an installed capacity of I 933.36 kW with reservoir storage evaluatedat 7.256 million cubic meters for dry periods. Support piers were designed to ensure stability whereas cost analysis estimated pier development at NRs. 57484.02. Additional inspections recommended repairs to prevent erosion and leaks. Funded by ADB, GON, and NEA, upgrades included new turbines, canal maintenance, as well as local support for increasing capacity from 640 kW to 1.2 MW.

12.2 Objectives

To study the hydropower system of the Sundarijal Hydropower Project (HPP) was the major atm.

Further aims were;

• To boost system efficiency by minimizing energy losses through best penstock alignment and effective site preparation.

• To improve the plant's durability and operational stability by assessing sediment load and implementing erosion control measures.

12.3 Organizational chart

Kathmandt1 University

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Biplav Acharya (Me)

Fig]: Organizational chart

12.4 Duties

• To gather comprehensive knowledge, journal papers were reviewed which included hydropower generation, focusing on site selection, energy grade lines, and system efficiency.

• To compt1te discharge, field measurements were conducted determining cross-sectional river areas as well as canal discharge to assess water availability.

• To design the penstock with the determination of velocity, diameter, wall thickness, and internal pressure as well as considering head loss.

• To ensure stability by designing the support piers factoring in forces, moments, and safety against sliding, overturning, as well as bearing pressure limits.

• To ensure sustainability with the execution of cost analysis, inspection of powerhouse equipment inspected, and repairs, as well as upgrading, and community involvement.

13PEA

13.1

I accumulated journal papers that were identical to the project to gather information on hydropower generation principles, site selection criteria, and the factors affecting project feasibility. I gained knowledge of the specific topographical as well as geological requirements needed to develop a reliable hydropower plant. I studied the critical role of the penstock in transporting water, as well as paying special attention to the importance of penstock alignment for minimizing energy losses. I investigated the concepts of gross head as well as net head to understand how water flow and head height contribute to the plant's potential energy generation. I inspected flow duration along with the mass flow curves to assess seasonal variations in water availability which directly impacted power production. I acknowledged the importance of energy grade lines in visualizing the energy potential across various stages which helped to ensure ideal design and system efficiency. I learned that leveling as well as careful site preparation were crucial for precise penstock alignment long with stable infrastructure. I understood that evaluating sediment load and potential erosion factors in the water source was essential for long­ term project sustainability. I reviewed the overall project plan ensuring that each component met the design requirements as well as contributed to maximizing efficiency. I further conducted the fly leveling on the site.

Figure 2: Team executing fly levelling

1

1

2

Figure 6: Velocity determination

Di lance m

13

13

13

Figure 7: Canal Discharge evaluation

Flow Duration Curve

6.5

6.0

-;;;, 5.5

- 5.0

4.5

\_ 4.0

3.5

.0.\_0

3.0

2.5

2.0

- 1.5

C 1.0

0.5

0.0

0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95100

?robabilty of exceedence %

Figure 8: Flow duration Curve

13.3

I then initiated the design of the penstock. I computed the velocity of water in the penstock using the USBR formula and found it to be 8.187 m/sec. I determined the penstock diameter through various methods including Sarkaria and JNN guidelines resulting in a range of diameters around

0.411 m. I computed the internal pressure in the penstock considering the dynamic head besides found it to be 22.2051 kg/cm2. I also determined the wall thickness using ASME codes including a corrosion allowance as well as estimated it between 0.82 and 0.86 I cm. I analyzed the penstock alignment using Google Maps, estimating the length at 1.41 km. I evaluated major and minor head losses with friction as well as other factors leading to a total head loss of 20.417 m. I adjusted the power output factoring in these losses and recomputed it to be approximately 1.8 MW. I also analyzed seasonal power output estimating firm and secondary power to assess energy production. I concluded that the project had an installed capacity of 1933.36 kW with favorable economic feasibility as well as a benefit-cost ratio of 2.6923. I evaluated the reservoir

storage needed to sustain water supply in dry periods finding a requirement of 7.256 million cubic meters. I stated that the project was economically viable as well as had the potential for increased output.

Figure 9: Penstock alignment

S.N.

Months

Factor

Discharge(m3/s)

Days

Volume (m3/day)

Cumulative volume (m3-

day)

1

Januarv

2.71

0.635

3I

19.678

19.678

2

February

1.88

0.440

28

12.330

32.008

3

March

1.38

0.323

31

10.021

42.029

4

April

1

0.234

30

7.027

49.056

5

May

1.88

0.440

31

13.651

62.708

6

June

3.13

0.733

30

21.995

84.702

7

July

13.54

3.172

31

98.319

183.021

8

August

25

5.856

31

181.534

364.555

9

September

20.83

4.879

30

146.375

510.930

10

October

10.42

2.441

31

75.663

586.593

11

November

5

1.171

30

35.136

621.728

12

December

3.75

0.878

31

27.230

648.959

> 700.000

600.000

e soo.ooo

GI

§ 400.000

g 300.000

-; 200.000

.!e!!:

Figure 10: Flow Mass Curve evaluation

Flow Mass Curve

-+-Cumulative

volume(m3-day)

:::,

100.000

u 0.000

Figure 11: Flow mass curve

13.4

I designed support piers along the straight sections of the exposed penstock between anchor blocks spacing them a maximum of 5 meters apart to avoid overstressing. I considered the weight of the pipe as well as enclosed water, frictional forces, and forces from soil pressure on the upstream face. I omitted hydrostatic pressure within the bend, thermal expansion, and pipe diameter reduction due to the minor bend present. I computed the weight of the penstock, saddle plate, and enclosed water which totaled 2332.56 kg, and used a friction coefficient of0.57 to find a frictional force of 1329.56 kg. I determined the pier's stability by analyzing forces assessing moments, and iterating to achieve safe dimensions of 2.2 m by 2 m by 2 m. I checked for safety against overturningensuring the resultant force acted within the middle third of the base as well

asconfirming an eccentricity of0.0078 m well below the allowable limit. I verified safe bearing conditions by computinga base pressure of 4943.7 kg/m2 within the allowable 5000 kg/m2 for soft clays. I checked sliding stability with a factor of 7.48 which exceeded the required 1.5. I finalized these dimensions to ensure stability as well asthe replacement of degraded piers at the site.

THIC ESS OF PENSTOOK 8.00

INTERNAL DIAIETER

oo.oo

THICKNESS OF STEEL SADDLE 18.00

ALL DIMENSIONS ARE IN 11m

Figure 12: Penstock cross-section

Figure 13: Support pier

11!8

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Figure 14: A-A cross-section of penstock

13.5

For executing the cost analysis, I computed the total PCC volume for support piers as 3.I 25 m3, estimating costs at NRs. 57484.02 for three piers including materials, labor, and contractor profit. I inspected the power house confirming equipment functionality as wel I as recommended reservoir cleaning to prevent silt erosion in turbines. I reviewed the penstock along with the anchor block as well as dam on the site. I determined that additional water sources such as Nagmati, could support power upgrades while the Shayalmati canal required repair due to wall collapse. Observing penstock leaks as well as deteriorating anchor blocks, I suggested repairs and sediment flushing. Rehabilitation efforts were underway with ADB, GON, and NBA funding including mechanical, along with electrical, as well as civil maintenance. I determined that the proposed upgrades covered turbines, penstock sllpport, canals, and a new staff quarter. I further governed that the residents showed interest in maintenance and upgradation from 640 kW to 1.2 MW but expressed concerns over outsourced tenders impacting local jobs as well as possibly delaying site rehabilitation. I further prepared tlhe project schedule and reviewed the outcomes with the accomplishment of project works on time.

Particulars

Quantir or Nos.

Rate

Excavation

2.42 m'

NRs. I 0 per cu.m

Materials

Unskilled

13.5 bags

9.75 cu.fl

17.7 cu.fl

NRs. 00 per bag

NR . 90 per cu.fl NRs. I r cu.fl

I for 2 clays

4 for 2 cla

NRs. 530 per

NRs. 320 er

T ta!

Figure 15: PCC analysis rate

Figure 16: Penstock resting on support pier

Figure 17: Displaced anchor block

Figure 18: Dam

Figure 19: Reservoir

Figure 20: River stretch

1.4 Issue and Solution

I observed silt accumulation in the reservoir which posed a risk of eroding turbine components as well as reducing their efficiency ultimately affecting the hydropower plant's long-term

3

water velocity of 8.187 m/s along with an internal pressure of 22.205 I kg/cm2. After accounting for energy losses, the adjusted power output reached an installed capacity of I 933.36 kW, with

7 .256 million cubic meters of reservoir storage reserved for dry seasons. Stability-focused support pier designs were completed, with construction costs estimated at NRs. 57484.02. Further inspections suggested erosion control and leak preventjon measures. Funded by ADB, GON, and NBA, the project upgrades included turbine replacements, canal repairs, and community-supported plans to increase output from 640 kW to 1.2 MW. The project enhanced the system efficiency with further improvement of plant durability which determined that the mentioned secondary goals were also accomplished.

I gained valuable insights into hydropower systems enhancing my technical knowledge as well as practical skills. I improved project management abilities by coordinating tasks, setting goals, and maintaining timelines effectively. I became more proficient in communicating with teammates and supervisors.