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DESIGN AND ANALYSIS OF ANCHOR BLOCK AND PENSTOCK PIPE OF A HYDROELECTRIC PROJECT

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Abstract - *KSEB Ltd. has been executing a hydroelectric project naming Thottiyar hydroelectric project with an installed capacity of 40 MW envisaged to produce an annual energy of about 90 million units. This is a runoff the river scheme. This project is situated in Idukki district in Devikulam Taluk. The project has a head of about 470m and having long-water conducting system, of about 1.5KM .Out of this 1.5km, 1.25KM is penstock pipe having 14 anchor blocks. Anchor blocks are typically used in waterworks applications where thrust restraint of a pipeline is desired and wherever there occurs any vertical or horizontal bends. Penstock pipes are used to carry water to Power House from reservoir for generation of electricity. These pipes are supported at bends by anchor blocks and at intermediate by rocker or saddle support. These pipes are designed for internal pressure, support movements, reactions etc. This project deals with the design of sample anchor blocks and design of penstock pipes at several locations at different heads, and analysing them, taking into account the water hammer effects. Detailed design procedures are available in references noted .The preliminary details of this site for executing the project is intended to obtain from KSEB Ltd. on request for study purpose.*

Key Words: ***Penstock, anchor block, water hammer, thrust, rocker***

1. INTRODUCTION

The function of the anchor block is to fix the penstock and do not allow the pipe with any direction of movement. The installation site of the anchor block is usually at the connection of forebay pool and pressure pipe, connection between pressure pipe and power house, and when pressure pipe changes its direction. The change of direction can be vertical or horizontal. In either cases anchor blocks should be provided. They are designed to ensure the thrust restraint of water. The penstock between the anchors are supported by rocker supports.

Penstock pipes are also called pressure pipes, they are used to carry water from the forebay or reservoir to the powerhouse. These pipes should be designed for the water pressure the desired levels, mostly at the anchor block. The design aspects are explained in the noted references. These penstock pipes are site welded or fabricated at site.

The main force of that decides the design of penstock at lower levels near to the power house is water hammer effect. When a fully running machine or turbine comes to a sudden stop due to any technical difficulties, or when valve for water inlet is to be closed, the running water generates a huge amount of energy and this water waves back to the upward direction inside the penstock. This is the worst case of pressure acting in the penstock. To ensure safe operation of penstock, a surge tank is introduced in the water conducting system so that this extra pressure is accommodated by surge tank. But in our case, The Thottiyar HEP doesn't have a surge tank, instead we assume the amount of water hammer at valve closure and design the penstock at lower levels for this pressure.

Fig -1: Penstock pipe

Fig -2: Anchor Block

2. SCOPE OF THE PROJECT

The design of anchor blocks and penstock is not part of any B.Tech curriculum. The design procedures and works here are done by staffs of KSEB Ltd. Since this design is

completely a new knowledge to fresher, they can explore the civil engineering applications that they studied through their academic years. The designing procedures are bit long u have to rely upon softwares like Microsoft word, Excel etc. so apart from the basic civil engineering knowledge, computer based software knowledge can also be acquired.

The engineering drawing includes LS of Penstock, Index Map of the area, and Reinforcement details of the Anchor Block etc. so different kinds of engineering drawing knowledge can be acquired.

3. METHODOLODGY

3.1 Data Collection

Preliminary data such as index map, location map, L.S of Penstock was obtained from KSEB Ltd. and was studied. Data includes chainages of different anchor block at different point, their elevation, location of center line of anchor blocks and turbine at powerhouse.

The salient features of the work are

Basin: Periyar
River: Thottiyar (Deviyar), a tributary of Periyar River

Full Reservoir Level	: +522.424m
Minimum draw down level	: +516m
Type of Structure	: Concrete Gravity
Total Length	: 222 m
Top Length of overflow section	: 82.50m
Normal Bed Level of River	: +513
Crest Level of overflow section	: +520.424
Top of None overflow section	: +523.164
Height of overflow section above bed level	: +7.50m
Maximum Water Level	: +522.164
Upstream profile	: vertical
Downstream profile	: Ogee curve up to Tangent point and then a slope of 0.70H to 1V

3.2 Studying the Design Procedure

The design of Anchor block is done according to IS 5330:1984. The design of penstock is done using IS Code: 11639(Part 1):1986. The code says about the numerous forces acting in the anchor block both in pipe full condition and pipe empty condition. The penstock design forces are also mentioned in the code. The sample design was done by hand calculation.

3.3 Design and Analysis

The design and analysis of the anchor block and penstock was done in Microsoft Excel. The initial values were fed accordingly until a stable design was obtained. Then the dimensions for the anchor block was finalized.

Table -1: Design Forces on Anchor Block

sl.no	Load/Forces	Forces KN	Expanding condition		Contracting condition	
			Hor.Force	vert.Force	Hor.Force	vert.Force
1	Hydrostatic Force u/s	14987.676	14987.11409	129.7441863	14987.114	129.744
1	Hydrostatic Force d/s	14987.676	-14012.34976	-5318.315207	-14012.35	-5318.315207
2	Dynamic Force u/s	108.471	108.47	0.94	108.47	0.94
2	Dynamic Force d/s	108.471	-101.41	-38.49	-101.41	-38.49
3	Dead wt. u/s	18.394	18.39	0.16	18.393	0.16
4	Dead wt. d/s	51.719	48.35	18.35	48.35	18.35
5	Sliding friction of pipe on piers u/s	783.611	783.58	6.78	-783.58	-6.78
6	Sliding friction of pipe on piers d/s	38.720	-36.20	-13.74	36.20	13.74
7	Sliding friction of u/s Exp. Joint	2551.278	2551.18	22.09	-2551.18	-22.09
8	Sliding friction of d/s Exp. Joint	2556.079	-2389.7	-907.01	2389.74	907.01
9	Hydrostatic Pressure u/s	1220.714	1220.67	10.57	1220.67	10.57
10	Hydrostatic Pressure d/s	1286.193	-1202.49	-456.40	-1202.49	-456.40

3.3 Design Conclusion

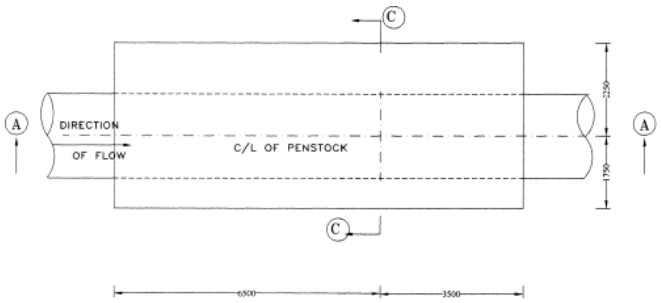

Fig- 1: Plan of Anchor Block

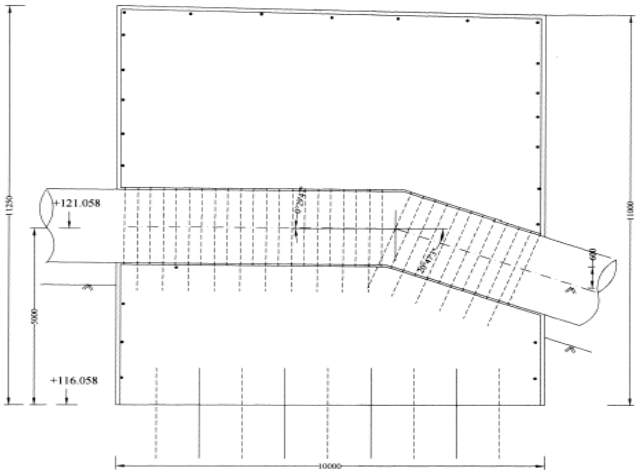

Fig-2: Section AA of Anchor Block

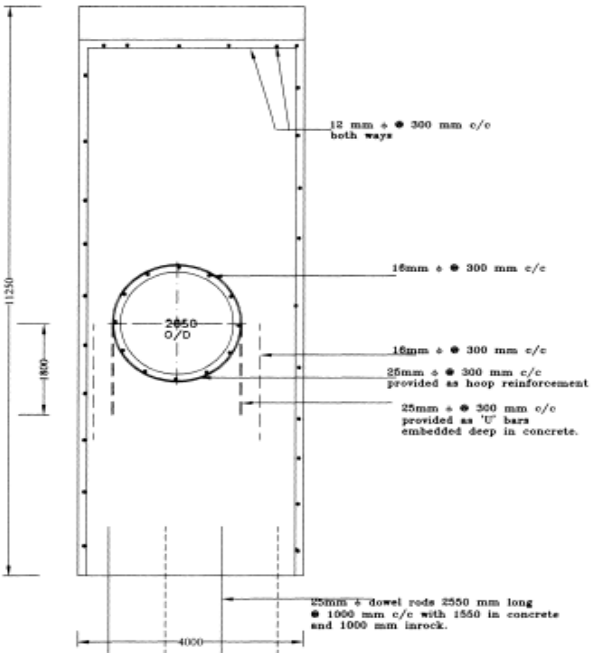

Fig-3: Section CC of Anchor Block

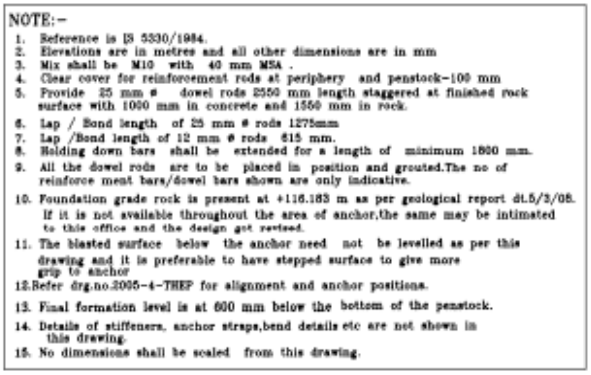
NOTE:-
1. Reference is IS 5330/1984.
2. Elevations are in metres and all other dimensions are in mm
3. Mix shall be M10 with 40 mm MSA .
4. Clear cover for reinforcement rods at periphery and penstock-100 mm
5. Provide 25 mm ϕ dowel rods 2550 mm length staggered at finished rock surface with 1000 mm in concrete and 1550 mm in rock.
6. Lap / Bond length of 25 mm ϕ rods 1275mm
7. Lap /Bond length of 12 mm ϕ rods 615 mm.
8. Holding down bars shall be extended for a length of minimum 1800 mm.
9. All the dowel rods are to be placed in position and grouted.The no of reinforce ment bars/dowel bars shown are only indicative.
10. Foundation grade rock is present at +116.183 m as per geological report dt.5/3/08. If it is not available throughout the area of anchor,the same may be intimated to this office and the design get revised.
11. The blasted surface below the anchor need not be levelled as per this drawing and it is preferable to have stepped surface to give more grip to anchor
12. Refer drg.no.2095-4-THEP for alignment and anchor positions.
13. Final formation level is at 600 mm below the bottom of the penstock.
14. Details of stiffeners, anchor straps,bend details etc are not shown in this drawing.
15. No dimensions shall be scaled from this drawing.

Fig-4: Note

4. CONCLUSION

The design for a sample Anchor Block by providing minimum dimensions as per the IS code was done and this failed the stability criteria. An increase in dimensions made the anchor block satisfy the stability criteria. The penstock design was done, and proportional increase in thickness from upstream to downstream ranging from 12mm to 42 mm respectively.

REFERENCES

[1] Manual on design fabrication Erection and maintenance of steel penstocks (Hydel Civil design directorate, Central Water and Power Commission-New Delhi)

[2] IS Code 5330: 1984 Criteria for Design of Anchor Blocks for Penstocks with Expansion Joint

[3] IS Code 11639(Part 1): 1986 Criteria for Structural Design of Penstocks