these layers are extracted through a silt ejector, relatively clear water is obtained downstream of ejector.

1.2 CLASSIFICATION OF SEDIMENT CONTROL MEASURES:

The various means of controlling sediment into the canal and ejecting that enters the canal may be categorized as follows:

1.2.1 Sediment Preventive Measures

One of the most commonly used preventive measures is the sediment excluder. The excluder is constructed in the river bed in front of the canal head regulator to prevent, as far as possible, excess sediment entering in the offtaking canal.

1.2.2 Sediment Curative Measures

Some of the devices like silt ejector, settling basin are used to eject out the already entered silt in the canal. The brief discussion about these devices are given below: -

(b) **Sediment ejector-** It is constructed in the head reaches of approach channel. It also takes the advantage of vertical sediment concentration distribution and removes the bc layers laden with high sediment concentration. see Fig: 1.1. The ejector should neither be too far nor too near from the head regulator. The main components of an ejector include a diaphragm slab, tunnels & sub-tunnels, control structure, and outfall channel. The escape discharge along with ejected sediment is discharged back to the downstream of weir through an outfall channel. The detailed design considerations are described in IS 6004-1980. The design procedure outlined in the code is based on the thumb-rule based on past experience. The sediment transport carrying capacity of the tunnels and sub-tunnels is based on the concepts of limiting velocity only.

(c) ***Settling basin***: - In a settling basin, constructed near the bed of canal, the flow velocity is reduced considerably by expanding the cross sectional over the length of the basin. The reduction in the velocity, accompanied with reduction in the shear and turbulence, stops the movement of the bed materials and also causes the suspended material to deposit on the setting basin, see Fig:1.2. The deposit material on the bed of settling basin should be removed by some means. The detailed design procedures of settling basin has been described by Grade et al. (1990)

1.3 SCOPE OF WORK

The present work has been planned to design a silt ejector for a canal based on the recent concept of sediment transport through closed conduit. The present project work has been planned with the following objectives:

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(b) To design the components of silt ejector, particularly tunnels and sub-tunnels, based on the existing sediment transport concept through the closed conduit.

(c) To develop a computer program in C++ language to make the design of sediment ejector easier as several trails are involved for setting the efficient structure

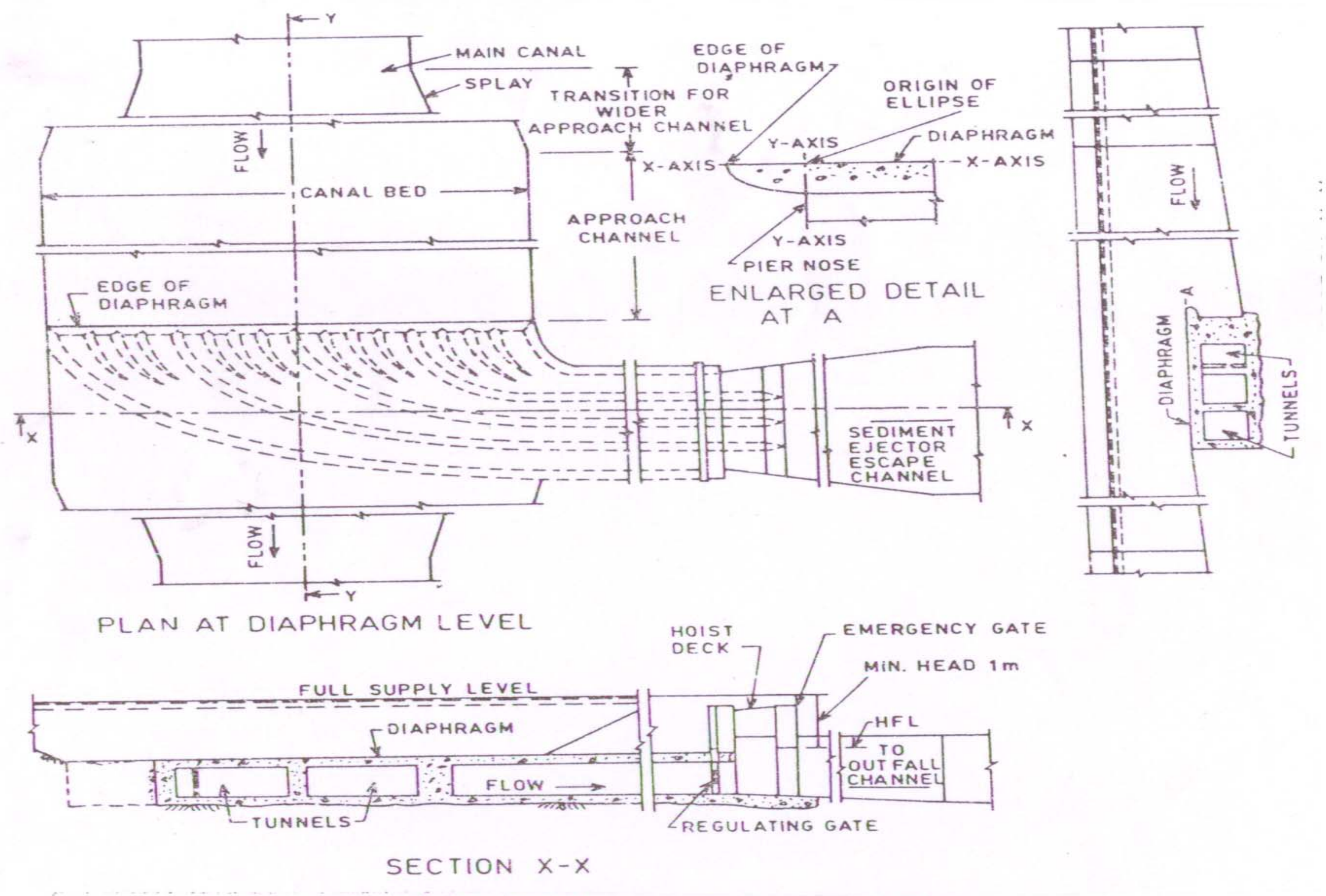


Fig. 1.1: Typical Layout of a Sediment Ejector

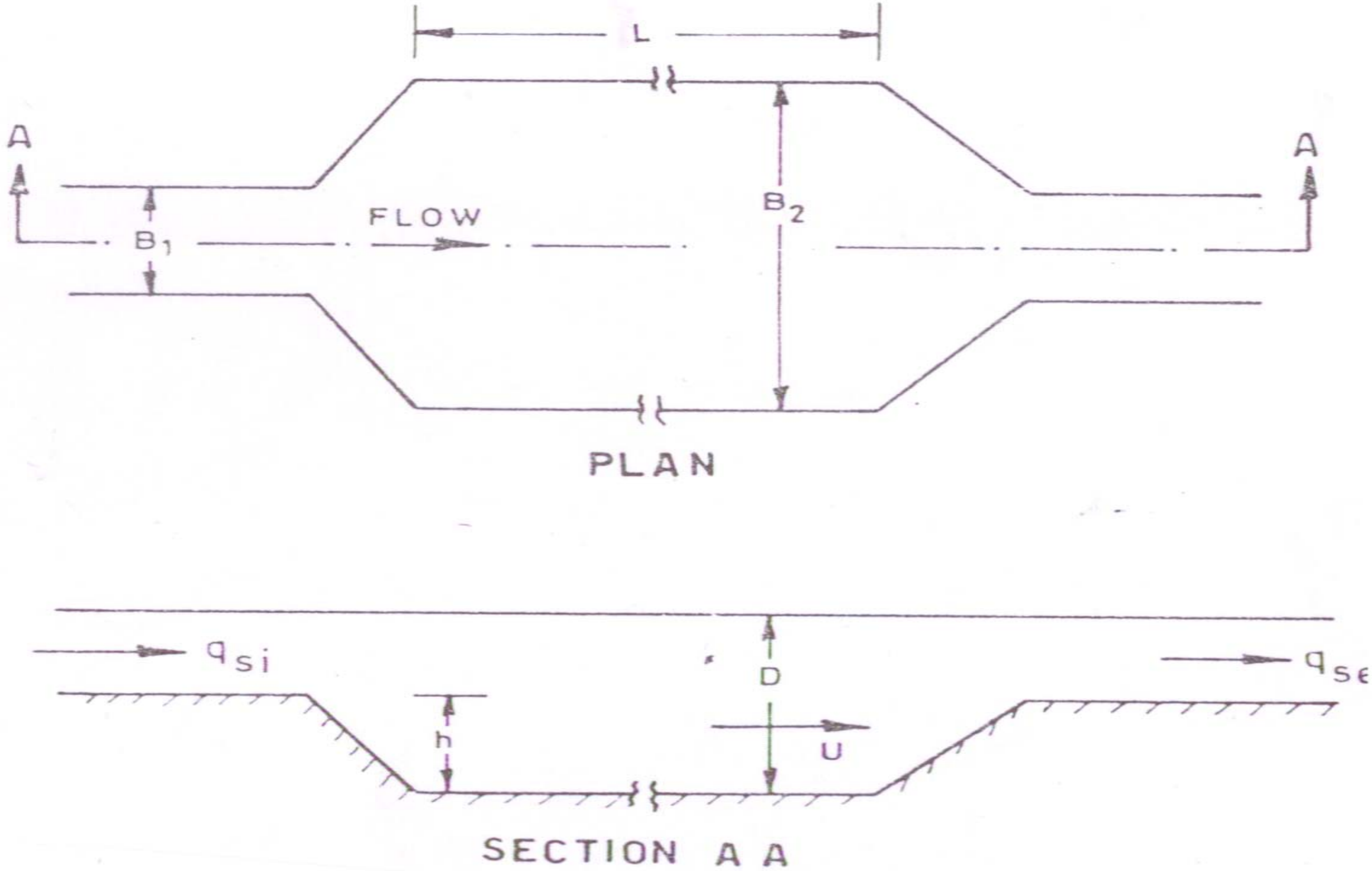


Fig. 1.2: Settling basin – Definition Sketch

CHAPTER-2

REVIEW OF LITERATURE

2.1 GENERAL

Despite measures, which may be taken to prevent sediment entry into the canal, a part of the suspended sediment of the river would always enter the canal. If the sediment carrying capacity of the canal is not adequate to carry this sediment, the canal would be silted. In such cases ejectors are provided in the head reaches to eject part of the coarse sediment that entered the canal.

2.2 DATA REQUIRED

The following data relating to the canal are needed for design of sediment ejector:

2.2.1 Canal Data

(a) Cross section and other design data of the canal upstream and downstream of the proposed location.

(b) Canal discharge.

2.2.2 Sediment Data

(a) Silt load both suspended and bed load daily, fortnightly or monthly, as available. For suspended silt, data should be available at different depths along at least three equidistant verticals across the width, at the proposed site of the ejector. The bed load should be observed up to 0.2 d, where d is the depth of water (subject to a maximum of 0.5 m) and

(b) Permissible size of silt can safely be allowed downstream of the silt ejector. In case of power channels generally sediment size larger than 0.2 mm is intended to be ejected and

2.2.3 Data for Design of the Outfall Channel:

(a) Contour plan,

(b) Cross sections,

(c) Stage discharge curve and the hydrograph of the stream at the outfall and

(d) Discharge capacity.

2.3 DESIGN CONSIDERATIONS:

Indian standard code IS 6004-1980 deals with the criteria for hydraulic design of tunnel type sediment ejector for irrigation and power channels. The design consideration of silt ejector is described in the following subparagraphs:

2.3.1 Approach Channel

The approach channel upstream of the ejector should be straight and without any obstruction. Anything in the form of a curve or a kink shall change the sediment concentration across the channel and disturb the uniform distribution of flow in front of the ejector. This results in low efficiency and even in choking of a few ejector tunnels.

In order to concentrate the sediment charge in the bottom layers, the bed of the canal depressed by 0.3 to 0.5 m (approximately 1 in 100 slope of bed) at the mouth of the ejector so that bed load may be trapped.

2.3.2 Location of Ejector

- The approach channel upstream of the silt ejector preferably be straight as otherwise it is likely to change the sediment concentration across the channel, and disturb the uniform distribution of the flow in front of the silt ejector.
- In certain unavoidable cases where silt ejector has to be provided in the curved reaches of the channel, it should be done after conducting model studies.
- The silt ejector should not be sited too near the head regulator as the residual turbulence may cause the sediment load to remain in suspension and prevent its ejection to the desired extent, at the same time it should not be far away from the head reach otherwise the sediment may settle down in earlier reaches and reduce the channel capacity upstream.

- The ejectors designed for the canal, taking off from boulder stage river, should be sited at a distance of 150m to 300m from the head regulator (about 4 to 8 times the canal width). In the alluvial stage, this distance should be increased to about 600m or more.
- The working head available, i.e. the difference in the water level in the canal upstream of the silt ejector and the outfall channel at the exit of ejector tunnel, shall be sufficient to extract the desired sediment. A working head of about 1 m is generally satisfactory for the purpose.
- While deciding the location of the silt ejector, availability of suitable outfall channel has to be kept in view.

2.3.3 Diaphragm

The Diaphragm should be so placed that it should cause least disturbance in front of the ejector tunnels so as not to disturb the normal sediment distribution in the vertical plane at its edge when the ejector is drawing its due share of discharge. In fixing the diaphragm level due consideration should be given to the following factors:

- Desired sediment size to be trapped and extracted,
- Bed level and size of tunnels,
- Thickness of diaphragm, and
- Bed level of canals downstream of the silt ejector.

It is desirable to place the diaphragm at the downstream bed level of the canal. However, if the diaphragm has to be place higher from other considerations , the conditions for all particularly for low supplies should be checked and, if necessary, proper energy dissipation arrangements provided.

The diaphragm should be properly tied to the support as otherwise the diaphragm is likely to be dislodge. Prototype measurements of sediment distribution in channels have indicated that concentration of coarse sediment usually persists in $1/3^{rd}$ to $1/4^{th}$ of the depth of flow. As such, the height of the diaphragm in most of the ejectors has been kept in this range.

2.3.4 Shape and Projection of Diaphragm

The diaphragm is extended beyond the pier nose by about twice its thickness and is suitably streamlined conforming to quadrant of the ellipse,

$$\frac{x^2}{4a^2} + \frac{y^2}{a^2} = 1 \qquad (2.1)$$

where,

a = thickness of diaphragm slab,

2.3.5 Main tunnel and Sub-tunnel

- The ejector should normally span the entire width of the canal and shall be divided into a number of compartments of tunnels by vanes gradually converging so as to accelerate the escaping flow for delivering it to the outfall channel on one side of the canal.
- These main compartments shall be subdivided into smaller compartments or sub-tunnels by vanes of radii varying from 3 to 4 times the width of sub-tunnels to avoid cross flow in the transition section.
- The upstream noses of vanes shall have cut water shapes. Downstream end of vanes shall be fish tailed.
- The tunnel dimensions at the entry and exit shall be so fixed as to ensure velocities that would carry the size of sediment to be removed.
- The section of the sub-tunnel at the entry shall be so chosen that the velocity of flow at the intake is slightly higher than the velocity of bottom filaments of water upstream of the ejector.
- The section of sub-tunnels up to their exit, where these end into the main tunnels, shall be reduced gradually in such a way that there is an over all increase of 10 to 15 percent in velocity of emerging flow.
- At the exit of sub-tunnels the section of the main tunnel, shall be designed such that the flow velocities of the combined discharge are not, less than the velocities emerging out from the sub-tunnels. The section at the exit of the main tunnels shall be so designed as to attain a velocity of 2.5 to 6 m/s depending on the grade of sediment to be ejected.
- The depth of the main tunnels should be kept about 1.8 to 2.2 m to facilitate inspection and repair work. Their width should be so adjusted as to have equal losses, in each tunnel. The tunnels shall be designed to run full bore to secure maximum efficiency.
- A triangular distribution of sediment concentration can be assumed at the mouth of the ejector to work out the quantity of sediment entering the ejector.

- In addition to the points mentioned above, in fixing the dimensions of tunnels, it should be kept in mind that all the main tunnels has minimum and equal head loss and carrying equal discharge through each of them.

2.3.6 Losses in Tunnels

These loses include friction losses and losses due to bends and those due to transitions in contractions or expansions.

These losses are briefly described in subsequent paragraph:

Friction losses – These shall be computed by the Manning's formula:

$$h_f = \frac{(V^2 n^2 L)}{R^{4/3}} \qquad (2.2)$$

where,

h_f = head losses in m,

V = average velocity in m/s

L = length of tunnel in m,

n = rugosity coefficient of the tunnel surface and

R = hydraulic mean radius in m.

Loss Due to Bend – It shall be calculated by the following equation:

$$h_b = \frac{FV^2}{2g}\frac{\theta}{180} \qquad (2.3)$$

where,

h_b = head loss due to bend in m,

$F = 0.124 + 3.104\,(S/2R)^{1/2}$

S = av. width of tunnel in m,

R = radius of the bend along center line of tunnel in m,

g = acceleration due to gravity in m/s^2, and

θ = angle of deviation in degrees.

Contraction Losses-- It shall be obtained by the following equation.

$$h_e = 0.1\left(\frac{V_1^2}{2g} - \frac{V_2^2}{2g}\right) \quad (2.4)$$

where,

h_e = head loss due to contraction in m ,

V_2 = average velocity at the exit of transition in m/s, and

V_1 = average velocity at the entrance of transition in m/s,

Expansion losses – These shall be computed by the following equation

$$h_e = 0.2\left(\frac{V_1^2}{2g} - \frac{V_2^2}{2g}\right) \quad (2.5)$$

where,

h_e = head loss due to contraction in m,
V_2 = average velocity at the exit of transition in m/s, and
V_1 = average velocity at the entrance of transition in m/s,

2.3.7 Sediment Transport Capacity

The following design procedure calculate the sediment transport capacity:

(a) The velocity in the ejector tunnels, U_{ex} is chosen to lie between the critical velocity U_c (at which sediment starts moving) and the limiting deposit velocity U_L (at which no sediment will be deposited) for the maximum sediment size, d_m. The critical velocity U_c is given as:

$$\frac{U_c}{\sqrt{\frac{\Delta\rho_s}{\rho} g d_m}} = 1.6\left[\frac{R_{ex}}{d_m}\right]^{1/8} \quad (2.6)$$

and the limiting deposit velocity is given as

$$U_L = F_1\sqrt{8gR_{ex}(S_s - 1)} \quad (2.7)$$

where,

S_s = ρ_s/ρ
ρ_s = the mass density of sediment,

ρ = the mass density of water,

R_{ex} = the hydraulic radius of the ejector tunnel.

and, F_1 depends on the concentration and size distribution of sediment. For uniform sediment F_1 can be approximated as unity.

(b) If the ejector velocity U_{ex} is greater than U_L there will be no deposition of sediment in ejector. However, the value of U_L is generally large and, hence, U_{ex} is usually less than U_L and, therefore the ejector tunnels are partially blocked. The free flow area in such a case can be calculated from:

$$\frac{U_{fex}}{\sqrt{4gR_{fex}}} = \frac{U_L}{\sqrt{(4gR_{ex})}} \qquad (2.8)$$

where $$U_{fex} = \frac{Q_{ex}}{(B_{ex}D_{fex})} \qquad (2.9)$$

and $$R_{fex} = \frac{B_{ex}D_{fex}}{2(B_{ex}+D_{fex})} \qquad (2.10)$$

Thus, combining Eqs. (2.7 – 2.10) one gets

$$\frac{Q_{ex}^2\left(\frac{1+D_{fex}}{B_{ex}}\right)}{gD_{fex}B_{ex}^2} = 4F_1^2(S_s-1) \qquad (2.11)$$

Here, the suffix ‘fex’ refers to the free (i.e. unblocked) flow area available, and the suffix ’ex’ refers to the ejector. B, D and Q are, respectively, the width, depth and discharge of ejector. Using the above equations, D_{fex} can be calculated. Hence, the blockage of the tunnels is obtained as $D_{ex} - D_{fex.}$

(c) The carrying capacity of ejector is calculated using Gibert-Condolios equation:

$$C_v = \frac{(J-J_o)}{J_o\phi} \qquad (2.12)$$

Swamee & Ojha Equation

$$V^* = \frac{V}{\left\{\frac{(p_s-pw)}{(pw)d^3}\right\}^{0.5}} \qquad (2.13)$$

$$\omega = \sqrt{(s-1)gd}\{[(18\nu_*)^2 + (72\nu_*)^{1.7} + 1.43\times10^6]^{-0.346}\}^{-0.1} \qquad (2.14)$$

$$\omega_o = V^* = \frac{\omega^*}{\left\{\frac{(p_s - pw)}{(pw)d^3}\right\}^{0.5}} \quad (2.15)$$

$$R_s = \frac{\omega_o}{v} dn \quad (2.16)$$

DRAG COEFFICIENT:

$$C_\rho = 0.5\left\{16\left[\left(\frac{24}{R_s}\right)^{-1/6} + \left(\frac{130}{R_s}\right)^{0.72}\right]^{2.5} + \left[\left(\frac{40,000}{S_s}\right)^{-2} + 1\right]^{-0.25}\right\}^{0.25} \quad (2.17)$$

RESISTANCE COEFFICIENT

$$f = \left\{\left(\frac{64}{R_e}\right)^8 + 9.5\left[\ln\left(\frac{ks}{3.7D} + \frac{5.74}{R_e^{0.9}}\right) - \left(\frac{2500}{R_e}\right)^6\right]^{-16}\right\}^{0.125} \quad (2.18)$$

$$R_e = \frac{VD}{\nu}$$

Where,

K_s = Average height of the roughness

R_e = Reynolds number

$$\phi = 150\left[\frac{(U_{fex}^2 \sqrt{Cd}}{4gR_{fex}(S_s - 1)}\right]^{-3/2} \quad (2.19)$$

where,

J = Head loss in ejector tunnel due to sediment water mixture and can be taken as difference of upstream and downstream total energy line

$$J = \left(\frac{\Delta h}{\Delta L}\right)_m \quad (2.20)$$

Jo = head loss due to clear water for same set of ejector tunnels

$$J_o = \frac{fU_{ex}^2}{8gR_{ex}} \qquad (2.21)$$

2.3.8 Control Structure

The discharge from the sediment ejector is controlled by set of emergency and regulating gates. It would be desirable to operate these gates fully open or fully closed. In case any of the tunnels gives an indication of variation in discharge, the gate opening should be adjusted to pass equal discharge through each tunnel.

2.3.9 Outfall Channel

The outflow from the ejector is led to a natural drainage through an outfall channel. The outfall channel should be designed to have a self cleaning velocity so that the ejected material is transported without deposition. Adequate drop between the full supply level of the outfall channel at its tail end and the normal high flood level of the natural stream is desirable for efficient functioning of the channel.

The section of the escape channel should be so designed as to have adequate capacity to transport the total quantity of sediment entering it .

The discharge through escape channel is regulated by providing gates at the tail end of main tunnels . In case any of the tunnels gives an indication of variation in discharge , the gate opening should be adjusted to pass equal discharge through each tunnel.

2.3.10 Escape Discharge

The escape discharge will be governed by the following considerations:

a) Discharge required to remove the desired sediment size and load

b) Minimum discharge required for flushing individual tunnels.

Generally, an escape discharge equal to 10 to 20 percent of the full supply discharge of the canal downstream of the ejector will be adequate for this purpose.

2.3.11 Flushing

During the period when sediment ejector is not required to function, it is desirable to operate the regulation gates occasionally for short periods to flush the tunnels consistent with the economy in water requirements for irrigation and power generation. Otherwise, the tunnels are likely to get choked and may require manual clearance which may be possible only during closure of the canal.

At times during the normal operation of the sediment ejector, the approach channel or tunnel or both may require flushing. This may be done by running the tunnels in rotation to achieve higher velocities.

2.3.12 Hydraulic Model Studies

There are many unknown factors in the design of the silt ejectors, such as the capacity of the silting basin in the approach channel, layout of the sub tunnels and main tunnels, flushing velocity for the particular characteristics of the sediment to be ejected, and flow pattern of the bottom

layers of the discharge etc. As such it is essential that the layout based on the theoretical design be checked by model studies to ascertain the adequacy of the silt ejectors.

CHAPTER-3

SOURCE OF DATA

3.1 GENERAL

This chapter includes the data obtained from an existing prototype structure. The data related to the hydraulic as well as sediment has been used for illustrating the computer-aided design of silt ejector.

These data include the variable, namely canal discharge, bed width, bed slope, full supply depth, bed level, side slope of canal and sediment load. These data have been compiled for Tanakpur barrage site on Sharda River.

The data related to the geometry and hydraulic characteristics are included in Table 3.1.

Table 3.1 : Input Data for Design of Ejector

Design Discharge Capacity	680 cumecs u/s of silt ejector 566 cumecs d/s of silt ejector
Bed Width of canal	41.915m u/s of silt ejector 12.5m d/s of silt ejector
Bed level of power canal	240.235m at beginning 236.555m at end
Bed slope	1:8300 u/s of silt ejector 1:10500 d/s of silt ejector
Full supply depth	6.14m u/s of silt ejector
Side slope	1.5 H:1V
Size of particle to be removed	0.5 mm

through silt ejector

Manning’s Coefficient “n” 0.016

value for concrete lining

The detail of sediment measurement in the existing power canal has been included in Appendix ’ A’.

CHAPTER- 4

ANALYSIS OF DATA

4.1 GENERAL

The different components of silt ejector as discussed in chapter-2 are designed based on the data enumerated in chapter-3. The location of approach channel in the canal bed and the depth of water in front of sediment ejector has been calculated. Also, the geometry of the main-tunnel and sub-tunnel has been decided to carry the flow into escape channel smoothly.

The sediment ejector has been designed in such a way so that:

(a) All the sub-tunnels and main tunnels carry equal discharge.

(b) The head loss through each main tunnels and sub-tunnels should be same for all the main tunnels and sub-tunnels.

(c) The sediment transport carrying capacity of the ejector should be more than the likely load to enter into the tunnels

(d) Blockage of tunnels should be within permissible limits

4.2 FIXATION OF GEOMETRY OF SUBTUNNELS AND MAIN TUNNELS

The sub-tunnel and main tunnel have been designed with rectangular cross-sections. The sub tunnels are aligned as circular arc and the complete deviation of ejector tunnels is achieved at their end. However, these sub tunnels, end into the main tunnel which are straight in alignment and ends into escape channel. The mathematical equations for the subtunnel geometry and their parameters are included in succeeding paragraphs.

4.2.1 Computations of outer and inner radii of sub tunnels (Ref. Chapter 5)

4.2.2 Computation of End Width of Subtunnels (Ref. Chapter 5)

4.3 DEVELOPMENT OF SOFTWARE FOR SEDIMENT EJECTOR DESIGN

A computer program has been written in C++ language to design the sediment ejector based on the principle described in chapter – 2 and satisfy the condition enumerated in section 4.1 and 4.2 above. The flow chart of the program in shown fig 4.1, however, the detailed coding of the program is shown in Appendix ‘A’. The detailed design calculations for the selected trial is described in succeeding sections.

4.4 APPROACH CHANNEL

CALCULATION OF DEPTH & VELOCITY OF FLOW:

STEPS:

- Calculate $E_1 = y_1 + \frac{U_1^2}{2g} = y_1 + \frac{Q_c^2}{2gA_1^2}$ (4.1)

  $A_1 = (B + my_1)y_1$

  $y_1 = 6.14$

  $B = 41.915$

  $m = 1.5$

  $Q_c = 680\ m^3/sec$

  $E_1 = 6.379\ m$

- Calculate $E_2 = E_1 + \Delta Z$ (4.2)

  $\Delta Z = 0.46\ m$

  $E_2 = 6.839\ m$

- Calculate y_2 by trial & error from the following equation

  $E_2 = y_2 + \frac{Q_c^2}{2gA_2^2}$ (4.3)

  $A_2 = (B + my_2)y_2$

  $Q_c = 680\ m^3/s$

  $m = 1\ V : 1.5\ H$

$B = 41.915$ m

$y_2 = 6.658$ m

Calculate y_2 by hit -& -trial.

- Calculate , $U_2 = \frac{Q_c}{A_2}$. (4.4)

where,

E_1 = Energy head at section 1-1

E_2 = Energy head at section 2-2

y_1 = Depth of flow in the canal

y_2 = Depth of flow in the approach channel

U_1 = velocity of flow in the canal

U_2 = velocity of flow in the approach channel

A = area of section

Q_c = Discharge in cumecs.

B = Bed width of canal

m = side slope .

ΔZ= Depression in canal bed.

- The ejector is provided at a distance of 251.50 m from head regulator (6 times upstream bed width of canal). (ref.2)
- The canal bed just u/s of silt ejector is depressed by 0.46m at a slope of 1 in100 to eject the bed load concentration upstream of ejector.
- Design discharge of silt ejector = 25% of upstream discharge of canal $= \frac{25 \times 680}{100} = 170\ m^3/s$
- Area of cross-section of channel upstream of silt ejector = (B + m y) y = (41.915+1.53 6.14) 6.14

  $= 313.90\ m^2$

- Mean velocity of flow = Discharge / Area of cross- section = 680/313.90 = 2.17 m/s

4.4 DIAPHRAGM

The diaphragm is extended beyond the pier nose by about twice its thickness and is suitably streamlined conforming to quadrant of the ellipse, see fig. 2.1

$$\frac{x^2}{4a^2}+\frac{y^2}{a^2}=1 \qquad (4.5)$$

where

a = thickness of diaphragm slab,

a = 400 mm

The complete profile of diaphragm nose at the entrance is calculated from eq. (4.5) and shown in Table 4.1

Co-ordinate of ellipse:

X	Y
0	400
200	237.3
400	346.4
600	264.6
700	193.6
750	139.19

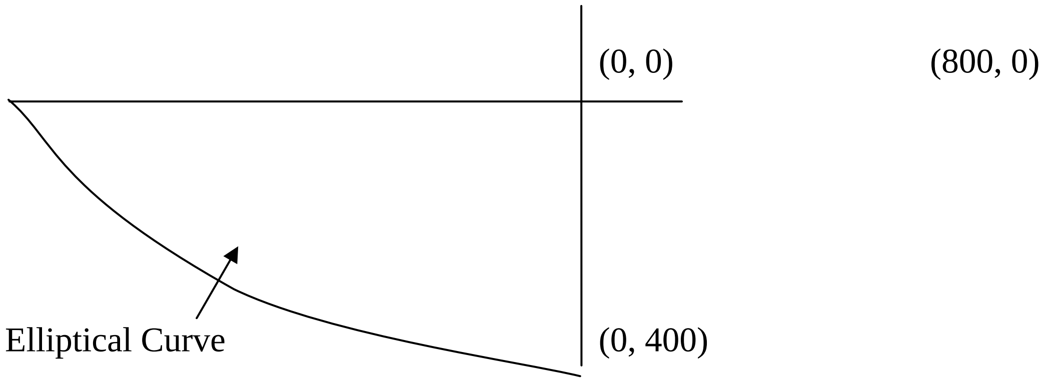


Fig. 4.1 : Profile of Diaphragm

4.5 TUNNEL & SUB-TUNNEL

STEPS:

- Decide the thickness of pier at the entrance (vane) : t

  $t = 1.4$ m

- Decide the number of main tunnels (n_1) and sub-tunnels(n_2).

  $n_1 = 3$ $n_2 = 3$

- Calculate the discharge through ejector (Q_{ej})

  Q_{ej} =25 % of canal discharge (upstream) (4.6)

  $Q_{ej} = 0.25\times Q_c = 0.25\times 680 = 170\ m^3/s$

- Calculate the discharge through each sub-tunnel(Q_{sub}):

$$Q_{sub} = \frac{Q_{ej}}{(n_1 \times n_2)} \tag{4.7}$$

  $Q_{sub} = 18.88\ m^3/s$

- Calculate clear width of ejector at the entry:

  B_{ej1} = total canal width – $((n_1 n_2 - 1)\ t)$ (4.8)

  Total canal width = 41.915 m

  $B_{ej1} = 30.715$ m

- Assume height of tunnel at entry D_1. It should not be less than 1.8 mm

  $D_1 = 1.8$ mm

- Decide the percentage of blockage (B_p) and calculate the free flow depth at entry D_{fex1} from the following equation:

$$B_p = \frac{D_1 - D_{fex1}}{D_1} \times 100 \tag{4.9}$$

  $B_p = 40\%$

  $D_{fex1} = 1.08$ m

- Clear width of sub-tunnel at the entry:

$$B_1 = \frac{B_{ej1}}{(n_1 n_2)} \qquad (4.10)$$

$B_1 = 3.412$ m

- Calculate the area of cross section of sub-tunnel at entry:

$$A_1 = D_1 \; B_1 \qquad (4.11)$$

$A_1 = 6.14 \text{ m}^2$

- Velocity at the entry: $V_1 = \frac{Q_{sub}}{A_1} = 3.073$ (4.12)

V_1 should be between 10 to 15 % more than the velocity of the bottom filament in approach channel as per code

- Calculate the outer radius of curvature (R) of sub-tunnel

$$R = 3.5 \, B_1 = 11.94 \qquad (4.13)$$

- Decide the value of ' α '.

The value of α is so chosen as the flow interval is deviated fro 60° to 80° from original flow in the canal.

$$\alpha = 90 - x \qquad (4.14)$$

where,

x = angle of tunnel with horizontal

$x = 23°$ $\alpha = 67°$

- Calculate ' β ' by hit and trial method from eq. (5.1):

$$R \sin\alpha \cos\beta = (R \cos\alpha - (R - t)) \sin\beta + R \sin\alpha \qquad (4.15)$$

$\beta = 56°$

- Calculate inner radius (r):

$$r = R\left(\frac{\sin\alpha}{\sin\beta}\right) \qquad (4.16)$$

r = 13.28 m

- Calculate m_1

$m_1 = \tan\alpha$

$m_1 = 2.355$

- Calculate b [Ref. eq. No. (5.6)]

$b = R + B_1 - r$

R = 11.94 m

$B_1 = 3.412$ m

r = 13.288 m

b = 2.06 m

- Calculate c [Ref. eq. No. (5.7)]

$c = m_1 b$

c = 4.85 m

- Calculate (x_2, y_2) and (x_3, y_3) and B_2 from eq. (5.10, 5.11, 5.13 and 5.14) respectively.

B_2 = clears width of sub tunnel at exit

$B_2 = 3.07$ m

- Calculate the width of main tunnel at exit

$B_{22} = n_1 \times B_2$ $\qquad$ $n_1 = 3$

$B_{22} = 9.2$ m

- Calculate velocity at the exit of sub tunnel V_2 and kept in between 10% to 15% of V_1

$V_2 = 1.15\ V_1$

$V_2 = 3.5339$ m/s

- Calculate area of Cross section A_2

$$A_2 = \frac{Q_{sub}}{V_2}$$

$A_2 = 5.34\ m^2$

- Calculate the height of sub-tunnel (D_2) at the exit:

$$D_2 = A_2 / B_2 \tag{4.17}$$

$D_2 = 2.615$ n

- Calculate width of ejector at exit of sub tunnel

$B_{ej2} = n_1 \times n_2 \times B_2$

$B_{ej2} = 18.387$ m

- Calculate D_{fex2} from the following eq.

$$Q_{ej}^2 \left(1 + \frac{D_{fex2}}{B_{ej2}}\right) = 4F_1 (S_s - 1) g D_{fex2}^3 B_{ej2}^2 \tag{4.18}$$

$Q_{ej} = 170\ m^3/s$

$F_1 = 1$

$g = 9.81$

$S_s = 2.65$

$B_{ej2} = 18.387$

$D_{fex2} = 1.569$ m

- Calculate the curvature length of sub-tunnel (L_{cur}):

$$L_{cur} = R\pi \frac{\alpha}{180} \tag{4.19}$$

$R = 11.94$, $\alpha = 67$

$L_{cur} = 13.96$ m

- Calculate the straight length of tunnel after the curvature:

$$L_1 = \frac{\{B_1 n_2 + t(n_2 - 1)\} n_1 + t(n_1 - 1)}{\cos x^o} \quad (4.20)$$

$$L_2 = \frac{\{B_1 n_2 + t(n_2 - 1)\} (n_1 - 1) + t(n_1 - 2)}{\cos x^o} \quad (4.21)$$

$$L_3 = \frac{\{B_1 n_2 + t(n_2 - 1)\} (n_1 - 2) + t(n_1 - 3)}{\cos x^o} \quad (4.22)$$

Suffix 1, 2, 3 denotes for tunnel 1, 2, 3 respectively.

B_1 = 3.412 m

n_1 = 3

n_2 = 3

x° = 23

L_1 = 45.537 m

L_2 = 29.851 m

L_3 = 14.165 m

- Calculate the total length of tunnel up to the start of escape channel:

$L_{11}=L_{cur}+L_{11}$; (4.23)

$L_{22}=L_{cur}+L_{22}$; (4.24)

$L_{33}=L_{cur}+L_{33}$; (4.25)

Suffix 11, 22, 33 denotes for tunnel 1, 2, 3 respectively.

L_{11} = 59.49 m

L_{22} = 43.813 m

L_{33} = 28.127 m

- Calculate the discharge through main tunnel =Q_{main}

$$Q_{main} = \frac{Q_{ej}}{n_1}; \quad (4.26)$$

Q_{main} = 56.66 m^3/s

- Decide the width of tunnel –1 at the end = B_{end1}

B_{end1} = 8.5 m

- Calculate the velocity at the end

$$V_{en} = \frac{Q_{main}}{B_{end1} D_2} \quad (4.27)$$

V_{en} = 3.5 m/s

Velocity should not exceed more than 6 m/s.

- Calculate the head loss through main tunnel-1

h_{f1} = friction loss + contraction loss

$$hf_1 = \frac{\left(\frac{V_2 + v_{en}}{2}\right)^2 n^2 L_1}{\left(\frac{R_1 + R_2}{2}\right)^{4/3}} + 0.1\left(\frac{V_{en}^2}{2g} - \frac{V_2^2}{2g}\right) \quad (4.28)$$

$$R_1 = \frac{B_{22} D_2}{2(B_{22} + D_2)} \quad (4.29)$$

$$R_2 = \frac{B_{end1} D_2}{2(B_{end1} + D_2)} \quad (4.30)$$

B_{22} = 9.2 m

D_2 = 2.6150 m

B_{end1} = 8.5 m

R_1 = 0.91648 m

R_2 = 0.88502 m

V_{en} = 3.939 m/s

n = 0.016

L_1 = 45.537 m

V_2 = 3.5339 m/s

hf_1 =0.205 m

- Equate the head loss of first tunnel equal to head loss of second tunnel i.e., sum of friction losses and contraction losses get the velocity of at the end (V_{22}).

$$h_{f1} = \frac{\left(\frac{V_2 + V_{22}}{2}\right)^2 n^2 L_2}{\left[0.25 \frac{\left(B_2 + \frac{Q_{main}}{V_2 D_2}\right) D_2}{\left(\frac{B_2 + \frac{Q_{main}}{V_2 D_2}}{2}\right) D_2}\right]^{4/3}} + 0.1\left(\frac{V_{22}^2}{2g} - \frac{V_2^2}{2g}\right) \tag{4.31}$$

$V_{22} = 4$ m/s

- Calculate width of tunnel –2 at the end = B_{end2}

$$B_{end2} = \frac{Q_{main}}{V_2 D_2} \tag{4.32}$$

$B_{end2} = 7.45$ m

- Equate the head loss of first tunnel equal to head loss of third tunnel i.e., sum of friction losses and contraction losses get the velocity of at the end (V_{33}).

$$h_{f1} = \frac{\left(\frac{V_2 + V_{33}}{2}\right)^2 n^2 L_3}{\left[0.25 \frac{\left(B_2 + \frac{Q_{main}}{V_{33} D_2}\right) D_2}{\left(\frac{B_2 + \frac{Q_{main}}{V_{33} D_2}}{2}\right) D_2}\right]^{4/3}} + 0.1\left(\frac{V_{33}^2}{2g} - \frac{V_2^2}{2g}\right) \tag{4.33}$$

$V_{33} = 5.1$ m/s

- Calculate width of tunnel –3 at the end = B_{end3}

$$B_{end3} = \frac{Q_{main}}{V_3 D_2} \tag{4.34}$$

B_{end3} = 5.84 m

- Calculate the av. hydraulic radius of flow:

$$R_{ex} = \frac{0.25(B_{ej1} + B_{ej2})(D_1 + D_2)}{(B_{ej1} + B_{ej1} + D_1 + D_2)} \tag{4.35}$$

R_{ex} = 0.872 m

Calculate the critical velocity of flow (U_c):

$$\frac{U_c}{\sqrt{(\Delta\rho_s / \rho g d_m)}} = 1.6\left[\frac{R_{ex}}{d_m}\right]^{1/8} \tag{4.36}$$

U_c = 0.365 m/s

and the limiting deposit velocity is given as:

$$U_L = F_1\sqrt{(8gR_{ex}(S_s - 1)} \tag{4.37}$$

U_L = 10.626 m/s

- Calculate the av. velocity of flow (U_{ex}) through ejector:

$$U_{ex} = \frac{(4Q_{ej})}{(D_1 + D_2)(B_{ej1} + B_{ej2})} \tag{4.38}$$

U_{ex} = 3.385 m/s

- Calculate the av. Hydaulics radius of clear flow:

$$R_{fex} = \frac{0.25(B_{ej1} + B_{ej2})(D_{fex1} + D_{fex2})}{(B_{ej1} + B_{ej2} + D_{fex1} + D_{fex2})} \tag{4.39}$$

R_{fex} = 0.537 m

- Calculate the av. velocity of clear flow (U_{fex}) through ejector:

$$U_{fex} = \frac{4Q_{ej}}{(B_{ej1} + B_{ej2})(D_{fex1} + D_{fex2})} \qquad (4.40)$$

U_{fex} = 5.64 m/s

- Calculate sediment capacity of tunnel (Cv) as under:

$$C_v = \frac{(J - J_o)}{J_o \phi} \qquad (4.41)$$

J = Head loss in ejector tunnel due to sediment water mixture and can be taken as difference of upstream and downstream total energy line

$$J = \left(\frac{\Delta h}{\Delta L}\right)_m \qquad (4.42)$$

J = 0.0219

Jo = head loss due to clear water for same set of ejector tunnels

$$Jo = \frac{fU_{ex}^2}{8gR_{ex}} \qquad (4.43)$$

f = 0.023

J_o = 0.049

For a spherical particle of diameter d. Swamee and Ojha (1991) gave the following equation for C_ρ:

$$C_\rho = 0.5\left\{16\left[\left(\frac{24}{R_s}\right)^{-1/6} + \left(\frac{130}{R_s}\right)^{0.72}\right]^{2.5} + \left[\left(\frac{40,000}{S_s}\right)^{-2} + 1\right]^{-0.25}\right\}^{0.25} \qquad (4.44)$$

in which R_s = sediment particle Reynolds number given by in which ω = fall velocity of sediment particle. Eq. (4a) is valid for $R_s \leq 1.5\times10^5$. Denoting $v_* = \frac{\nu}{\left[d\sqrt{(s-1)gd}\right]}$ Swamee and Ojha (1991) gave the following equation for the fall velocity of a spherical particle:

$$\omega = \sqrt{(s-1)gd}\{[(18v_*)^2 + (72v_*)^{1.7} + 1.43\times10^6]^{-0.346}\}^{-0.1} \qquad (4.45)$$

This equation is valid for $\nu_* \geq 4 \times 10^{-5}$.

$V^* = 0.02223$

$\omega^* = 0.8370$

$\omega_o = 0.07473$

$R_s = 37.3636$.

$C_d = 1.96482$

$$\phi = 150\left[\frac{U_{fex}^2\sqrt{C_d}}{4gR_{ex}(S_s - 1)}\right]^{-3/2} \qquad (4.46)$$

$\phi = 18.326$.

$C_v = 5688$ ppm

Refer the following table 1, from the above data standard deviation (σ)=10603.836ppm

Table 4.1: Max.Concenteration of the month of each year

month	1996	1997	1998	1999	2000	2001	2002	2003
june	0	1991	21350	6278	20000	4063	5240	0
july	12736	19990	8500	13843	7500	14321	5375	7688
august	3184	7164	6230	6700	8000	5000	5313	4938
september	0	2189	3725	9918	8500	3875	6250	6417
october	0	0	0	5600	0	500	4375	0

conc(ppm)	$c - \overline{c}$	$\overline{c - \overline{c}}^2$
0	-6168.825	38054463.6
1991	-4177.825	17454263.5
21350	15181.175	230468226
21350	15181.175	11919.1806
20000	13831.175	3443382910
4063	-2105.825	4434498.93
5240	-928.825	862715.881
0	-6168.825	38054401.9
12736	6567.175	43127787.5
19990	13821.175	191024878
8500	2331.175	5434376.88
13843	7674.175	58892961.9
7500	1331.175	1772026.88
14321	8152.175	66457957.2
5375	-793.825	630158.131
7688	1519.175	2307892.68
3184	-2984.825	8909180.28
7164	995.175	990373.281
6230	61.175	3742.38063
6700	531.175	282146.881
8000	1831.175	3353201.88
5000	-1168.825	1366151.88
5313	-5290.836	27992945.6
4938	-1230.825	1514930.18
0	-6168.825	38054401.9
2189	-3979.825	15839007
3725	-2443.825	5972280.63
9918	3749.175	14056313.2
8500	2331.175	5434376.88
3875	-2293.825	5261633.13
6250	81.175	6589.38063
6417	248.175	61590.8306
0	-6168.825	38054401.9
0	-6168.825	38054401.9
0	-6168.825	38054401.9
5600	-568.825	323561.881
0	-6168.825	38054401.9

	500	-5668.825	32135576.9
	4375	-1793.825	3217808.13
	0	-6168.825	38054401.9
Total sum	**261825**		4497419261
mean	6168.83		
std.dev	10603.8		

Assuming the triangular distribution of conc. the total incoming silt load is = 4019.934 ppm

Check whether C_v is more than incoming concentration of sediment

If not , take another trial till it is not true.

4.6 ESCAPE CHANNEL:

STEPS:

- Adopt a suitable value of depth of flow in the escape channel (y).

  y = 2 m

- Calculate area of cross section, A =(B+my)y, (4.47)

  $A = 49.60\ m^2$

- Calculate wetted perimeter , $P = B+2y(1+m^2)$, (4.48)

  P = 29.01

- Calculate hydraulics radius , R = A/P, (4.49)

  R = 1.71 m

where:

B = sum total of the width of all main tunnels at the end.

$= B_{end1} + B_{end2} + B_{end3} + 2\ t$ (4.50)

m = side slope =1.5

B = 21.90

- Calculate velocity in escape channel (v)

$$V = \frac{Q_{ej}}{A} \quad (4.51)$$

V = 3.4 m/s

- From manning's eq. , calculate the slope of escape channel i.e

$$S_o = \frac{V^2 n^2}{R^{4/3}} \qquad (4.52)$$

$S_o = 0.00120$

- The next value of velocity should be more than the immediate previous value of velocity for an accelerating flow. This condition must be satisfied.

4.7 DESIGN RESULT

No. of main tunnels	3
No. of sub tunnels	3
Width of canal (m)	41.915
Discharge through main tunnel (m^3/s)	56.66
Discharge through subtunnel (m^3/s)	18.888
Height of sub tunnel at entry(m)	1.8
Depth of clear flow(m)	1.08
% of blockage	40
Height of sub tunnel at exit (m)	2.615
Width of subtunnel at entry(m)	3.41
width of sub tunnel at exit(m)	3.01
Velocity at entry(m/s)	3.01
Velocity at exit(m/s)	3.3
Radius of outer wall of sub tunnel(m)	11.94
Radius of inner wall of sub tunnel(m)	13.288
Thickness of pier(m)	1.4
Value of angle of curvature(degrees)	67
Angle of inclination with horizontal(degrees)	23

Value of manning coefficient 0.016

TUNNELS

Tunnel No.	length (m)	Width at end of tunnel(m)	Velocity at end of tunnel(m/s)
1	59.5	8.5	3.5
2	43.8	7.45	4
3	28.1	5.84	5.1

Sediment transport capacity (ppm) 5688

ESCAPE CHANNEL

Width of escape channel(m) 21.9

Depth of flow(m) 2

Area of cross section(m^2) 49.60

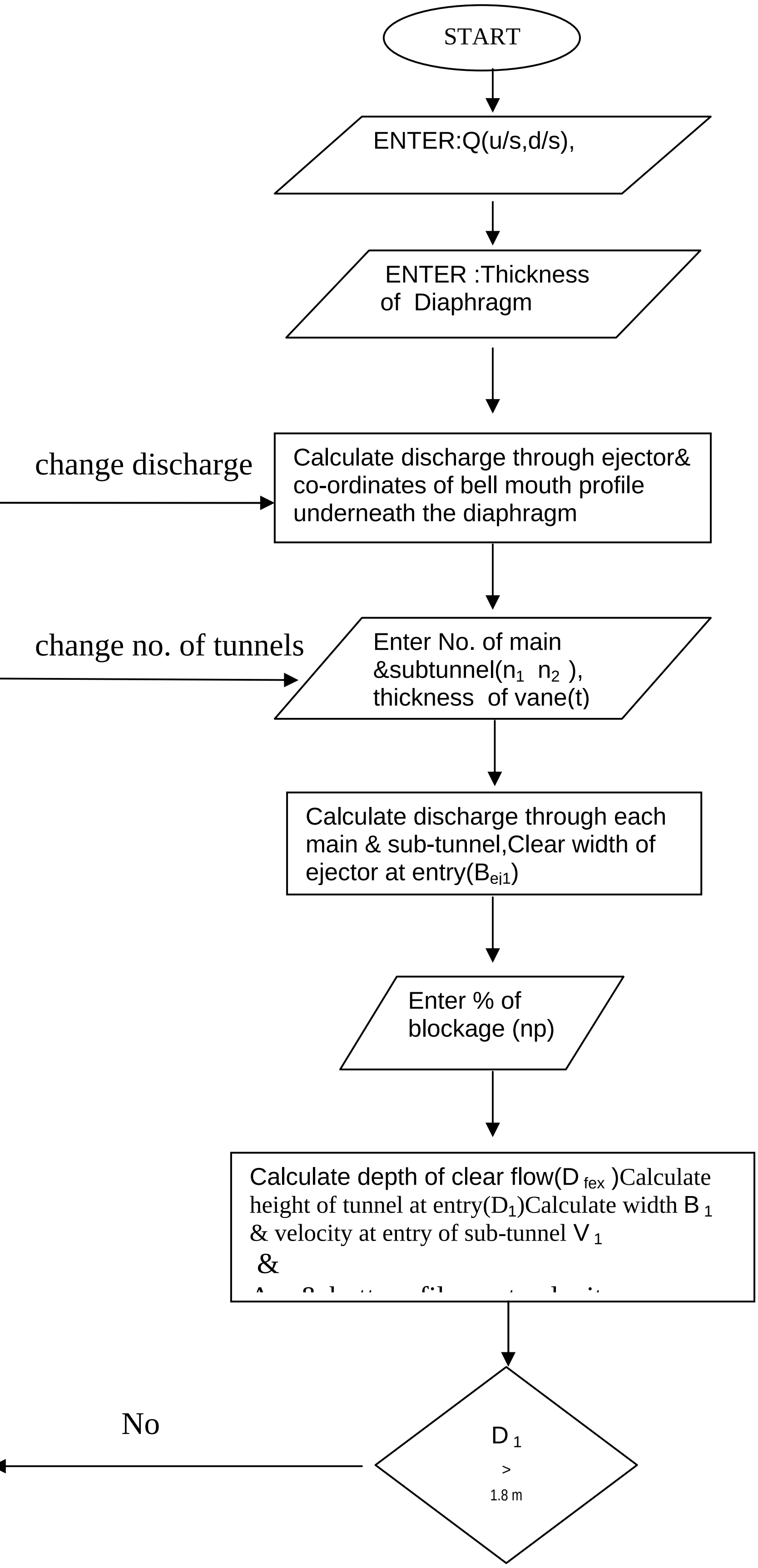
Wetted perimeter(m) 29.01

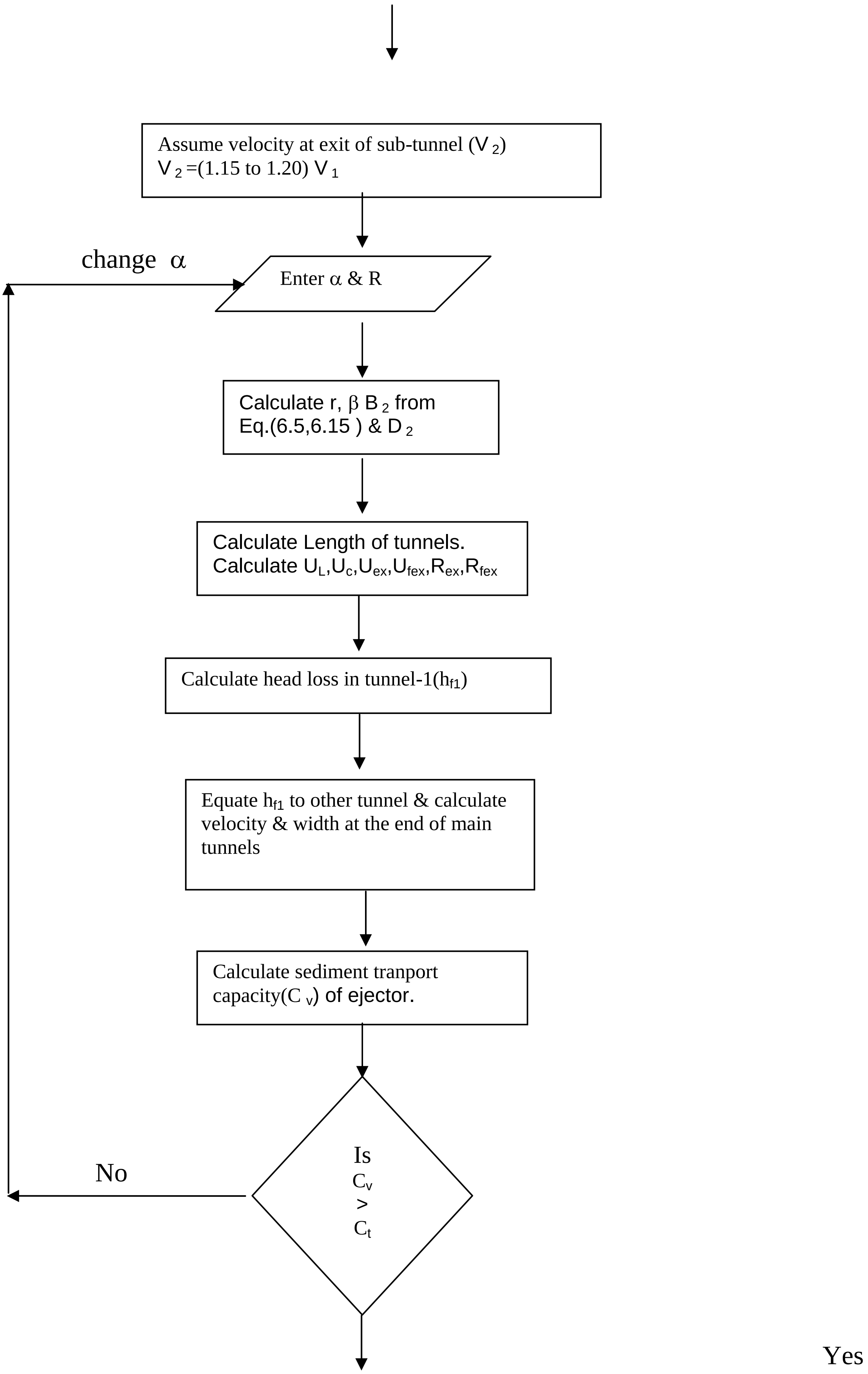
Hydraylics radius(m) 1.71

Velocity of flow(m/s) 3.4

Slope of channel 0.00102

The autocad drawing drawn for above details is attached with project in the end.


START
ENTER:Q(u/s,d/s),
ENTER :Thickness of Diaphragm
change discharge
Calculate discharge through ejector& co-ordinates of bell mouth profile underneath the diaphragm
change no. of tunnels
Enter No. of main &subtunnel(n_1 n_2), thickness of vane(t)
Calculate discharge through each main & sub-tunnel,Clear width of ejector at entry(B_{ej1})
Enter % of blockage (np)
Calculate depth of clear flow(D_{fex})Calculate height of tunnel at entry(D_1)Calculate width B_1 & velocity at entry of sub-tunnel V_1
&
No
D_1 > 1.8 m


Assume velocity at exit of sub-tunnel (V_2)
V_2 =(1.15 to 1.20) V_1
change α
Enter α & R
Calculate r, β B_2 from Eq.(6.5,6.15) & D_2
Calculate Length of tunnels.
Calculate U_L,U_c,U_{ex},U_{fex},R_{ex},R_{fex}
Calculate head loss in tunnel-1(h_{f1})
Equate h_{f1} to other tunnel & calculate velocity & width at the end of main tunnels
Calculate sediment tranport capacity(C_v) of ejector.
No
Is C_v > C_t
Yes

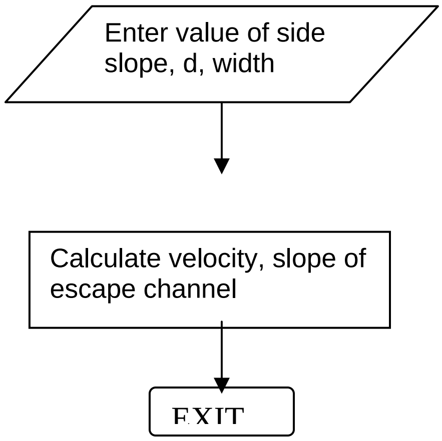


Fig. 4.2 : FLOW CHART FOR THE HYDRAULIC DESIGN OF SEDIMENT EJECTOR

CHAPTER–5

DESIGN DERIVATION

DERIVATION OF EQUATION TO CALCULATE INTERNAL RADIUS OF CURVE (r) :

Refer to fig .5.1,

Using sine rule:

$$\frac{r}{\sin\alpha} = \frac{r-(R-t)}{\sin(\alpha-\beta)} = \frac{R}{\sin\beta} \qquad (5.1)$$

From above equation we get :

$$r = \frac{R\sin\alpha}{\sin\beta} \qquad (5.2)$$

Substituting this value in equation (5.1) we have :

$$\frac{R}{\sin\beta} = \frac{r-(R-t)}{\sin(\alpha-\beta)} \qquad (5.3)$$

$$\frac{R}{\sin\beta} = \frac{\frac{R\sin\alpha}{\sin\beta}-(R-t)}{\sin\alpha\cos\beta-\cos\alpha\sin\beta} \qquad (5.4)$$

From above equation we get :

$$R\sin\alpha\cos\beta=(R\cos\alpha-(R-t)\sin\beta+R\sin\alpha \qquad (5.5)$$

by hit & trial , find value of β.

Using equation, find value of ‘r’.

DERIVATION OF WIDTH OF SUB-TUNNEL AT VARIOUS SECTIONS :

From the diagram

$$b = (R + w - r) \qquad (5.6)$$

Eq. Of line passing through (b , 0) :

$$y = m_1 x + c \qquad (5.7)$$

As it passes through (–b , 0),

$$0 = m_1 (-b) + c$$

$$c = m_1 b \quad (5.8)$$

Equation of circle (of outside wall)

$$(x + b)^2 + y^2 = R^2 \quad (5.9)$$

$$x^2 + y^2 + b^2 + 2xb = R^2$$

$$x^2 + y^2 + 2xb + b^2 - R^2 = 0$$

$$x^2 + y^2 + 2xb + (b^2 - R^2) = 0$$

$$x^2 + (m_1 x + c)^2 + 2xb + (b^2 - R^2) = 0$$

$$x^2 + (m_1 x)^2 + c^2 + 2 m_1 c x + 2xb + (b^2 - R^2) = 0$$

$$(1+m^2{}_1) x^2 + (2m_1c + 2b) x + (b^2 - R^2 + c^2) = 0$$

on solving quadratic eq. & simplifying :

$$x_2 = \frac{-(b+m_1c)+\sqrt{(m_1c+b)^2-(1+m^2)(b^2-R^2+c^2)}}{(1+m_1^2)} \quad (5.10)$$

$$y_2 = m_1x_2 + m_1 b \quad (5.11)$$

from inner circle , the value of (x_3 , y_3)

$$x^2 + y^2 = r^2 \quad \& \quad y = m_1 x + c \quad (5.12)$$

$$x^2 + (m_1 x + c)^2 = r^2$$

$$(1+m^2{}_1) x^2 + 2m_1cx + (c^2 - r^2) = 0$$

$$x_3 = \frac{-(m_1c)+\sqrt{(m_1c)^2-(1+m^2)(c^2-r^2)}}{(1+m_1^2)} \quad (5.13)$$

$$y_3 = m_1x_3 - m_1b = m_1(x_3 - b) \quad (5.14)$$

So we have (x_3 , y_3) & (x_2 , y_2)

By distance formula

$$D = \sqrt{(x_3 - x_2)^2 + (y_3 - y_2)^2} \qquad (5.15)$$

get the value of width of sub-tunnel at exit from eq. 5.15.

where

r = radius of inner circle,

R = radius of outer circle,

D = width at various sections.

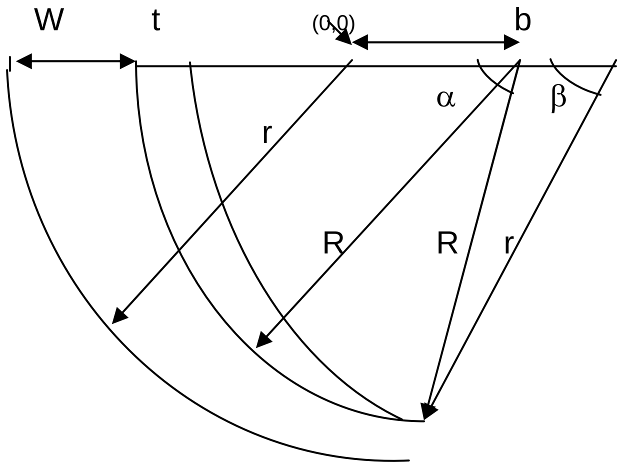


Fig.5.1 :Geometry of Subtunnel

CHAPTER- 6

CONCLUSIONS

6.1 GENERAL

The present work includes the presentation of state-of- art on the design of sediment ejector and modification to them based on the recent studies on sediment transport concept. The following conclusions can be drawn from the for going study:

(a) The data for design of sediment ejector have been obtained from the field for design of sediment ejector of an existing power canal.

(b) A computer program has been written in C++ language for design of sediment ejector based on exiting recommendations of IS:6004- 1980

(c) Over and above, the existing IS:6004-1980 recommendations, for design of sediment ejector, the following modifications suggested and included in the developed program:

1. The geometry of the sub-tunnels have been specified more clearly to carry the sediment laden water from upstream of ejector to the escape channel.

2. Using the sediment transport concept through the conduit, the ejector tunnel have been designed to carry the flow in the escape channel without any objectionable deposition.

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5 ASCE-1945 Journal
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8. S.K.Garg "Design of Hydraulic Structures" Khanna publishers.

APPENDIX-I

```
*************************************************************

File name:     Design  _ silt.cpp

Description:                                             This program designs a silt ejector for given
data

Auther:                                                  Suchitra Rani Gautam

*************************************************************/

#include<iostream.h>

#include<conio.h>

#include<math.h>

void main()

{

clrscr();


double Qc,Qej, n1,n2,x,np,a,b,tmp,L1,t,L2,L3,L11,L22,L33,Uc,Ufex;

double Qsub,D1,D2,Dfex,Bej1,Bej2,Bmain,B,B1,B2,w,A1,A2,V1,V2,Vc,Vl,Uex;

double Rex,Rcur,Lcur,Rfex,V3,hh1,hh2,hh3,hh4,V4,g=9.81,f=0.0293;

double M,N,O,Cv,Qmain,Bend1,Bend2,Bend3,Ven,rend,rexit,hf1,n=0.016;

double W,y1,v,A,So,P,r,k,L,m=1.5,alpha,beta,a11,a22,a33,a44,Dfex1,Dfex2,L111;


cout<<"get the value of canal discharge   (Qc)                    ";

cin>>Qc;


Qej=(0.25)*Qc;

cout<<"discharge through ejector is (Qej)          " <<Qej<<endl;
```

```
cout<<"get the value of no. of main tunnel (n1)            ";

cin>>n1;

cout<<"get the value of no.of subtunnels (n2)              ";

cin>>n2;

Qsub=Qej/(n1*n2);

cout<<"discharge through subtunnel is (Qsub)               " <<Qsub<<endl;

Qmain=Qej/n1;

cout<<"the discharg of the main tunel is:"<<Qmain<<endl;

cout<<"get t;he value of canal width at entry (B)          ";

cin>>B;



cout<<" pier width (t)          " ;

cin>>t;

Bej1=(B-((n1*n2)-1)*t);

cout<<"clear width of ejector at entry  (Bej1)             "<<Bej1<<endl;

B1=Bej1/(n1*n2);

cout<<"clear widht of the subtunel is :     "<<B1<<endl;

cout<<"enter the tunnel height at entry:";

cin>>D1;

cout<<" enter the percentage of blockage == ";

cin>>np;


Dfex1=((100-np)/100)*D1;

cout<<"depth of  free flow at entryDfex1=="  <<Dfex1<<endl;
```

```
A1=B1*D1;

cout<<"area of cross section of subtunel at entry:    "<<A1<<endl;

V1=Qsub/A1;

cout<<"velocity of flow entry of subtunel is:    "<<V1<<endl;

cout<<"enter the angle of tunel with horizontal";

cin>>x;


Rcur=3.5*B1;

cout<<" Rcur    "<<Rcur<<endl;




V2=1.15*V1;

cout<<"velocity of flow at exit of sub tunnel V2==  "<<V2<<endl;

A2=Qsub/V2;

cout<<"area of croos-section at exit of sub tunnel A2==  "<<A2<<endl;

cout<<"enter the tunnel height at exit";

cin>>D2;


B2=A2/D2;

cout<<"B2=="<<B2<<endl;


double B22=n2*B2;

cout<<" width of main tunnel at exit of sub tunnel ==   "<<B22<<endl;

Bej2=n1*n2*B2;

cout<<" width of ejector at exit of sub tunnelBej2==  "<<Bej2;
```

```
Dfex2=((100-np)/100)*D2;
cout<<"depth of free flowat exit of subtunnel Dfex2==   "<<Dfex2<<endl;

Lcur=Rcur*(90-x)*3.14159/180;
cout<<"curved lenth of subtunnel (Lcur)                    "<<Lcur<<endl;

L1=(((B1*n2)+(t*(n2-1)))*(n1)+(t*(n1-1)))/cos(x*3.14159/180 );
L2=(((B1*n2)+(t*(n2-1)))*(n1-1)+(t*(n1-2)))/cos(x*3.14159/180);
L3=(((B1*n2)+(t*(n2-1)))*(n1-2)+(t*(n1-3)))/cos(x*3.14159/180);
L11=Lcur+L1;
L22=Lcur+L2;
L33=Lcur+L3;

cout<<"straight lenth of tunnel 1 (L1)             "<<L1<<endl;
cout<<"straight lenth of tunnel 2 (L2)                     "<<L2<<endl;
cout<<"straight lenth of tunnel 3 (L3)                     "<<L3<<endl;
cout<<"total lenth of tunnel 1  (L11)                      "<<L11<<endl;
cout<<"total lenth of tunnel 2  (L22)                      "<<L22<<endl;
cout<<"total lenth of tunnel 3 (L33)                       "<<L33<<endl;

cout<<"Enter the width of tunnel at end:";
cin>>Bend1;
```

```
Ven=Qmain/(D2*Bend1);
cout<<"velocity of flow at end of main tunnel-1  Ven==            "<<Ven<<endl;

double R2=(D2*Bend1)/(2*(D2+Bend1));
double R1=(D2*(n2*B2))/(2*(D2+(n2*B2)));
double R3=(R1+R2)/2;
cout<<"R3(average of R1 and R2              "<<R3<<endl;

double P1 = ((V2+Ven)/2)*((V2+Ven)/2)*n*n*L1;
cout<<"P1 =="<<P1<<endl;


hf1=  (P1/(pow(R3,1.333))); /*+ (0.1/19.62)*((Ven*Ven)-(V2*V2));*/
cout<<"head loss in tunnel -1(hf1)==    "<<hf1<<endl;
double V22=1;
a=hf1;
do
{
hh1=(((V2+V22)/2)*((V2+V22)/2))*n*n*L2;
hh2=((B2+(Qmain/(D2*V22))/2)+D2);
hh3=0.25*(B2+(Qmain/(D2*V22)))*D2;
hh4=0.1*((V22*V22/19.62)-(V2*V2/19.62));

b=(hh1/pow((hh3/hh2),1.333))+hh4;
```

```
tmp=a-b;

V22+=0.1;
}while(tmp==.01);
V22=V22+3.5;

cout<<"velocity of flow at end of main tunnel-2  V22   "<<V22<<endl;
Bend2= Qmain/(V22*D2);
cout<<"width of tunnel-2 at the end   Bend2    "<<Bend2<<endl;



double V33=1;
a=hf1;
do
{
hh1=(((V2+V33)/2)*((V2+V33)/2))*n*n*L3;
hh2=((B2+(Qmain/(D2*V33))/2)+D2);
hh3=0.25*(B2+(Qmain/(D2*V33)))*D2;
hh4=0.1*((V33*V33/19.62)-(V2*V2/19.62));
 b=(hh1/pow((hh3/hh2),1.333))+hh4;
tmp=a-b;
 V33+=0.1;
}while(tmp>=.001);

cout<<"velocity of flow at end of main tunnel-3   V33==            "<<V33<<endl;
```

```
Bend3= Qmain/(V33*D2);
cout<<" width of tunnel-3 at the end  Bend3        "<<Bend3<<endl;

double Bej3=Bend1+Bend2+Bend3+(2*t);
cout<<"total width of ejector at end of tunnel Bej3  = "<<Bej3<<endl;

Rex=0.25*(Bej1+Bej3)*(D1+D2)/(Bej1+Bej3+D1+D2);
cout<<"av hydraulic mean radius  (Rex)                    "<<Rex<<endl;

Uc=0.3722*(pow(Rex,0.1250));
cout<<"Uc                                                  "<<Uc<<endl;
double VL=11.379*pow((Rex),0.5);
cout<<"limiting deposit velocty of sediment (VL)        "<<VL<<endl;

Uex=(4*Qej)/((D1+D2)*(Bej1+Bej3));
cout<<"velocity through ejetor (Uex)                        "<<Uex<<endl;

Rfex=0.25*(Bej1+Bej3)*(Dfex1+Dfex2)/(Bej1+Bej3+Dfex1+Dfex2);
cout<<"av. hydraulcs mean radius for free flow   (Rfex)            "<<Rfex<<endl;

Ufex=4*Qej/((Bej1+Bej3)*(Dfex1+Dfex2));
cout<<"velocity for free flow  Ufex==    "<<Ufex<<endl;
```

```
L111=(L11+L22+L33)/3;

cout<<"Av, lenth of all tunnel  (L111)     "<<L111<<endl;



double S=(B1+B2)/2;

cout<<"av width S=="<<S<<endl;

double V=(V1+V2)/2;

cout<<"av velocity V=="<<V<<endl;

double F=0.124+(3.104*pow((S/(2*Rcur)),1/2));

cout<<"F=="<<F<<endl;

double hb=F*((V*V)/(2*g))*((90-x)/180);

cout<<"bend loss hb=="<<hb<<endl;


double J=1/(L1);

cout<<"head loss in ejector tunnel due to sediment mixture J=="<<J<<endl;



double Jo=( ((f*(Uex*Uex))/(8*g*Rex)));

cout<<"head loss due to same set of ejector tunnels  Jo  = "<<Jo<<endl;

M=((Ufex*Ufex)*sqrt(19.68));

N=64.746*Rfex;


O=150/(sqrt((M/N)*(M/N)*(M/N)));


cout<<"O  ="<<O<<endl;
```

```
Cv=((J-Jo)/(Jo*O))*1000000;

cout<<"Cv sediment transport capacity of ejector  = "<<Cv<<endl;



double y,Cb,Cb1,Ct;

cout<<"enter the depth of flow in  canal ";

cin>>y;

Cb=11904*2*y;

cout<<"conc at the bed Cb "<<Cb<<endl;

Cb1=((D1*Cb)/y);

cout<<"conc at the height D1 from bed Cb1 ="<<Cb1<<endl;

Ct=((Cb+Cb1)/2)*D1;

cout<<"incoming conc of sediment design value Ct =="<<Ct<<endl;



W=Bend1+Bend2+Bend3+(2*t);

cout<<"W width of escape channel==        "<<W<<endl;




cout<<"enter depth of flow                         ";

cin>>y1;

A=(W+m*y1)*y1;

cout<<"area of X-section of escape channel   (A)    "<<A<<endl;
```

```
v=Qej/A;
cout<<"velocity of escape channel   (v)              "<<v<<endl;




P=(W+2*y1*sqrt(1+m*m));
cout<<"wetted Perimeter of escape channel   (P)                    "<<P<<endl;

r=A/P;
cout<<"hydrailic radius of escape channel   (r)              "<<r<<endl;

So=(v*v*n*n)/(pow(r,1.333));
cout<<"So (slope of escape channel)                          "<<So<<endl;

getch();
}
```

APPENDIX II

TANAKPUR POWER STATION

DAILY SUSPENDED SEDIMENT DATA OF SHARDA RIVER

STATION : TANAKPUR BARRAGE SITE **YEAR :1996**

DATE	JUN		JULY	AUG			SEPT		OCT		NOV	
	U/S Barrage	D/S H.R.	U/S Barrage	D/S H.R.	U/S Barrage	D/S H.R.	U/S Barrage	D/S H.R.	U/S Barrage	D/S H.R.	U/S Barrage	D/S H.R.
	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)
1	-	-	1592	995	796	597	-	-	-	-	-	-
2	-	-	677	597	1393	995	-	-	-	-	-	-
3	-	-	557	378	1692	1194	-	-	-	-	-	-
4	-	-	975	597	1194	592	-	-	-	-	-	-
5	-	-	1612	995	570	3184	-	-	-	-	-	-
6	-	-	1393	836	3582	2786	-	-	-	-	-	-
7	-	-	1592	896	2009	1990	-	-	-	-	-	-
8	-	-	776	398	2189	1592	-	-	-	-	-	-
9	-	-	3980	12736	2189	1791	-	-	-	-	-	-
10	-	-	1493	1095	1990	1791	-	-	-	-	-	-
11	-	-	1692	2189	1791	1194	-	-	-	-	-	-
12	-	-	2090	1095	2189	2189	-	-	-	-	-	-
13	-	-	1234	796	2189	1990	-	-	-	-	-	-
14	-	-	1871	1393	3582	1791	-	-	-	-	-	-
15	-	-	3184	2189	2189	2189	-	-	-	-	-	-
16	-	-	1990	796	1194	1194	-	-	-	-	-	-
17	-	-	1692	1194	1294	995	-	-	-	-	-	-
18	-	-	1791	995	1592	1294	-	-	-	-	-	-
19	-	-	1393	995	1393	995	-	-	-	-	-	-
20	-	-	995	758	1294	1194	-	-	-	-	-	-
21	-	-	2592	975	1393	995	-	-	-	-	-	-
22	-	-	796	458	1990	1790	-	-	-	-	-	-
23	-	-	995	697	2189	1394	-	-	-	-	-	-
24	-	-	1592	1192	1592	1194	-	-	-	-	-	-
25	-	-	1393	1393	1791	995	-	-	-	-	-	-
26	-	-	1592	796	1194	696	-	-	-	-	-	-
27	-	-	1194	896	796	597	-	-	-	-	-	-
28	-	-	1791	796	696	597	-	-	-	-	-	-
29	-	-	1195	796	597	497	-	-	-	-	-	-
30	-	-	1095	995	1393	796	-	-	-	-	-	-
31			995	597	1791	1493	-	-			-	-

National Hydroelectric Power Corporation Ltd., Faridabad

TANAKPUR POWER STATION

DAILY SUSPENDED SEDIMENT DATA OF SHARDA RIVER

STATION : TANAKPUR BARRAGE SITE **YEAR :1997**

DATE	JUN		JULY		AUG		SEPT		OCT		NOV	
	U/S Barrage	D/S H.R.	U/S Barrage	D/S H.R.	U/S Barrage	D/S H.R.	U/S Barrage	D/S H.R.	U/S Barrage	D/S H.R.	U/S Barrage	D/S H.R.
	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)
1	-	-	2189	1990	2189	1791	199	199	398	199	-	-
2	-	-	1194	995	2786	2985	597	597	398	199	-	-
3	-	-	2388	1791	6965	7164	1194	995	-	-	-	-
4	-	-	1791	1692	4975	4776	1393	1194	-	-	-	-
5	-	-	2786	2388	2587	3582	1393	995	-	-	-	-
6	-	-	1990	2388	2388	4179	1990	1592	-	-	-	-
7	-	-	2985	2189	2388	2985	2388	1791	-	-	-	-
8	-	-	1393	1194	1194	1393	2587	1990	-	-	-	-
9	-	-	1791	1592	2388	3383	1990	1592	-	-	-	-
10	-	-	1990	1194	2587	1791	1990	1592	-	-	-	-
11	-	-	2189	1990	6368	5771	3383	2189	-	-	-	-
12	-	-	1592	1393	2587	2587	1592	995	-	-	-	-
13	-	-	1990	1791	3781	3781	1990	1592	-	-	-	-
14	-	-	1393	1194	2587	2587	1194	995	-	-	-	-
15	-	-	1592	1194	2189	1990	1194	796	-	-	-	-
16	-	-	1592	1194	1990	1791	1593	1393	-	-	-	-
17	2388	1991	3582	4776	3184	2189	1592	1194	-	-	-	-
18	796	557	4776	3980	1990	1393	796	597	-	-	-	-
19	597	358	4189	3383	1990	1791	995	796	-	-	-	-
20	995	796	3582	4378	2189	1791	796	597	-	-	-	-
21	597	358	995	1194	995	796	995	995	-	-	-	-
22	1990	1791	4178	3781	1393	1194	597	597	-	-	-	-
23	1791	1393	597	995	1791	1592	995	796	-	-	-	-
24	995	796	1194	1393	1393	1194	398	398	-	-	-	-
25	1751	1194	796	995	2189	1592	796	597	-	-	-	-
26	1990	1393	1393	1592	1592	1393	398	199	-	-	-	-
27	1393	995	1393	1592	2388	1990	796	597	-	-	-	-
28	1791	796	1393	1791	1990	1791	597	398	-	-	-	-
29	1194	995	1791	1791	1393	995	398	199	-	-	-	-
30	1194	796	2388	2388	1194	597	398	199	-	-	-	-
31			1990	19990	1791	1592			-	-		

National Hydroelectric Power Corporation Ltd., Faridabad

TANAKPUR POWER STATION

DAILY SUSPENDED SEDIMENT DATA OF SHARDA RIVER

STATION : TANAKPUR BARRAGE SITE **YEAR :1998**

DATE	JUN		JULY		AUG		SEPT		OCT		NOV	
	U/S Barrage	D/S H.R.	U/S Barrage	D/S H.R.	U/S Barrage	D/S H.R.	U/S Barrage	D/S H.R.	U/S Barrage	D/S H.R.	U/S Barrage	D/S H.R.
	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)
1	-	-	6330	6980	1120	1400	3080	3725	-	-	-	-
2	-	-	2280	2360	3770	4650	585	620	-	-	-	-
3	-	-	7500	5850	1720	1800	1040	1980	-	-	-	-
4	-	-	2000	2190	4150		640	655	-	-	-	-
5	-	-	2480	3187	2450	2670	700	745	-	-	-	-
6	-	-	9092	8500	1520	1570	370	590	-	-	-	-
7	-	-	4270	4690	1630	1780	2430	2500	-	-	-	-
8	-	-	2660	2940	1820	1910	400	540	-	-	-	-
9	-	-	2440	3010	2230		350	320	-	-	-	-
10	-	-	6200	5150	3320	3490	280	355	-	-	-	-
11	-	-	2540	3250	2680	2770	355	355	-	-	-	-
12	-	-	2793	4170	2430	2780	410	485	-	-	-	-
13	-	-	1930	2530	1700	1930	210	240	-	-	-	-
14	-	-	3080	3830	1630	1880	-	-	-	-	-	-
15	1190	1310	2220	3550	1170	1640	430	500	-	-	-	-
16	920	1030	1700	2210	1480	1750	-	-	-	-	-	-
17	14330	12430	2900	3420	2390	2960	470	535	-	-	-	-
18	1650	1870	2300	2250		1285	200	350	-	-	-	-
19	1890	1900	3300	3030	3840	2180	260	275	-	-	-	-
20	1750	1750	3570	3300	5090	4630	-	-	-	-	-	-
21	2850	3030	1519	2382	850	980	-	-	-	-	-	-
22	2830	2860	2480	1680	1475	1540	150	215	-	-	-	-
23	3630	3690	1700	1820	1130	1960	120	175	-	-	-	-
24	4260	4310	1550	1690	4760	6230	1140	1240	-	-	-	-
25	3200	3450	1420	1180	900	969	-	-	-	-	-	-
26	4350	4350	880	1250	2145	2480	500	580	-	-	-	-
27	20720	21350	1060	1050	2300	1086	-	-	-	-	-	-
28	3250	3100	920	1460	1372	1880	400	495	-	-	-	-
29	6440	6870	1780	1870	-	-	-	-	-	-	-	-
30	5290	3510	825	925	1900	2020	290	340	-	-	-	-
31			1020	1110					-	-		

National Hydroelectric Power Corporation Ltd., Faridabad

TANAKPUR POWER STATION

DAILY SUSPENDED SEDIMENT DATA OF SHARDA RIVER

STATION : TANAKPUR BARRAGE SITE **YEAR :1999**

DATE	JUN		JULY		AUG		SEPT		OCT		NOV	
	U/S Barrage	D/S H.R.	U/S Barrage	D/S H.R.	U/S Barrage	D/S H.R.	U/S Barrage	D/S H.R.	U/S Barrage	D/S H.R.	U/S Barrage	D/S H.R.
	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)
1	2000	1375	3125	2750	4250	3812	1875	1625	1625	1500	-	-
2	1250	1500	3000	2500	3312	2687	2812	2250	1200	900	-	-
3	2125	1625	5875	5750	3125	2750	2062	1687	1500	1375	-	-
4	1500	1000	4250	3750	4063	3625	1428	1214	3500	4900	-	-
5	500	500	3625	3125	9200	6700	1500	1214	1250	1125	-	-
6	NM	NM	3150	2875	7079	6579	750	667	786	643	-	-
7	NM	NM	2785	2550	3786	3619	1000	857	6250	5600	-	-
8	NM	NM	3728	3365	3688	3188	625	625	1250	1400	-	-
9	1000	500	4225	3775	2688	2250	1500	1375	500	500	-	-
10	NM	NM	3328	3075	4071	3643	2125	1562	4000	3000	-	-
11	1000	835	3750	3375	3125	2938	5250	6125	NM	NM	-	-
12	1750	1250	3000	2750	2875	2688	4000	3591	500	500	-	-
13	1625	1125	3875	2125	2875	2438	2375	2063	NM	NM	-	-
14	2375	2000	1500	1000	1812	1375	2563	2250	NM	NM	-	-
15	2750	2250	2000	1500	1125	750	1750	1438	NM	NM	-	-
16	2375	2000	3500	2750	1562	1250	2250	1875	-	-	-	-
17	2000	1375	3625	3375	5111	2944	2437	2188	-	-	-	-
18	3625	3000	2500	1625	1143	928	1938	1375	-	-	-	-
19	4300	3600	2875	2375	1375	1188	5042	4417	-	-	-	-
20	4875	4625	6812	5687	1562	1250	3000	2625	-	-	-	-
21	3500	3125	3437	2937	2312	2312	1563	1500	-	-	-	-
22	3625	3125	3250	2750	3312	2875	10318	9918	-	-	-	-
23	7111	6278	2937	2437	3000	2825	3438	3063	-	-	-	-
24	3000	2500	5187	5000	3187	2875	2188	1875	-	-	-	-
25	3125	2250	17399	13843	3500	3125	900	700	-	-	-	-
26	2825	2600	6292	5479	3375	2875	500	500	-	-	-	-
27	3000	2775	4062	3500	3125	2750	500	500	-	-	-	-
28	4250	3875	5146	4542	2357	2143	500	500	-	-	-	-
29	2625	2125	4625	4021	2428	2143	500	500	-	-	-	-
30	2250	1750	3853	3265	2614	2325	900	800	-	-	-	-
31			4417	3958	1715	1428			-	-		

National Hydroelectric Power Corporation Ltd., Faridabad

TANAKPUR POWER STATION

DAILY SUSPENDED SEDIMENT DATA OF SHARDA RIVER

STATION : TANAKPUR BARRAGE SITE **YEAR :2000**

DATE	JUN		JULY		AUG		SEPT		OCT		NOV	
	U/S Barrage	D/S H.R.	U/S Barrage	D/S H.R.	U/S Barrage	D/S H.R.	U/S Barrage	D/S H.R.	U/S Barrage	D/S H.R.	U/S Barrage	D/S H.R.
	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)
1	-	-	-	-	4250	4750	2000	1500	-	-	-	-
2	-	-	-	-	-	-	-	-	-	-	-	-
3	-	-	-	-	3750	3500			-	-	-	-
4	-	-	-	-	3250	2500	4000	3000	-	-	-	-
5	-	-	-	-	3000	2000	9000	8500	-	-	-	-
6	-	-	-	-	-	-	7500	7000	-	-	-	-
7	12250	9500	1000	1000	-	-	4500	3500	-	-	-	-
8	10667	10667	-	-	-	-	-	-	-	-	-	-
9	21250	20000	-	-	5667	5333	-	-	-	-	-	-
10	8250	8250	-	-	8500	8000	-	-	-	-	-	-
11	-	-	6500	5750	5500	5000	-	-	-	-	-	-
12	-	-	5750	5250	-	-	-	-	-	-	-	-
13	-	-	5500	5250	-	-	-	-	-	-	-	-
14	-	-	4750	4500	-	-	-	-	-	-	-	-
15	-	-	6500	6000	3000	2500	-	-	-	-	-	-
16	4000	4000	7625	6750	2000	1500	-	-	-	-	-	-
17	2500	2000	8500	7500	2000	1500	-	-	-	-	-	-
18	-	-	5000	4750	4000	3000	-	-	-	-	-	-
19	2500	2500	5000	5000	4500	4000	-	-	-	-	-	-
20	7500	5000	5000	4000	3000	2000	-	-	-	-	-	-
21	6250	8250	4500	4000	2500	2500	-	-	-	-	-	-
22	5000	4500	2500	2000	2000	2000	-	-	-	-	-	-
23	-	-	2000	1500	2000	1500	-	-	-	-	-	-
24	-	-	2500	2250	4000	3000	-	-	-	-	-	-
25	-	-	2250	1750	8333	7667	-	-	-	-	-	-
26	2500	2500	2500	2000	-	-	-	-	-	-	-	-
27	8000	8000	1500	1000	-	-	-	-	-	-	-	-
28	-	-	1500	1000	-	-	-	-	-	-	-	-
29	-	-	1500	1000	-	-	-	-	-	-	-	-
30	-	-	2250	2000	-	-	-	-	-	-	-	-
31			6333	6167	6500	6000			-	-		

National Hydroelectric Power Corporation Ltd., Faridabad

TANAKPUR POWER STATION

DAILY SUSPENDED SEDIMENT DATA OF SHARDA RIVER

STATION : TANAKPUR BARRAGE SITE **YEAR :2001**

DATE	JUN		JULY		AUG		SEPT		OCT		NOV	
	U/S Barrage	D/S H.R.	U/S Barrage	D/S H.R.	U/S Barrage	D/S H.R.	U/S Barrage	D/S H.R.	U/S Barrage	D/S H.R.	U/S Barrage	D/S H.R.
	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)
1	833	542	4214	3357	3000	2688	2625	2250	500	500	-	-
2	3250	2833	4813	3063	2750	2313	4750	3125	500	500	-	-
3	3233	3583	5000	4786	2438	2250	3375	3188	500	500	-	-
4	3083	2500	3938	3438	1500	1250	1083	1000	500	500	-	-
5	2250	2000	3375	2875	1429	1143	3625	3875	500	500	-	-
6	2167	1667	2750	2563	1429	1214	3500	2786	500	500	-	-
7	1000	500	4063	3750	2000	1688	2250	1938	500	500	-	-
8	1033	550	3000	2625	2938	2688	1813	1563	500	500	-	-
9	1000	500	4000	3938	4563	4313	1063	875	500	500	-	-
10	1833	1417	4875	4188	4125	3625	563	875	500	500	-	-
11	2083	1583	4875	4286	3000	3813	1063	875	500	500	-	-
12	2000	1500	5375	4750	3875	3313	1063	688	500	500	-	-
13	2833	2333	5126	4625	3500	3375	2375	1875	500	500	-	-
14	3833	1750	3786	3214	3750	2938	813	750	500	500	-	-
15	4583	4000	7143	6143	2438	2125	500	500	500	500	-	-
16	3250	2917	10875	8750	2563	2313	500	500	-	-	-	-
17	2417	2250	5125	4563	4643	3875	500	500	-	-	-	-
18	3375	3438	4250	3917	4375	3875	500	500	-	-	-	-
19	2833	2417	2875	2813	5143	4714	1186	500	-	-	-	-
20	2056	1611	2813	2750	5438	5000	500	500	-	-	-	-
21	1929	1571	3786	3357	3438	3063	500	500	-	-	-	-
22	3375	3250	3167	2750	4625	4250	500	500	-	-	-	-
23	3833	3250	4000	4000	4875	4438	500	500	-	-	-	-
24	3938	4063	4188	3625	4313	4000	500	500	-	-	-	-
25	2375	2000	4563	4250	3625	3000	500	500	-	-	-	-
26	3063	2625	7563	7063	3875	3250	500	500	-	-	-	-
27	3063	2625	16714	14321	3250	3000	500	500	-	-	-	-
28	1357	1000	9583	6583	3313	3313	500	500	-	-	-	-
29	1786	1500	4688	4563	2563	2000	500	500	-	-	-	-
30	1571	1357	4500	3438	2750	2250	500	500	-	-	-	-
31			5357	4214	2875	2500			-	-		

National Hydroelectric Power Corporation Ltd., Faridabad

TANAKPUR POWER STATION

DAILY SUSPENDED SEDIMENT DATA OF SHARDA RIVER

STATION : TANAKPUR BARRAGE SITE **YEAR :2002**

DATE	JUN		JULY		AUG		SEPT		OCT		NOV	
	U/S Barrage	D/S H.R.	U/S Barrage	D/S H.R.	U/S Barrage	D/S H.R.	U/S Barrage	D/S H.R.	U/S Barrage	D/S H.R.	U/S Barrage	D/S H.R.
	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)
1	813	563	1625	1250	688	563	1813	1563	500	500	-	-
2	500	500	2000	1250	1438	1138	1938	1750	500	500	-	-
3	813	688	5563	4563	3500	3286	1313	1125	500	500	-	-
4	688	750	6625	5250	3938	3438	5625	5125	500	500	-	-
5	813	563	6000	5063	1929	1643	Depletion	Depletion	500	500	-	-
6	688	563	2063	1563	2714	2214	6188	5438	500	500	-	-
7	938	813	1188	1063	1063	1000	6875	6250	4375	4375	-	-
8	1286	929	1125	938	1500	1250	4625	4125	500	500	-	-
9	1563	1125	875	813	1375	1188	3375	3063	250	250	-	-
10	3063	2813	1250	1063	4563	4000	1438	1188	1125	875	-	-
11	3750	3125	2188	1625	5938	5313	2750	2313	250	250	-	-
12	3437	2875	1150	813	3125	2688	5250	3875	-	-	-	-
13	2813	2188	750	500	2125	1750	3763	3563	375	375	-	-
14	1813	1438	688	625	1938	1625	3188	2563	-	-	-	-
15	688	625	1063	813	688	625	2625	2188	-	-	-	-
16	750	563	1688	1500	1250	1188	3500	3125	-	-	-	-
17	1125	1000	1063	813	1725	1750	2488	2625	-	-	-	-
18	938	813	813	563	4375	3750	1563	1500	-	-	-	-
19	500	500	5875	5375	1250	1063	625	500	-	-	-	-
20	563	500	5875	5313	1500	1125	875	688	-	-	-	-
21	5063	688	5313	4625	2563	2125	813	750	-	-	-	-
22	1438	1063	2125	2312	5375	5000	750	688	-	-	-	-
23	1813	1313	2312	1750	3583	2833	1563	1188	-	-	-	-
24	6125	5240	875	688	2688	2125	875	750	-	-	-	-
25	3500	3938	1875	1438	1438	1313	563	500	-	-	-	-
26	3000	2625	750	625	1125	1000	500	500	-	-	-	-
27	2688	2250	1250	1000	1875	1500	500	500	-	-	-	-
28	1750	1313	1188	1000	1438	1188	500	500	-	-	-	-
29	1583	1167	813	625	1813	1563	500	500	-	-	-	-
30	1571	1214	625	563	1375	1000	500	500	-	-	-	-
31			1750	1563	813	688			-	-		

TANAKPUR POWER STATION

DAILY SUSPENDED SEDIMENT DATA OF SHARDA RIVER

STATION : TANAKPUR BARRAGE SITE **YEAR :2003**

DATE	JUN		JULY		AUG		SEPT		OCT		NOV	
	U/S Barrage	D/S H.R.	U/S Barrage	D/S H.R.	U/S Barrage	D/S H.R.	U/S Barrage	D/S H.R.	U/S Barrage	D/S H.R.	U/S Barrage	D/S H.R.
	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)
1	-	-	2063	1563	3688	3188	2375	1875	-	-	-	-
2	-	-	1688	1250	3125	2688	7333	6417	-	-	-	-
3	-	-	1938	1500	3438	2875	3063	2563	-	-	-	-
4	-	-	3563	3063	2938	2375	2250	1750	-	-	-	-
5	-	-	8563	7688	2563	2188	2188	1688	-	-	-	-
6	-	-	8000	7313	3563	3000	2313	1938	-	-	-	-
7	-	-	4286	3714	2125	1625	1938	1500	-	-	-	-
8	-	-	3063	2563	2313	1875	1625	1125	-	-	-	-
9	-	-	4563	4000	2250	1750	1813	1438	-	-	-	-
10	-	-	5938	5313	2563	2000	1875	1375	-	-	-	-
11	-	-	4563	4000	2563	2063	1563	1063	-	-	-	-
12	-	-	4813	4313	2313	1813	1250	1000	-	-	-	-
13	-	-	3125	2688	1688	1188	1375	875	-	-	-	-
14	-	-	2250	1750	1688	1188	1438	1000	-	-	-	-
15	-	-	1813	1375	1813	1375	3125	2625	-	-	-	-
16	-	-	2375	1938	2063	1563	2125	1688	-	-	-	-
17	-	-	3938	3313	1625	1125	2000	1500	-	-	-	-
18	-	-	2688	2188	2313	1813	4000	3563	-	-	-	-
19	-	-	4313	3625	5100	4200	3125	2625	-	-	-	-
20	-	-	3375	2813	5563	4938	1125	813	-	-	-	-
21	-	-	5333	4833	5143	4571	1375	875	-	-	-	-
22	-	-	2667	2000	3750	3250	1188	1000	-	-	-	-
23	-	-	2625	2188	4188	3688	1875	1438	-	-	-	-
24	-	-	2438	1938	2688	2188	2250	1750	-	-	-	-
25	-	-	2250	1750	2250	1750	5875	5250	-	-	-	-
26	-	-	2313	1813	2250	1750	1813	1250	-	-	-	-
27	-	-	2250	1750	2188	1688	1000	500	-	-	-	-
28	-	-	4500	3938	1938	1438	1000	500	-	-	-	-
29	-	-	2625	2063	2000	1500	1000	500	-	-	-	-
30	-	-	2313	1875	1813	1375	1000	500	-	-	-	-
31			2750	2250	2000	1500			-	-		

National Hydroelectric Power Corporation Ltd., Faridabad