IMPORTANCE OF DESIGN STANDARDS IN HYDROPOWER PROJECTS

JADE CONSULT
Providing Quality consulting since 2001

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IMPORTANCE OF DESIGN STANDARDS

• Demonstrates credentials to customers, employees and stakeholders.
• Improves performance.
• Creates a common framework.
• Helps you work effectively with supply chains and partners
• Reduces risks that might hit the investors.
CONSULTING IS MORE THAN GIVING ADVICE

• Providing information to the client.
• Solving client’s problems.
• Facilitating client learning on how to resolve similar problems in the future.
• Providing all necessary technical support to hydro power developers
• Linking them with contractors, suppliers, financiers and equipment manufacturers.
Over 2 dozen hydro power projects
Totaling capacity of 3130MW
Experience of HV transmission line system of up to 400kV
Total length of more than 1075 km

One of the leading consultants in Hydropower Development over short period of time
OUR VALUE PROPOSITION

• We make our clients and Investors aware about the required standards and procedures used in the project.
• We follow specific design codes and guidelines for safe and feasible design.
• The Design standards followed ultimately plays a very significant role during the appraisal stage of the project.
• Our standards help in getting compliance with different Acts and Policies.
  • Hiring a good consultant only costs you a minimal percentage of the project.
  • A good consultant saves your time and money.
DOED GUIDELINES

Guidelines provided by the Ministry of Water Resources, DoED is strictly followed.
These guidelines cover the scope of works in defined formats for different studies and specific details for each of those studies.

The guidelines cover the following phases of study:
1. Reconnaissance or preliminary study
2. Pre-feasibility study
3. Feasibility study
STANDARDS AND PROCESSES INCORPORATED DURING FEASIBILITY AND DETAIL DESIGN STUDY
Feasibility study

Desk Study

Apply Survey Licence to DoED

Start

Collect Topo sheets and digital map of project area from Dept. of Survey

Collection of hydrological data from DHM

Start Topographical Survey (Field work)

Start hydrological and flood analysis and fix the design flow and return period floods

Start Geological and Geotechnical Study of the project area

Alternative layout & optimisation study and Selection of preferred layout

Start Hydraulic design and sizing of project components

Start Geological and Getotechnical Study of the project area

Alternative layout & optimisation study and Selection of preferred layout

Start Hydraulic design and sizing of project components of preferred option

Stability analysis of project components

Start Producing civil drawings

Hydro-mechanical and Electro-mechanical sizing

Power Evacuation Study

Quantity and Cost Estimate and Project evaluation

Construction Planning and Scheduling

Draft feasibility Report

Incorporate comments from Client

Final Feasibility Study

Softwares: HEC-RAS, MS Office, ArcGIS, Auto CAD, SW DTM, Phase2 (RS2)

Contd.....
Review of feasibility study

Accept or amend design assumptions in feasibility study

 Modifications on feasibility study drawings as required

Detail hydraulic calculations of each project components

Detail geotechnical investigations including core drilling

Add details on civil structures considering construction viewpoint

Carry out detail structural analysis by both analytical and numerical approach

Produce both detail civil drawings and reinforcement drawings

Quantity and Cost Estimate

Construction Planning and Scheduling in detail

Detail hydro-mechanical and Electro-mechanical design

Access Road Survey and Design with tender documents

Transmission line Survey and Design with tender documents

Draft Detail Project Report and Tender Documents

Comments and Suggestions

Softwares: HEC-RAS, MS Office, Auto CAD, SW DTM, ArcGIS, Phase2 (RS2), SAP 2000, SW Road

Final Detail Project Report (DPR) and Tender Documents
CASE STUDY:
FEASIBILITY STUDY AND DETAILED DESIGN OF BUDHIGANDAKI PROJECT
GEOLOGICAL AND GEOTECHNICAL INVESTIGATIONS
Investigation Adits

6 Investigation Adits with total length of 896m
Plate Jacking Tests

12 large scale plate jacking tests and 500m of Scarabee or “petite sismique” method in the investigation adits.
Borehole Core Drilling

1837m of core drilling in the dam and powerhouse foundation including permeability tests and dilatometer tests.
Geophysical Investigations

- 6 km of seismic refraction survey.
- 3.5 km ERT survey
• Dam and Appurtenant structures located in the most favorable stretch of the river.
• Potential failure scenarios involving discontinuities considered for stability calculations.
• Deterministic Seismic Hazard Assessment was done taking account of horizontal accelerations.
HYDROLOGICAL AND SEDIMENTOLOGICAL STUDIES

• Discharges measured at Arughat DHM, and at dam were used.
• A sediment rating curve was applied to long term river discharge (1964-2012).
• The volume of sediment due to rare catastrophic events such as Landslide dam outburst flood (LDOFS) or Glacial Lake Outburst Flood (GLOFS) was considered.
More than 600 sediment samples including 54 large samples extracted with pump sediment sampling method.

General view of the sediment pumping rig looking upstream.

Assembling submersible pump and flexible delivery pipe.
Automatic Meteorological Station at Project Site

24 months of climatological stations monitoring.
• 125 km$^2$ of LiDAR topographic survey covering the reservoir, the dam and the power house areas.
• 100km of transmission line corridor survey.
• 431 river bathymetric sections.
• Establishment of a Survey Control Network with 20 permanent new monuments.
• 24 months of river gauging stations monitoring including 78 river flow measurements.
• Numerous laboratory tests on core samples and construction materials.
DETAILED DESIGN OF DAM

- Double curvature arch dam \textit{(most economical dam alternative)}.
- 8 levels of galleries for access, maintenance, and monitoring.
- All facilities for the flood control

STABILITY CALCULATIONS:
- Analysis against static and dynamic forces.
- FEM software: Based on a 3D finite-elements model,
- Numerical Modelling and analyses.
- Rock wedges stability calculations
- SWEDGE (Curran, et al. 1994) and GEOSLIDE (Carter, et al. 1993)
Physical Hydraulic Model Test

Spillway configuration tested on a physical hydraulic model at Hydro Lab Kathmandu. Hydraulic Model - scale 1:100.
OTHER WORKS

DESIGN OF APPURTE NANTS:
Waterways(intake)
Intake and headrace tunnels
Temporary Support
Power house and Tailrace works

POTYARD AND TRANSMISSION LINES
GIS
Switchyard
Technical building
Mechanical auxiliary systems
Transmission
Grid impact studies

HYDRO AND ELECTROMECHANICAL EQUIPMENT
Turbine
Main Inlet Valves
Governor
Oil Pressure System
Generators
Static Excitation System and Step-up transformers
Overhead and gantry cranes
Electrical Auxiliaries etc
COST ESTIMATION

• Unit prices have been worked out from aggregate price, that involves more than 50 projects around the world and from current under construction and planned projects in Nepal.
• The project cost has been estimated to 2,593 million USD

CONSTRUCTION SCHEDULE AND MANPOWER REQUIREMENT

Based on the most recent international experience of completed projects similar in size.
ENVIRONMENT IMPACT ASSESSMENT

Misconceptions related to EIA:
• Waste of time and money.
• Delays a project
• Very hard to conduct
• We can skip EIA study

Proper EIA study results in:
• Providing opportunity for the public to get involved
• Enhancing public confidence and public relations
• Cost-saving modifications in project design.
• Increased project acceptance.
• Avoided impacts and violations of laws and regulations.
EIA Study- Public Hearing
Environmental and Social Impact Assessment
RESULTS

- **River runoff at dam site** is likely to be **26% higher** than anticipated in the hydrological study of the Feasibility Report.
- **Energy output increased** to 4250 GWh per annum.
- **Guaranteed capacity** of 970 to 1200 MW.
A CURIUS CASE OF BUDHI GANDAKI

A project of National pride

Double curvature Arch Dam height of 263 m

- 600 MW during ToR preparation
- 1200 MW after thorough investigation

Fulfillment of dry energy demands

- 540 amsl fixed as full supply level
CHALLENGES

- Sensitivity of the project
- Local and political obstacles
- Skepticism and doubts regarding the Project
- Wrong and baseless rumors about the project
- LARRAP (Land Acquisition, Resettlement And Rehabilitation Action Plan)
- PCDP (Public Consultation and Disclosure Plan)
- IPVCDP (Indigenous People and Vulnerable Community Development Plan)
• Design Criteria report is submitted enlisting possible criteria and design standards to be used.

• Design concepts were established
  ▪ Assumptions and parameters,
  ▪ Standards applied,
  ▪ Loading conditions,
  ▪ Factors of safety,
  ▪ Stability criteria etc.

• Design works done in accordance with one or more internationally recognized standards of practice.
HYDRAULIC DESIGN

• **Design floods** were selected in accordance with internationally accepted standards for flood safety including guidelines published through ICOLD.

• The power intake was designed to prevent entrainment of air as a result of intake vortex phenomena.

• Spillway was designed to prevent damage due to cavitation and erosion for floods.

• Computations, analytical models and physical models were used to demonstrate the adequacy of the designs.
SEISMIC DESIGN

Seismic design events includes:
Operational Basis Earthquake (OBE) ICOLD 2010 and Safety Evaluation Earthquake (SEE) ICOLD 2010.

The following horizontal accelerations were taken into account:

OBE: 0.61g
SEE: 1.2g
RESULTS

Static loading:
The maximum downstream deformation at crest level is 17cm when the reservoir is reaching the FSL El.540.

Dynamic loading:
The maximum displacements at the dam crest level for the SEE are 68cm downstream and 61cm upstream.

From the calculations and analyses, the Dam is safe against Seismic forces.
GEOTECHNICAL DESIGN

• Soil pressures calculated by Rankine’s and Coulomb’s theories
• Earthquake loading calculated using pseudo-static methods and full dynamic analyses
• Journals of Geotechnical Engineering ASCE
• Rock mass classification done by (Q) method and (RMR) method
• Assessment of rock mass failure criterion was made on the basis of the rock mass classification, laboratory test and insitu tests.
• Rock slope stability was analyzed using limit equilibrium methods
• Softwares used were SWEDGE (Curran, et al. 1994) and GEOSLIDE (Carter, et al. 1993)
• For soil foundations, Rankine’s theories for stability and loads, and Terzaghi’s formula for bearing capacity
• Computer codes used to perform numerical analyses to analyze and optimize foundation design.
CIVIL AND STRUCTURAL DESIGN

- Eurocode 0 for combinations
- Eurocode 1 for solicitations
- Eurocode 2 for RCC structures
- Eurocode 3 for steel structures
- Eurocode 6 for masonry structures
- Eurocode 7 for geotechnical structures
- Eurocode 8 for seismic design
- ICOLD and USACE for specific problems, not addressed in Eurocodes
• **Uplift analyses**- Safety Factor requirements from USACE manual EM 1110-2-2100

• **Dam design**- USCE Engineering Manual EM 1110-2-2201

• **Earthquake analysis**: ER 1110-2-1806, Earthquake Design and Analysis for Corps of Engineers Dams

POWERHOUSE:

• Eurocode 2 for RCC structures
• Eurocode 3 for steel structures
• Eurocode 6 for masonry structures
• Minimum steel reinforcement for beam, slab, walls, columns and raft designed with accordance to NF EN 1992-1-1
• Structural steel was designed using allowable stress design (ASD) method
Hydro-mechanical equipments:

Codes and Standards used:

• EN European Standard
• DIN Deutsche Industries Norman
• ANSI American National Standards Institute
• ASME American Society of Mechanical Engineers
• ISO International Organization for Standardization
• Japan Hydraulic Gate and Penstock Association

Electro-mechanical equipments:

• Relevant codes by International Electrotechnical Commission standards (IEC codes) were followed
Following design standards increases cost???

Strictly following design standards and proper guidelines results in increased cost of:

• Feasibility study,
• Field investigations,
• Environmental costs,
• Technical and human resources,
• Management costs.
Conclusion

• Through the case study the aim of this presentation is to point out the importance of design standard to achieve a better result. It is very important because this will ensure smooth operation and optimum generation from the project.

• In summary to implement the project, a project design standard needs to be created and put in position to manage different aspects of the Project at different stages.
THANK YOU FOR YOUR TIME