

REPORT ON SONAGAZI 50 MW SOLAR POWER PLANT DESIGN REVIEW OF DYKE, SIUCE GATE ETC.

BACKGROUND

1. Electricity Generation Company of Bangladesh (EGCB) has taken up program to build one 50 MW Photo Voltaic Solar Power Plant at Sonagazi Upazila, Feni District, adjacent (eastern side) of the newly built BWDB Musapur Closure (1.08 km length) over little Feni River. The EGCB has acquired a large area of around 1000 acres of land on the eastern side of the closure to build Solar Power Plants in phases. In the first phase, the Company has planned to build 50 MW Plant in part of the area measuring around 165 acres to feed the under construction BEZA area on the southern side. This Plant site needs to be protected from tidal flooding and cyclonic surge event for safe operation. A feasibility report has been prepared earlier by Feasibility Report prepared by Wind Force Management Services Pvt. Ltd. India, and Sun trace GmbH - Germany and EQMS Consulting Ltd. – Bangladesh and the report gave an outline of the height of the flood protection dyke and design of the internal drainage system. In order to review the design of the proposed dyke, and other civil infrastructure such as drainage network, internal roads etc., the World Bank advised EGCB to hire a short term Disaster Risk / Civil Engineer.
2. Following the recommendation of the Bank, EGCB hired Engr. GM Akram Hossain Peng, a Senior Civil Engineer, who worked (in the immediate past) as Team Leader, Design & Supervision Consultants of the IDA funded Emergency 2007 Cyclone Recovery & Restoration Project (ECRRP), BWDB Part. A contract was signed between the Consultant and EGCB for 20 days with additional 10 days (if needed for pre-bid meetings etc.) intermittently over a period of 5.5 months from 29 May 2019. Mr. Akram (Civil Engineer / Consultant) commenced work with a visit to the proposed Power Plant site on 29 May 2019.

PROJECT SITE VISIT

3. The site visit was made by the Disaster Risk / Civil Engineer (Consultant) along with the Project Director/Superintending Engineer (Procurement), EGCB, on 29 May 2019 to assess the design section of the peripheral dyke and to review the design of internal canal network and the drainage system. Before the visit to the site, Consultant had telephone discussions with BWDB Superintending Engineer, Design Circle II, Mr. Md. Harunur Rashid to get access to the design information of the Musapur Closure. Project Director, Sonagazi Power Plant & Superintending Engineer (Procurement), EGCB, Mr. Md. Anwar Hossain also wrote an official letter to BWDB Design Office to get information on the design of the Musapur Closure. Mr. Rashid was nice enough to introduce the EGCB team with Mr. Md. Abul Kauser, Superintending Engineer, Design Circle IV, BWDB, who was the Officer that designed the closure. Accordingly the team had a meeting with Mr. Kauser, in his office at 72, Green Road, Dhaka on 23 May 2019. Mr. Kauser was extremely cooperative with the EGCB team and shared copies of relevant drawings of Musapur Closure from his Design Cell Archives. He further called Executive Engineer, Noakhali O&M Division, over phone to provide additional design data check list of the closures to assist in the assessment of dyke design along the Plant periphery.

4. On the day of the visit on 29 May 2019, the team met Mr. Md. Nasir, BWDB Executive Engineer, Noakhali O&M Division, in his office at Noakhali District Headquarters. Mr. Nasir was very cooperative and supplied a set of design data check list of the Musapur Channel closure for use in the design review of dyke for the protection of Solar Power Plant site.
5. After the meeting with Executive Engineer, BWDB, the team visited the proposed Solar Power Plant site and the sites of Musapur Regulator and Closure. The Musapur Regulator (23 Vent 3.0 x 3.0 meter) was constructed in 2009 on a diversion and the main channel is closed (figure 1 & 2) with the closure dam. The regulator site was photographed during the site visit (figure 3). The Solar Power Plant site is located adjacent to the Musapur Closure on the north eastern peninsula. The photographs of the site taken during the visit on 29 May 2019 is presented in figure 4&5. The 23 Vent Musapur Regulator drains a huge catchment of Little Feni River and the Dakatiya River into the Sandwip Channel of the Bay of Bengal and is now only around 900 meter from the regulator with eminent danger of erosion. BWDB has taken up program under O&M to protect the regulator by dumping CC Blocks along the outfall channel and the work was seen ongoing during the visit. A photograph of the CC Block manufacturing yard is presented in figure 6.



Fig 1: BWDB Musapur Closure



Fig 2: BWDB Musapur Regulator Deck



Figure 3 Musapur Regulator Site, Sonagazi, Feni District



Fig 4: Sonagazi Solar Power Plant Site



Fig 5: Project Director & Consultant at Site



Figure 6: Photo BWDB CC Blocks Manufacturing Yard at Sonagazi

6. After the site visit the Project Director / Superintending Engineer (Procurement) made a courtesy call on the Upazila Nirbahi Officer (UNO), Sonagazi Upazila, Mr. Sohel Parvez, in connection with payment for resettlement for Project Affected Persons (PAPs). The list of people met during the preparation of this review report is presented in **Annex 1**.

EMBANKMENT DESIGN REVIEW

7. The feasibility report recommended **sea dyke height of 5.0 meter from existing ground level of the Plant site (average level around 5.0 meter PWD)**. Again the revised Bidding Document suggested that the protective dyke stands at 11.00 m

height. Disaster Risk /Civil Engineer (Consultant) reviewed the Data Check list collected from Executive Engineer, BWDB O&M Feni Division. The analysed BWDB data gave the 25 – year highest water level as 6.80 Meter PWD at the nearest Water Level Station located at Companygonj. This level is similar to the highest water level recorded at the gauge station installed at the Musapur Regulator pier by the Institute of water Modelling (IWM). The crest level of the Musapur regulator deck (completed in 2009) was set at 7.60 meter PWD (figure 7) and that of the Musapur Closure (built in 2015) was set at 8.10 meter PWD. These data were collected during the site visit on 29 May 2019.



Fig: 7 Bench Mark (BM) on Musapur Regulator Deck

8. According to BWDB Superintending Engineer, Design Circle IV, Mr. Kauser, the Musapur Closure's crest level was designed as 8.10 meter PWD considering 25 year highest water level with 0.90 meter free board and 0.30 meter allowance for climate chance option. He further added that BWDB now has a mandate to design coastal dyke with 100 year flood frequency and 1.50 meter free board keeping 30 cm allowance for climate change.
9. **Design Crest Level of Dyke:** As mentioned above, the analysed 25 year high water level at the nearest BWDB water level gauge station at Companygonj is 6.80 meter PWD¹. In the feasibility report, the analyzed 25 year level is 7.00 m PWD. The Log Pearson Type III distribution yields a yearly rising trend of around 0.0072 meter which if extrapolated to 100 year frequency, the level results in 7.34 m PWD. With 1.50 meter free board (to allow wind set up and wave run off) and 30 cm allowance for climate change, the sea dyke design crest level turns out to be around 9.14 meter PWD. Considering 7% shrinkage and settlement of the foundation soil under the dyke, the crest level turns out to be $9.14 + (9.14-5.00)*0.07 = 9.45$ m PWD. This level may be rounded to 9.50 m PWD.

¹BWDB data Check List supplied by Executive Engineer, Noakhali O&M Division.

10. Further, the Feasibility Report reported the storm surge height of 4.5 meter on land during 1961 cyclonic event² at the Meghna estuary near Feni River and around 4.0 meter surge height at the site in May 1991 cyclone. Both are highest recorded surge height near the Project site. Taking care of these historical surge height, the crest level required is $(5.00 + 4.50) = 9.5$ meter. When a 50 cm free board is added to the surge height, the crest level turns out to be around 10.00 m PWD (not 11.0 meter PWD as suggested in the revised report) along the sea front with protective works. Under these scenarios, it is recommended to raise the crest along the southern sea front to 10.00 meter PWD from Chainage around 900 meter to around 2700 meter = 1800 meter length and gradually reduced to 9.5 meter for the remaining length of the dyke along the south eastern and along the main access road on the northern boundary (please see layout plan Map) with 3% longitudinal slope for easy movement of vehicle. A comparative statement in reference to decision making of the crest level is presented in the tabular matrix below:

Table 1: Dyke Crest Level³ Reference

Reference	Maximum WL (meter PWD)		Free Board (Meter))	Climate Change (m)	Shrinkage Settlement	Design Crest level (m PWD)
	25 Yr.	100Yr				
Feasibility Report						10.00 ⁴
BWDB Data	6.80		1.00	0.30		08.10 ⁵
Consultant	6.80	7.30	1.50	0.30	0.30	9.40~10.0 ⁶

11. **Dyke Crest Width:** The crest width of the dyke may be kept as 5.5 meter (3.70 + 0.90 x2) including 90 cm shoulders on both sides to use the dyke as service road. **The dyke will also be used as road** during construction of the second phase 100 MW Solar Power Plant,

12. **Dyke Side Slope:** The feasibility report suggested side slopes of 1:2 (V: H) on the plant side and 1:3 (V: H) on the sea side. Consultant recommends 1:2 on the country side (plant side) as in the feasibility report, but the sea side slope needs to be increased to 1:3.5 (V:H) with a 3 meter berm at around mid-height (level 7.00 m) in accordance BWDB sea dyke in the nearby Polders. The flatter slope is required on the seaside to take care of wave run off and wind set up and to keep the phreatic line within the dyke for the safety of the dyke against seepage failure (revised dyke section in the Annex2).

²Feasibility Report prepared by Wind Force Management Services Pvt. Ltd. India, and Sun trace GmbH - Germany and EQMS Consulting Ltd. – Bangladesh

³Source: Feasibility Report prepared by **Wind Force Management Services Pvt. Ltd.** India, and **Sun trace GmbH - Germany** and **EQMS Consulting Ltd. – Bangladesh**, and Bangladesh Water Development Board (BWDB) Design Circle IV.

⁴The feasibility Report prepared by Feasibility Report prepared by Wind Force Management Services Pvt. Ltd. India, And Sun trace GmbH - Germany and EQMS Consulting Ltd. – Bangladesh, recommended 5.0 meter dyke from existing average ground level of 5.00 m PWD.

⁵Constructed crest level of the Musapur Closure adjacent to Plant site.

⁶The crest level of the dyke is raised to 10.0 m PWD along the sea front with protective works on the south western and southern boundary to take care of historic cyclonic surge and gradually reduced to 9.50 meter along the eastern and north eastern boundary.

DRAINAGE SYSTEM DESIGN REVIEW

- 13. Existing Roadside Canal:** The existing roadside canal along the western side may be developed through re-excitation to have a water body with clean water environment at the plant site and an option may be to use the water body as a potential fish farm. The existing top width of the canal (measured during the site visit on 29 May 2019) was found around 55 feet (17 meter) as shown in figure 6. It is recommended to reshape the canal in a trapezoidal section with top width as 20 meter, depth to 2.0 meter and bottom width of 14 meter with side slope 1:1.5 (V:H). To reduce percolation and to increase water holding capacity of the canal, 30 cm clay cover may be applied on the side slope and the bottom after re-excitation. The contractor may include this provision in the bidding document. When re-excavated, it would be an ideal spot for fish culture. The canal will be designed with minor dyke (2.0 meter high) with crest level raised to 7.00 m PWD with 2.5 meter crest having tree plantation along the toe and the berm (3 meter berm may be kept on both sides). The western end of the canal will be provided with a check structure /check culvert to control water level in the canal and to check external flooding. A fish net will prevent escaping of fish population. Proposed design section of the canal with minor dyke and tree plantation is presented in Annex 3.
- 14. Cross Drainage Culverts:** A major culvert will be installed across the canal at the main entrance to Project site along the 20 meter wide approach road on the northern boundary. The culvert shall be designed with H20 loading to take care of the loaded trucks. The hydraulic design of the culvert will take into account an outside inflow of a catchment of around one half square kilometres. The culvert will have two bays of 6.0 m clear span with fish net provision and the deck level set at 10.0 m PWD with transition of 3% longitudinal slope to match the crest level of 9.50 m PWD. A sample sketch is provided in Annex 4.



Figure 6: Existing Road side Canal along western boundary

- 15. Internal Drainage Management:** The natural drainage channel network will be developed with minor dyke (0.90 meter high) and 2.5 meter crest width (side slope 1: 1.5) on the Project side with crest level at around 5.90 m PWD with suitable species of tree plantation along both sides.
- 16. Design of Drainage Sluice:** To dispose of accumulated internal rainwater and an outside inflow of about half square kilometres, a single Vent 2.44 meter wide x 1.60 meter high Conduit type Drainage Sluice may be provided at the end of the channel (See plan in Annex 5). The sluice will be provided with light weight flap gate on the sea side to open under water pressure when tide level permits. The size needs to be during detail design. When the level does not permit drainage, pumps will be installed by the side of the sluice gate to pump out rain water out into the sluice outfall channel as suggested in the feasibility report. The sluice outfall

channel may needs to be re-excavated up to the estuary for effective drainage. Contractor will carry out sluice site survey work (grid survey) for an area 100 meter x 100 meter from the centre line at the dyke section. It may be a plane table survey with spot level taken at every 5 meter interval. The contractor will also conduct geotechnical investigation at the sluice site (three bore holes to be done with Standard Penetration Test (SPTs) extending to 20 meter with samples taken at every 5 meter for testing) to design the foundation of the Sluice. The contractor will carry out detail engineering design of the Sluice and prepare BOQ.

17. Determining Capacity of Pumps: As per data provided by BWDB, 280.20 mm was the highest recorded historic rain fall in a day of 13 May 1984 (source: Feasibility report). Rounding up the highest rainfall to maximum 300 mm per day, the runoff generated within the 165 acres (66.80 hectares) of PV Plant area is calculated to around 36,736 gallons per minute (table 2).

18. The table shows that there is a need for around 8 (eight) number of 30 horse Power pump to be installed suitably by the sluice gate with pipe extended to the pool in front of the sluice to drain 100% of the rain water falling in the PV plant site. However if we consider to pump out 85% of the accumulated water, the required number of pump is 6 (six). The remaining 15% of the accumulated water will inundate the site to an elevation of 5.225 m PWD for five day historic rainfall. In other words, there will be around 23 cm (9 inches) of flooding inside PV plant site which may be acceptable.

Table 2: Calculation of Pump Capacity & Number

Parameter	Value	Unit	Source
Project Area	165	Acres	Site Survey
Maximum Rainfall	0.0125	m/hour	As per BWDB Data, - highest recorded historic rain fall is 280.20 mm in a day of 13th May 1984 (Source Feasibility Report). This is further rounded to maximum 300 mm per day.
Rain water Collected at site	36,736	gallons/min	Calculated
Water horse power needed to discharge rain water at the same rate of the hourly rain fall	185.53	Horse Power	$HP = QhSg/3960$, where Q is the discharge in gallons/minute, h is the water head and Sg is Specific Gravity, Water head is taken = 6.0 meter, Sg = 1.0
Number of 30 HP Pumps	6.18~ 8.0	Number	Total 30 HP pump required is 6. With added 2 (two) number as stand by, the number of pump is 8 (eight)

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