

# THE FIRST CUT- OFF WALL IN THE INDIAN HIMALAYAS FOR THE DAM OF THE DHAULIGANGA HYDROELECTRIC PROJECT

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**ABSTRACT:** In the far north of Uttar Pradesh Province in the Indian Himalayas; the 280 MW Dhauliganga hydroelectric power plant is under construction by National Hydroelectric Power Corporation ( NHPC ), a state- owned enterprise; and a joint venture of Kajima Corporation of Tokyo and Daewoo Corporation of Seoul. This project sets out to develop the lower section of the mountain cascade of the Dhauliganga river, a tributary of the Sarda river, with a 311 m gross head. The 1362 km<sup>2</sup> mountainous catchment area is bounded in the north- east by the Chinese border and in the south- east by the Nepalese border. The dam project is located in a remote area north of the principal town of Darchula of the upper Sarda valley, which is one of the seismically most active regions of India. The dam 56 m high rock fill dam, which will be the first of its kind in India, is faced with concrete and has a 1 m thick, at its crown 270 m long and over 70 m deep cut- off wall of plastic concrete below its toe. The cut- off wall, with a total area of 7500 m<sup>2</sup>, is constructed by a combination of Bauer hydraulic grabs, assisted by chisels and a Bauer BC 40 cutter which enables the overlapping joint system to be installed, guarantees optimum verticality and enables the cut- off to be keyed into the bedrock formation.

## 1 INTRODUCTION

### 1.1 General

Due to India`s growing energy demand in future the Himalayan region will in future be used increasingly for establishing hydroelectric power generation projects. National Hydroelectric Power Corporation ( NHPC ) was appointed by the Indian government to carry out the Dhauliganga Hydroelectric Project together with a joint venture of Kajima Corporation of Tokyo, Japan and Daewoo Corporation of Seoul, Republic of Korea and consultants Elektrowatt Engineering Ltd. ( EWE ) of Zürich, Switzerland, in joint venture with Nippon Koei Ltd. ( NK ) of Tokyo, Japan.

The Dhauliganga power plant project with an installed capacity of 4 x 70 MW or 280 MW, will develop the lower section of the Dhauliganga river cascade and is a run- of- river scheme with a gross head of 311 m. The name Dhauliganga means "white water" and this part of the river is a truly roaring torrent almost everywhere as it passes through almost perpendicular cliffs on either side.

### 1.2 Location

The project is located in the far north of Uttar Pradesh Province in one of the seismically most active regions of India. The Dhauliganga river is a mountain river of the Indian Himalayas and a tributary of the river Sarda. The Dhauliganga flows in a generally southerly direction to its confluence with the Sarda near the village of Tawaghat, about 15 km upstream of Darchula, the principle town of the upper Sarda valley. The catchment of the Dhauliganga has an area of 1360 km<sup>2</sup> and is located in a high mountainous area bounded to the south- east by the Nepal border and in the north- east by the Chinese border. The access road is over 250 km long.

### 1.3 Geology

At the location of the power plant project, the valley is wide and asymmetric with exposed rocks on both side slopes and a 70 m thick alluvial overburden in the river bed section. The crystalline rock types present in the area are biotite gneiss and augen gneiss with subordinate bands of mica schists.

## 2 DAM AND CUT- OFF WALL DESIGN

The dam is built as a 56 m high concrete- faced rock fill dam with a length of 270 m at its crown. A cut- off wall is to be constructed on the upstream side of the dam extending down from the dams plinth to bedrock level. The initial tender design included a short grout curtain which was to bridge the gap between the toe of the cut- off wall and the bed rock and also provide a socket into the bedrock. As the Bauer cutter is capable of keying the cut- off wall straight into the bedrock, the grout curtain has been omitted in favour of this technical superior solution ( Figure 1 ).

The cut- off wall, which is 1 m thick and over 70 m deep, has a total area of 7500 m<sup>2</sup> and consists of plastic concrete.

## 3 MAIN EQUIPMENT FOR THE CUT- OFF WALL

- 1 BC 40 cutter / BS 6100 carrier
- 1 Hydraulic grab carrier BS 6100
- 2 Hydraulic grabs DHG 1000 x 2800
- 1 Hydraulic grab DHG 1000 x 2100
- 2 Chiseling base machines GB 30
- 4 Cross chisel 14 ton
- 2 Box chisel 13 ton
- 1 Cut chisel 8 ton
- 3 Bentonite mixer BM 1000
- 1 Desander BE 500 and 1 Desander BE 100

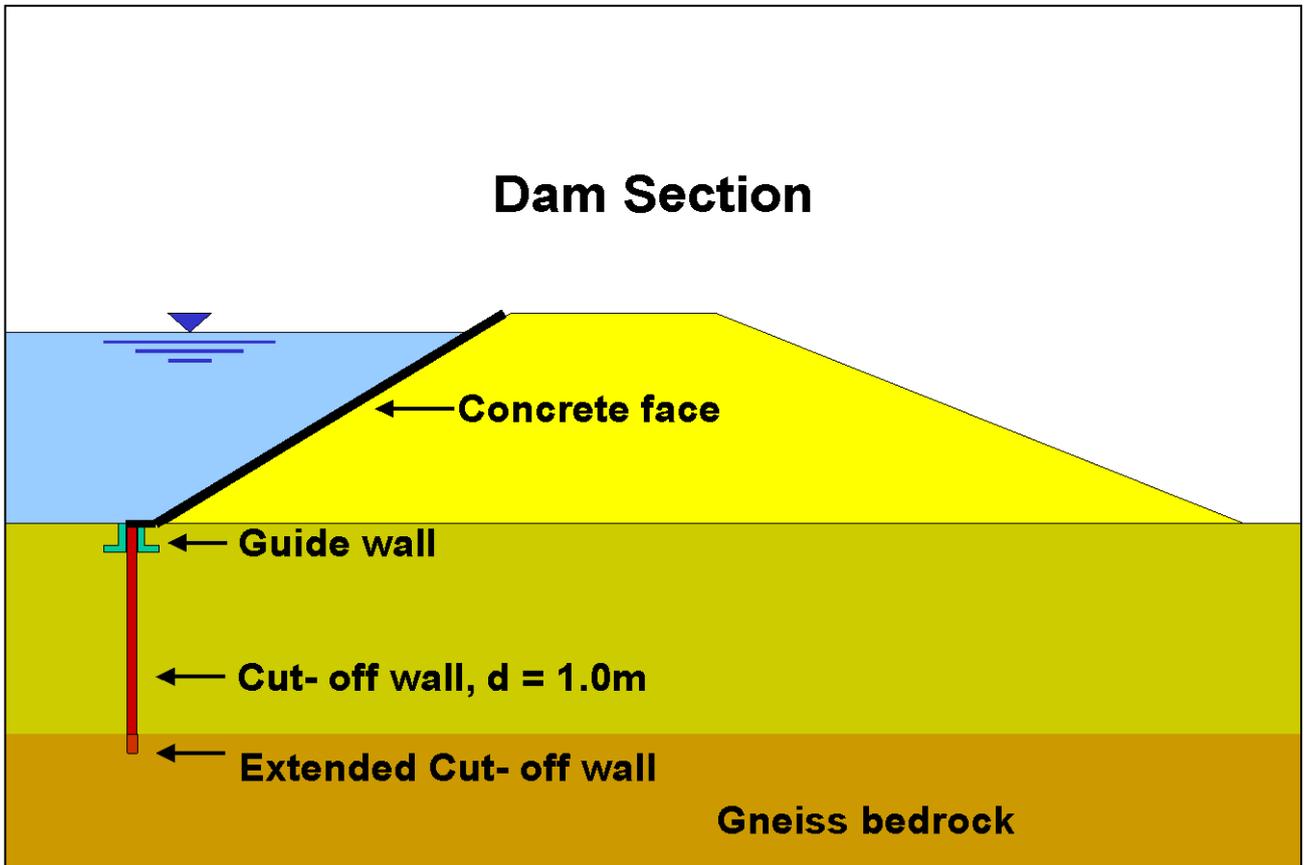


Figure 1

#### 4 CONSTRUCTION OF CUT-OFF WALL

The cut-off wall is constructed as a series of primary and secondary panels ( Figure 2 and 3 ).

The closing forces are activated by a cylinder which is installed vertically inside the base body. High closing forces in combination with the possibility of multiple grabbing at the trench bottom result in high excavation rates even in dense and very hard soil.

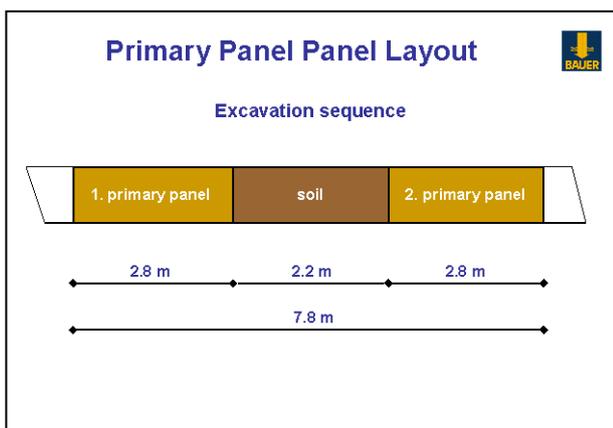


Figure 2

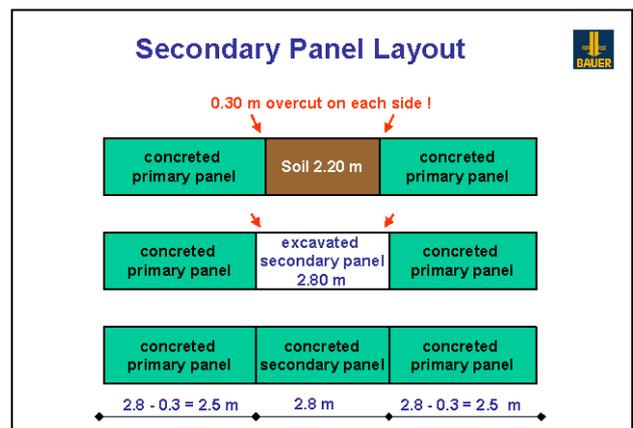


Figure 3

Excavation of the panels is carried out in single bites by Bauer DHG hydraulic diaphragm wall grabs, supported by box chisel, cross chisel and Bauer BC 40 rock cutter. The bite length of the equipment is 2.8 m. Trench stability is provided by bentonite slurry which is mixed in a separate mixing plant and stored in holding tanks.

The DHG grab is rope suspended and operates hydraulically.

The GCS grab monitoring system continuously monitors the verticality of the cut-off wall during excavation. An inclinometer for measuring the inclination of the trench is built into the grab. Data transfer from the grab to the operator's cab is by heavy duty electric cable.

Experience gained on site clearly indicates that the project could not be carried out successfully without the use of a cutter.

Whenever grab and chisel were unable to achieve satisfactory rates of penetration, the cutter was set up to proceed with the excavation, particularly through hard boulders. In addition, deployment of a cutter was essential to key the cut-off wall into the underlying bedrock.

## 5. THE BAUER CUTTER

The application of the Bauer trench cutter technique in the construction of deep cut-off walls offers advantages in the following key areas:

- economy
- output
- accuracy
- reliability
- environmental compatibility.

The cutter continuously removes soil or rock from the bottom of the trench, breaks it up and mixes it with the bentonite slurry in the trench. The slurry charged with soil particles is pumped through a ring main of hose pipes to the desanding plant where it is cleaned and returned to the trench.

### 5.1 Cutter head

The heart of the system, the actual Bauer trench cutter consists of a heavy steel frame with two drive gears attached to its bottom end which rotate in opposite direction round horizontal axes. Cutter wheels, suitable in this case for the soil and rock to be worked in, are mounted onto the drive gears. As they rotate, the soil beneath the cutter is continuously removed, broken up, mixed with the bentonite slurry in the trench and removed towards the opening of the suction box. The BC 40 trench cutter breaks up the soil and rock into 80 mm fractions. The openings of the suction box are reduced to half the diameter of the hose pipe in order to prevent blockages in the mud hose pipes.

### 5.2 Hard rock wheels

Cutting into rock with cutting wheels armoured with tungsten carbide teeth becomes uneconomic when the rock strength exceeds 50 – 80 MN/m<sup>2</sup>, and cutters can even be brought to a stand still when working in rocks with strengths of 100 MN/m<sup>2</sup> or more. To overcome this problem Bauer has developed cutting wheels fitted with roller bits or round shank chisels which can excavate into hard rock such as granite, basalt, gneiss, etc., with strengths of up to 250 MN/m<sup>2</sup>.

The lay out of roller bits on a rock roller cutter wheel ensures that the entire rectangular cross section of the cut-off wall is cut by the cutter. The ridge remaining in the area of the gear shield is effectively broken up by flipper-roller bits. In order to apply adequate crowd pressure on the roller bits or round shank chisels, the cutter frame can be surcharged with additional weights. Following several test runs, the hard rock cutter was the first time deployed in volcanic andesites with a single-axial strength in excess of 200 MN/m<sup>2</sup> during the construction in 1990 of the Shiokawa Dam project in Japan.

### 5.3 Mud pump

Positioned immediately above the cutter wheels is the centrifugal pump which pumps the bentonite slurry charges with spoil or

cuttings continuously to the surface and form there to the mud plant.

### 5.4 Verticality control

Built into the cutter is an electronic inclinometer which measures the cutter's vertical deviation in two directions. The deviation is continuously displayed both in degrees and in centimetres on the monitor inside the operator's cab ( Figure 5 ). If the cutter deviates from its vertical axis, its position can be adjusted with the help of the hydraulically operated steering plates ( Figure 6 ).

### 5.5 Hose guide systems

Both hydraulic and mud hoses have to follow all movements of the cutter with the tension on the hoses remaining constant. For deep cut-off walls to be constructed in confined areas, hoses are rolled onto hose drums. The possibility of collecting the hoses onto drums reduces the height needed for the boom and hence the capacity of the crane. Hydraulic hoses and mud hoses for extensive trench depths are guided in special linked hose trays in order to reduce hose tension.

## 6 WALL JOINTS

The use of a cutter is also essential for the formation of the joints between panels. A secondary panel is formed between two previously completed primary panels, usually by a single bite. 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 panels is 300 mm ( Figure 4 ).

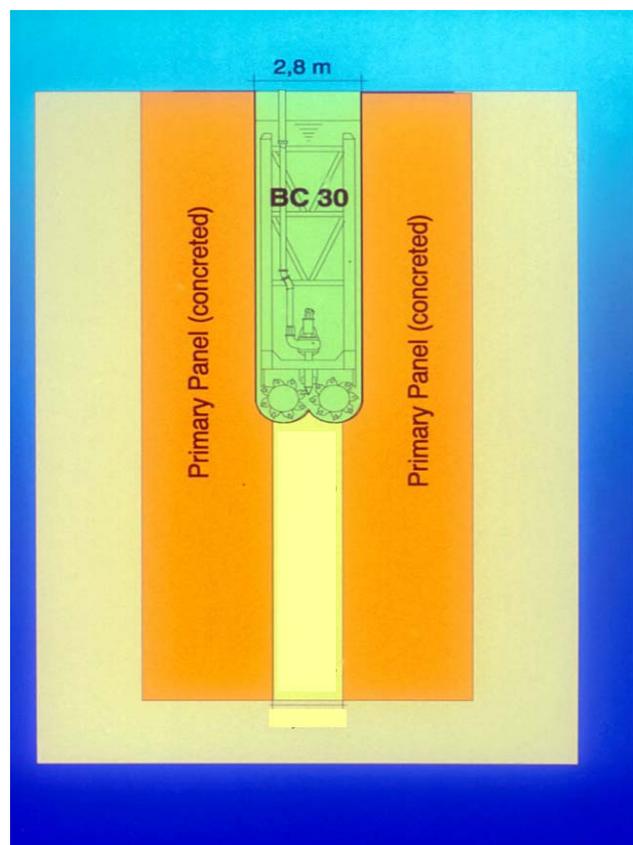


Figure 4

Joints produced in this manner are watertight, because they consist of a serrated surface resulting from the formation of grooves cut into the plastic concrete of the primary panels by the cutter wheels.

The advantages offered by the cutter over other available systems include a consistently high output, an extremely high degree of verticality, watertight joints and the ability to cut through even the hardest boulders and key into bedrock.

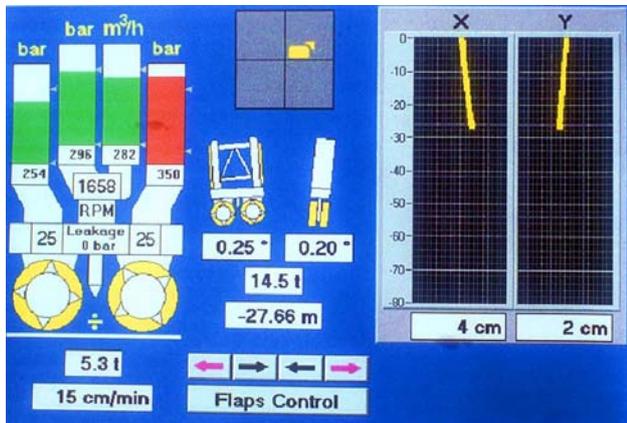


Figure 5

## 7 MUD PLANT

The bentonite slurry is continuously recycled and passed through desanding units, where it is cleaned and regenerated. The units comprise coarse vibrating screens, hydrocyclones and fine dewatering screens.



Bauer DHG hydraulic grab

Bentonite slurry recovered from the process will be subjected to suitability checks prior to being returned to the trench. Any bentonite found to be unfit for re-use is disposed off site.

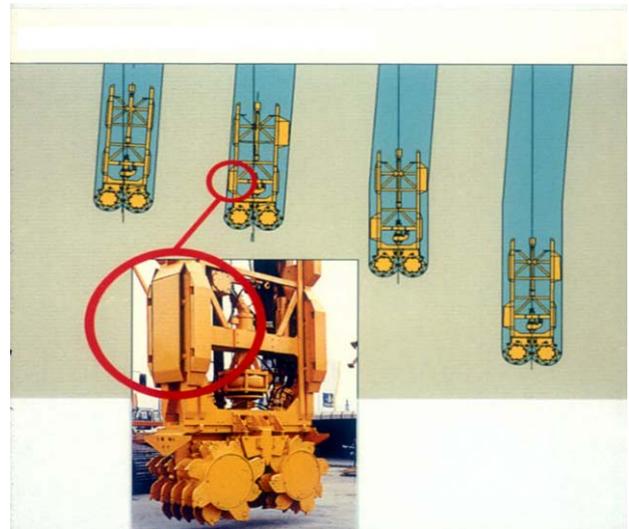


Figure 6

## 8. SUMMARY:

After its successful completion, the Dhauliganga project will surely be considered the key project for many similar hydroelectric power generation projects to be undertaken in the Indian Himalayas in the future.



Bauer cross chisel and Bauer DHG hydraulic grab



Bauer BC 40 cutter



Bauer BC 40 cutter



Job site set up