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RESEARCH REPORT

Design of Small Hydro Power Project on Main Tirhut Canal, Champaran, Bihar, India

Kumar Manish

Senior Engineer, Sumitra Constructions
Email: sccplimited@gmail.com

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ABSTRACT

To meet the agriculture and domestic energy demands of the Champaran district of the state of Bihar, the small hydro project at RD-79 on TMC (Tirhut Main Canal) has been planned and designed. The project comprises of construction of a cross regulator having ten gates to regulate the flow and to raise the head across TMC.A head regulator has been envisaged upstream of the cross regulator to pass a designed discharge of 80 cumecs on tubular turbines, installed in power house to generate a power of 1852 kw (kilowatt). A tail race channel has been proposed from the power house to carry the flow back to the TMC. The cost of generation has been worked as Rs.2.14 with subsidy and Rs.2.28 per unit without subsidy. The project has been found techno economically viable and will supply the power to the nearby area suffering from power crises.

KEYWORDS: Cross regulator, tubular turbines, subsidy, and power house, potential.

INTRODUCTION

Tirhut Main Canal is the main branch of Eastern Gandak Canal system. And it originates from Gandak Barrage located at Valmiki Nagar in Western Champaran district in State of Bihar, which passes through district of East Champaran and Muzaffarpur. There are number of drops located upstream of canal at various places. In view of the Government's thrust to develop and utilize the micro/mini hydro projects of the state of Bihar, Bihar Hydropower Corporation has further decided to harness power potential of some more canal drops located at RD (Reduced Distance) -79, RD-43, RD-65, RD-89, RD-111.5 and RD-311.5. Here the complete planning and design of small hydro power

project at RD-79 has been done, bringing out the cost benefit at 1999 price level. Planning of project was studied under two alternatives and final alternative which found most economical and was selected (Fig. I)

The project is located on Indo Gangatic plane of North Bihar which is densely populated which depends on agriculture. The area is industrially underdeveloped .The acute power shortage could be one of the reasons. The power requirement even for the agriculture is not fulfilled. The population depends on fossil fuels like diesel, petrol and oil for running their agriculture appliances. By and large the socio economic conditions of the people in this area are far below average standards. Therefore installation of the proposed power project may supplement in the agriculture growth of nearby areas besides meeting domestic demands. The project is aimed to utilize the canal drop of 1.79 m at RD 79 for generation of electricity. The TMC has been designed for discharge of 300 cumecs. However the factual discharges as collected from Irrigation Department is much less. For realistic assessment, the factual figures have been considered in order to provide a techno economical viable proposition.

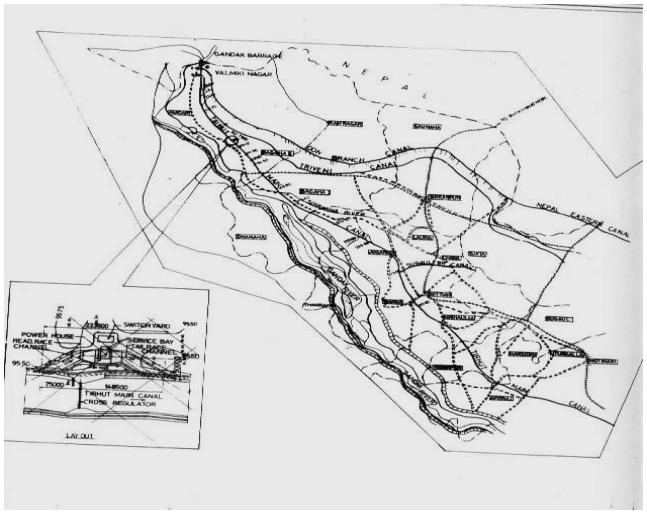

Fig. 1 : Layout of the project

HYDROLOGY

Hydrological study of main Tirhut canal project of drop 1.79 m at RD-79 for generation of electricity has been carried out with an objective to assess the actual water availability to determine power potential under proposed scheme, and for estimating the design flood peak for sizing of system. All the relevant data had been collected from Department of Irrigation, Bettiah Division Govt. of Bihar. Eastern Gandak canal draws water from Barrage which has been constructed on Gandak canal. The catchment area of the Gandak River at Barrage site is 39314 sq.km. of which about one sixth is above snow line .The Gandak River is perennial .The source of water is snow and rainfall. The canal going down stream of RD-0.5 is known as Triveni Link canal. The canal going down stream of Rd 9.5 is known as Tirhut main canal, on which the proposed scheme has been planned.

Precipitation and Rain Fall Pattern

Due considerations of data available with Irrigation Department has been given while planning. The precipitation data of Gandak River and rainfall data recorded at various rain gauge stations were studied. The annual rainfall varies from 1105 mm to 3087 mm in the region of catchment area of Gandak River. The available rainfall record indicates that approximately 75 % of the annual precipitation accounts during monsoon rain.

Since the actual data round the year is available, it is therefore necessary to rely on 10 daily discharges data only and hence rain fall data has not been considered.

Existing Water Uses

Tirhut Main canal is an irrigation canal .However one power station of capacity 3x5 MW has been commissioned at RD- 6.7 at the Eastern Gandak Canal near Valmiki Nagar.Water drawn for power generation is fed back to main canal through tail race channel.

Gauge and Discharge

The gauge discharge data in eastern Gandak canal has been taken into account. The discharge in Eastern Gandak canal was observed at barrage site till 1974 by current meter.

Table 1: Ten daily discharges At Rd-79

Months	Average Discharge (Cumecs)	Months	Average Discharge (Cumecs)
JAN 1-10	51.45	JULY 1-10	108.26
JAN 11-20	71.04	JULY 11-20	100.88
JAN 21-31	88.07	JULY 21-31	105.1
FEB 1-10	88.00	AUG 1-10	83.29
FEB 11-20	76.54	AUG 11-20	96.4
FBE 21-28	67.41	AUG 21-31	104.21
MAR 1-10	57.67	SEP 1-10	97.88
MAR 11-20	57.26	SEP 11-20	91.35
MAR 21-31	28.96	SEP 21-30	79.67
APR 1-10	0.00	OCT 1-10	100.69
APR 11-20	0.00	OCT 11-20	103.03
APR 21-30	0.00	OCT 21-31	48.99
MAY 1-10	26.07	NOV 1-10	5.5
MAY 11-20	32.39	NOV 11-20	0.00
MAY 21-31	64.39	NOV 21-30	0.00
JUN 1-10	98.2	DEC 1-10	0.00
JUN 11-20	104.12	DEC 11-20	0.00
JUN 21-30	112.79	DEC 21-31	0.00

Table 2: Average dependable discharges At Rd-79

% Dependable Flow	Average Discharge (Cumecs)	% Dependable Flow	Average Discharge (Cumecs)
2.67	113.79	51.35	67.41
5.41	208.26	54.04	64.39
8.11	105.1	56.76	57.67
10.81	104.21	59.46	57.26
13.51	104.12	62.15	51.45
16.22	103/03	64.86	48.99
18.92	100.88	67.57	32.39
21.62	100.69	70.27	28.96
24.32	08.27	72.97	26.07
27.03	97.88	75.68	16.98
29.73	96.40	78.38	5.50
32.43	91.35	81.08	0.00
35.14	88.07	83.78	0.00
37.84	88.00	86.49	0.00
40.54	83.29	89.19	0.00
32.24	79.67	91.89	0.00
45.95	76.54	94.59	0.00
48.65	71.04	97.30	0.00

After 1974 discharge has been observed by head of water upstream and downstream and by applying free flow and submerged weir formula at different locations near Rd 9.5, RD-124, and RD-311.5.Daily discharge measured at RD-9.5 has been made available for the years 1981 to 1992 by irrigation department Bettiah. There is no outlet or distributaries between RD-9.5 and RD-79.The

seepage loss in canal has been considered as one cusecs per thousand feet length. Taking this into account 10 daily discharges at RD-79 have been calculated and shown in table-1. Calculations for dependable discharges has been made by writing the available data on 10 daily discharges in descending order and considering each variant to have equal probability of occurrence. The percentage dependability for average year has been arrived by using Weibuls Distribution Method (Table-2).

Design Flood

The highest flood occurred near Barrage site in 1956.Estimated maximum discharge during that period is 19,549 cumecs as per record available with Irrigation department. This discharge will not have any effect on hydraulic structures, since the regulated discharge is released from the Barrage. However highest flood level in the vicinity of canal has been taken into account for design of bypass channel and foundation of the equipment.

GEOLOGY

The area lies in an Indo Gangetic plain, consists of thick alluvium track of the Ganges. The deposit of the thick track belongs to the last phase of depositional history of earth and conceal beneath them the northern fringes of peninsular and southern fringes of extra peninsular formation. Litho logically this entire loose unconsolidated sequence is composed of brown black elastic clay. Ground water was recorded at a depth of 0.25 m below the ground.

Bearing Capacity

MIT Muzzafarpur was engaged in carrying out soil investigation at RD-311.5 .The average cohesion was found as 0.25 kg/cm2 and angle of internal friction as 28 degree. The bearing capacity was determined for the following criteria:

i. Safe bearing capacity -0.7 kg/cm2.
ii. Shear failure criteria -0.957 kg/cm2.
iii. Triaxial compression test –Safe bearing capacity-1.44kg/cm2

Out of three, the lowest value of 0.7 t/m2was adopted. Same value was considered for the RD-79

WATER POWER STUDIES

Available data.

Water power studies have been carried out based on dependable flow and net head.

Dependable Flow

The data on hydrological studies indicating the dependable discharges in the canal for power generation has been discussed. The percentage dependable flow at proposed location (RD-79) has been worked out on available discharges of canal at RD-79. The same has been indicated in table 2. From the hydrological data it is evident that the canal remains closed for about three months. Thus the flow is available for about 72.6 % of the time in a year.

Net Head Available

The head available at proposed site due to canal drop is 1.372 m only, which is not adequate to generate power economically. To make the project viable it has been envisaged to raise the water level in the canal by constructing a suitable weir at canal drop. The project will have a suitable weir of suitable height to divert water in power canal. The head water level in the power channel will be 98.43 m. The weir will have spillway arrangement so that the excess water can flow through the main canal. The water level in the downstream varies. The gross head too will vary from 2.91 m to 4.35 m and net head will vary from 2.77 m to 4.13 m., considering a head loss of 5 %.in the system.

POWER POTENTIAL

The discharge of 80 cumecs has been considered for the analysis of the power potential. Considering the turbine efficiency 91.5 %, generator efficiency 95.5 % and gear box efficiency as 98 5%., the firm power potential of scheme has been worked out as

Power Potential = 9.81X Net head X Design discharge X Turbine efficiency X Gear box efficiency=9.81x2.77x0.915x0.955x0.98=1852 kw.

Installed Capacity

The installed capacity has been selected on the basis of power demand, minimising period of running one machine on part load, total energy generation and incremental benefit vis a vis additional cost incurred. Energy generation has been worked out for different installed capacities varying from 1600 kw to 2400 kw. Based on CEA guidelines only two units of 1000 wk have been adopted.

DESIGN OF CIVIL WORKS

The project has been planned in such a way that power potential of canal at fall is utilized for generation of power .A lined head race channel will lead water from upstream of a fall to power house .From power house water will be fed back to the main canal through lined tailrace channel.

From consideration of economy and to minimize friction losses, the tail race channel and the head race channel have been planned very close to the existing canal. The design of civil works comprises of cross regulator on existing canal, head regulator on head race channel, power house, by pass, and tail race channel (Fig 1).

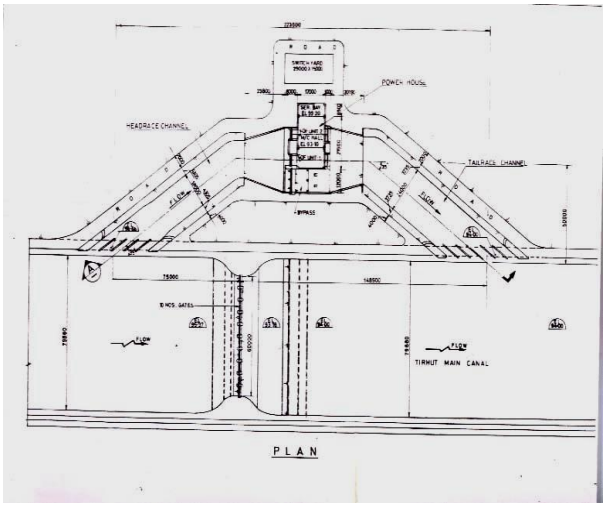

Fig. 2: Plan of the Project

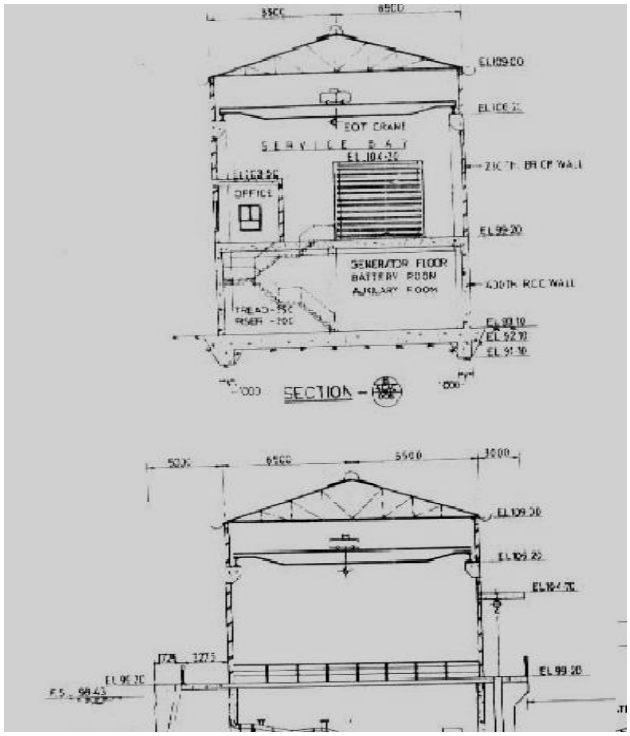

Fig. 3: Sectional View

Cross Regulator on Tirhut Main Canal

There is fall at RD-79 on TMC.A cross regulator is proposed on main canal just upstream of fall. It will head up the water even main canal is running with low discharge. The construction of cross regulator will be carried out by modifying existing fall structure. Ten number of gates will be constructed to control the discharge (Fig.2).

Head Regulator on Head Race Channel.

Head regulator with bed width of 20 m and 5 number ungated bays have been proposed

Head Race Channel

Hydraulically lined trapezoidal section has been adopted for head race channel. The design discharge of 80 cumecs has been considered. Freeboard level of 0.75 m has been kept. Take off angle of 35 degree has been provided for the diversion channel. The bed slope of power channel has been kept art 1:1317 and side slope 1.5:1 (H: V) is provided for stability point of view.

Design parameters are –
Design Discharge = 80 cumecs
Full supply depth =1.82 m

Manning coefficient = 0.017
Velocity =1/n R 2/3 S ½
= 2.1 m/sec

The velocity is acceptable for a concrete channel.

Power House

The power house building has been planned and designed to house generating units, auxiliary equipment, and control panels. The size of the building will be 28x17x6.5 m.A separate control room, battery room etc.has been proposed. The machine hall shall be placed on raft foundation due to consideration of vibration and uplift pressure. The foundation shall be constructed in RCC. Tubular trusses with CGI sheet roofing are proposed to be provided. This will economize on cost. and reduce the construction time (Fig.3).

Bypass Channel

In case of sudden tripping of the plant the water level in head race tunnel will tend to rise above full supply level till the automatic gates provided in bypass channel will open. Bypass channel will discharge the excess water back to the canal
Tail Race channel.

The design of tail race channel is based on the Manning's formula. Thus using Manning equation the following section has been adopted.

Design discharge = 80 cumecs
Full supply depth = 1.44 m
Free board = 0.75 m.
Manning's coefficient f =0.017
Slope = 1: 1135
Side slope = 1.5:1
Velocity = 2.1 m/sec
Bed width =24 m

Electro Mechanical Works

To keep pace in line with the development of mini/micro/small hydro projects, the endogenous turbo generator sets are quite economical and comparable to global standard. Based on techno economic studies and choice of scheme the selection of electro mechanical equipment has been done.

i) Turbines **:** For the low head projects specific speed of the turbine is quite high, ranging from 700 to 1000.Therefore tubular type turbine has been selected. Turbine will be placed horizontally inside steel conduit through which water is allowed to pass from head race channel to tail race channel. Following parameters are designed for tubular turbines.

Type of turbine – S type horizontal axis
Number of units = Two
Design out put = 1071 wk +10 % overload.
Design discharge = 40 cumecs for each turbine
Design head = 3 m
Runner diameter = 3200 mm.
Efficiency = 91.5 %

ii) Generators**:** Induction type of generator is provided with horizontal shaft arrangement.
The generator will be connected to turbine through speed increase arrangement. Each generator shall be capable of generating 110 % of rated output (Fig.3).

Cost Analysis of The Project

Based on 1999 price level, the total cost of the project has been worked out as Rs.1455.55 lakhs.The cost of generation at bus bar has been worked out as Rs. 2.14 per unit with subsidy and Rs. 2.28 per unit without subsidy.

CONCLUSIONS

The project has been found technically and financially viable.It will provide electricity to the area for agriculture and domestic use.

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