

PRELIMINARY INVESTIGATION AND DESIGN CONSIDERATIONS FOR THE REHABILITATION OF TRASH SCREEN AT JOR RESERVOIR LOW LEVEL OUTLET

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Abstract. Jor reservoir was constructed to assure flow regulation for the Woh hydroelectric power station, as well as to provide storage for flood control. The reservoir outlet is frequently operated once every three months to flush the deposited sediments accumulated within the reservoir. Preliminary testing and inspection on the reservoir outlet revealed that the trash screen located at upstream of reservoir outlet had been damaged and dislodged creating a large opening at the trash screen thus permitting entry of larger logs which blocks the passage of water through the reservoir outlet. Bathymetric survey showed the total height of sediment deposition above the reservoir outlet covering the trash screen was estimated at approximately 13 m. The sediment volume estimated to be cleared from above the reservoir outlet area is 15,000 m³. Soil investigation conducted shows that the sediments deposited within the reservoir exhibits various different profile and characteristics. The average sediment distribution at deeper depths closer to the trash screen was found to be of 27% clay, 26% silt, 43% sand and 4% gravel. The rehabilitation works on structure as the low level outlet serves as an important feature for reservoir sedimentation management as well as for safe flood discharge release as designed for the dam. It is important that the function of the reservoir outlet structure is maintained in accordance to the International Dam Safety Standards.

1. Description of Jor Reservoir

Jor reservoir was constructed to assure flow regulation for the Woh hydroelectric power station, as well as to provide storage for flood control [1]. The reservoir is confined by two earthfill dams namely Jor Dam and Jor Saddle Dam which forms part of the Batang Padang Hydroelectric Scheme. Jor Dam is situated in a narrow section of the valley of the Sungai Batang Padang, together with the saddle dam on the low ridge on the right bank of the river. Jor reservoir covers a total area of 80 acres (350,000 m²) and has an approximate total storage volume of 3.8 million m³ with approximately 3.0 million m³ as live storage for hydropower power generation. During the preliminary stage of construction, a 14 ft (4.3 m) diameter concrete lined diversion was driven from the outlet structure to connect with the spillway tunnel. The Batang Padang River was diverted through the diversion tunnel and spillway tunnel on October 1965 and the diversion tunnel was closed on July 1967 when the impounding of the reservoir commenced.

2. Description of Jor reservoir outlet

The Jor reservoir low-level outlet is equipped with a hollow jet valve of 72 in diameter [1]. The sill level of the outlet intake is 463.30 m (1520 ft). The hydraulic capacity of the valve is 1100 ft³/s (31 m³/s) when the reservoir is draw down just below the sill level of Menglang tunnel intake that is 468.78 m (1538.5 ft). This flow of 31 m³/s corresponds to the average natural inflows to Jor

reservoir of 10 m³/s plus the peak discharge from Jor power station of 21 m³/s [2]. In normal hydrologic conditions the low-level outlet has sufficient capacity to evacuate the entire flow entering Jor reservoir. Apart from discharging flood waters and to provide control during reservoir draw down and flood release [3], the reservoir outlet is frequently operated once every three months to flush the deposited sediments accumulated within the reservoir. Above the low level outlet, is the trash screen constructed from pre-cast concrete Class ¾.

3. Problem Statement

The reservoir outlet is an important structure to control the release of flood discharge downstream. This control enable the operator to adhere to the strict restriction imposed by the local authorities to reduce downstream flooding as well to maintain the acceptable water quality during the release. The reservoir outlet began experiencing blockage since 2007 where the guard valve could not be closed completely during regular reservoir drawdown.

Investigation revealed that the trash screen above the reservoir outlet failed to sieve off the large incoming logs from the upstream end. It was suspected that the trash rack bars of the screen might have been damaged and dislodged creating a large opening at the trash screen thus permitting larger logs to enter the reservoir outlet.

4. Objectives

The rehabilitation Works on the trash screen was immediately recommended to be carried out urgently to enable the continuous use of the outlet valves without further blockages. The objectives of the paper are to:

- i. Discuss the findings of the preliminary investigation during project planning;
- ii. Discuss the scope of work adopted to execute the underwater rehabilitation work;
- iii. Present the basic design parameters for the project.

5. Rehabilitation investigation

Given the complex nature of the project, each component for the project was required to be investigated in detail and custom designed to suit the site condition as well as to maintain an economical cost for the rehabilitation works. Among the field investigation carried out prior to the rehabilitation works includes:

- Bathymetric survey and estimation of sediment depth and volume above reservoir outlet;
- Soil investigation for sediment characteristic profiling;
- Physical dam safety inspection to determine and further signs of damages;
- Reservoir outlet testing to confirm discharge capabilities;
- Dam instrumentation monitoring and interpretation.

5.1 Bathymetric Survey

From the survey, the cross section of the reservoir bed was plotted which shows an average existing bed elevation of 476 m. The reservoir outlet is located at an elevation of 463 m. From the data analyzed, the total height of sediment deposition above the reservoir outlet covering the trash screen was estimated at approximately 13 m. The final sediment volume estimated to be cleared from above the reservoir outlet area was 15,000 m³.

5.2 Soil Investigation

Soil investigation was carried out in accordance with the requirements of BS 5930. The soil investigation report is included in the reference. Samples were extracted at two specific locations namely BH 14 and BH 15. The soil investigation showed that the sediments deposited within the reservoir exhibits various different profile and characteristics. The average observed sediment types at deeper depths closer to the trash screen location have sediment distribution of 27% clay, 26% silt, 43% sand and 4% gravel. As results of the soil investigation, it is concluded that the design of de-sludging mechanism must be of portable heavy – duty submersible pump type with capacity of de-sludging rate ranging between 200 - 300 m³/hr and capable of de-sludging / dredging a wide range of sediments types and to be fitted with two agitators to stir or churn heavily cemented or compacted type of sludge conditions.

6. Scope of rehabilitation works

The implementation of the entire rehabilitation works includes:-

- To carry out Pre, Interim & Post Hydrographic Survey to continuously monitor the sediment build up at the excavated area;
- To design and construct a complete set of dredger pontoon equipped with the working platform, lifting equipment, mechanical pump, agitators/cutters;
- To carry out de-sludging/dredging Works to clear the sediments, trash, debris, tree branches, etc. deposited on top of the existing trash screen;
- To carry out underwater physical inspection;
- To design, fabricate and install a new high tensile trash screen above the reservoir outlet area;
- To design and fabricate a complete set of turbidity/silt curtains as a separator and as sediment control system;

7. Rehabilitation works design considerations

7.1 Design for dredger and working pontoon

A customized pontoon design was proposed for the project to include all dead and live loading and working platform for all other associated equipments including cutters and compressors, pump handling equipment, air conditioning or heating, anchor booms, production measuring equipment, and pipeline components, power pack, operators, etc. and for the installation of the trash screen, platform launching for divers and stationing of divers equipments (facilities), connecting of the cables with mounted pumps and agitators, etc. The main design parameter considered for the pontoon design is as shown in Table 1.

Table 1: Basic design parameters for dredger and working pontoon

Dredger Pontoon		
Proposed Width, W	15	m
Proposed Length, L	15	m
Proposed Depth, d	1.6	m
Working Pontoon		
Proposed Width, W	6	m
Proposed Length, L	6	m
Proposed Depth, d	1.5	m

7.2 Design selection for dredger pump

The de-sludging pumps was designed to be a complete set of diesel driven de-sludging equipments which includes Portable Heavy-Duty Submersible de-sludging pumps (Dragflow) and fit for deep water dredging / de-sludging activities with capacity range between 200 - 300 m³/hr, and with compressors or agitators to stir or churn heavily cemented or compacted type of sludge conditions. The pumps, compressors, agitators, etc shall have readily available complete set of locally available spare parts, maintenance. The main design parameter considered for the dredging pump design is as shown in Table 2.

Table 2. Basic design parameters for dredger pump selection

De-sludging Pump Selection		
Sediment Quantity	40,000	tons
Rate Per Hour of Sand	133	tons
Dredging Rate	m ³ /hr	200 - 300
Specific Gravity of Slurry	2.65	-
Average Particle Size	0.6	mm
Concentration of Solids	30	%
Static Discharge Head, Z _d	3	m
Submerged Working Depth, Z _m	28	m
Suction Head, Z _s	0	m
Total Length of Pipeline	278	m

7.3 Design selection for sediment control system

During the lowering of the reservoir it is highly anticipated that high sediment volumes will convey to the downstream area towards the working or dredged area. Therefore the silt curtain was proposed to be installed at selected locations to reduce the inflow and as containment for the dredged sediments to be pumped into. The technical requirement was designed for moderate current conditions. The silt curtain has the following properties:

- Fabric - Polyester reinforced vinyl high visibility yellow 18 oz/yd² weight.
- Connector - Shackled and bolted load lines.
- Flotation - 8" expanded polystyrene over 19 lbs/ft buoyancy.
- Ballast Line/Ballast - 5/16" galvanized chain (1.1 lbs/ft).
- Top Load Line - 5/16" galvanized wire rope enclosed in heavy tubing.

7.4 Design of New Trash Screen

The design of the trash screen includes the provision for overburden loads and pressure from the deposition of sediments, trash, logs, debris, etc. in design for the trash screen. The loads were calculated based on the characteristics of the sediments depths and volume deposited above the reservoir outlet. The new trash screen was designed to be fabricated at factory and install underwater directly on top of the existing trash screen. Suitable factors of safety were adopted in order to determine the most practical depth of sediment deposition expected for a period of 50 years. The metal works installation includes:

- High tensile, hot – dipped steel trash screen including all necessary fittings to be installed above the existing trash screen at the reservoir outlet.

- The new trash screen were to be fully assembled at factory and be installed directly on top of the existing trash screen by drilling;
- The new trash screen mobilization and installation works was designed to be carried out entirely underwater.

During the design of the trash screen, provision is included for over design estimation due to unavailability of as-built drawings, overburden loads and pressure from the deposition of sediments, trash, logs, debris, etc. in design for the trash screen. The basic design values are shown in Table 3.

Table 3. Basic design parameters for steel trash screen

Highest Possible Water Level	1623	ft
Base Level of Screen	1519	ft
Maximum Sediment Deposition (70% of Depth)	64	ft
Sediment Density Characteristics (Saturated and dense sand, silt and clay)	16.5	kN/m ³
Water Density	10	kN/m ³
Density of Submerged Logs	12	kN/m ³

8. Summary

The operation of reservoir outlet is frequently impeded due to the increase in annual sediment deposition in the reservoir. As this sediment deposits further at deeper depths within the reservoir it undergoes rapid consolidation due to the overburden pressure and making the sediment flushing less efficient. Another challenge faced in operation of reservoir outlet is the strict restrictions on discharge regulations imposed by the local authorities. The restriction is normally imposed to reduce flooding to downstream populations as well to control the environmental concerns on water quality during release. The sediment flushing structure such as the low level outlet serves as an important control structure for hydropower plant operators for reservoir sedimentation management as well as for safe flood discharge release as designed for the dam. It is important that the function of the reservoir outlet structure is maintained in accordance to the International Dam Safety Standards.

Acknowledgment

All view expressed are the writers and do not necessarily reflect those of the Tenaga Nasional Berhad.

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