Lower Churchill Project

Muskrat Falls Generation Plant

Construction Schedule

The document intends to summarize the main principles considered by Astaldi in its Construction Schedule

The Drivers

The construction schedule has been driven by the following main items (in order of importance):

1) The Milestones and the and the Interfaces given by the Owner (Rev 5);
2) The five winter periods, considered from November 1st to April 30th on the basis of the climatic dataset available for the job site;
3) The project details delivered by the Engineer, (construction joints, pour elevation, temperature control, etc.)
4) The procurement process of plants, equipment and materials
5) The production of some special materials, such the LH-C Cement
6) The capability to product aggregates for the first winter period
7) The availability of specialized and not specialized manpower
8) The expected productivity parameters for every single activity
9) The method of construction chosen for each structure
10) The type of formworks, cranes, concrete pumps, etc.

Construction Strategy

The main strategy of Astaldi to execute the works and achieve the milestones and Interfaces has been founded on the following steps:

1) Purchase, mobilization and installation before the first winter period 2013 – 2014 of the temporary crushing and batching plants in order to produce the aggregates for the first winter season (2013/14) and to produce the concrete for the installation and for the foundation treatment
2) Purchase, mobilization, installation and testing of the final crushing and batching plants in order to start the industrial production (March 2014)
3) Final design and approval of the Integrated Cover System of the Intake-Powerhouse in the Fall 2013
4) Procurement and construction of the ICS in the first months of 2014
5) As soon as possible, starting from October 2013, development of the site installations in all those available areas not used by other Contractors (camp site, laydown area, etc.)
6) From November 15th, 2013, installation of the facilities close to the spillway area (upstream and downstream)

7) From November 30th 2013, installation of the facilities close to the powerhouse area (upstream and downstream)
8) From January 1st 2014, full takeover of the construction areas and of the existing drainage system
9) Foundation preparation of the Spillway, Separation Wall and Central Transition Dam during the winter 2014 under temporary heated protections
10) Spillway slabs pouring after the foundation preparation
11) Spillway wall erection during spring and summer 2014 in order to achieve the Milestone M4A (February 15th, 2014)
12) Intake and powerhouse pouring starting from April 2014 in order to achieve the Milestone M18 (July 31th, 2018)
13) Concreting of the transition Wall, North and first two monoliths of the Center Transition Dams in order to achieve the Milestone M4
14) Drill holes and grouting of the Spillway piers

The Integrated Cover System will essentially permit to achieve the following goals:

1) Create an isothermal environment which is not affected by external changes in temperature
2) Maintain a constant productivity facture all the year long, avoiding loss of production during the winter period
3) Permit to organize the entire production sequence by the mean of an industrial approach
4) Become an attractive working environment for the manpower reducing turnover and consequent loss of productivity.

The Intake and the Powerhouse (Turbine axis and Draft Tubes) will be executed starding from the unit 1 to the unit 4, with a about 40 days of delay between the different units. All the vertical section of the southern service bay between -31 to +15.5 will be executed during the summer and the fall 2014.

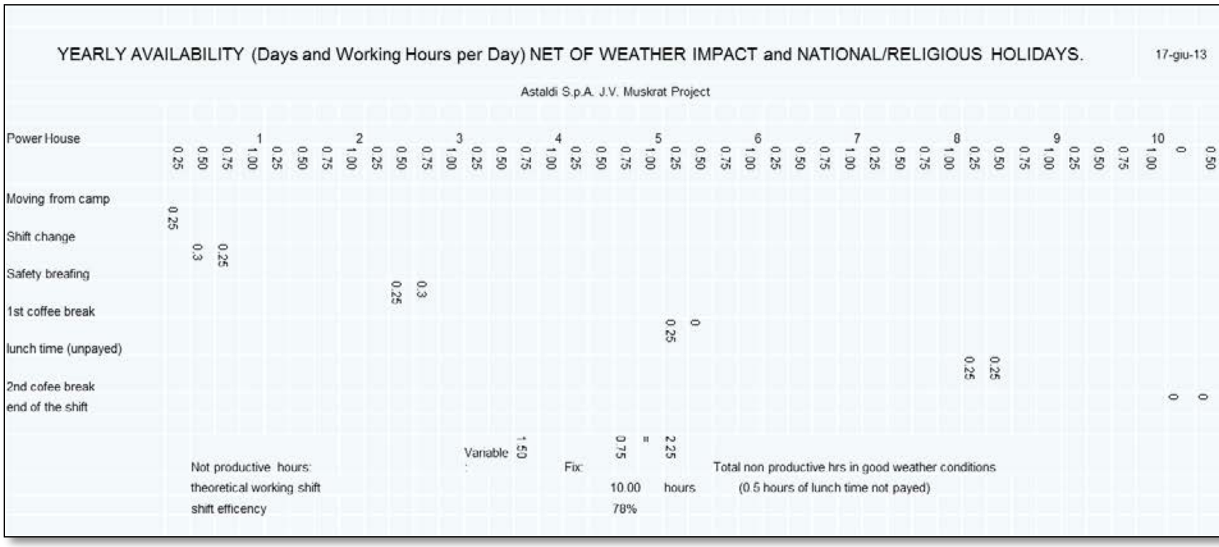
The Separation Wall and the Transition Dams (north, center and south) will be poured during the summer period or the first part of the autumn 2014. In case of winter pouring, temporary heated shelters will be installed.

Work schedule organization and calendars

As mentioned in the Project Execution Plan, Astaldi in planning to work 7days/week on two shifts of 10 (ten) hours each. The remaining hours will be used for maintenance and or work completations. All the national and provincial holidays have been considered.

A certain number of losted days have be considered during the winter period due to snow storms.

under ICS, Astaldi considers to have a theoretical efficiency of 78%, also considering the not productive time such as (a) shift takeover (b) safety meetings (c) coffee breaks (d) lunch break and (e) work delivery to the other shift.



Calculated man-hours parameters

The construction schedule has been generated considering, for each item listed in the Schedule of Price Breakdown, the Man-hours on site per unit.

The table below shows the man-hours values per cube meter of concrete placed on site. These man-hours values consider the concrete production and placement cycle, that is the result of:

a. Aggregate production
   i. Borrow pit operations
   ii. Aggregate transportation
   iii. Rock stockpile operation
   iv. Crushing plant operation and maintenance
   v. Aggregate handling
b. Concrete production and transportation
   i. Batching plant operation and maintenance
   ii. Concrete transportation
c. Concrete placement
   i. Pumping operation and maintenance
   ii. Concrete tower and booming operation and maintenance
d. Formwork installation and maintenance (assembling, disassembling, lifting, etc.)
e. Concrete curing, etc.

The concrete production and placement cycle is depending from the type of structure to be executed. Here below are summarized the different man-hours parameters calculated for each item.

NORTH TRANSITION DAM	U.M.	Man-hours (at site) per unit
Dental Concrete	m^3	1.8
Concrete	m^3	3.9
CENTRE TRANSITION DAM		
Dental Concrete	m^3	1.8
Concrete Below El. 42.00 m	m^3	4.2
Concrete Above El. 42.00 m	m^3	4.1
Concrete - Slab on Steel Deck	m^3	4.0
SOUTH TRANSITION DAM		
Dental Concrete	m^3	1.8
Concrete	m^3	4.0
SEPARATION WALL		
Dental Concrete	m^3	1.8
Concrete - Separation Wall	m^3	5.0
SPILLWAY		
Concrete - Slabs	m^3	2.7
Concrete - Piers and Walls	m^3	7.5
Concrete - Rollways	m^3	2.7
Overbreak Concrete	m^3	2.1
Concrete - Slab on Bridge Deck	m^3	3.6
Concrete - Slabs (CVC)	m^3	4.2
Concrete - Walls (CVC)	m^3	6.7
INTAKE		
Concrete - Substructure below El. 45.5 m	m^3	4.6
Concrete - Gate Hoist Building and Elevator Room above El. 45.5 m	m^3	9.9
Overbreak Concrete	m^3	1.9
POWERHOUSE		
Concrete - Powerhouse Substructure below El. 6.5 m	m^3	3.6
Concrete - Substructure between lines 6 and 7, including Sump Pit, Shafts for Stair & Elevator up to El. 45.5m	m^3	10.5
Concrete - Slabs and Walls between El. 6.5 and 15.5, including North and South Service Bays, Slab on grade, Basins and Bases for GSU transformer up to El. 16.8 m. Air vent enclosures on **Powerhouse** tailrace deck **and North Service Bay**, Access enclosure to stair no. 8 and Oil/Water separator enclosure.	m^3	10.0
Concrete - Slab on Steel Deck including Mezzanines	m^3	1.8
Overbreak Concrete	m^3	2.0
Concrete Unit Masonry (Exterior)	m^2	5.3

Values vary from 1.8 Mh[i]/m3 for the less complicated items such the Slabs or the overbreak concrete, to 10 Mh/m3 for the more complicated structures. The factor that plays a fundamental rule in the performance is represented by the formworks and the geometry of the structure.

All parameters have been compared with previous similar hydro works in Canada.

[i] Mh = man-hours