KATHMANDU UNIVERSITY

Dhulikhel , Kavre

Kabeli-A Hydroelectric Project

Presented By:

Shrija Shrestha (027917-20)

Sarita Sapkota(028084-20)

Dharambir Yadav(028097-20)

Rajesh Yadav(028098-20)

Acknowledgement

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Gratitude to Kathmandu University, Department of Civil Engineering for their support throughout this journey.

Objectives

- To Gain practical exposure to hydropower construction and operations.
- To Understand project management and coordination in hydropower development.
- To Enhance problem-solving and technical skills through site experience.
- To Familiarize with key hydropower infrastructure components.

History

1. Location: Panchthar & Taplejung, Nepal
2. Capacity: 37.6 MW
3. Developer: Kabeli Energy Ltd. (KEL) and Butwal Power Company (BPC)
4. Initial Contractor: Zambala Construction Pvt Ltd, Paramax Constructions, Sherpa Hydro Constructions
5. Consultants: Units Engineering Consultancy
6. Commencement Date: Project development started in the early 2010s
7. Funding: Initially backed by the World Bank
8. Termination: The financial closure failed, leading to project termination

Fig 1 :Transmission Pole

Salient Features

S.N.	Item	Description
1	Project Name	Kabeli-A Hydroelectric Project
2	Location	Hilihang RM (Panchthar) & Pathivara/Yangbarak RM (Taplejung)
2.1	Project Boundaries	East: 87° 45′ 50″ E, West: 87° 40′ 55″ E, North: 27° 17′ 32″ N, South: 27° 13′ 41″ N
3	Type of Development	Run-of-River (Cascade RoR)
4	Hydrology at Intake	Catchment Area: 713.90 km^2, Mean Monthly Flow: 47.078 m^3/s, 100-Year Flood: 1020 m^3/s
5	Pipe from Phawa Khola to Tailwater Taping Canal	Surface, Mild Steel, Length: 200 m, Internal Diameter: 1.2 m, Thickness: 6-8 mm
6	Tailwater Taping Canal	RCC Pressurized Box Canal, Size: 4.2 m × 3.6 m, Length: 366 m
7	Approach Tunnel	Inverted D-shaped, Concrete Lined, Size: 68 m × 6.33 m × 4 m
8	Additional Intake	Side Intake, Size: 3.0 m × 1.5 m, Gate: Vertical Fixed Wheel

Salient Features

9	**Additional Intake Approach Canal**	RCC Box Culvert, Length: 265 m, Dimensions: 2.7 m × 3.5 m
10	**Settling Basin**	Simple Rectangular, Number of Chambers: 1, Dimensions: 55.0 m × 13.5 m × 10.4 m
11	**Headrace Canal (Convey Chamber to Headpond)**	RCC Box Culvert, Size: 4.25 m × 4.25 m, Slope: 1:700, Length: 1161 m
12	**Head Pond**	Rectangular Concrete Lined, Length: 55 m, Width: 8.0 m, Height: 8.9 m, Max Storage Volume: 3825 m^3
13	**Headrace Canal (Head Pond to Inlet Portal)**	RCC Pressurized Box Culvert, Size: 4.2 m × 4.2 m, Length: 33.0 m
14	**Headrace Tunnel**	Inverted D-shaped, Shotcrete & Concrete Lined, Length: 4657 m, Diameter: 5.65 m
15	**Surge Shaft**	Underground & Exposed to Surface, Internal Diameter: 12.0 - 12.9 m, Height: 55 m

Salient Features

16	**Penstock**	Material: Mild Steel, Length: 254 m before Trifurcation, Length of Each Leg: 80.75 m, Internal Diameter: 3.8 m
17	**Powerhouse**	Semi-Surface, Size: 58.80 m × 19.40 m × 28.50 m, Machine Floor Level: 465.00 masl
18	**Tailrace**	Design Tailwater Level: 458.0 masl, Length: 123 m, Cross-section: 5.5 m × 3.0 m
19	**Turbine**	Horizontal Axis Francis, Units: 3, Rated Speed: 600 rpm, Output: 12,930 kW each
20	**Generator**	Salient Pole Rotor Synchronous Generator, Units: 3, Voltage: 11 kV, Rated Capacity: 14,750 kVA
21	**Transformer**	Three Phase, Oil Immersed, Outdoor Core, Units: 3, Rated Capacity: 16.5 MVA
22	**Power and Energy Output**	Installed Capacity: 37.60 MW, Gross Head: 120.50 m, Estimated Annual Energy: 218.99 GWh

Salient Features

23	**Transmission Line**	Voltage: 132 kV, Length: Loop-in Loop-out with Kabeli Corridor Transmission Line
24	**Access Road**	To Headworks: 7.4 km, To Powerhouse: 15 km from Mechi Highway
25	**Project Cost**	Total Cost: NRs. 7520 million, Per MW Cost: NRs. 200 million
26	**Financial Analysis**	NPV: NRs. 10,290,000, B/C Ratio: 1.19, ROE: 15.55%, IRR: 12.75%

Location

Province : Province No. 1

Districts : Panchthar & Taplejung

River Basin : Kabeli River

Elevation : 450 m to 2000 m above sea level

Coordinates:

East: 87° 45’ 50’’ E

West: 87° 40’ 55’’ E

North: 27° 17’ 32’’ N

South: 27° 13’ 41’’ N

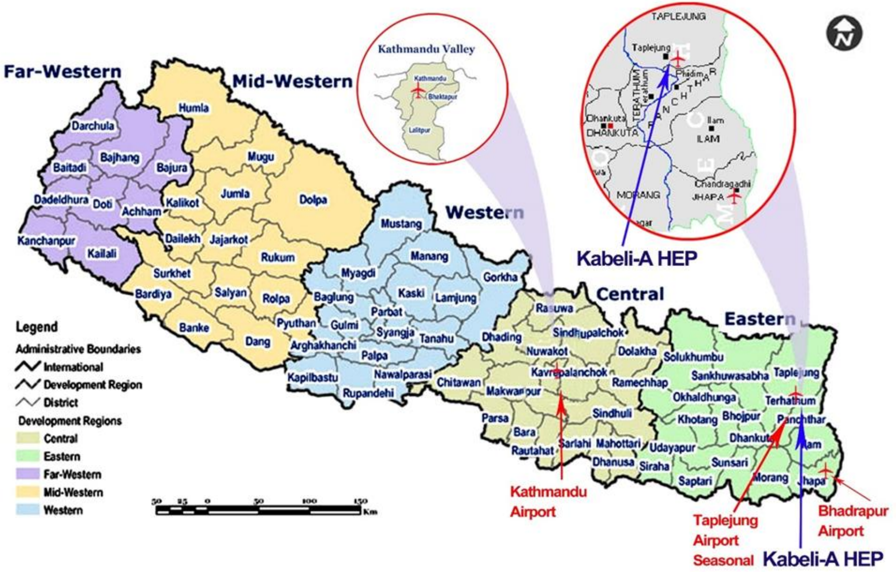

Fig 2 : Location of site

Source: Final DPR KAHEP Report

Geology

The project area lies in the Lesser Himalayan zone, mainly composed of granite with smaller amounts of phyllite, quartzite, gneiss, and schist from the Taplejung window. Granite dominates the headworks area, while the surge shaft and powerhouse areas consist of phyllite, schist, and quartzite. Foliation generally trends 30˚–40˚ northward.

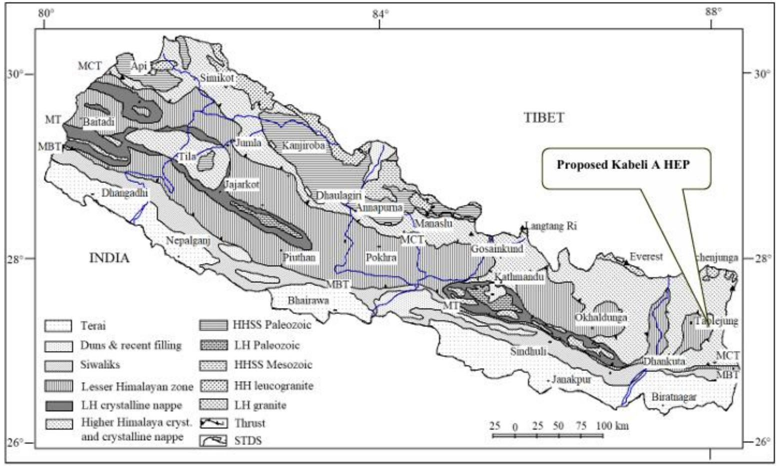

Fig 3 : Geological map of Nepal

Hydrology

The total discharge required to obtain the installed capacity of 37.6 MW IS 37.73 m³/s. Out of this 35.1m³/s is obtained from Kabeli B1 Intake and the remaining 2.6m³/s is obtained from Phawa khola tailrace.

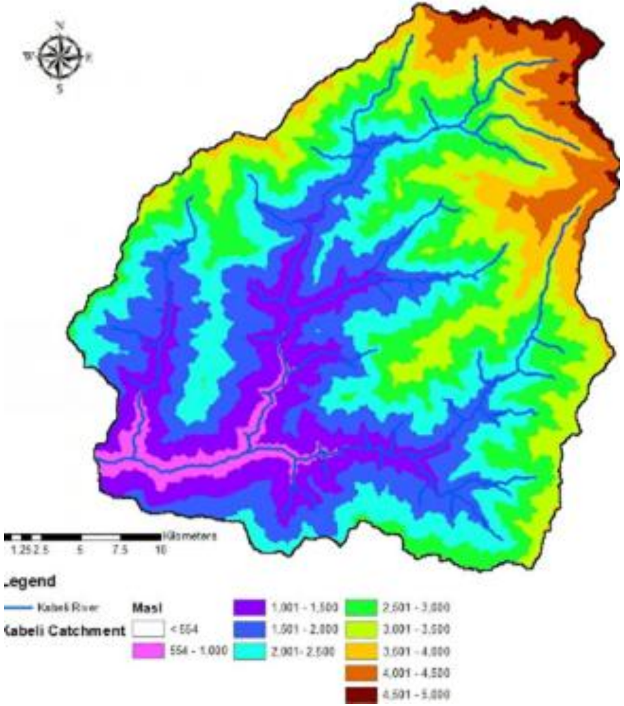

Fig 4: Catchment area of Kabeli River

Source: Final DPR KAHEP Report

Hydrology

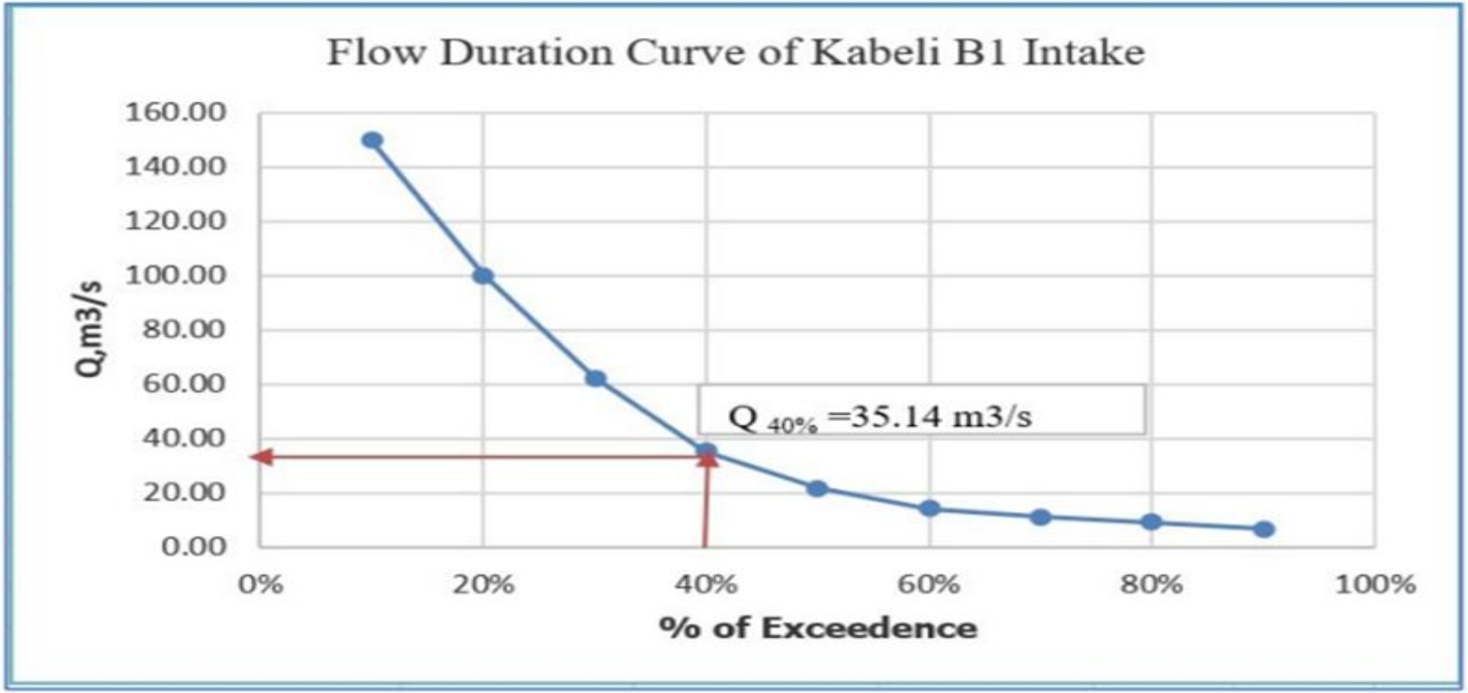

Fig 5 : Flow duration curve of Kabeli B1
Source: Final DPR KAHEP Report

Project Components

Interconnection Conduit

- Transfers water from KB1HEP cascade tailrace to Headpond.
- 366m long RCC pressurized canal (4.2m x 3.6m).
- Design discharge: 37.23 m^3/s,
- Velocity: 2.4 m/s.

Fig 6 : Interconnection Chamber

Additional Intake Gate

- Side intake with three orifices (3m x 1.5m each).
- Designed for 12 m^3/s with 1 m/s velocity.
- Trash racks prevent debris; vertical gates control flow.

Fig 7 : Additional Intake Gate

Additional Intake Approach Canal

- 265m long
- RCC box canal (2.7m x 3.5m)
- Regulated by a vertical lift gate

Fig 8 : Approach Canal

Approach Tunnel

Excavated Dimensions: 7.15 m (W) × 5.25 m (H)

Rock Type: Type-IV and V

Lining Details:

- Concrete lining: 0.4 m thick (Invert, Wall, and Crown)
- Shotcrete: 10–15 cm thick (plain)
- Dividing wall thickness: 0.5 m

Fig 9 : Approach Tunnel

Settling Basin

- Removes sediments (≥0.2mm) to protect turbines.
- Single-bay, 55m long, 13.5m wide, 10.4m high.
- Flow velocity: 0.2 m/s, sediment flushing system included.

Fig 10 : Settling Basin

By Pass Gate

- Purpose: Maintenance of Headpond & Siphon
- Protection: Cutoff walls on both sides enhance stability.
- Risk: Long 1080 m headrace canal lacks breaking point, increasing failure risk.
- Benefit: Prevents canal collapse and ensures structural safety.

Fig 11 : By Pass Gate

Siphon

Purpose: Protect headrace canal from Khangrawa drainage (Kartikey Kholsi) during rainy season.

Length: 50 meters.

Functions:

- Diverts canal flow beneath the drainage.
- Maintains continuous water flow using pressure flow.
- Prevents canal collapse during heavy rainfall.

Fig 12 : Siphon

Head Pond

- Mixes water from KB1HEP and Phawa Khola.
- 55m x 8m x 8.9m, holds 3825 m^3 water.
- Fine trash rack (8m x 6.5m) prevents debris entry.

Fig 13: Head Pond

Spillway

- 40m long sharp-crested spillway.
- Discharges excess water back to Kabeli Khola (55 m^3/s capacity).

Fig 14 :Spillway

Headrace Tunnel

- 4657m long, 5.65 m width and 5.65 m height, inverted D-shape.

- Shotcrete-lined for cost-efficiency, velocity: 1.35 m/s.

Fig 14 :Headrace Tunnel

Surge Tank

- Vertical cylindrical tank (55m high, 12.0–12.90m diameter).
- Connected to a 254m-long, 3.80m-diameter steel pressure pipe.

Water levels

Normal (El. 573.30 masl),

Max (El. 591.45 masl),

Min (El. 558.15 masl).

Fig 15 : Surge Tank

Steel Penstock Pipe

- 254m long
- Mild steel pipe
- Optimized at 3.8m diameter.
- Thickness: 12mm to 25mm.

Fig 16 : Bifurcation of Penstock

Powerhouse

- Semi-underground powerhouse on the right bank of Piple Khola, Hilihang Rural Municipality-2, Panchthar.
- Dimensions: 58.80m (L) × 19.40m (W) × 28.50m (H).
- Tailrace canal: 90.1m long, conveying water to Tamor River via RCC canal
- 5.5m × 3.0m, 123m-long conduit.
- Turbine center line: 459.65 masl, Service bay level: 465.0 masl.

Fig 17 : Powerhouse

Tailrace

- Three individual tailrace units of 17.60 meters each.
- These units handle the outflow of water from the turbines and lead it into the combined tailrace.
- The tailrace maintains water pondage between RL 452.18 msl and 446.85 msl to regulate the water level.

Fig 18 : Tailrace

Work Progress

Tunnel Failure at 1+703 m section

Chainage: 1+703 m

Invert/Ground Level: 557 masl / 1257 masl

Overburden: ~700 m

Cause: High overburden stress

Damage:

- 25 m tunnel section failed
- 17 steel ribs damaged
- Backhoe loader in failure zone (equipment risk)

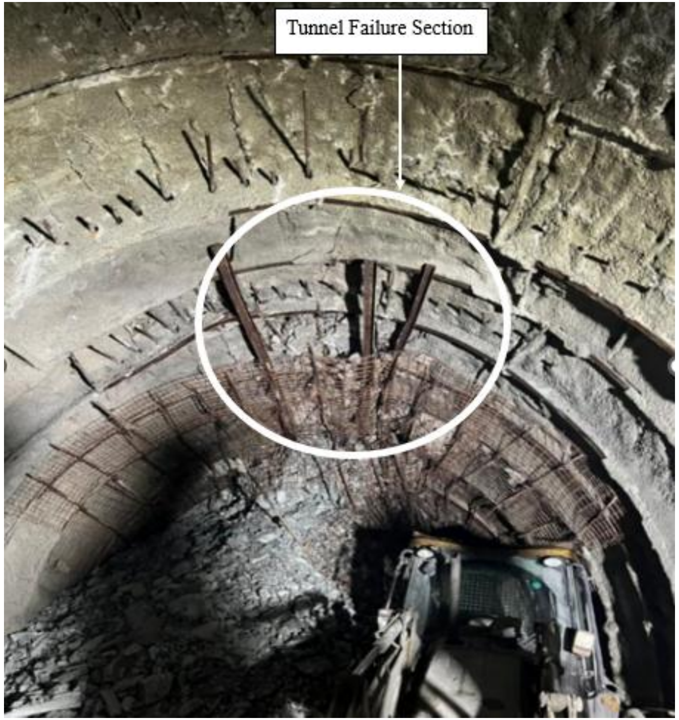

Fig 19: Tunnel Failure

Tunnel Protection Measure

- Installed wire mesh as an immediate support
- Ongoing reinforcement in failed section
- Mucking Process (Failure Section): Ongoing for 2 months to ensure proper clearance.

Fig 20 : Mucking of Debris

Concreting

- Headworks: Intake concreting nearly done; settling basin in progress
- Penstock: Plum Concrete placement ongoing
- Powerhouse: Turbine & generator foundation work almost complete
- Tailrace: Tailrace near completion; pondage work pending

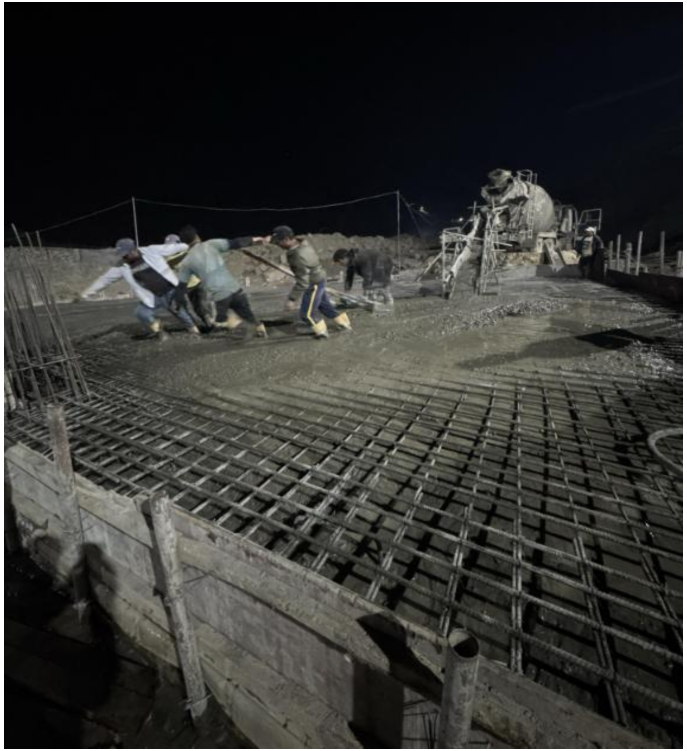

Fig 21 :Concreting

Reinforcement Placing

- Correct bar diameter, spacing, and layout as per structural drawings.
- Clean reinforcement (free from rust, oil, mud, etc.).
- Proper cover blocks used to maintain concrete cover.
- Bars securely tied using binding wire to prevent displacement during concreting.
- Overlap maintained properly.
- Hooks, bends, and anchorage as per design for proper stress transfer.

Fig 22 :Reinforcement Placing

Soling and PCC

- M10 grade is used for pcc

Things to be considered:

1. Surface Preparation
2. Compaction
3. Level and Slope
4. Thickness

Fig 23 : Soling

Soling and PCC

- **PCC**

1. M10 grade.
2. 10 cm thickness.
3. Reduces seepage and provides a smooth surface

- **Soiling**

1. 15 cm depth.
2. Provides base stabilization.

Fig 24 : PCC

Excavation for Cutoff Wall

The protection work around this structure is carried out using a cut-off wall to ensure safety against the river meandering process and the water pressure of the river having a width of 3.0 m and height of 6.8 m throughout the interconnected gate portion

Fig 25 : Excavation Work

Drilling and Blasting

The methods of Drilling and Blasting may vary depending on the quality and condition of the rock.

1. Drill pattern design
2. Drilling
3. Loading and Blasting
4. Ventilating
5. Mucking
6. Securing
7. Geological Mapping

Fig 26 : Arrangement for Blasting

Project Activities

Conducting Tests

Cube test

28-day cube test of the concrete block 15*15*15 cm was carried out and the test generated a strength of 26 MPa for M25 concrete

Slump Cone Test

The slump cone test resulted in a 75 mm slump, indicating a true slump with good workability suitable for construction.

Conducting Tests

Fig 27 : Compressive Testing Machine

Fig 28 : Slump Cone Test

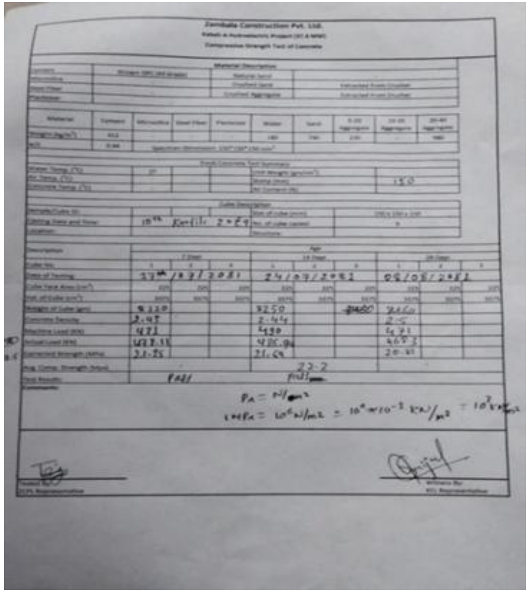

Fig 29 : Bar Bending Schedule Sheet

Quality Checks

Construction quality control was conducted by inspection to ensure compliance

1. Cover block presence checked.
2. Bar bending schedule reviewed.
3. Adequacy of lap length verified.
4. Formwork placement inspected.
5. Mix design quality ensured.

Fig 30 : Checking of cover blocks

Bar Bending Schedule

The bar bending schedule (BBS) was carried out to ensure that sufficient reinforcement availability for structural safety and integrity. It also served as a crucial reference for billing work, helping to verify the quantity of reinforcement used in the construction process.

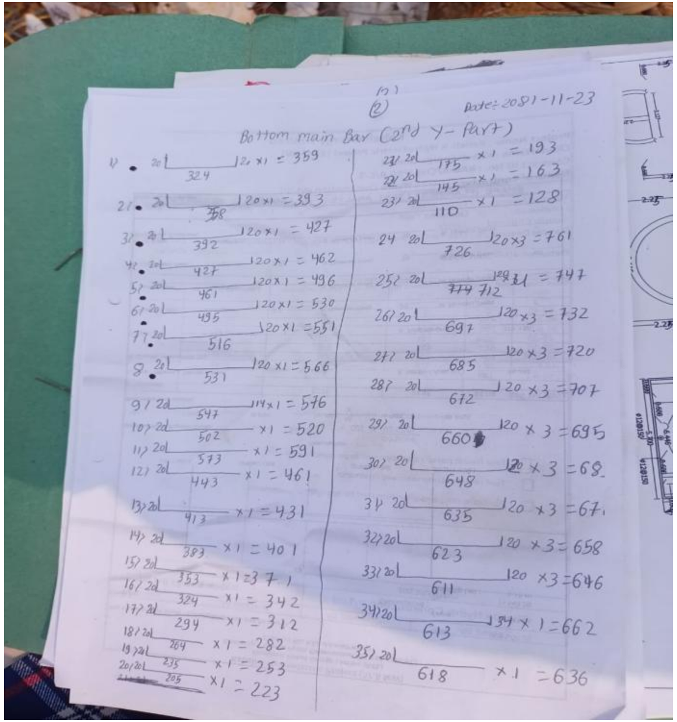

Fig 31 : Bar Bending Schedule

Drawing Analysis

The observation and review of CAD drawings, including longitudinal (L-section) and cross-sectional (X-section) views, were conducted to ensure accuracy and alignment with the actual site dimensions. This process helped verify design conformity and identify any necessary adjustments during construction.

Drawing Analysis

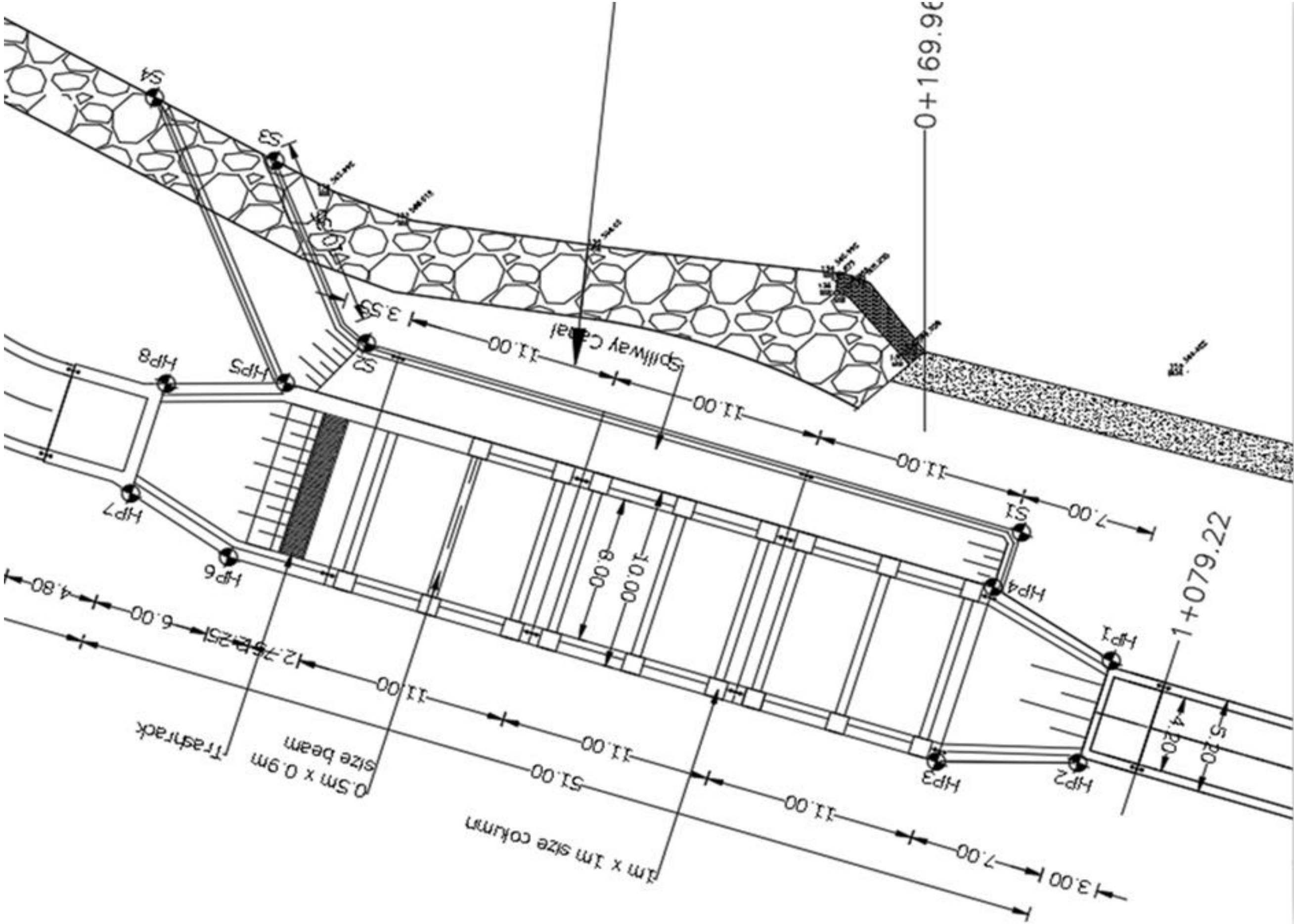

Fig 32 : CAD drawing of Headpond

Office Work

- Analyzed survey data (layout)
- Prepared as-built drawings,Drafting & drawing tasks
- Surge tank level calculation , Turbine selection study , Energy output calculation
- Internship report Preparation.
- Project presentation preparation
- Academic poster design

Conclusion

This internship provided hands-on experience in hydroelectric project construction, enhancing our skills in structural work, quality control, and design verification. It bridged theoretical learning with practical application, equipping us with valuable insights for a career in civil engineering.

Cost Estimation

S.N.	Description	Amount (NPR)	Contingency (%)	Contingency Amount (NPR	Tax/VAT (NPR)	Total Amount (NPR)
A	Pre-Operating	400,000,000.00	-	-	-	400,000,000.00
B	Civil Construction Works	3,059,330,618.90	5-7%	189,492,767.80	419,641,804.40	3,647,655,684.70
C	Hydromechanical Works	177,161,524.70	5%	8,858,076.20	16,702,295.50	202,721,896.50
D	Electromechanical Works	1,213,060,000.00	5%	60,653,000.00	19,105,695.00	1,292,818,695.00
E	Transmission Line & Interconnection	100,000,000.00	3%	3,000,000.00	13,390,000.00	116,390,000.00
F	Others	1,664,001,661.00	5%	120,295,782	96,710,250	1,881,007,693
Grand Total Cost with IDC	-	-	-	-	-	7,540,593,969.90
Project Cost per MW	-	-	-	-	-	200,547,712.00

References

- · Final DPR KAHEP Report pdf
- · https://www.kel.com.np/
- · https://www.bpc.com.np/projects/kabeli-a-hydro-electric-project
- · https://www.bpc.com.np/group-companies/subsidiaries/kabeli-a-hydro-electric-project

Annex

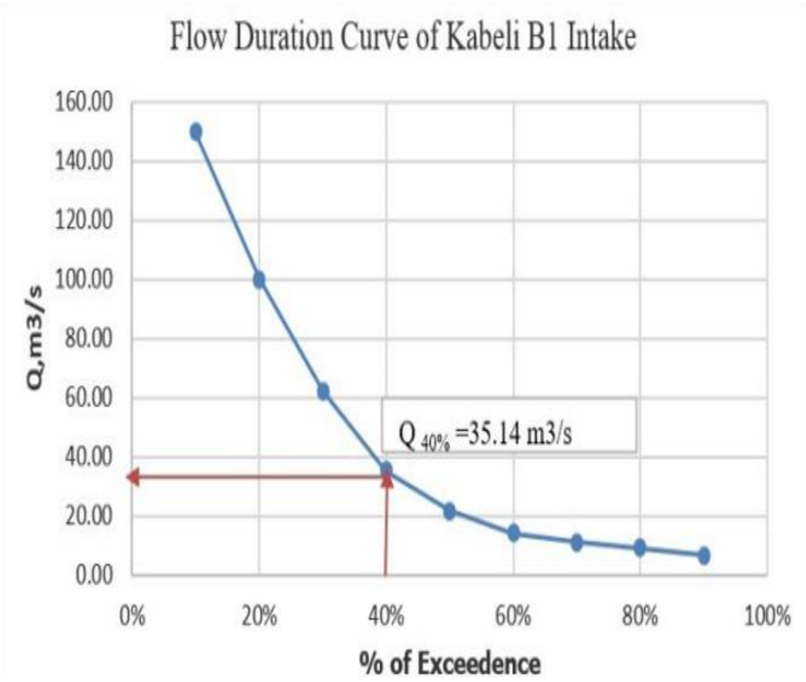

Fig 33 : Flow Duration Curve
Source: Final DPR KAHEP Report

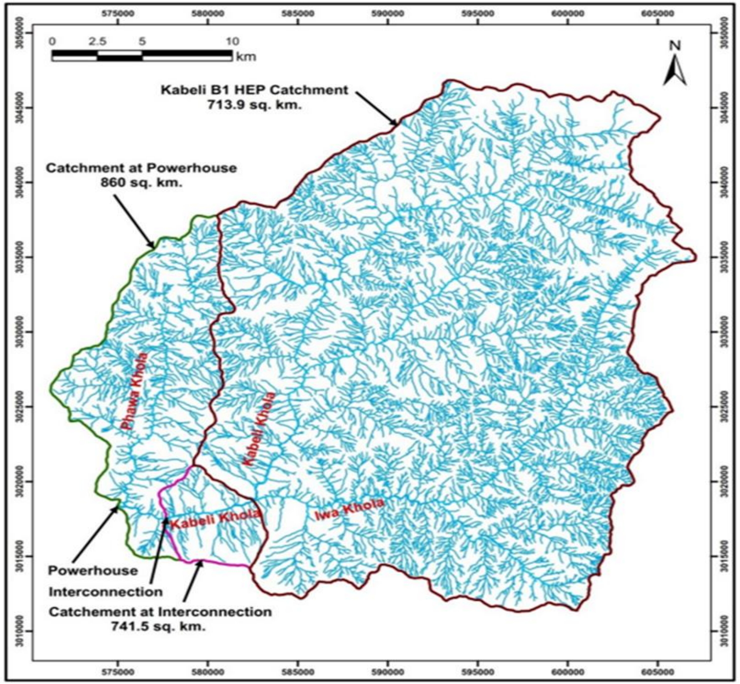

Fig 34 : Catchment Area
Source:https://projects.worldbank.org/en/projects-operations/project-detail/P122406

Annex

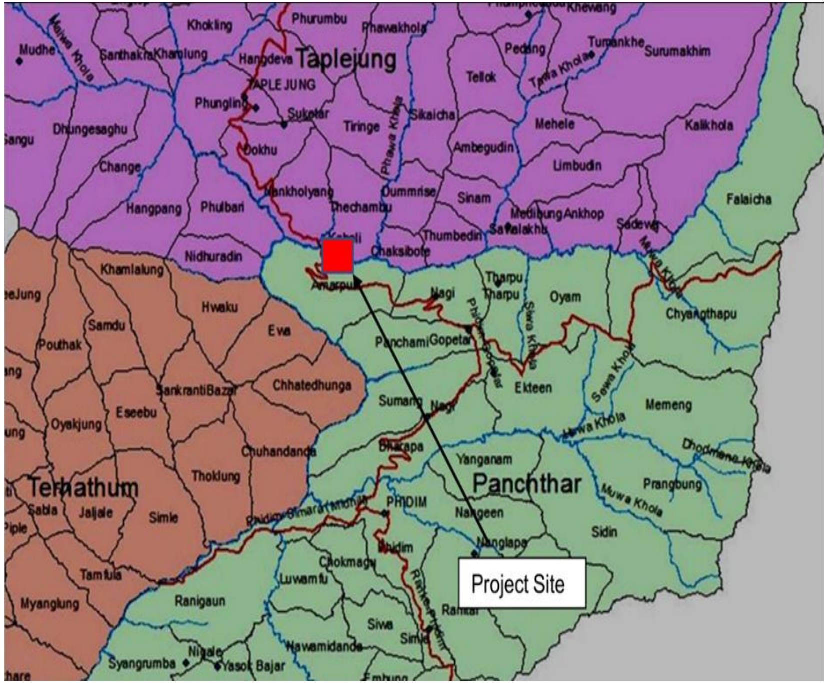

Fig 35 : Location of Project

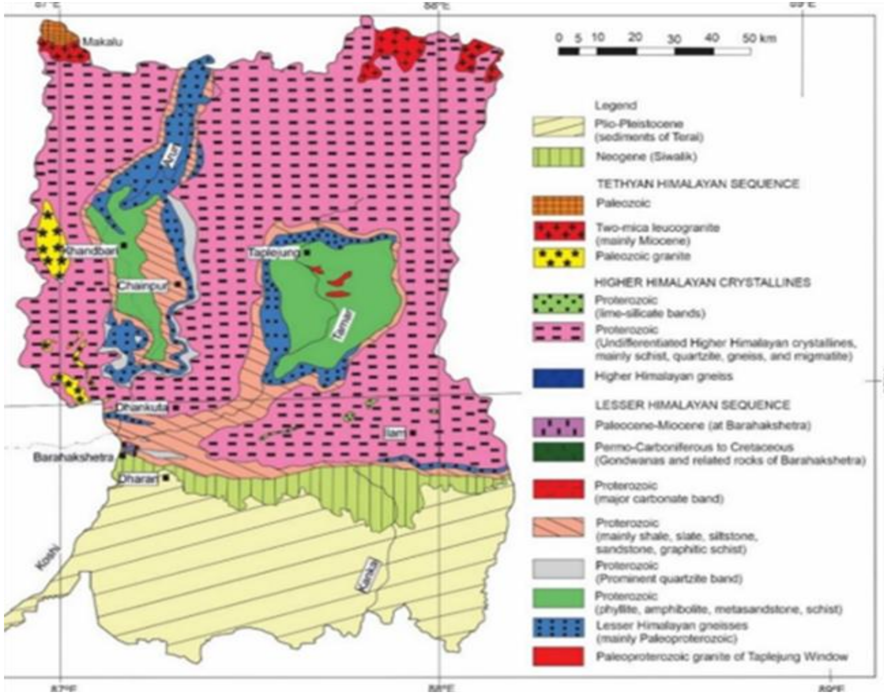

Fig 36 : Geological map

Thank you