Estimating Heavy Civil Hydroelectric Projects

Introduction

Estimating Heavy Civil Hydroelectric Projects requires an estimator to have experience in all phases of construction including Earthworks, Dewatering, Tunnels, Structural Concrete, Structural Steel as well as Mechanical and Electrical works. The majority of the projects are founded on Rock and the estimator must be familiar with estimating Drilling and Blasting as well as Crushing operations. In addition heavy civil hydro electric projects require temporary works such as cofferdams or diversion tunnels. A major component of these projects also includes the supply and installation of the Electric Generators and Turbines, also referred to as Water to Wire Equipment. These projects are normally located in remote locations requiring separate Access Roads and Camps to be constructed in support of the project. The estimator must also be trained in developing and analyzing construction equipment rates as Heavy Civil Projects are won and lost often based on how the bidder estimates the cost of owning and operating the equipment.

Phases of a Heavy Civil Hydroelectric Project

Hydroelectric projects usually span over several years with some large projects taking upwards of 10 years to complete. The projects can be divided into distinct phases;

- Access Road Construction
- Site Preparation
- Camp Construction
- Cofferdam Construction
- Water Diversion
- Spillway Construction
- Powerhouse Construction
- Intake Construction
- Penstock Construction
- Gate Installations
- Dam Construction
- Water to Wire Equipment
- Balance of Plant Mechanical & Electrical

The Spillway, Intake, Penstock and Powerhouse are usually constructed behind the cofferdams after the water has been diverted. In some cases the Spillways can be located away from the main Powerhouse and constructed separately.

Analyzing Material Borrow Sources

The key to minimizing costs on a heavy civil hydroelectric project is to obtain the Dam Embankment fills and Concrete Aggregates from borrow sources as close to the site as possible. When determining the location for a hydroelectric project the availability of quality embankment and aggregate material is essential. This includes impervious tills, granular sources and rock sources for concrete aggregates and riprap erosion protection.

When estimating a hydroelectric project the first thing the estimator must do is a "Material Balance" chart in order to analyze the material available from excavations vs the material required for embankments and concrete in order to determine the amount of borrow required. The depth of the available borrow is also important to determine the amount of stripping required to access the borrow areas. The haul distances to the various borrows must also be summarized.

Cofferdams and Dewatering

Hydroelectric Projects involve harnessing the flow of water but also involve diverting the flow of water during construction. These diversions are usually done with Cofferdams. This construction usually can only be performed at certain times of year when the flow is the lowest. No cofferdam is ever fully watertight and estimating the amount of pumping required to keep the foundations dray is difficult to predict.

Estimating Rock Excavation

The majority of heavy civil hydroelectric projects, for stability reasons must be situated on competent rock. This usually involves drill and blasting operations as well as line drilling in order to prepare vertical rock faces. The cost of sub-grade preparation is also high on these projects because the rock must first be cleaned prior to concreting.

Estimating Concrete and Formwork for Heavy Civil Hydroelectric Projects

Estimating concrete and formwork costs on heavy civil projects is much different that estimating the same costs on traditional building projects. Formwork production rates can be 3-5 times slower on a Hydroelectric Project than on a building project. The forms are often curved and constructed against rock requiring special forms and rock anchors. The forms must also support heavier pours and quite often cannot be reused as often as on traditional building projects. Invariably the concrete is also cast against blasted rock which leads to expensive rock anchors being required for the formwork as well as much more wasted concrete, called "Overbreak" than would be traditionally found on a building project.

Estimating Penstock Fabrication & Erection

Penstocks are usually large diameter steel structures used to carry water from the Intake to the Powerhouse. The large diameter penstock segments require heavy lifting. When the Penstock reaches the Powerhouse it must be split into small diameter sections before being feed into the Turbines. Estimating this work requires good knowledge of Steel Hoisting techniques as well as complicated welding procedures. The cost of Penstock Steel can often be 3-4 times the cost of traditional building structural steel.

Estimating Gate Fabrication and Installation

Intake Structures, Spillway Structures and Powerhouse Draft Tubes usually require steel gates to be installed that can be opened and closed to control the flow of water. The gates can be flat or “Vertical” gates or curved “Radial” gates. The gates are usually accompanied by either wire-rope or hydraulic hoists so they can be opened and closed. Steel Guides must also be embedded in the concrete before the gates are installed. These guides must be installed precisely in order to guarantee water tightness.

Powerhouse Building and Overhead Crane

These projects also usually include the construction of a building in order to house the Turbines and Generators and to provide space for ongoing operations and maintenance. This building usually comes complete with a large capacity overhead crane capable of listing out the heaviest pieces of the Turbines and Generators.

Installation of Water to Wire Equipment

The final stage in the construction of a hydroelectric project is the supply and installation of the Turbines, Generators and Transformers. This equipment must be procured often as much as 2 years prior to installation. The equipment is usually installed indoors after the Powerhouse building has been erected utilizing the permanent overhead crane. During the installation second stage concrete is poured in order to embed the turbine units in their final location.

Balance of Plant Equipment

This is a term used to describe the remaining Mechanical and Electrical equipment required to support the powerhouse building operations.

Estimating Camp, Catering and Travel Costs

Invariably Heavy Civil Hydroelectric Projects are situated in isolated locations far from the nearest town or city. Based on the man-hours generated from the estimate and the schedule the estimator must develop a resource histogram in order to calculate the man-days of camp requirements. The cost to erect and operate the camp and provide meals can

often be 20-50% of the cost of labour. The cost of transporting the workers to and from the site and to and from the camp can also be in the order of 10-20% of the cost of labour.

Estimating Overtime and Shift Differential Costs

Constructing a Hydroelectric Project is a 7 day a week 24 hour per day operation. Monitoring Cofferdams and Dewatering is a 24 hour a day operations. As such, Overtime and Shift Differential Costs are normally much higher than traditional building or highway projects. At the end of a shift, you can't lockup the site and go home for the weekend. Overtime premiums can also run to 15-20% of labour costs.

Estimating Indirect Costs on Hydroelectric Projects

Due to the isolated nature of these projects, contractors must provide their own infrastructure including temporary power, water and compressed air. They must also service all their own equipment and transport the workforce around a large site. For these reasons the indirect costs can be as high as 20-25% of total costs as compared to 5-10% for building or highway projects.

Conclusion

Estimating a Heavy Civil Hydroelectric Project is much different than estimating traditional building or highway projects. Excavation is normally in rock and sub-grade preparation costs are high. Dewatering is expensive and unpredictable. Concrete Formwork is more complicated and concrete wastage is high. Indirect and overtime costs are higher than normal and camps usually required to house the workforce.