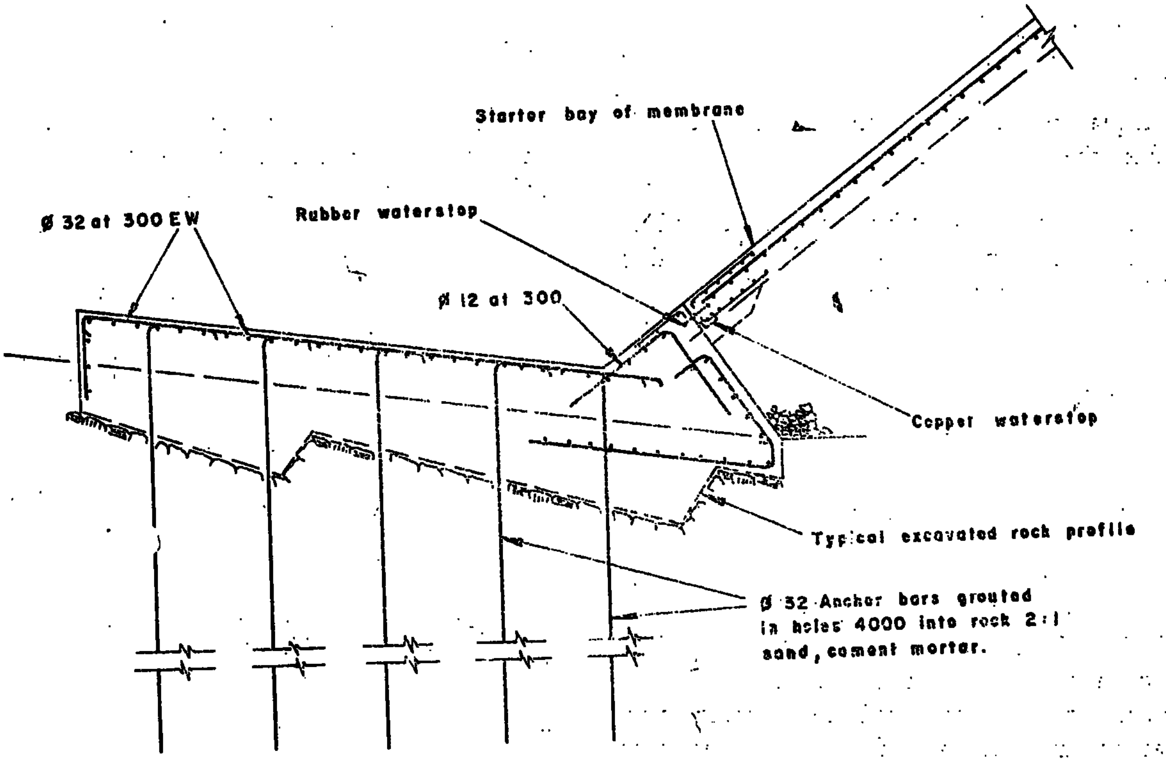
PLINTH CONSTRUCTION OF KOTMALE DAM

A. P. Ranasinghe

Abstract

Construction features of the plinth of the Kotmale Dam are described. Problems encountered in excavations shuttering water stops and concreting and how they were dealt with are described in detail.

The concrete membrane is connected to the rock by a reinforced concrete plinth structure (Figure 1). The object of this paper is to discuss some of the problems encountered in the construction of the plinth at Kotmale and how they were dealt with.



PLINTH SECTION

1.0 Introduction

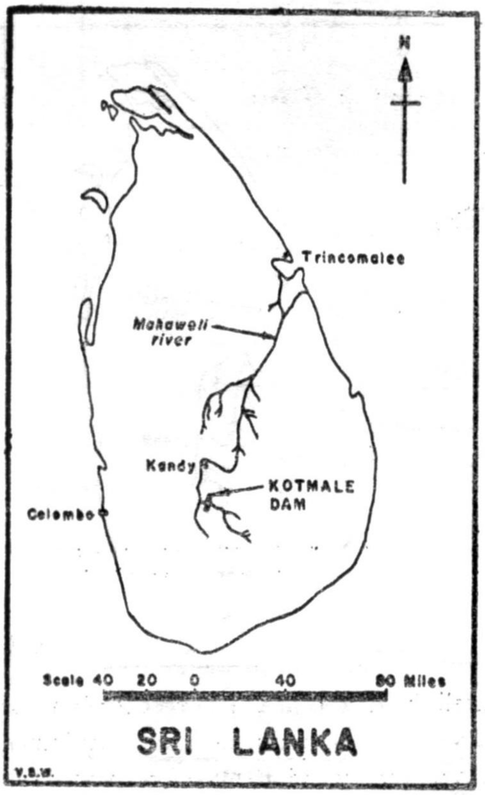
Kotmale Project is the uppermost of the five major headworks projects in the Accelerated Mahaweli Scheme situated about 80 km. east of Colombo and 30 km. South of Kandy. Its primary function is the generation of electric power. The project consists of a regulating reservoir on the Kotmale Oya and a system of tunnels leading the regulated flow to an underground hydro-electric power station (201MW) and then discharging it into the Mahaweli River, below its confluence with the Kotmale Oya.

The dam of the regulating reservoir is 87 m. high above river bed level with a crest length of 600 m. It impounds a gross storage volume of 174×10^6 m^3 and is constructed of quarried rockfill and made impervious by a reinforced concrete membrane on its upstream face.

2.0 Excavation

Excavation for the plinth was initially carried out in soft ground and then in rock to the lines and levels given in the drawings. The last 0.5m was excavated separately from bulk foundation excavation. Explosives used for blasting of rock were in such quantity and power to prevent opening of seems, cracks or excessive damage of rock beyond the prescribed limits of excavation. Hand and small excavation machines

Arjuna P. Ranasinghe graduated with a B.Sc. (Eng.) Hons. degree from the University of Peradeniya in 1981. He worked at the Kotmale Hydropower Project site for about 1½ years attached to the Central Engineering Consultancy Bureau. He is at present reading for a Masters Degree in Water Resources Engineering at the AIT, Bangkok.



were used where necessary. Where excessive over break occurred, concreting of the plinth was carried out in two stages (see 8.0). When the plinth became too thick due to overbreaks a buttress wall was constructed down stream of the plinth.

3.0 Foundation Clean-up and Treatment

Plinth foundation was cleaned up by barring, wedging and picking to remove all loose, shattered or disintegrated rock. Then the area was jetted with water or air, and geological inspection and mapping were carried out. A photograph of the foundation of each pour was also taken.

Seams of erodible materials such as clayey, silty or sandy materials wider than 25mm were cleaned and filled with a 3:1 sand/cement mortar or grade 25/20 concrete. Thin and deep cracks were filled with the same grout used for dowels (see 4.0) and treated with dental concrete. Foliation shear zones and excessively shattered rocks were treated with a 40-70mm thick layer of shotcrete.

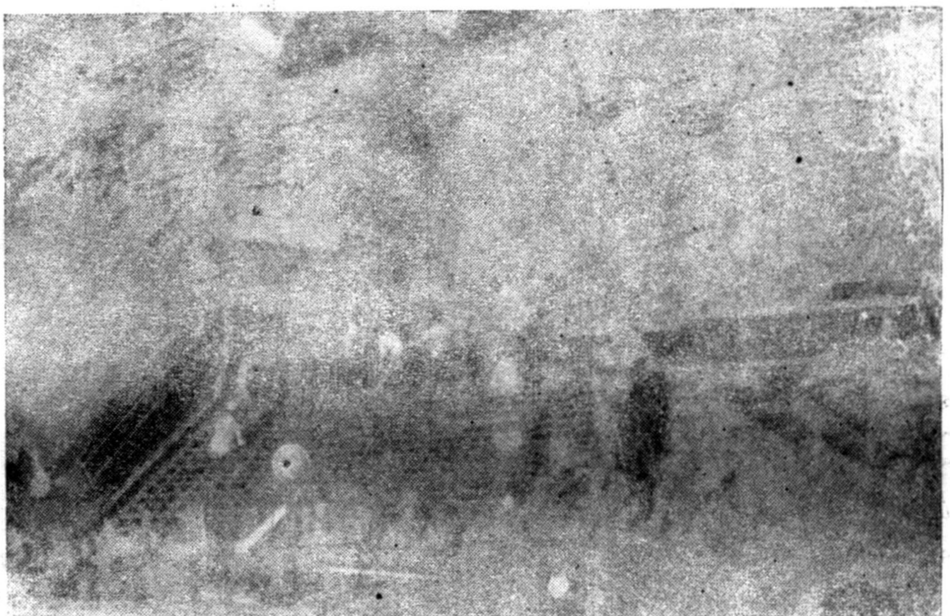
Curing of treated areas was carried out at least for three days.

Places that were treated were mapped for each pour. This was very useful for placement of additional grout pipes specially in pours which were concreted in two stages. Locations and elevations of visible marks of drill holes used for excavation were also logged on these maps. They are helpful to ascertain whether an overbreak was due to geological reasons or not.

In pours with only one stage of concreting, foundation treatment was carried out after the plinth anchors before the installation of plinth dowels, the mortar treatments are liable to damage due to the vibration of drilling for the installation of plinth anchors.

4.0 Anchors

Holes for the anchors were drilled with Air Tracks and were cleaned with water. The head of water was were installed. If foundation treatment was done observed after cleaning to notice if it drops quickly. The holes were filled with grout by placing a hose in



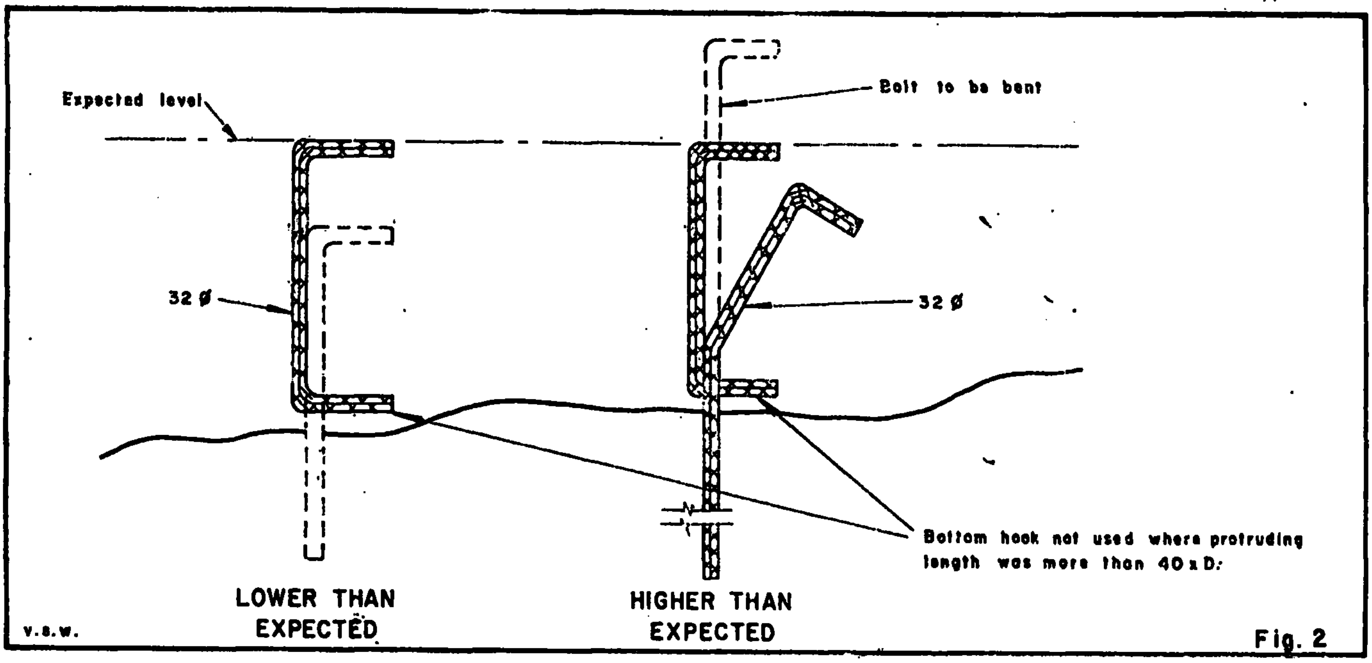
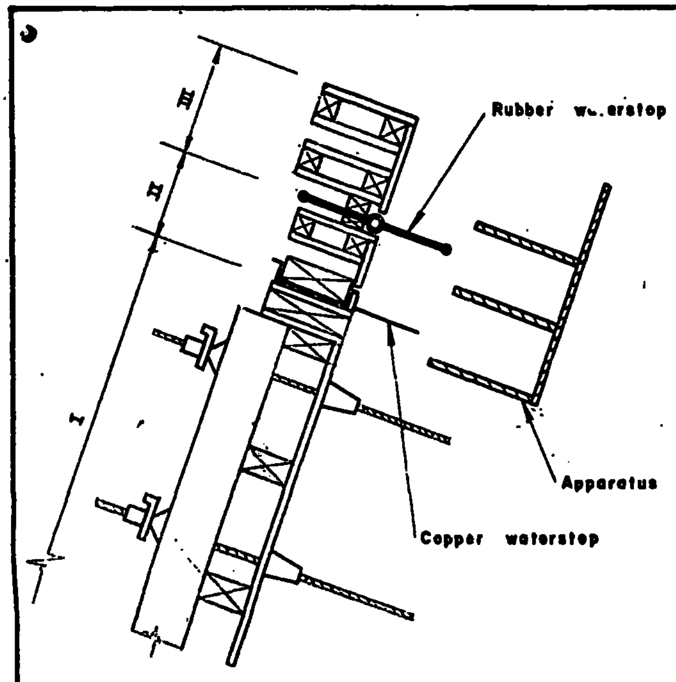


Fig. 2

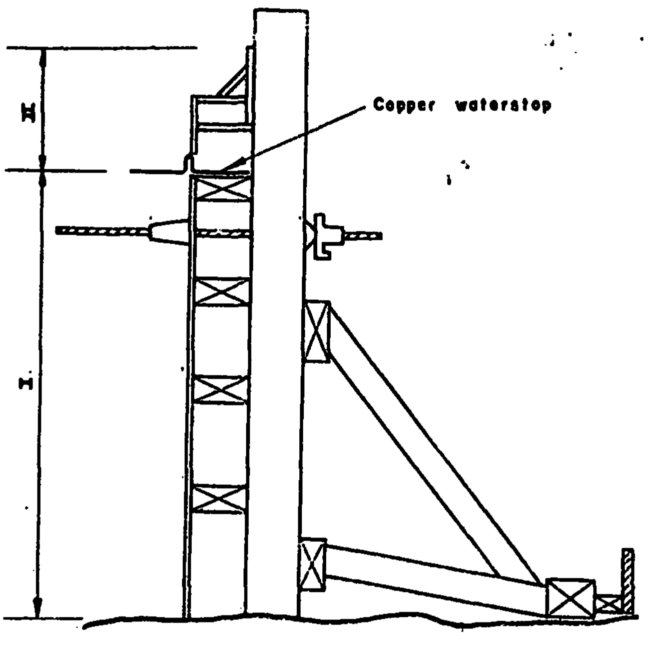
the bottom of the hole. As the grout was filled the hose was withdrawn slowly in order to push out water in front of the grout. When the hole was filled to the top, the grout head was observed for five minutes. If it fell more grout was added. When the grout level was steady, T32 anchor bars were installed to the correct depth, protruding length and level. After installation, frequent observations were made and when needed additional grout was filled until it was steady at the top of the hole.

To install the dowels at the correct levels a laser eye was used once, but conventional survey equipment and some strings were found to be more practicable and gave good results though not very accurate. If the hook of an anchor was found to be higher or lower than the required level the arrangement shown in Fig. 2 was used to correct it. The grout mix used was 2:1 sand/cement mortar mix with a 0.6 water/cement ration.



PERIMETRIC JOINT SHUTTER

Fig. 3



CONTRACTION JOINT SHUTTER

Fig. 4

5.0 Shutters

The perimetric joint shutter was constructed in three stages. By placing the legs of the simple apparatus shown in Fig. 3, touching with the perimetric joint shutter, it was possible to check whether the three stages were in the same plane. In very deep pours, openings were made in the 1st stage of the shutter to place concrete, thus preventing any segregation of concrete, due to a long fall.

The contraction joint shutter was constructed in two stages (Fig. 4), and for sloping surfaces a top shutter was used in two stages (Figs. 5 & 6).

6.0 Reinforcement

Position and level of the bottom mat was varied to suit the excavated rock profile. Exact locations of the bars were logged for each pour. These were very helpful later, to avoid the bars when drilling for grouting purposes and text cores.

7.0 Water Stops

7.1 Rubber Water Stops

Rubber material selected was resistant to ozone/oxygen attack. Hot vulcanizing was used to join the rubber water stops. To ensure proper placing and compaction of concrete around the rubber water stop, the web to be embedded in concrete was held in place by hooks made of 12mm bars. The hooks at about 1m centres were removed as concrete was completed.

7.2 Copper Water Stops

Copper water stops were bent into the correct shape and annealed half hard before they were brought to site. Joints were made by soldering with silver rods (50% Ag) and flux in powder form. Great care was taken when selecting these materials to prevent dezincification of the joints. As the water in contact with the brazed joint is in a closed cell between the copper water stop and the rubber water stop and contains the salts leached out of concrete there is always the danger of dezincification. Although the chloride and carbonate contents of the river water were outside the region expected to cause dezincification, considering the difficulty of rectification it is worth the effort made in this direction.

The water stop was lapped so that gap between the lapped ends was within 0.05 and 0.25mm, if necessary by jigging, since wider gaps impede the joint filling by capillary action and good fillet formation. Flatness and true rib shape was ensured before brazing as dents and bends prevent uniform flow of filler material. The filler alloy rod was applied on one side only to melt and flow with flux through the joint to the other side. To minimise joint remelting, interrupted fillets were filled very quickly with a small flame. The flux residues were removed by washing with water. Temperature of brazed components were limited to the initial melting point of the braze.

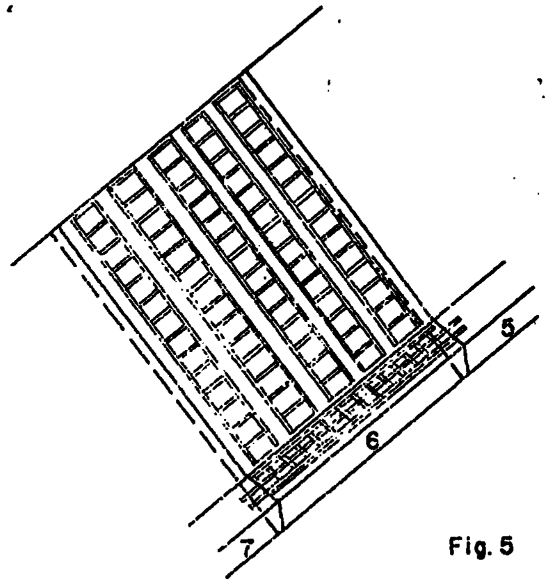


Fig. 5

START OF POUR

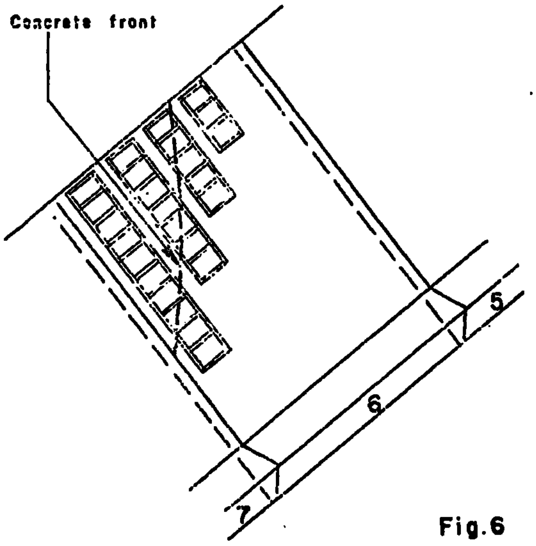


Fig. 6

FEW HOURS LATER

V.S.W.

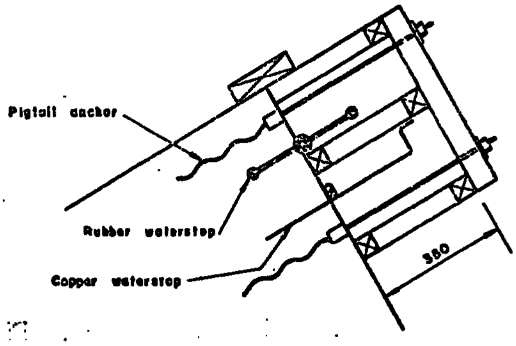
The completeness of the joint was checked by examing the back to find the silver solder run through to fill the space between the two copper surfaces. If a small electrical screw driver could be caught between the surfaces, extra work on the back face was done.

Closed cell polyethylene foam filler insert and a neoprene rod were used to fill the rib in the copper water stop. Since the purpose of the neoprene rod is to permanently ensure that a rib radius is maintained when the water stop is deformed by joint movements, it was selected to be solid and of a diameter that matches the end radius of the rib as closely as possible. As the polyethylene filler insert prevents the ingress of concrete during construction, it was selected to be rigid but collapsible when compressed so that it will not prevent compression of the water stop.

Special care was taken not to damage the water stops, specially with nails and chisels. A puncture from a nail was once repaired by a combination of fibre glass and epoxy. It was not possible to braze a repair in the copper water stop in this instance as the puncture was against concrete where it was impossible to heat the copper sufficiently.

7.3 Protection of Waterstops

This was constructed out of timber to protect both rubber and copper water stops, on the perimetric joint until the membrane was constructed. (fig. 7).



WATER STOP PROTECTION

FIG. 7

8.0 Grout Pipes

Grout pipes were placed in the pours to facilitate drilling for consolidation and curtain grouting. Their locations were altered to avoid contraction joints and the interception of grout holes with plinth anchors.

9.0 Concrete

The water/cement ratio of the concrete for the plinth was required to be less than 0.5 and the maximum cement content 340 kg/m. The specified temperature of the concrete when deposited was not to exceed 30°C. The maximum concrete temperature after placing was not to exceed the higher of 50°C and 30°C above the concrete temperature at the time of placing.

Concreting was in two stages, where the depth of pour exceeded 2.5m. In order to increase durability and workability and to reduce permeability, an air entraining agent was used in conjunction with a water reducing admixture. Two separate dosage tanks were used for them.

The slump range of the concrete was 40 to 60 mm at the placing point, placed around 25°C, with a nominal air content of 4.5%. Slump tests were done for each transmixer load of 4m. A sample was taken for every $25m^3$ of concrete, for 3 cubes for compressive strength tests and for fresh density and air content tests. At least 6 air content tests were done for a pour.

A bituminous solution was used as a bond breaking agent on subvertical joints between pours. Finished concrete was covered with wet gunny bags and cured for seven days. A curing membrane was not used as activities in subsequent pours could impair the action of the curing membrane.

10.0 Acknowledgements

The author wishes to express his gratitude to Mr. J. W. Reeves, Resident Engineer (Reservoir Works) of Sir William Halcrow and Partners for his encouragement and guidance during the preparation of this paper. The assistance of Mr. J. G. Mahawatta in the provision of photographs is much appreciated.

The author also thanks Mr. V. S. Wanniarachchi for the assistance extended in preparation of sketches and Miss P. Ehelepola for typing the manuscript.