

Construction of the first Cut-off Wall by a Low Headroom Trench Cutter inside a Dam Tunnel in China

Herstellung der ersten Dichtwand mit einer Spezialschlitzwandfräse in einem Dammtunnel in China

Wolfgang G. Brunner, Arthur Bi, William Chang, Dunfeng Zong

Abstract

In Sichuan province the 240 MW Yeleh hydroelectric plant is constructed by Sichuan Nanya River Basin Hydraulic Power Development Co. Ltd and China Gezhou Ba Water & Power Group Co. Ltd. The specialist contractor Foundation Engineering Company of China Water Resource and Hydropower was awarded the foundation treatment at the right bank, including construction of a concrete cut-off wall inside the dam tunnel using a BAUER Low Headroom Cutter using the overlap cutter joint.

Zusammenfassung

In der Sichuan Provinz wird das 240 MW Yeleh Wasserkraftwerk von Sichuan Nanya River Basin Hydraulic Power Development Co. Ltd und China Gezhou Ba Water & Power Group Co. Ltd. gebaut. Die Firma Foundation Engineering Company of China Water Resource and Hydropower erhielt den Auftrag für die rechtsseitige Gründung einschließlich der Ausführung einer Betondichtwand mit überfrästen Fugen, die in dem Dammtunnel mit Hilfe einer BAUER Schlitzwandfräse mit niedriger Bauhöhe ausgeführt wurde.

1 Introduction

In the South of Sichuan province the 240 MW Yeleh hydroelectric plant is constructed by Sichuan Nanya River Basin Hydraulic Power Development Company Limited, a state-owned enterprise, and China Gezhou Ba Water & Power Group Company Limited. This project sets out to develop the mountain cascade of the river Nanya, a tributary of the river Dadu, to provide superior electricity and adjust flood peak and frequency. The project is located in a high seismic zone (design intensity VIII) and represents with its 125.5 m high dam the highest rock/soil fill dam with an asphalt concrete core in Asia. Grout curtains and cut-off walls are designed as a combined system. The specialist contractor Foundation Engineering Company of China Water Resource and Hydropower (FEC) was awarded the contract YL/C I, foundation treatment at the right bank, which included the construction of a 75 m deep and 1 m thick concrete cut-off wall (COW) inside a 6.0 m wide x 6.5 m high tunnel. The requirement for 19 317 m³ cut-off wall to be constructed in permeable and very dense gravel, cobble and boulder formations and a demanding project programme led FEC to adopt the BAUER Low Headroom Trench Cutter CBC25/MBC30 in conjunction with the overlap cutter joint (OCJ). Due to the cutter technique, the construction of watertight joints is now much easier and much more effective than with the conventional rope grab method. The use of the cutter is essential for the formation of the joints between panels. A secondary panel is formed between two previously completed -concreted-

primary panels, usually a single cut. The cut-back or overlap between primary and secondary panels is generally 300 mm. Joints produced in this manner are watertight, because they consist of a serrated surface resulting from the formation of grooves cut into the concrete of the primary panels by cutter wheels. The advantages offered by the cutter over the other available systems include a consistently high output, an extremely high degree of verticality control as it is equipped with electronic inclinometers and its position adjusted with the help of hydraulically operated steering plates, watertight joints and the ability to cut through even the hardest boulders and also key into bedrock if required.

2 General

Earth dams must be safe against overtopping, their slopes must be stable under all conditions, their foundations must not be overstressed, and they must be safe against internal erosion and water forces and pressures. A large percentage of earth dam failures reported by Justin (1936) and Sherard et al. (1963) likewise were seepage failures. As such the formation of an effective water barrier beneath dams is one of the most important tasks in building dams.

The oldest method of installing a barrier beneath is the grouted cut-off technique. A complete positive grouted cut-off is often difficult and costly to attain. As a result of this problem, alternative processes have been developed during which soil is excavated and the resulting voids backfilled by a barrier material of well defined properties, e.g. concrete or cement-bentonite mix. The most important method for constructing a positive cut-off wall is the use of slurry trench, diaphragm wall technology. A case history of a 75 m deep concrete cut-off wall for a big rock/soil-fill dam in Sichuan illustrates the possibilities for constructing cut-off walls inside an extremely limited working space, a 6.0 m x 6.5 m tunnel, with the latest technology Bauer low headroom cutter CBC25/MBC30.

3 Project Data

3.1 Scope of Works for Construction of the right Bank Cut-off wall inside the Tunnel

Due to high rock level encountered near the ground surface on the left bank, a conventional grout curtain was executed. On the right bank a cut-off wall was executed from the surface and inside the 6.0 m x 6.5 m tunnel. The excavated volume for the Yeleh cut-off wall was 19 317 m³ (whereas out of this quantity 6 284 m³ were excavated by Wu-Ka-S rigs, a local percussion rig, and 13 033 m³ by the BAUER low head room cutter CBC25/MBC30). The strength of the cut-off wall concrete is 35 MPa. The wall measures 302 m in length with a width of 1000 mm, a depth of 60.95 - 77.95 m and consists of 68 panels. The verticality requirement is 1:200.

3.2 Site Geology

At the location of Yeleh hydropower station, the valley is wide and asymmetric with exposed Quartz-Feldspar rock face on the left bank and more than 200 m thick alluvium and lake deposit on the right bank.

Soil type estimated in % on the right bank:

5 % Quartz, Feldspar and Basalt boulders (200 mm above), 35 % Quartz, Feldspar and Basalt cobbles (60 - 200 mm), 20 % gravel (2 - 60 mm), 40 % sand and silt (< 2 mm). The strength of boulders and cobbles was not tested but estimated with 100 - 160 MPa.

4 Main Equipment for the Construction of the Cut-off Wall

4.1 General

For constructing diaphragm walls, several systems and types of equipment are available. The selection of an appropriate equipment setup for constructing a diaphragm wall project is a key decision in the planning phase that will significantly govern the technical and economical success of the works. Specific characteristics of excavation equipment and the main reasons for selecting them for the use on Yeleh hydropower station are described.

4.2 Local Percussion Rig Wu-Ka-S

The local made Wu-Ka-S rigs, due to their good mobility but slow performance, ventilation, noise and excessive concrete over-break problems, were used at beginning stage for the execution of the river bed and left bank cut-off walls but thoroughly moved out after cutter started cutting work on site.

4.3 Custom made BAUER Low Headroom Cutter CBC25/MBC30

The trench cutter is a hydraulic operated machine, which works on the principle of reverse circulation. During the cutting process, soil and rock directly beneath the diaphragm walling is continuously loosened by two powerful cutter wheels rotating in opposite direction, broken down into smaller fragments, mixed with the stabilizing slurry in the trench and moved towards the suction intake. A centrifugal pump mounted on top of the suction box pumps the spoil enriched slurry to the regenerating plant, where the soil fractions and rock cuttings are removed from the bentonite slurry by a system of vibrating screens and cyclones. The regenerated clean slurry is then returned to the trench. Built into the cutter is an electronic inclinometer, which measures the cutter's verticality deviation in two directions. The deviation is continuously displayed both in degrees and in centimetres on the B-Tronic monitor inside the operator's cabin]. If the cutter deviates from its vertical axis, its position can be adjusted with the help of the hydraulically operated steering plates.

For Yeleh hydropower station a custom made BAUER Low Headroom Cutter CBC25/MBC30 was selected. It has a weight of about 25 ton, working height 5.3 m and is mounted on a specially designed hydraulic base carrier BS 100B and directly powered from the 420 kW engine installed in the base machine (**Figure 1**) [1]. The main reasons for selecting the Low Headroom Trench Cutter were that the 75 m deep cut-off wall has to be constructed inside a 6.0 m wide x 6.5 m high tunnel, dense gravel and cobble layer encountered, almost vibration free during cutting process, demanding project programme and requirement of strict verticality with water tight wall joints.

4.4 Mud Plant

The bentonite slurry is continuously recycled and passed through desanding units type Bauer BE 500, where it is cleaned, regenerated and then returned into the trench. The units comprise

coarse vibrating screens, hydro-cyclones and fine dewatering screens. After the cutter itself the mud plant is the second most important component in the cutter

technology. Throughput and desanding capacity have to be closely matched with the soil and the cutter performance.



Figure 1: Bauer Low Headroom Trench Cutter [1]

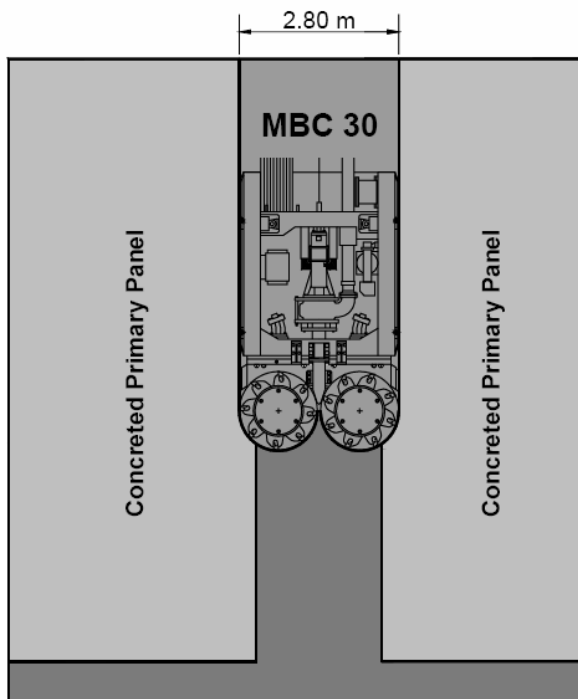


Figure 2: Overlap Cutter Joint [2]

5 Construction of the Cut-off Wall

5.1 Construction Sequence

The cut-off wall is constructed as a series of primary and secondary panels:

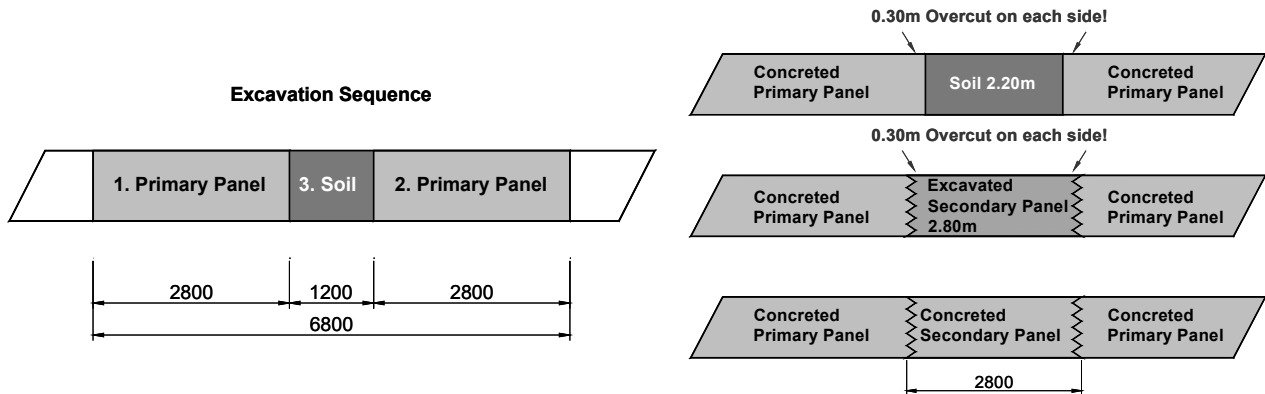


Figure 3: Typical primary panel layout and typical secondary panel [3]

5.2 Wall Joints as Overlap Cutter Joint

The use of the cutter is also essential for the formation of the joints between panels. A secondary panel is formed between two previously completed primary panels, usually as single or three cuts. As the cutter descends it encroaches on the adjacent primary panels and thereby cuts back a fillet from each end of the previously concreted primary panels. The cut-back or overlap between primary and secondary panel is 300 mm required by the specifications (**Figure 2 and 3**) [2,3]. Joints produced in this manner are watertight, because they consist of a serrated surface resulting from the formation of grooves cut into the concrete of the primary panels by cutter wheels. The advantages offered by the cutter over the other available systems include a consistently high output, an extremely high degree of verticality control as it is equipped with electronic inclinometers and its position adjusted with the help of hydraulically operated steering plates, watertight joints and the ability to cut through even the hardest boulders and also key into bedrock if required.

6 Conclusion

The construction of the concrete cut-off wall at the Yeleh hydropower station is a very recent and impressive case that proves the technical and economic feasibility of the diaphragm walling technology for making a watertight cut-off wall more than 75 m deep even in very limited space, a 6.0 m x 6.5 m tunnel. It also shows quite clearly that such a task can only be performed when utilizing not only advanced technologies and when planning the works on the basis of selecting the feasible excavation equipment. This paper is presented to offer a case experience related to a deep concrete cut-off walling in dense gravel/cobble layer using a custom made Bauer low headroom trench cutter CBC25/MBC30 in conjunction with cutter overlap joint and believe it will serve as an important reference, and be helpful for the future projects in similar circumstances.

Literature

[1] Wolfgang G. Brunner, Artur Bi, William Chang, Dunfeng Zong, Hydro 2005 Villach, Austria

Authors' Names and Affiliation

Wolfgang G. Brunner
BAUER Maschinen GmbH
Marketing Director
P.O. Box 1260
D-86522 Schrobenhausen
Germany
Wolfgang.Brunner@bauer.de

Artur Bi and William Chang
Bauer Technologies Taiwan Lt.
Taipei, Taiwan
Dunfeng Zong
Foundation Engineering Company of China Water Resources and Hydropower
Beijing
China