

Rehabilitation of Penstock in Kameng HEP using combination of CFRP and GFRP	 	Annexure 1 of Corrigendum VII Additional Scope of Work NIB No. NEEPCO/PEN/IND/001 Date: 20/04/2019
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## Annexure 1

### “ADDITIONAL SCOPE OF WORK ON “REHABILITATION OF PENSTOCK USING FRP LINING”

Additional clauses to be included in Bid document Part 5 (Technical Specification & Design)

#### **2.9. DESIGN AND ANALYSIS OF FRP LINING OF PENSTOCK**

- 2.9.1 From the Valve House to MIV, the penstock II is subjected to different pressure loads at different zones (Zone 1 to Zone 12). The design pressure is varying from 2.49 MPa to 6.94 MPa.
- 2.9.2 Designer has to consider that the minimum gap between two successive penstock pipes is 3mm in circumferentially. 1/4<sup>th</sup> of thickness in a pipe should be covered by welding and remaining of 3/4<sup>th</sup> thickness shall have a gap of 3mm. Designer has to carry out 3D finite element model for different groups of joints by varying thickness of CFRP depending on the load conditions. Over and above the joints, some of the layers of CFRP & GFRP for entire length of penstock II shall also be considered.
- 2.9.3 The axial joints/longitudinal joints to be analysed with the same conditions referred at 2.9.2 para for all the zones.
- 2.9.4 During design and analysis, the Bidder should generate material test data (preferably 3 $\sigma$  should be considered).
- 2.9.5 The structural analysis document including thickness & no of layers is to be submitted to the Corporation/Consultant for review and approval. The bidder has to consider that the factor of safety on CFRP should be minimum of 5 (The maximum allowable strain on CFRP at design pressure is 2000  $\mu$ s).

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- 2.9.6 The bidder has to study another design option with uniform thickness of CFRP for entire penstock II and provide a design details along with technical bid **(option II)**.
- 2.9.7 The ferrules are covered with 800 mm PCC and it is not a load bearing member. Hence there is no external restraint on radial displacement of penstock.
- 2.9.8 Bidders have to use the materials like Carbon Fabric, Glass Fabric, Resin system etc. meeting the specifications provided in the bid documents. Equivalent material can also be used by the bidders subject to it meeting the specifications/performance parameters given in the bid documents which will be verified by NEEPCO's third party consultants without accepting responsibility for design and installation. Necessary test results of such material, and references of its applications under similar conditions, must accompany the proposal.

## **2.10 FRP lining & QA**

- 2.10.1. After design approval, the lining of CFRP to be carried out on a full scale model ( $\varnothing 3.75\text{m}$  ID and length of 2.5m) with joint condition mentioned at paras 2.9.2 & 2.9.3 above. CFRP shall be provided by the successful bidder. The metallic test article will be provided by NEEPCO **(details of test article given in Fig.1)**. The test shall be carried out by the Corporation/Consultant in presence of successful bidder. The design qualification test at 7.7 MPa will carried out on full scale model at Hyderabad, India premises after FRP lining. CFRP system shall be tested against fatigue and long term static internal pressure by cyclic load test. Cyclic load shall be followed by hydro static test. After successfully testing, entire CFRP materials should be dispatched to NEEPCO, Kimi, India.
- 2.10.2. The adhesive strength between the metallic surfaces to adhesive layer should maintain a minimum of 8 MPa. The bond strength test to be done and submit report to NEEPCO. 3(three) adhesion tests shall be performed on each test patch and in each zone there shall be one test patch.
- 2.10.3. The complete ply sequence (i.e: GFRP layer, CFRP and abrasive resistance coat) and thickness of layup should be provided by Bidder.

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- 2.10.4. The CFRP structural layers should not be exposed directly to the water flow. The designer shall consider in their scope for arresting the edge failure in CFRP against flow.
- 2.10.5. Visual inspection: The FRP lining of penstock (100%) shall be inspected visually against a lamp (100watts) for blowholes, pin holes, dry patches, inclusions, nature of the scratches and delamination's. If an air pocket is suspected, an acoustic tap test will be carried out with a hard object to identify delaminated areas by sound, with at least one strike per one 0.1 m<sup>2</sup>.

**Acceptance standard:**

- Blow holes and pin holes are not acceptable
- Dry patches and inclusions are not allowed
- Deep Scratches are not allowed

Repairing of the defects shall be carried out as per the repair procedure mentioned at Clauses 3.3.6.2, 3.3.6.3 and 3.3.6.4 of Part-5 (Technical Specifications).

- 2.10.6. The NDE (Ultrasonic Test) shall be carried out progressively after FRP installation for finding out de-bond/delamination of FRP lining. The circumferential-24 points & longitudinal-5 stations on each ferrule shall be inspected and acceptance criteria for the same are as follows:

**Acceptance standard:**

- Delamination size less than 12mm is acceptable
- Delamination size of 12mm to 50mm observed in FRP lining, shall be repaired as per repair procedure at Clause. 3.3.6.2 of Part-5 (Technical Specifications).
- Delamination size more than 50mm observed in FRP lining, shall be repaired as per repair procedure at Clause 3.3.6.3 and Clause. 3.3.6.4 of Part-5 (Technical Specifications).

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- 2.10.7. Notwithstanding the provisions of tests in bidder's QA/QC, the bidder has to make test coupon for each batch as well as for every zone to find out the hardness and volume fraction of composite. The test coupon test shall be done by NEEPCO in presence of QA agency.
- 2.10.8. The bidder should submit the maintenance document for the desired life of repaired joints considering cyclic load.

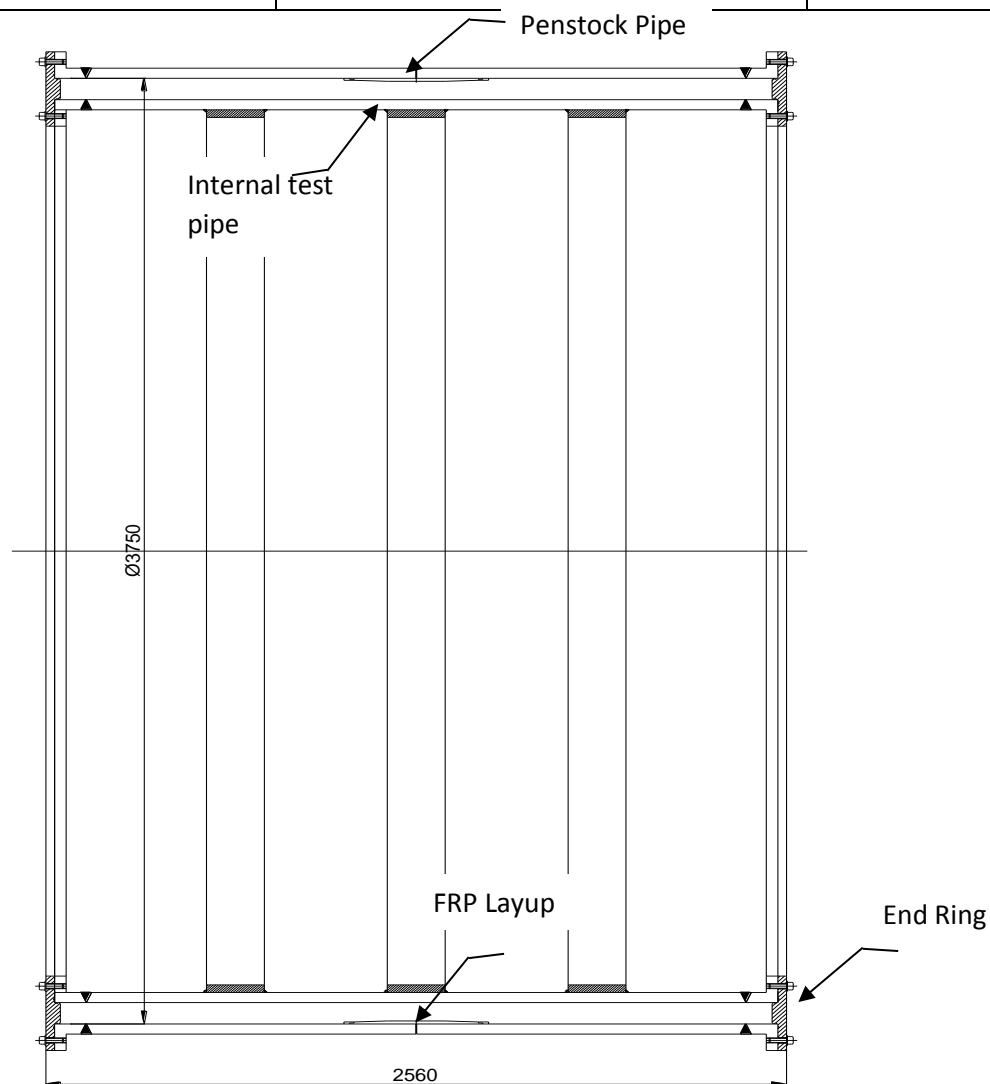


Fig.1– Full Scale joint with FRP lining (Indicative only. Longitudinal joint not shown)