KATHMANDU UNIVERSITY

SCHOOL OF ENGINEERING

DEPARTMENT OF CIVIL AND ENGINEERING

PROJECT PROPOSAL ON

STUDY REPORT AND 3D DEMONSTRATIVE MODEL OF PANAUTI HYDROPOWER STATION

SUBMITTED TO

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CERTIFICATION

PROJECT REPORT

ON

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BY:

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ACKNOWLEDGEMENT

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ABSTRACT

Hydropower is the term that refers to electricity generated by hydropower; the production of electrical power through the use of the gravitational force of falling or flowing of water. This is mostly used form of renewable source of energy. Basically there are 4 types of hydropower: Run off river (diversion), impoundment (storage), offshore (tidal), and pumped storage. Panauti hydropower is a run off river hydropower located at the Khopasi Kavre with the install capacity of 2.4 MW.

This project aims to construct a demonstrative model of Panauti Hydropower Project and study its different components. The peculiarity of this hydropower is analyzed theoretically by this project. In this project, we constructed a model of the dam site along with the power house reduced to an appropriate scale. The hydropower is based in references to Panauti Hydropower Project in Kavre district of Nepal.

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Chapter 1: Introduction

1.1 Background

Hydropower is one of the major sources of energy, form of renewable energy source. Hydropower plants are the most efficient means of producing electrical energy which comprises a set of electromagnetic equipment to transfers water's potential energy into electrical energy. The potential energy of the water stored in the dam gets converted into the kinetic energy of the moving water in the penstock. And this kinetic energy gets converted into the electrical energy with the help of turbine and generator combination. Hydropower is one of the largest and clean, renewable energy found on earth today. Hydropower plants fulfill the 30 % of the total energy needs of the world.

Panauti Hydropower Station (also called Khopasi Hydropower Station) is the third oldesthydropower station which was constructed in Nepal. It is the first megawatt (MW) capacity hydropower station in Nepal. It is a run-of-the-river hydroelectric plant with a intake right on the bank of RoshiKhola river and the power house is located at Khopasi,Kavre nearly 35 km east of Kathmandu. The plant is with installed capacity of 2.4 MW and annual design generation of 6.97 GWh. Open canals of 3,721 m long with discharge of 3.2 cu. m/s from headwork to reservoir has seven (7) outlet gates for irrigation in the vicinity of Khopasi.

Panauti hydropower was commissioned in 1965 AD (2022 BS) developed jointly by government of Nepal and Soviet Union Government at a cost of NRs. 27 million. The station was developed with a joint purpose of hydropower generation and irrigation. However, the water in the canal has also been used for drinking purposes as well.

Figure 1-1 Power of Panauti Hydropower Plant

Source:https://www.researchgate.net/profile/Gyatabya-Singh/publication/343850099/figure/fig1/AS:928298053926913@1598334911079/Powerhouse-of-Panauti-hydropower-plant.ppm

1.2 Location

Panauti hydropower plant is a run-of-the-river hydroelectric plant on the RoshiKhola river. This power station is located at Khopasi, Kavre district in Bagmati Province, 35 km east of Kathmandu and 7 km south-east from Panauti Bazar.   Latitude and Longitude of panauti hydropower station is 27.5631°N and 85.5361°E

1.3: Present status of Panauti Hydropower

After the major improvement activities accomplished in 2018/019 (Rehabilitation and Modernization of Switchyards of Panauti Hydropower Station located at Khopasi and Bhakatpur), Panauti Hydropower Station is generating maximum annual energy (in 2018/19) which the power plant had not been able to do since the last 11 years. The cumulative generation of the station has reached 138.066 GWh till F.Y. 2076/77 from its first run. At present the power plant is generating about 2.882 GWh of annual energy. The water users along the canal have the same irrigation facilities as earlier days. Recently the power station control, monitoring, substation and protection system is upgraded. (Wikipedia contributors, 2021)

Figure 1-2 Power of Panauti Hydropower Plant

1.4 Salient features of Panauti Hydropower

Table 1-1 Table of salient features of panauti hydropower

Type	Run of River
Location	Panauti Municipality – 10, Khopasi
Installed capacity	2.4MWh
Annual design generation	6.97GWh
Maximum gross head / Net head	66m /60m
Waterways	
Total length of the Canal	3.721 km
Discharge Capacity of Canal	3.2 m^3/s
Live storage volume of Regulating Reservoir	50,000 m^3
Penstock	1 No., 370m long, Dia1.4m
Turbine:	
Number and Type	3, Horizontal Francis
Rated discharge	1.61 m^3/s
Rated output	0.85 MW
Rated speed	1000 rpm
Generator:	
Rated output	1000 kVA
Rated voltage	6.3 kV
Rated frequency	50 Hz
Power factor	0.8
Power transformer	1550 kVA* 2Nos., 6.3 kV/33 kV, 3Phase
Transmission line	33 kV, 20 km, single circuit

Chapter 2: Objectives and limitations

2.1 Objectives

- Study and prepare the 3-D model for the powerhouse and switchyard of Panauti Hydropower Station.

2.1.1 Sub objective

- To study the placement of general equipment used.
- To study the working techniques, fieldwork, etc.

2.2 Limitations

- Restriction of close observation of equipment and machinery of the powerhouse.
- Expenditure may exceed the planned cost during model preparation.

Chapter 3: Literature review

There are basically four types of hydropower facilities: impoundment, diversion, offshore and pumped storage. Some hydropower plants use dams and some do not.

Hydropower plants range in size from small systems suitable for a single home or village to large projects producing electricity for utilities. Learn more about the sizes of hydropower plants.

3.1 Different types of hydropower facilities

3.1.1 IMPOUNDMENT

The most common type of hydroelectric power plant is an impoundment facility. An impoundment facility, typically a large hydropower system, uses a dam to store river water in a reservoir. Water released from the reservoir flows through a turbine, spinning it, which in turn activates a generator to produce electricity. The water may be released to meet changing electricity needs or other needs, such as flood control, recreation, fish passage, and other environmental and water quality needs.

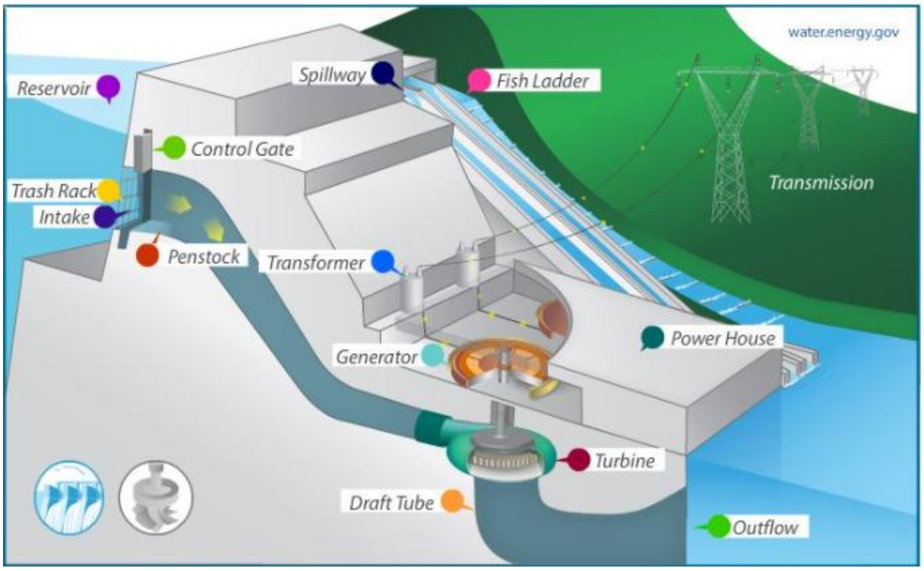


Figure 3-1 Components of a typical impoundment hydroelectric power plant.

Source: https://www.e-education.psu.edu/emsc297/sites/www.e-education.psu.edu.emsc297/files/impoundment%20hydropower%20facility%20-%20DOE.JPG

3.1.2 DIVERSION

A diversion, sometimes called a “run-of-river” facility, channels a portion of a river through a canal and/or a penstock to utilize the natural decline of the river bed elevation to produce energy. A penstock is a closed conduit that channels the flow of water to turbines with water flow regulated by gates, valves, and turbines. A diversion may not require the use of a dam.

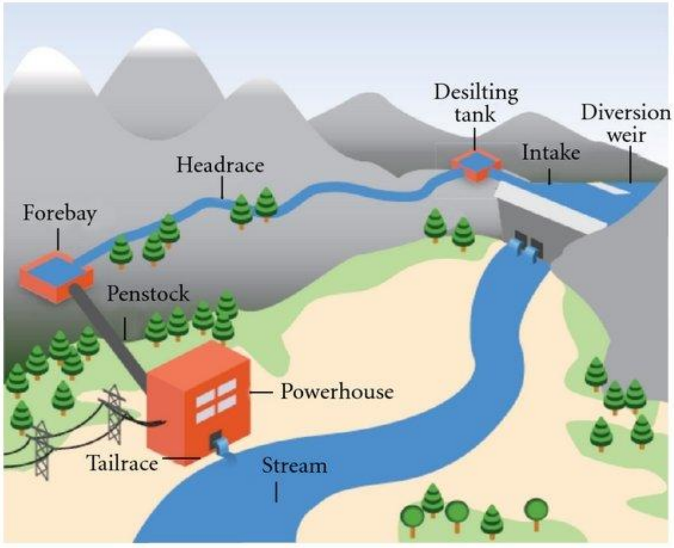


Figure 3-2 Diversion of River

Source: https://www.researchgate.net/profile/Cuthbert-Kimambo/publication/258404306/figure/fig6/AS:328303169818638@1455284983682/Schematic-diagram-of-a-typical-run-of-river-hydropower-system-4.png

3.1.3 PUMPED STORAGE

Another type of hydropower, called pumped storage hydropower, or PSH, works like a giant battery. A PSH facility is able to store the electricity generated by other power sources, like solar, wind, and nuclear, for later use. These facilities store energy by pumping water from a reservoir at a lower elevation to a reservoir at a higher elevation.

When the demand for electricity is low, PSH facility stores energy by pumping water from the lower reservoir to an upper reservoir. During periods of high electrical demand, the water is released back to the lower reservoir and turns a turbine, generating electricity.

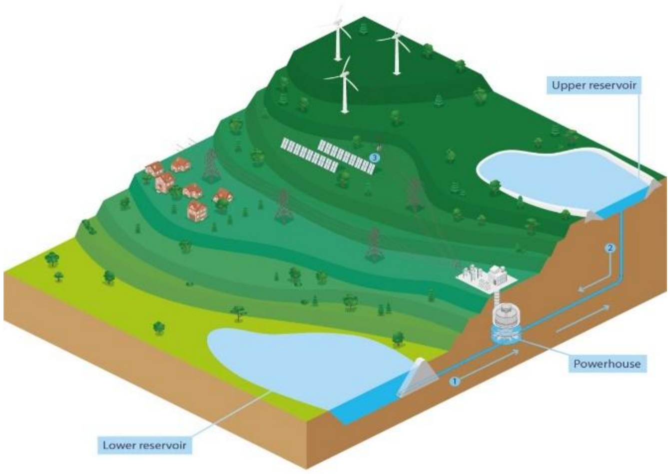


Figure 3-3 Pumped Storage of Hydropower

Source: https://assets-global.website-files.com/5f749e4b9399c80b5e421384/606347f29f7c537e31bb4a0a_5f8d70410533ac015c67bd89_pumped_storage_reservoir_-_online_use.jpeg

3.1.4 OFFSHORE HYDROPOWER

A less established but growing group of technologies that use tidal currents or the power of waves to generate electricity from seawater.

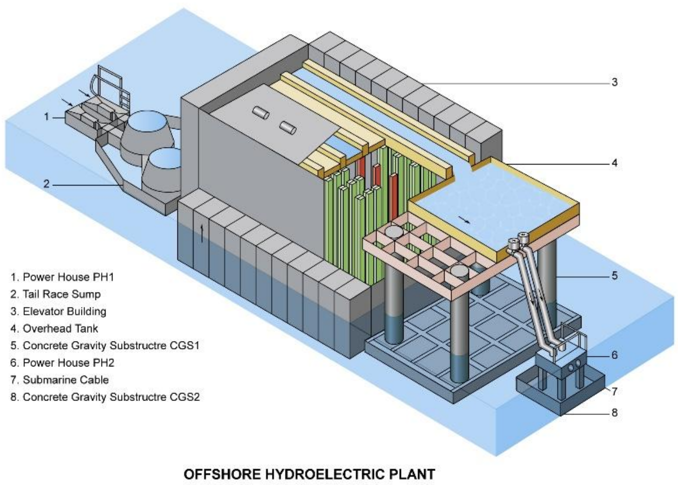


Figure 3-4 Offshore Hydroelectric plant

Source:https://upload.wikimedia.org/wikipedia/commons/d/d1/OFFSHORE_HYDROELECTRIC_PLANT_DESIGN_CONFIGURATION.jpg

(Office of Efficiency and Renewable Energy, n.d.)

Chapter 4: Components of a Hydropower Plant

4.1 Major components of a hydroelectric plant.

- Fore bay
- Intake structure
- Penstock
- Surge chamber
- Hydraulic turbines
- Power house
- Draft tube
- Tailrace

4.1.1. Forebay

A forebay is a basin area of hydropower plant where water is temporarily stored before going into intake chamber. The storage of water in forebay is decided based on required water demand in that area. This is also used when the load requirement in intake is less.

We know that reservoirs are built across the rivers to store the water; the water stored on upstream side of dam can be carried by penstocks to the power house. In this case, the reservoir itself acts as forebay.

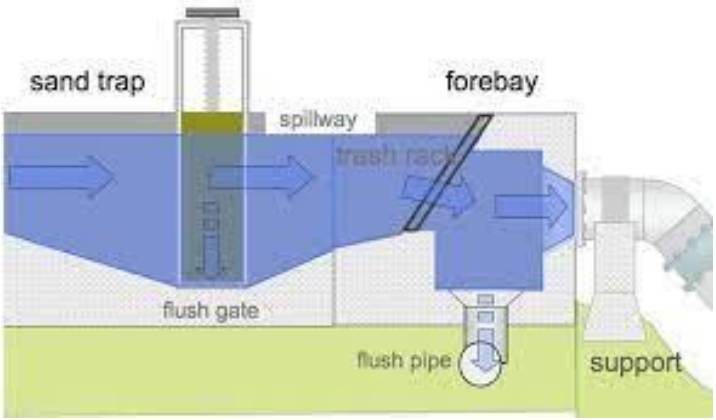


Figure 4-1 Forebay of hydropower plant

Source:https://energypedia.info/images/thumb/c/c6/Sand_trap_forebay.jpg/546px-Sand_trap_forebay.jpg

4.1.2. Intake Structure

Intake structure is a structure which collects the water from the forebay and directs it into the penstocks. There are different types of intake structures are available and selection of type of intake structure depends on various local conditions. Intake structure contain some important components of which trash racks plays vital role. Trash racks are provided at the entrance of penstock to trap the debris in the water.

If debris along with water flows into the penstock it will cause severe damage to the wicket gates, turbine runners, nozzles of turbines etc. these trash racks are made of steel in rod shape. These rods are arranged with a gap of 10 to 30 cm apart and these racks will separate the debris from the flowing water whose permissible velocity is limited 0.6 m/sec to 1.6 m/sec.

In cold weather regions, there is chance of formation of ice in water, to prevent the entrance of ice into the penstocks trash racks heated with electricity and hence ice melts when it touches the trash racks. Other than trash racks, rakes and trolley arrangement which is used to clean the trash racks and penstock closing gates are also provided in intake structure.

Figure 4-2 Intake structure of Hydropower plant

Source:https://i0.wp.com/theconstructor.org/wp-content/uploads/2017/11/intake-structure.jpg?w=1170&ssl=1

4.1.3. Penstock

Penstocks are like large pipes laid with some slope which carries water from intake structure or reservoir to the turbines. They run with some pressure so, sudden closing or opening of penstock gates can cause water hammer effect to the penstocks.

So, these are designed to resist the water hammer effect apart from this penstock is similar to normal pipe. To overcome this pressure, heavy wall is provided for short length penstock and surge tank is provided in case of long length penstocks.

Steel or Reinforced concrete is used for making penstocks. If the length is small, separate penstock is used for each turbine similarly if the length is big single large penstock is used and at the end it is separated into branches.

Figure 4-3Penstock of hydropower plant

Source: https://i0.wp.com/theconstructor.org/wp-content/uploads/2017/11/penstock.jpg?w=1170&ssl=1

4.1.4. Surge Chamber

A surge chamber or surge tank is a cylindrical tank which is open at the top to control the pressure in penstock. It is connected to the penstock and as close as possible to the power house. Whenever the power house rejected the water load coming from penstock the water level in the surge tank rises and control the pressure in penstock.

Similarly, when the huge demand is needed in power house surge tank accelerates the water flow into the power house and then water level reduces. When the discharge is steady in the power house, water level in the surge tank becomes constant. There are different types of surge tanks available and they are selected based on the requirement of plant, length of penstock etc.

Figure 4-4Surge Chamber of hydropower plant
Source:https://www.aboutcivil.org/sites/default/files/2017-12/surge-tank.jpg

4.1.5 Hydraulic Turbines

Hydraulic turbine, a device which can convert the hydraulic energy into the mechanical energy which again converted into the electrical energy by coupling the shaft of turbine to the generator.

The mechanism in this case is, whenever the water coming from penstock strike the circular blades or runner with high pressure it will rotate the shaft provided at the center and it causes generator to produce electrical power.

Generally hydraulic turbines are of two types namely

- Impulse turbine
- Reaction turbine

Impulse turbine is also called as velocity turbine. Pelton wheel turbine is example for impulse turbine. Reaction turbine is also called as pressure turbine. Kaplan turbine and Francis turbine come under this category.

Figure 4-5Turbine of hydropower plant

Source:https://energyeducation.ca/wiki/images/d/d7/Francis_turbine_for_Sakuma_power_station.jpg

4.1.6 Power House

Power house is a building provided to protect the hydraulic and electrical equipment. Generally, the whole equipment is supported by the foundation or substructure laid for the power house.

In case of reaction turbines some machines like draft tubes, scroll casing etc. are fixed with in the foundation while laying it. So, the foundation is laid in big dimensions.

When it comes to super structure, generators are provided on the ground floor under which vertical turbines are provided. Besides generator horizontal turbines are provided. Control room is provided at first floor or mezzanine floor.

Figure 4-6 Powerhouse of hydropower plant

Source: https://i0.wp.com/theconstructor.org/wp-content/uploads/2017/11/power-house.jpg?w=1170&ssl=1

4.1.7 Draft Tube

If reaction turbines are used, then draft tube is a necessary component which connects turbine outlet to the tailrace. The draft tube contains gradually increasing diameter so that the water discharged into the tailrace with safe velocity. At the end of draft tube, outlet gates are provided which can be closed during repair works.

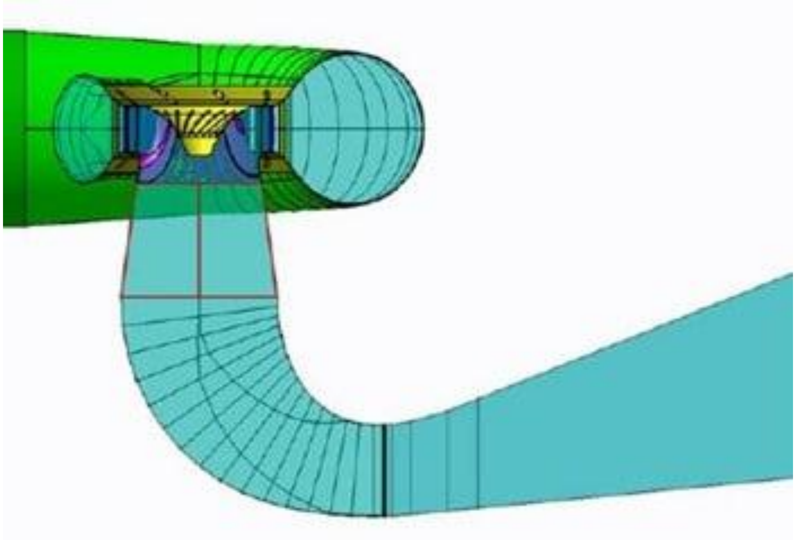


Figure 4-7 Draft tube of hydropower plant

Source: https://i0.wp.com/theconstructor.org/wp-content/uploads/2017/11/draft-tube-in-hydropower-plant.jpg?w=1170&ssl=1

4.1.8 Tailrace

Tailrace is the flow of water from turbines to the stream. It is good if the power house is located nearer to the stream. But if it is located far away from the stream then it is necessary to build a channel for carrying water into the stream.

Otherwise, the water flow may damage the plant in many ways like lowering turbine efficiency, cavitation, damage to turbine blades etc.

This is because of silting or scouring caused by unnecessary flow of water from power house. Hence, proper design of tailrace should be more important.

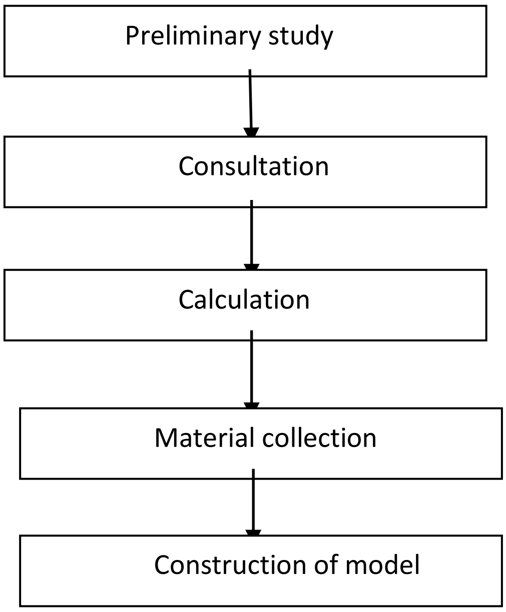
Figure 4-8Tailrace of hydropower plant

Source:https://i0.wp.com/theconstructor.org/wp-content/uploads/2017/11/tailrace-in-hydropower.jpg?w=1170&ssl=1

(S.Sen, 2015)

Chapter 5: Methodology

Methodology is a system of methods used in a particular area of study or activity. Researches regarding the hydropower and its different types were done by web surfing and consultation with our supervisor, teachers and seniors through the means of various book references were gathered about the basic principle of run of river (diversion) hydropower. The method that will be used in the development of this project is as follows:



5.1 Preliminary study

Preliminary study or discussions take place at the beginning of an event, often as a form of preparation. After finalizing the topic, researches regarding the Panauti Hydropower were surfed in the websites. References were also taken from various books related to hydropower. Field visit to Panauti hydropower, Khopasi also helped us to gather more statistical and visual information about the project.

5.2 Consultation

Respected supervisor sir was consulted for the initiation of the project. Seniors, teachers were approached regarding the idea and process that come across the project.

5.3 Calculation

Table 5-1 Calculation of reduced scaling

S. N	Name of components	Actual dimensions	Unit	Project dimensions	Unit	R. F
1	Length of diversion weir	45	m	21	cm	1:215
2	Breadth of diversion weir	7.5	m	8.5	cm	1:88
3	Length of water canal	3710	m	70	cm	1:5000
4	Breadth of water canal	2.5	m	2.5	cm	1:100
5	Area of reservoir	13136.9	m^2	620	cm^2	1:460
6	Length of penstock	370	m	50	cm	1:740
7	Internal diameter of penstock	1.4	m	1.6	cm	1:87
8	Power house(length*breadth*height)	(24.75* 18.4* 7.09)	m^3	(24.75* 18.4* 7.09)	cm^3	1:100
9	Switchyard (length*breadth*height)	(27.40*11.40 * 2.4)	m^3	(27.40*11.40 * 2.4)	cm^3	1:100

5.4 Materials Required

- Plywood
- Adhesive
- Paint
- Styrofoam
- Card board
- Pipes
- Wooden piece
- Screw and nails
- Sawdust

5.5 Tools Required

- Scale
- Hacksaw
- Paint brush
- Scissors
- Hammer
- Nails
- Rip saw

Chapter 6: Budget

Table 6-1 Table of expenditure

S. N	Materials	Units	Quantity	Rate (NRS)	Cost (NRS)
1	Plywood	m^2	2	700	1400
2	Adhesive	ml	2	150	300
3	Styrofoam	pieces	3	200	600
4	Cardboard	pieces	2	15	30
5	Color brush	-	2	90	180
6	Paints	L	4	200	800
7	Pipes	pieces	1	100	100
8	Miscellaneous	-	-	-	500
	Total				**3910**

Chapter 7: Work Schedule

Table 7-1Table for working schedule

MONTH	DEC		JANUARY				FEBURARY				MARCH				APRIL				MAY	
WEEK / DAYS	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd
Consultation and literature review																				
Proposal submission																				
Project defense																				
Materials selection and purchase																				
Model construction and fitting					Break						**Break**									
Midterm presentation																				
Finishing and coloring																				
Final report submission and presentation																				

Completed Work

Remaining Work

Chapter 8: Conclusion

Finally, after weeks of hard work we constructed a demonstrative model of Panauti Hydropower with assistance of our project supervisor and seniors. We built a working model and also got familiar with the engineering terms, skills, and the use of different tools. We faced a lot of problems during our project days but we seek the solutions for them. With the completion of the project, we successfully achieved our objectives. We completed our project within the expected time and estimated budget.

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ANNEX-I

Drawings

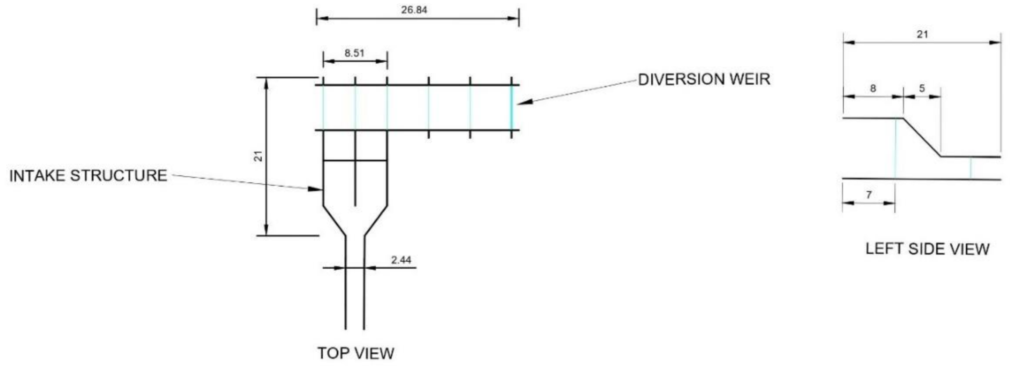

Figure: Plan and elevation of diversion weir

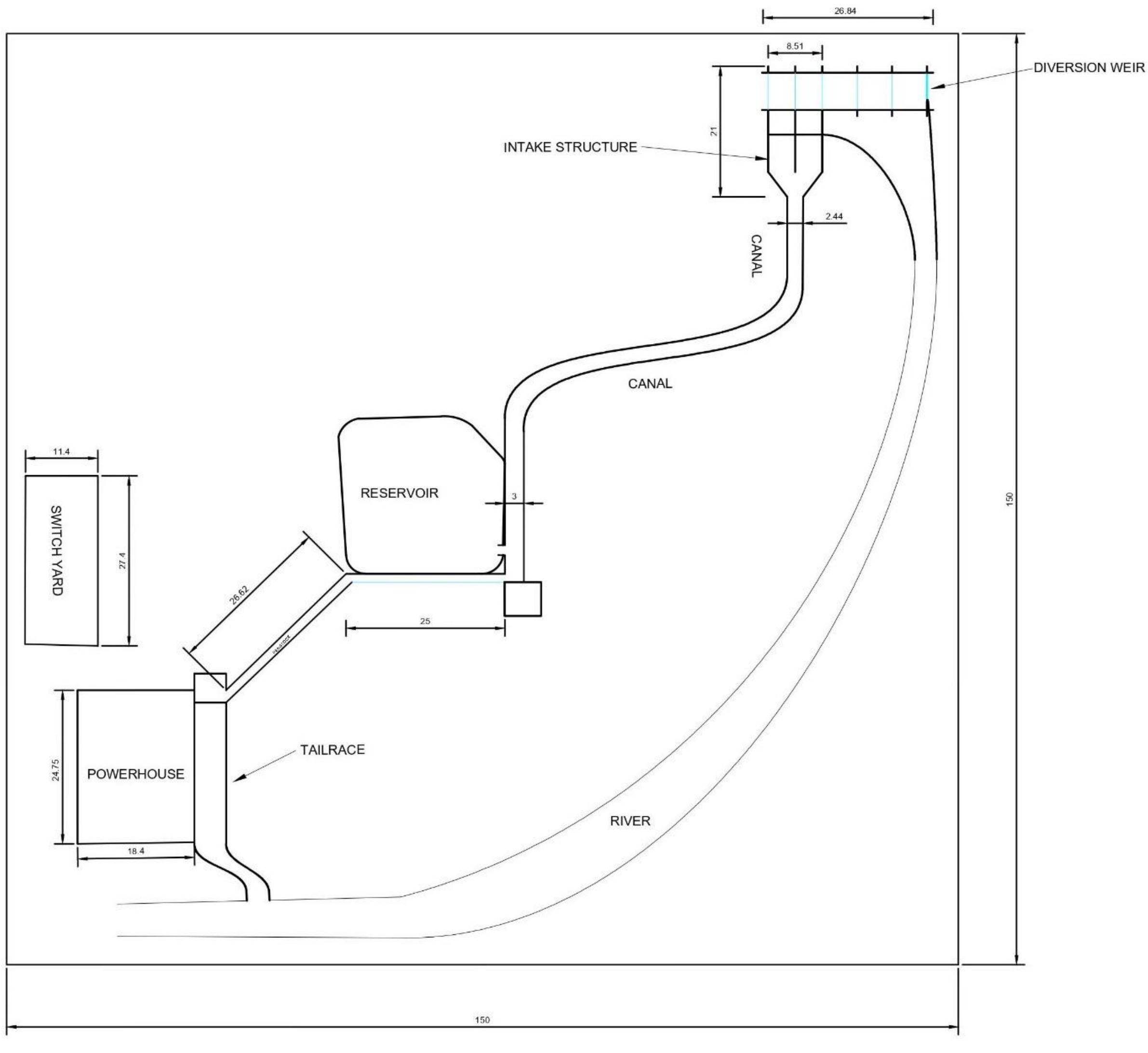

Figure: Drawing of the model

ANNEX-II

Photographs


DIVERSION WEIR
मल्पी
MALPI
WATER CANAL