HPP Ashta
Hydropower plants in Albania
Karlheinz Strutzmann

Introduction
In the autumn of 2008, the Albanian Ministry of Energy (METE) awarded a concession for the construction and operation of a hydropower plant in northern Albania near Shkodra, the country’s fourth-largest city, to Austrian energy utility Verbund. Together with a second Austrian utility company, EVN, Verbund founded the joint venture Energji Ashta Shpk to carry out the project, which is based on a BOOT (Build-Own-Operate-Transfer) contract with a contract period of 35 years.

The Ashta project completes a chain of existing hydropower plants, using the difference in level between the Spathara reservoir, which is fed by the river Drin, and the confluence of the rivers Drin and Buna. The Drin has a catchment area of 11,500 km² and a mean discharge rate of about 310 m³/s. The project is for a two-stage diversion power plant which incorporates some pre-existing structures.

A special feature of the project is that 2 x 45 hydro matrix turbines will be installed, making this the biggest installation of its kind worldwide.

Historical background
Back in the 1970s, a predecessor project (“Bushat”) to the current one was launched. It, too, foresaw a diversion HPP, but with a much longer canal and a longer tailrace. A weir with solid footing was completed in 1973, the intake structure plus road and rail bridge in 1975. However, works were stopped that year due to funding problems. An attempt to continue with the project was made in 2001, but failed for economic and also ecological reasons, as it was suspected that the power plant might have an impact on Lake Skadar whose Montenegrin part had been declared a National Park in 1996. The Albanian authorities subsequently redrafted the project so that the tailrace flows into the bed of the river Drin before its confluence with the Buna, ruling out any potentially negative impacts on the ecosystems of the Buna and Lake Skadar. Based on this design, an international tender for a concession project was then issued with the help of the IFC (International Finance Corporation).

After the concession had been awarded and all necessary approvals and permits obtained by 2009, Energji Ashta Shpk, a joint venture by Verbund Hydro Power AG and EVN, started the works in early 2010.

Project description
A 240 m long inflatable weir is placed in front of the existing weir and solid footing to achieve the desired dammed-up water level of 23 m above Adriatic sea level and to ensure the safe discharge of water in the event of floods. An intake canal is connected to the existing intake structure. It is 200 m long and widens from 104 m to 126 m (width of the power plant). The exit structure for a fish pass is located near the right river bank upstream of the power plant. The Ashta 1 powerhouse consists of nine separate sections, each of which houses five turbine-generator units (TGUs). Its foundation consists of rows of bored piles and reinforced diaphragm walls which serve as sealing walls for the construction pit during construction. A hydraulic trashrack cleaning rig keeps floating debris and bedload away from the turbines. Stop-planks can be used to dam off individual sections for inspection purposes. The electrical equipment, hydraulic aggregates and nine block transformers (20/3.3 kV) are housed in the gallery (machine hall). Electrical energy is carried via the transformers to the 20 kV substation in the station building, and from there to a 110 kV outdoor substation, to be fed into the Albanian...
grid. The power station building houses offices and a ground-
floor workshop as well as the power generation rooms.

Following a tailrace section of about 300 m, the actual
diversion canal is 85 m wide at the bottom and about 5 km
long. Residual water is discharged at a rate of 30 m³/s (i.e.
about 10% of the average river discharge) into the original
riverbed below the first weir; in combination with a state-of-
the-art fish pass (the first one built in Albania), this preserves
the ecological function of the old riverbed.

The embankments along the diversion canal are made of
locally available sandy gravel. The embankment slope has a
1:2 incline, and its 4-m wide top serves as a connecting road
between the two power stations. Embankment height varies
between 4 and 8 m. To prevent any impact on groundwater
regime in the area immediately south of the plant, the canal
bed is only partially sealed off with liner. The embankment
slopes and an adjacent stretch of about 20 m on either side of
the canal bed are lined with bentonite matting, but the central
part of the canal bed remains unsealed. The lower (widened)
section of the diversion canal then feeds into the 126-m wide
Ashta 2 power station. While Ashta 2 has no trashrack
cleaner and headrace stop-plank, the powerhouse
construction and equipment is the same as that of the first
stage.

The Ashta 2 powerhouse is followed by an 800-m tailrace.
This connects to a 2.3-km canal which is built by excavating
the natural terrain to a depth of about 5 m. The bed width is
85 m for both the tailrace and the canal. The banks are
protected against erosion by heavy riprap (single rock weight
300-800 kg).

**Technical data**

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<th>Ashta 1</th>
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<td>Head at $Q_A$</td>
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<td>Residual water discharge</td>
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<td>Power per TGU</td>
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<td>Total apparent power</td>
<td>21 MVA</td>
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<td>Annual power generation</td>
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<td>Number of TGUs</td>
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<td>Power per TGU</td>
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<td>Total apparent power</td>
<td>32 MVA</td>
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<tr>
<td>Annual power generation</td>
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</table>

**Main structure**

**Concrete structure**

Each of the two power stations Ashta 1 and Ashta 2 is made
up of five sections which have been designed for optimum
load-bearing capacity and distribution of expansion joints.
Each section consists of 20 concrete blocks, with block sizes
varying between 100 m³ and 400 m³. The blocks are erected
like a stair, rising from left to right, and reach a full height of
about 20 m. A submerged wall with trashrack cleaner is
additionally installed at the Ashta 1 stage.

In all, it took 90,000 m³ of concrete to erect the two power
stations. A specifically adjusted concrete mix recipe was used
to meet the demands placed on bulk concrete. The biggest
problem in this context was to supply the construction site
with the right kind of cement, as CEM III cement was not
available locally. Because of the high temperatures in
southern Europe most concreting took place at night, allowing
temperature differentials between concrete surfaces and
cores to be kept below the required maximum limit.

45 matrix turbines with steel draft tubes were placed side by
side on a rectangle of 126 m by 24 m. Guide rails were
installed to enable each turbine to be lifted out at any time for
maintenance work. The draft tubes for the matrix turbines are
integrated in the powerhouse block and were installed by
concreting with self-compacting concrete. During casting,
threaded rods were used to keep down the draft tubes, thus
counteracting uplift.

However, where the two power stations differ most is in their
subsoil conditions.

The Ashta 2 station was completely founded on hard rock. As
the construction pit was sealed off by an all-round diaphragm
wall that bonded directly to the rock underneath, de-watering
was a minor issue, involving only the management of residual
quantities of water.

Conditions were much more difficult at Ashta 1, where
extremely high permeability of the subsoil at the foundation
site required a more sophisticated engineering approach.

**Foundation**
The native soil at Ashta 1 consists of sandy gravel in loose
sediment layers; where the subsoil contains plate-like gravels,
it is capable of massive compaction, however. The
composition of the subsoil is typical for recent-era river
sediments, with a small portion of fine-grained material. The
stated permeability coefficient was 1.2 x 10^-3 m/s. The
groundwater table is only a short distance below the terrain
surface; owing to the high permeability of the ground, the
groundwater level varies widely and very quickly in response
to the water level fluctuations of the river Drin; these in turn
are big as a result of the hydropower generation along the
upper reaches of the river.

The bottom side of the Ashta 1 power station reaches down
to a depth of 6 m. Unlike Ashta 2, the ground under the
station consists exclusively of sandy gravel; neither is there
an impermeable layer that might
have been used as an embedment for a containment wall around the construction pit. When trial piles were driven into the ground, another phenomenon was observed: self-compacting of the soil during each drive or vibration. This occurred in layers up to 4 m thick at depths of about 7 m below the ground surface, and the compaction was so massive that any further pile drives or vibrations nearby became impossible.

Crater after trial pile drive
Image: PORR

Large-calibre exploration drilling revealed major amounts of platy gravel that tended to align like rooftiles during the pile driving, which made driving through these layers very difficult and apparently also resulted in compaction of the surrounding subsoil. Sheetpiling or a vib wall cut-off were therefore not an option.

Pumping trials showed permeability coefficients between 5 and 9 x 10^-3 m/s in some areas. This meant that realisation of the original design – a 20-m deep submerged wall and de-watering pumps – would have resulted in uncontrolled water ingress into the construction pit, with flow rates of some 3-4 m³/s. An additional concern was the risk of power outages, which have to be expected in Albania, during operation of the pumps. It was therefore decided that the only feasible alternative was to build a sealed tank with anchored diaphragm walls and a tied-back underwater concrete base.

Construction pit
The technological challenges posed by the Ashta 1 construction pit were major by any standard. Different international-standard underground engineering methods had to be applied to successfully control groundwater ingress from the river Drin.

- Bohrpfähle
- Schlitzwand
- Anker
- Gewi Pfähle
- Unterwasserbetonsohle

Construction pit: bored piles, diaphragm wall, anchors, Gewi piles, underwater concrete base
Image: PORR

First, eight rows of piles with a diameter of 90 cm were bored from the surface level to serve as the foundation for the actual power station. A transversal diaphragm wall which served as a bulkhead later doubled as the ninth row. The borings were executed to a depth of 12 m against pressing water. The piles were later cut down flush with the upper edge of the underwater concrete base.

A 15-m deep and 80-cm wide reinforced diaphragm wall was erected to seal off the construction pit and provide lateral support. To ensure load-bearing stability, the diaphragm wall was tied back with ground anchors above groundwater level. A transversal diaphragm wall was installed as a bulkhead, dividing the pit into two parts. This greatly reduced the area in which the difficult process of underwater casting of the concrete base had to be performed, and made it possible to start concreting the first part of the pit at an earlier point. Because of the different construction stages on either side, 3 HEM 300 profiles were used as stiffeners for the bulkhead.

Cross-section of the construction pit
Image: PORR

The total surface of the construction
pit was 128 m by 28 m. After the bored piles, the diaphragm wall and the ground anchors had been put in place, the pit was excavated, using a long-reach excavator, to the planned depth of the underwater concrete base bottom. The groundwater level in the pit remained unchanged, ensuring the necessary hydraulic and static balance.

To prevent the underwater concrete base from being lifted by the water pressure after the complete draining of the pit, an additional 216 Gewi piles were used to hold it down, counteracting the uplift. The 8-m deep Gewi piles were sunk from a movable bridge in a 3 m by 3 m grid. The bridge had a span of 30 m and consisted of four HEB 800 profiles with a square-edged timber superstructure. The bridge was set on rails and armoured bearings and was moved by two backhoe excavators.

After the Gewi piles had been put into place, the fines and sludge that had settled on the pit bottom were suctioned off. The connections between the concrete base and the diaphragm wall and piles were cleaned, and grouting hoses were additionally put in place. Anchor plates were used to bond the Gewi piles to the underwater concrete base.

The next step was the casting of the underwater concrete base, for which professional divers were flown in from Austria. They produced the 1.5-m concrete base in one piece, placing the concrete at a depth of 8 m below water level at a rate of 60 m³/h. The main challenge was to cast the underwater concrete continuously, preventing any sludge bubbles from becoming trapped in the concrete. The required volume of 3,000 m³ of concrete was placed within 50 hours.

The groundwater could now be safely pumped out from the first part of the pit, and everyone was happy that the installed grouting hoses were no longer needed.

Good cooperation between project owner, designers and the construction company made it possible to successfully implement the complex works, which comprised a series of sophisticated engineering tasks, within a short period of time and to a high quality standard. The heavy engineering machinery needed was shipped to the site via Trieste.

In addition to the two run-of-the-river power stations Ashta 1 and Ashta 2, the project also includes another significant structure.

This is the 5-km long diversion canal between the two power stations – a good example of a major effect being achieved on the basis of a simple technical idea.
Through the unsealed bottom part in the centre of its cross-section, the diversion canal communicates with the aquifer and the nearby river Drin so that a sufficient groundwater table is maintained. The embankments are lined with 300,000 m² of bentonite matting on the water side to seal off the inner slopes against the canal. On the land side, 400,000 tonnes of riprap are used to protect the canal against flooding.

The appropriateness of the design was proven even as the structures were being erected when heavy rainfalls hit the area for several weeks in December 2010. As the hydropower stations on the upper reaches of the Drin were forced to take emergency action to lower their water levels, the river’s discharge rate jumped to levels of up to 3,000 m³/s, ten times the mean discharge rate.

With respect to the laying of the bentonite liner, the original plan was to use the standard process, i.e. to roll out the mats on dry ground. However, this would have entailed the installation of bulkheads to lower the groundwater table, in some sections by up to 2 m.

Proposal for an alternative solution

As the groundwater lowering would have been very expensive, a proposal was made for an alternative approach whereby the bentonite matting is laid out directly under the surfaced groundwater in as simple and economical a manner as possible.

The idea was to use a structure very similar to a gantry crane to roll out the bentonite liner, much like a carpet, on the embankment slopes and on a 20-m wide stretch on each side of the canal bed, positioning the matting with maximum precision.

The biggest obstacle for this solution was that in most types of bentonite mats, the bentonite is added to the geotextile in powder form: the bentonite powder is embedded in the geotextile and bonded by needlepunching. When rolled out in water, this “quilt” would have a tendency to float up to the surface like an air-filled carpet. It was therefore necessary to find a supplier that uses granulated bentonite to make the liner. The larger grain size of the granules means that the interstices between them are also bigger, and air flows out much faster from the bigger hollows. As a result, the bentonite mat does not float on the surface, but quickly sinks to the ground under its own weight.

To make sure that this solution would work well, several trials were carried out with granulate-based bentonite mats which were laid out in quarry ponds in Austria.

Execution

The rollout assembly can place up to 15 bentonite mats per day. Given a length of 30 m and width of 4.5 m per mat, this equals a capacity of nearly 2,000 m² of liner per day. The rollout assembly basically consists of a truss girder that is moved by two backhoes at 4.5 m intervals. The rolls of bentonite matting are simply suspended from a movable hydraulic arrangement that is mounted on the truss, and are rolled out from there.
This simple technical adjustment resulted in significant advantages for both client and contractor. For the latter, the alternative proposal was an important factor in winning the contract, and for the former, overall project cost was significantly reduced because there was no need for temporary de-watering.

Conclusion
Carrying out exacting engineering works in a foreign country, in unknown terrain, and completing the job successfully and in a timely manner, of course involves major challenges. Albania, hitherto a white spot on the map for all those involved, turned out to be a welcoming country with hospitable people.
The project has been a positive experience, both for the client and for PORR, and we are looking forward with some excitement to its completion in late 2012.

Sunset at the construction site
Image: PORR