Surmounting Natural Obstacles at Tala Hydro

Teamwork Triumphs

The Tala Hydro scheme is being constructed in the remote Himalayan kingdom of Bhutan, using more than 40 items of equipment supplied by Atlas Copco. Delivery, commissioning, and maintenance of these units has not been easy, because of difficult access and poor communications. However, teamwork between the client, the contractors, and Atlas Copco India has combined to overcome these problems. The project has now recovered from the monsoon of August 2000, which was accompanied by the most devastating floods ever experienced. Roads were washed out, tunnels flooded, and communications disrupted. It took six months for the contractors to re-establish efficient working conditions, and the pressure for production has been on them ever since.

Atlas Copco Boltec 435 H at work in C-1 at Tala Hydro project.

Introduction

The Tala Hydroelectric Project is located in Chukha Dzongkhag in western Bhutan. The five comparatively remote sites that constitute the project are accessed from India through the border crossing at Phuentsholing, and thence towards the Bhutan capital Thimphu along the winding, steep, predominantly single-width National Highway No 2. The dam site is about 85 km by road from Phuentsholing, and is located near the village of Wangkha, on the Wangchu river, some 3 km downstream of the existing Chukha power station tailrace outfall.

The client is Tala Hydroelectric Project Authority (THPA), a body set up by the Government of India and the Royal Government of Bhutan specifically to carry the job to a successful conclusion. THPA has split the civil works into five major components and awarded these on a competitive tendering basis to three construction companies, namely Jaiprakash Industries Limited, Hindustan Construction Company, and Larsen & Toubro Limited. These contracts, designated C-1 to C-5, are closely monitored by THPA so that any changes required can be expedited with minimum delay. C-1 comprises the dam complex and 6.4 km of the headrace tunnel (HRT); C-2 involves excavation of the HRT from the 6.4 km mark to the 11.4 km mark; C-3 covers HRT excavation to the 15.8 km mark; C-4 covers completion of the HRT to the 23 km mark; and C-5 comprises the surge shaft, powerhouse complex and tailrace tunnel. All are set up with separate access and power supply, so that there is minimum interference between contracts. The powerhouse generating plant will be designed by BHEL with the assistance of GE (Energy) UK, and two alignments for the 400 kV transmission lines up to the Indo-Bhutan border have been optimized.

Main Features

The diversion will provide live storage capacity of 3.2 million cu m between full reservoir level of 1,363 m ASL and minimum drawdown level of 1,352 m. The three power intakes located on the right

Wagner MT 420 dumptruck, one of fourteen on the project.

bank of the reservoir will enable diversion of a discharge of 171 cu m/sec. Three desilting chambers sized at 250 m x 13.9 m x 18.5 m will allow the incoming water to settle sufficiently to remove silt particles of up to 0.2 mm. A flushing tunnel will remove the sediment, and carry it back to the Wangchu river downstream of the dam.

A 23 km-long, 6.8 m-finished diameter, 50 sq m modified horseshoe-shaped, concrete-lined headrace tunnel (HRT) with design discharge of 142.5 cu. m/sec will carry the intake water to the turbines. Five intermediate adits are facilitating its construction. The HRT is being excavated at 7.5 m diameter under minimum rock cover of 60 m, and maximum of nearly one kilometre.

A 168 m-high, 15 m-diameter surge shaft at the downstream end of the HRT will alleviate any overpressure from the 860 m head of water. Two steel-lined pressure shafts inclined at 51 degrees, each 1.1 km-long and 4 m-diameter, will emanate from the surge shaft, and trifurcate into 2.3 m-diameter penstocks near the powerhouse to feed the six 170 MW Pelton turbines, which will provide a total capacity of 1,020 MW. Two intermediate adits are facilitating construction of the pressure shafts. The underground powerhouse is 206 m-long by 20 m-wide and 45.5 m-high, and the transformer cavern is 191 m-long, 16 m-wide and 26.5 m-high.

A 3.1 km long x 7.75 m-diameter tailrace tunnel will discharge the water back into the Wangchu river.

Geology

The dam site is located in the Thimphu gneiss, and the section of HRT up to 14 km downstream from C-1 is in gneiss with quartzite bands and biotite schists. There are joint sets, and the rock is highly faulted, with foliation shears of varying thickness up to 30 cm. From 14 km to 23 km, the rock type is biotite gneiss with bands of quartzite, mica schist, and sericite schist with amphibolite. Rock conditions merit III-VI on the NGI Q system, with pretty poor conditions affecting parts of C-2, C-3, and most of C-4. The rock formation in the powerhouse, and penstocks, envisaged to be in classification II-III, has shown a large variance during actual excavation towards the poorer side. Maximum overburden on the scheme is 1,200 m, and minimum is 65 m, with an average of 400-700 m.

The rock quality encountered has largely been poor to very poor, with up to 67% classes IV, V, and VI, and only about 33% in the fair to good category class II and III, while class I, described as very good on the NGI Q system, has been seen only rarely.

In class I and II rock, wherever required, 3 off 25 mm-diameter, 3.5 m-long rock bolts and 50 mm of steel fibre reinforced shotcrete (SFRS) have been installed per metre above springing level. In class III rock, 7 off 25 mm-diameter, 3.5 m-long rock bolts per metre and 50 mm SFRS have been provided throughout the tunnel section.

Class IV rock has been supported either by 7 off 25 mm-diameter, 3.5 m-long rock bolts with ISMB 200 steel ribs and 50 mm thick SFRS, or by 13 off 25 mm-diameter, 3.5 m-long rock bolts with 100 mm thick SFRS, depending on site requirements.

In class V rock, either 7 off 25 mm-diameter, 4 m-long rock bolts with ISMB 200 steel ribs and 75 mm SFRS, or 13 off 25 mm-diameter, 4 m-long rock bolts with 150 mm-thick SFRS have been provided.

In class VI rock, 13 off 25 mm-diameter, 4 m-long rock bolts with ISMB 200 steel ribs and 100 mm thick SFRS are used.

Progress

Excavation of the 356 m-long diversion tunnel was completed on 19th May, 1999 and diversion of the river was achieved during January, 2000.

In the HRT tunnels, using the Atlas Copco Boomer 352s in rock classes I, II and III, the average advance has been 120 m/month, and in class IV rock up to 70 m/month. Class V rock, which has to be fully ribbed at 60-75 cm intervals, strutted, bolted, meshed and backfilled with concrete or shotcreted, slows advance to 30 m/month. Atlas Copco Rock Tools supplied the start-up packs of drilling accessories, and have been supplying consumables to all three contractors ever since. They also supplied their state-of-the-art Terox S5 grinders to ECC and Jaiprakash. The Secoroc button bits are reported by the contractors to be achieving up to 30% longer life than those from competing firms.

Package C-1

Contractor Hindustan Construction Company (HCC) arrived at site on 17th November, 1998 and commenced work on the diversion tunnel three days later, using one of the five new Atlas Copco 352 drill-rigs provided by THPA. The rock strength in the diversion tunnel proved to be poor due to schist bands, and average of 2 kg of gelignite was used to blast each cubic metre of solid rock, using Nonel detonation. The 3.5 m-long rockbolts were provided anchorage by five, 28 mm x 200 mm resin capsules at the end of the hole, followed by injection of cement capsules. 100 mm-thick Dramix-reinforced shotcrete was applied to walls and roof. The spoil was loaded into Wagner MT 420 trucks by a 90 t/h excavator fitted with a 1.2 cu m loading bucket. The intake tunnels were excavated using a third, refurbished Boomer 352. The dam foundations and the desilting caverns have been excavated concurrently. Each of the three desilting chambers is 250 m-long with a 250 sq m section, and located in class I-V rock. Some 180,000 cu m of the required 193,000 cu m of sequential excavation has been carried out, mostly by top heading to a full-width, followed by a bottom heading, two side slashes, and a floor slash.

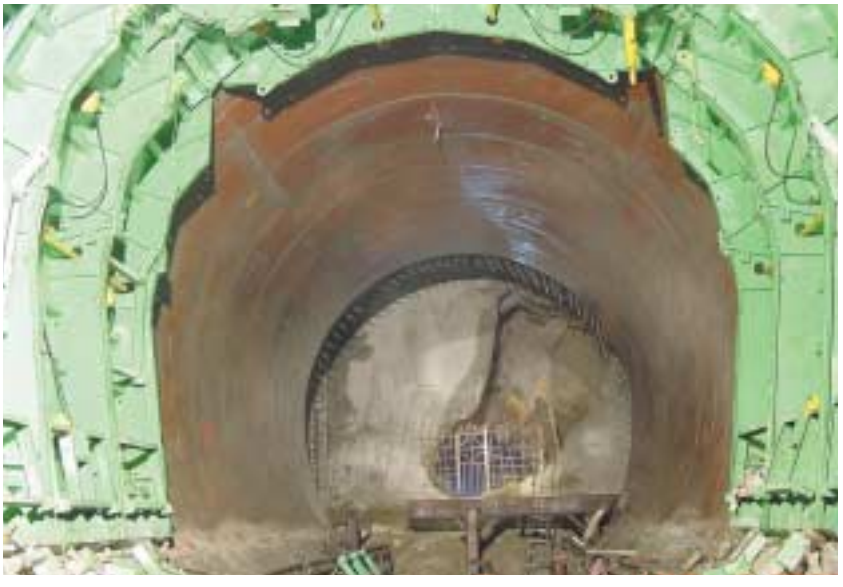
Because of cracks in the roof arch, the crowns of the desilting chambers have had to be supported by steel ribs, and the sidewalls have been clad with reinforced concrete. Excavation of the 6.4 km stretch of HRT included in the C-1 package was completed in May, 2002. It is accessed by two construction adits, one near the dam site, and the other about 5 km away.

Atlas Copco Rocket Boomer 352 at junction of Mirchingchu Adit with HRT.

Concrete lining of the HRT commenced during May, 2001 and 4,150 m of overt lining was completed by end-2002. Excavation of the desilting chambers has been completed by HCC, which has 2,000 personnel at site working 2 x 12h shift rotation, 7 days/week.

Package C-2

Contractor Jaiprakash Industries Limited had great difficulty constructing the



Lining the head race tunnel at Tala Hydro.

Repairs underway on Bhutan National Highway No 2.

267 m-long Padechu adit to facilitate excavation of its 5 km section of HRT. Adit excavation and support was undertaken by drill/blast, using one of two new Atlas Copco 352 drillrigs. Work was halted in mid-May, 1999 by a 15 m-long face collapse in the adit, some 118 m from the portal, when the tunnel encountered an underground aquifer discharging 300-1500 lit/sec. The contractor inserted six forepoles over the crown, and drilled 89 mm drainholes into which 2 m pipes were inserted. This was followed by a series of 102 mm angled holes to establish an 8 m depth of cement-grouted zone above the crown. The inflow was first arrested on the left-hand side of the drivage, and then on the right-hand side by backfilling the ribs with dry cement in bags. The face was then advanced cautiously, using a special blasting pattern comprising 80 short holes, and under the protection of three 15 m-long probeholes. As a result, by June, 2001, only 1,231 m of HRT had been excavated from this access. However, the geology improved later on, and a length of 4,650 m had been excavated by December, 2002.

Package C-3

Contractor ECC Group (Larsen & Toubro Limited) has constructed the 963 m-long Geduchu adit access to facilitate excavation of its 4.4 km section of HRT. The entire length of HRT was excavated within the original schedule, and concrete lining is in progress, with 1,488 m completed by December, 2002.

Package C-4

The 7.2 km-long section of HRT to be excavated by HCC at C-4 required two construction adits. The first adit was 320 m-long, and located near Mirchingchu. The second adit was moved to Kalikhola Nala, at the midway point between the original adit positions, because of poor rock conditions. HCC ordered five Atlas Copco 352 drillrigs and two Boltec 435 H rockbolters for this contract, where completion of the two adits made four faces available for development. By end-2002, some 6,400 m of HRT had been excavated, and 1,800 m of concrete lining placed.

Package C-5

Jaiprakash Industries is constructing adits, powerhouse caverns, surge shaft, pressure shafts and 3 km of tailrace tunnel (TRT). The pressure shafts have been developed in six sections, which can be accessed at the 525 m-level, the 765 m-level, the 1,010 m-level, the 1,252 m-level and the 1,425 m top level. Pilot holes for pressure shafts between the 1,252 m and 1,010 m levels, the 1,010 m and 765 m levels, and the 765 m and 499 m levels have since been completed, and widening is underway. A 1.8 m-diameter pilot hole was raised in the surge shaft by a Robbins raise borer, but it was blocked by loose rock falls at about 90 m depth from the top. A conventional 3 m-diameter pilot shaft is being sunk from the top to relieve this blockage. Some 1,910 m of TRT had been excavated by December, 2002, and 86,400 cu m of the machine hall cavern and 37,500 cu m of the transformer hall cavern had been completed. Surge shaft, pressure shafts, and TRT are now critical path activities, but the overall project is back on track for commissioning on schedule in September, 2005. ■

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