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Case Study

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Intake Structure and Protection Works for Alluvial River in Eastern India - A Case Study

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ABSTRACT

Major alluvial rivers in India originate in Himalayan range and flow towards sea while passing through plains. It is well known that these rivers carry variable sediment load. There would be either sediment deposition or erosion, depending on the discharge and corresponding sediment load. Such an imbalance can lead to changes in deep channel and/ or banks of alluvial rivers. River is one of the commonly source of water supply for domestic and industrial units. Location of intake structure under such a situation would lead to consideration of different aspects like availability of channel of adequate dimension for drawing water, proximity to site, stability of river channel and availability of nodal point(s). Further, there are factors like availability of land for locating pump house, switchyard and construction activity as well as passage for carrying pipeline. In addition, one has to look for available resources like financial, human and infrastructural items. The study is carried out by taking into account of these aspects in an integrated manner while arriving at the results for intake structure and protection works for alluvial river in Eastern India.

INTRODUCTION

The shortages of power experienced widely over the country need not be emphasized. To mitigate shortages of power by expansion of existing power projects as well as construction of new power projects is being undertaken. Water requirement for the power plant can be drawn from nearby water body like lake, river or sea or through ground water. Water is drawn from the river through intake structure in the form of jack well or fore bay structure. It is well known that the aspects related to the location of intake require review of changes in bank line of river in the study area. These studies gain importance, if the river has braided pattern and shows tendency of shifting from one bank to another. The objective of the study is made to integrate the aspects like stability of channel, availability of adequate depth and space for switchyard, pump house etc in the vicinity of the proposed site for deciding the location and type of intake for a thermal power plant in Eastern India [1].

STUDY AREA

M/s Damodar Valley Corporation (DVC) is proposing to set up a new thermal power plant at Durgapur adjacent to the existing powerhouse of Durgapur Steel Plant. Durgapur town is on the trunk line from Howrah to Mumbai. The proposed Durgapur Steel Thermal Power Station, (DSTPS) located on left bank of river Damodar about 12 km upstream of Durgapur barrage, is proposed with installed capacity of 1000 (i.e., 2 units each one with 500 MW) MW. The project extends over an area of 516 ha (1276 acres). Overall terrain in the plant area is flat in nature with mild slope towards river Damodar (Figure 1). Singaran nala originates upstream of project area, passes through plant area and out fall in river Damodar river.

Figure 1: Location Map of DSTPS

MATERIALS AND METHODS

Study task was achieved through different stages and duly considering the aspect associated in each stage. These stages include:

i) Collection and analysis of Survey of India (SoI) satellite data to identify changes in bank line and river channels.
ii) Inspection of site, discussions with project officers and local inquiry to identify possible location of intake.
iii) Development of 1-D mathematical model to estimate hydraulic parameters for deriving bank protection measures near intake.
iv) Derivation of schematic of intake structure.

RESULTS AND DISCUSSIONS

Analysis of Bank Line Data

It is necessary to review the stability of the bank before deciding the location of intake. In order to ascertain the stability of the bank, the changes in bank line are to be studied. In the present situation, the bank line data from SoI sheets for 1930 and 1976 were collected. In addition, satellite data for the year 1992, 2002, 2004 and 2006 were collected from the then National Remote Sensing Agency (NRSA), Hyderabad. The bank line vectors were extracted from the data. It was noticed in the initial comparison that the changes in bank line in SoI toposheets for the year 1930 and 1976 are almost negligible. Accordingly, it was decided to consider the bank lines in 1976 toposheet for comparison purpose. The proposed locations of intake for DSTPS are broadly in two areas situated near Durgapur barrage and upstream of confluence with Singaran nala. The stretch of river Damodar was divided in two segments A and B. The stretch of river Damodar extending to 6.9 km upstream of Durgapur barrage is included in segment B. Segment A covered the reach of river Damodar for a length of 9.3 km upstream of segment B.

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It was noticed from the superimposition of bank lines that there has been change in the stretch covered in segment A with respect to 2004 and as well as with respect to toposheet. Table 1 shows maximum change in bank line for a particular year with respect to reference bank line. Sample of superimposed bank lines and channel lines is shown in Figures 2A and 2B.

Table 1: Maximum Change in Bank Line Segment A

Reference Bank line	Maximum Change in Bank line (m) Segment A				
	Topo sheet	1992	2002	2004	2006
2004	264	57	46	-	29
Toposheet	-	340	274	-	157

The comparison of bank lines in segment A showed that:

a) There are changes in left bank line of river Damodar in upstream and downstream of confluence with Singaran nala.
b) In a stretch of about 500 m upstream of Singaran nala confluence, it was seen that there is a channel hugging left bank. Attempts were made to measure the width of channel in different years.

It was noticed that channel width is varying from 84 m in the 1976 year to 334 m in the year 2006. Prima facie, it appeared that water requirement for proposed DSTPS of 1.3 m^3/s (46 cusecs) can be satisfied from this location.

Identification of Possible Location of Intake

Hydrographic survey data and Survey of India Toposheets were reviewed and likely locations were decided. In order to review prevailing situation and conformation of preliminary results, inspection of river Damodar from Durgapur barrage upto a stretch of about 18 km on upstream was carried out in January 2007 and September, 2007. Initially left bank was inspected at (i) Ashishnagar (ii) Rathuria near permeable spur location, (iii) Near ash pond of existing thermal power station and (iv) Confluence of Singaran nala.

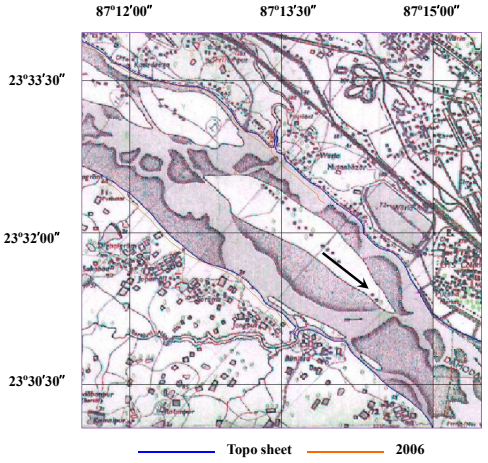

Figure 2A: Superimposed Bank lines for Segment A of Toposheet and 2006

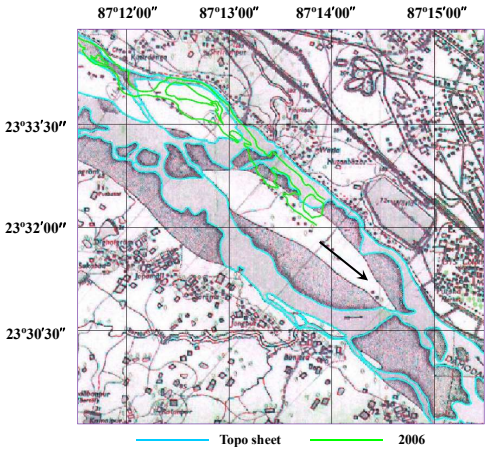

Figure 2B: Superimposed Channel lines for Segment A of Toposheet and 2006

Latter, six locations were visited viz. (i) Mejia intake, (ii) Sites A, B and C, (iii) Water supply

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canal at head, (iv) Rathuria near Kalimata Mandir, (v) Stretch of river Damodar upstream of location D and (vi) Location E (Figures 3A and 3B). Local inquiry with the villagers was carried out during inspection.

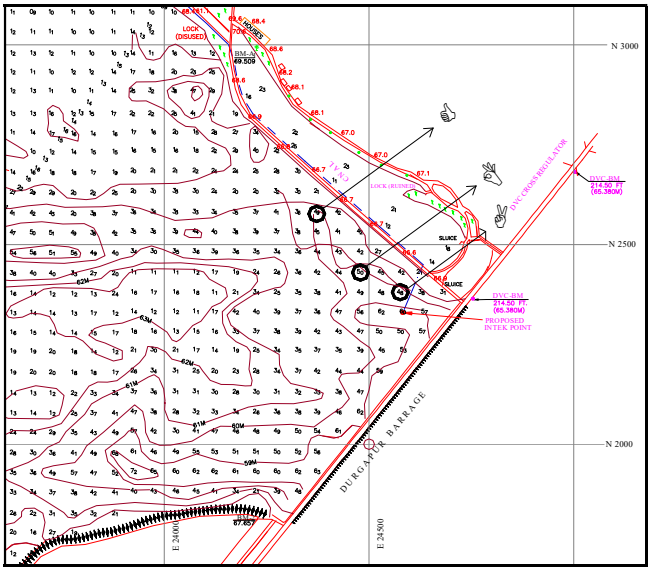

Figure 3A: Alternate Intake Locations

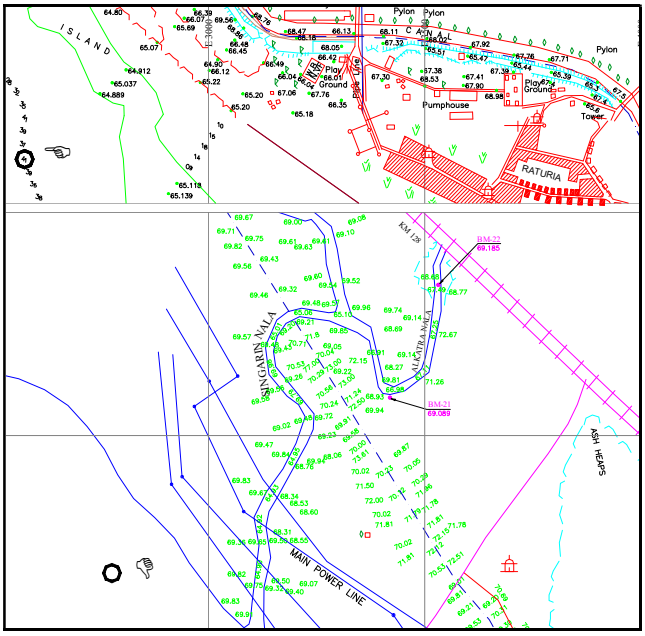

Figure 3B: Alternate Intake Locations

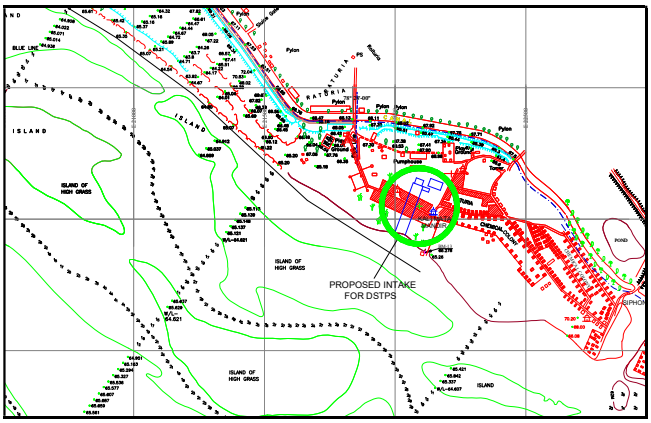

Figure 4: Location of Proposed Intake for DSTPS

The general observations during the inspection are given below:

a) Although adequate depth is likely to be available, the locations A, B and C are not to be considered due to space constraints as well as pipeline corridor problem.

b) The location at Rathuria near Kalimata mandir is in the vicinity of active erosion and as such would lead to frequent maintenance to keep the channel of river active on long term basis. This would require initial and maintenance dredging from time to time, till development of river channel near bank is complete.

c) Alternative D cannot be considered advisable due to presence of active erosion and likelihood of non-availability of water in the river channel.

d) Location in water supply canal near head has many positive points with respect to availability of space for pump house, switch room and construction activities as well from approach considerations. However, there can be difficulties during construction as different major units including municipal water supply are fed through this canal and

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utmost care has to be taken to ensure continuous water supply.

Comments and difficulties expressed by the project authorities have been duly considered. In view of the difficulties indicated by the project authorities the location on left bank of river Damodar near Kalimata Mandir can be considered for construction of intake structure (Figure 4) The prevailing ground situation at this location indicates that except at 1 or 2 spots, depth of 1 to 2 m only would be available with barrage maintained at MDDL i.e. RL 63.4 m.

Other aspects to be taken into consideration include:

a) The bank of river Damodar intake near Kalimata Mandir at Rathuria is not stable and is undergoing changes since past few decades.
b) Villagers have attempted to provide protection to left bank of river Damodar using permeable spurs made from locally available wood.
c) The above situation would require stabilization of the bank prior to locating the intake. This work would include construction of permeable/ solid spurs and providing pitching to the left bank at least for a length of 500 m on upstream and 200 m on downstream of the proposed location.
d) In addition to intake, separate works in the form of permeable spurs/porcupines would be necessary to stabilize the bank on upstream.
e) Non-availability of adequate depth would necessitate dredging of river bed to ensure adequate depth. This channel is to be developed initially and maintained in the subsequent years to ensure the availability of depth.

Bank Protection Measures near Intake

High velocity flow is likely to prevail during passage of high flood and it is necessary to provide protection to the bank with stone in crates [2-3]. The details of pitching can be derived using the hydraulic parameters like HFL, velocity and intensity of discharge [4-5]. Since observed data on these parameters in not available, the values were obtained from the simulation run taken on HEC-RAS model developed by U.S. Army Corps of Engineers. A stretch of 18 km upstream of Durgapur barrage was considered and hydraulic parameters were determined (Table 2).

Table 2: Hydraulic parameters

Sl. No.	Parameter	Value
1	Maximum water level (m)	68.44
2	Velocity (m/s)	2.04
3	Depth (m)	8.32
4	Discharge intensity ($m^3/s/m$) with 20% enhancement	20.36
5	Mean Diameter (mm)	0.25

Further soil properties of bank materials like silt factor, c and φ were considered and thickness of pitching was derived as 0.5 m. Further, width and thickness of apron and width of apron were also derived. This would require laying stone in crates of size 1 m x 1 m x 0.5 m thick (Figure 5). These crates are to be laid over non woven geo-fabric filter. This filter is proposed to prevent escape of fines. A slope of 1V: 3H is proposed. The pitching is to be provided for a length of

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about 500 m on upstream and 200 m downstream of intake. Clay core is suggested wherever height of bank exceeds 5 to 6 m. Toe wall and 5 m wide x 0.5 m thick apron made from same crates are proposed.

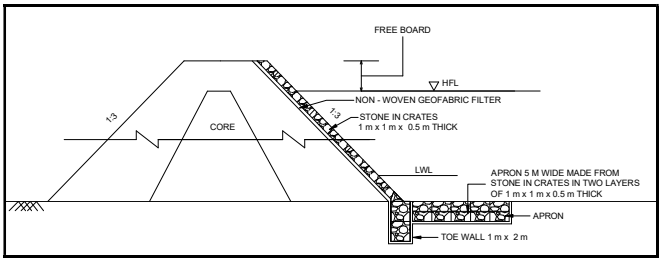

Figure 5: Bank Protection Scheme for DSTPS Intake

Schematic for Intake Structure

Different types of intakes are in vogue. These includes: (i) Jack well in deep channel; (ii) Jack well with pipe connected to deep channel; (iii) Jack well with pipes to collect percolated water and (iv) Sump with open channel

The type of intake suitable for particular site can be decided after review of local conditions. Jack well type of intake is being used for a variety of condition since past 3 to 4 decades. However, it is necessary to ascertain the availability of adequate depths to prevent occurrence of vortex during pumping. Accordingly, intake can be located in deep channel or on the bank with pipe connected to the channel; alternatively, pipes leading percolated water to jack well can be used. Sump with open channel drawing water from different sections of the river is another type of intake. This type is generally resorted when lower depths of water are available. In the present situation the above factors have been taken into consideration and sump with open channel is selected.

A review of intake provided in the vicinity of the plant area has been taken and necessary modifications for accounting change in site conditions have been made. Schematic of intake structure has been derived under the assumptions for type and number of pumps (including stand by pumps) has been derived. Arrangements have been made to remove the sediment at entry point by increasing the width and providing silt trap at the later location. Periodical removal of the silt from the trap is suggested. Sill level of weir and the approach channel is derived to ensure the adequate quantity of water towards sump. Necessary flexibility in dimensions of the structure is provided to account for change in type and number of pumps. Schematic of intake structure is shown in Figures 6A and 6B.

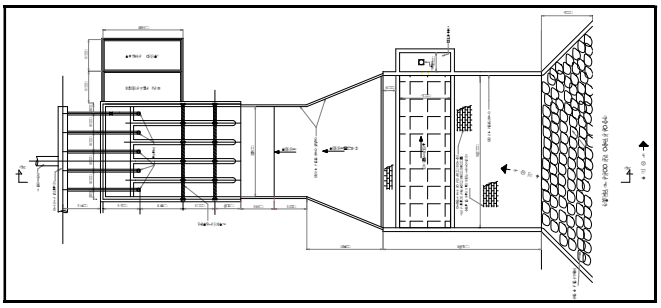

Figure 6A: Plan of Approach Channel for DSTPS Intake

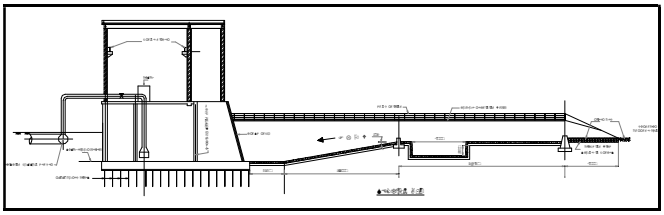

Figure 6B: Sectional Elevation of Approach Channel for DSTPS Intake

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CONCLUSIONS

Studies have been carried out to decide location and type of intake for proposed power plant at Durgapur. Important conclusions of study and different aspects related to selection of intake are given below:

i) Factors related to location and type of intake is identified. Integration of these aspects includes: Identification of changes in bank line and river channel of river, Inspection of site for acquaintance and confirmation, Proximity to the plant, Accessibility and flow conditions at site, Availability of land for raw water pump house/ pipe corridor and Protection measures required in the vicinity of intake

ii) It is proposed to draw plant water requirement through intake well located near Rathuria near Kalimata mandir on left bank of river Damodar using sump type intake.

iii) Principal and maintenance dredging for initializing the channel near left bank are recommended.

iv) Sump type intake with approach channel is suggested for DSTPS. The dimensions are flexible to accommodate minor changes due to selected type and number of pumps.

v) Bank protection in the form of pitching with stone in crates of size 1 m x 1 m x 0.5 m is suggested. These are to be laid over a dressed slope of 1V: 3H. A non-woven geofabric filter is recommended. Protection for a length of at least 500 m on upstream and 200 m on downstream of the intake structure near Rathuria is suggested.

vi) Necessity of separate measures for stabilizing river bank upstream of intake location is identified. These would include construction of permeable spurs/porcupines and subsequently pitching of bank after ascertaining the stabilization achieved.

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