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CONSTRUCTION OF A DEEP SLURRY TRENCH CUT–OFF WALL, HARRIS DAM, WESTERN AUSTRALIA

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SYNOPSIS

Slurry trench walls have been used widely in the construction industry since 1953. However there are few published descriptions of their applications as a method of seepage control in water supply dams. The Harris Dam in Western Australia successfully adopted this method of cut-off in a weathered rock foundation.

INTRODUCTION

The Harris Dam is a recently constructed water supply dam, located in the southwest of Western Australia (Fig. 1). The dam is a 37 m high earthfill embankment with a crest length of 430 metres. A design catchment area of 0.321 million square kilometres will yield an overall storage capacity of 72 million cubic metres to supplement existing potable water supplies for the numerous country towns in the southwest of Western Australia.

BACKGROUND INFORMATION

Geological Setting

The damsite is located in Archaean meta-igneous rocks on the margin of the Yilgarn Craton (Wilde and Walker, 1982), and is characterized by extensive and deep weathering of the granitic and doleritic bedrock. The maximum 27 m thickness of weathered material occurs in the central foundation (Fig. 2) of the embankment. However, the extent of weathered material may vary significantly over the length of the dam, particularly in the abutment areas (Fig. 3).

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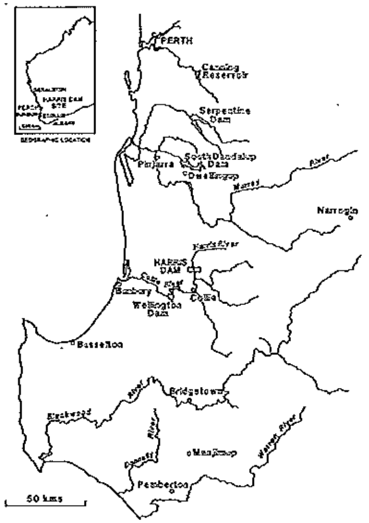

Fig. 1 Location of the Harris Dam

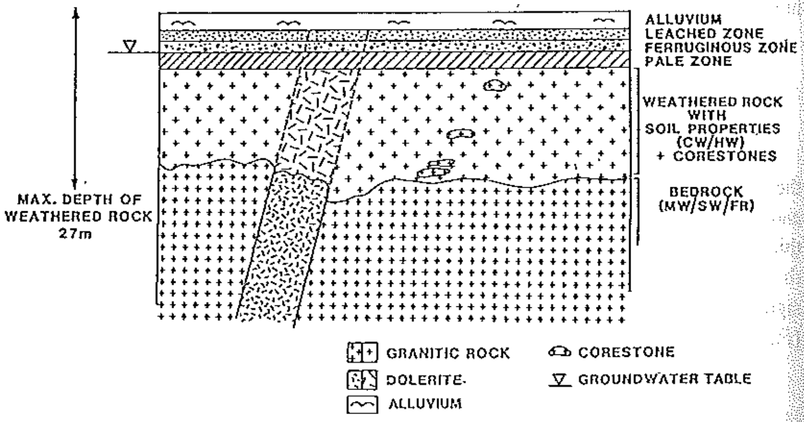

Fig. 2 Typical Geology in the Central Foundation Area

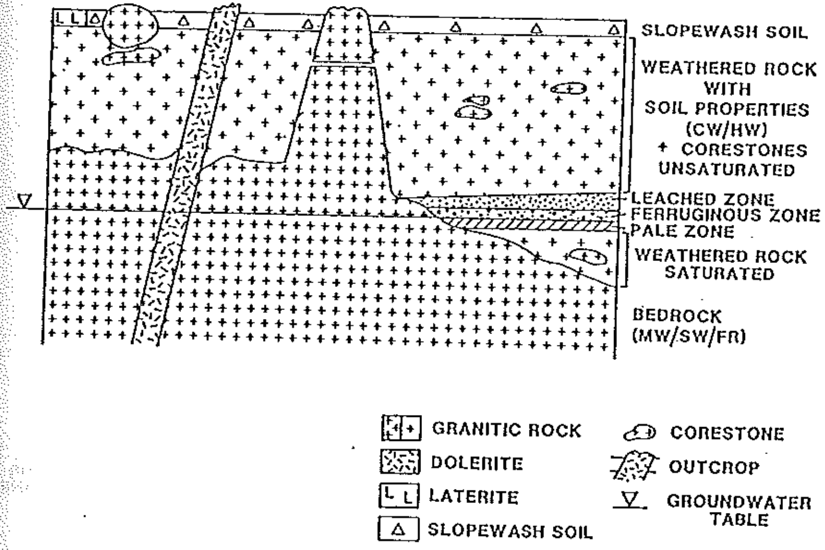

Fig. 3 Typical Geology in the Abutment Areas

The weathered profile has locally been modified as follows;

- in the vicinity of the standing water table leaching and secondary deposition of iron from solution has produced pale, iron-depleted clays, and an iron-cemented layer termed the ferruginous zone (Figs. 2 and 3);
- preferential weathering along dykes, shear zones and relict jointing has yielded significant variations in the bedrock surface (Fig. 4);
- corestones of less-weathered material have resulted from preferential weathering along the broadly orthogonal joint patterns (Fig. 5).

Design features of the embankment

The extensive thickness of weathered material posed a number of problems in relation to the design of the embankment. Following confirmation of the in-situ, residual nature of the completely weathered soil-like materials, the physical properties of these materials were evaluated by comprehensive field and laboratory testing programmes. These studies identified the following significant characteristics:

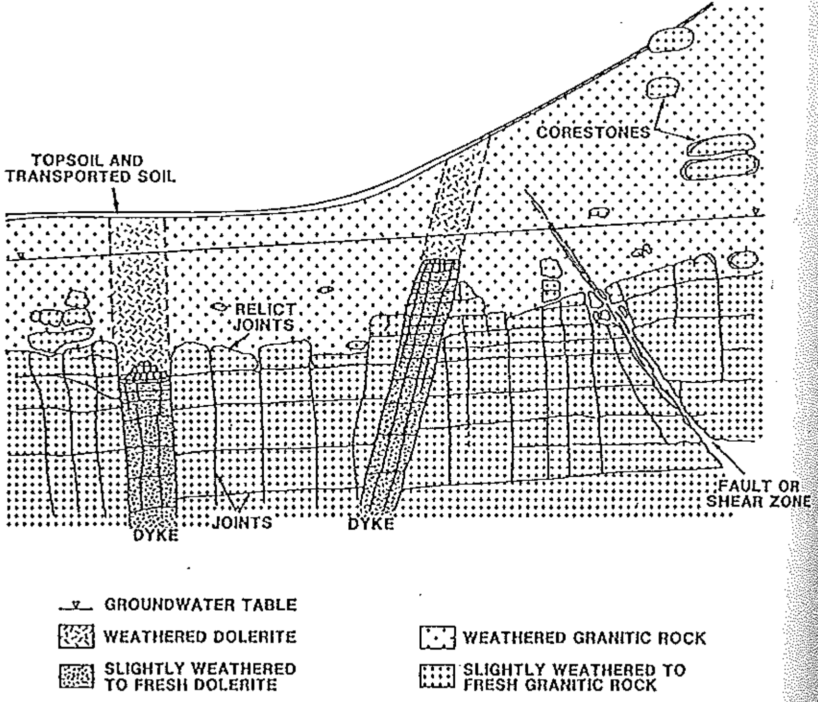

Fig. 4 Variations in the Bedrock Surface

- the weak, compressible nature of the foundation materials - settlements of up to 600 mm were predicted under simulated embankment loadings, and
- the relatively high permeability of the weathered rock materials, typically associated with relict fractures and joint systems.

After considering the prohibitive cost of a conventional clay-core cut-off trench, the safety problems associated with such a deep excavation, as well as the significant uncertainities associated with alternative cut-off systems such as grouting, the decision was made to adopt a bentonite-cement slurry wall as a means of establishing the primary cut-off within the weathered materials. Whilst other applications of slurry trench walls as a construction technique have been described (Goto and Iguro, 1989; De Paoli et al., 1989; Meseck and Hollstegge, 1989; Bechis, 1988), a search of the technical literature revealed few published construction case histories of applications in a weathered rock foundation for a water supply dam. This paper does not attempt to describe the general methods and techniques of slurry wall excavation and installation which are fully described elsewhere (Xanthakos, 1979).

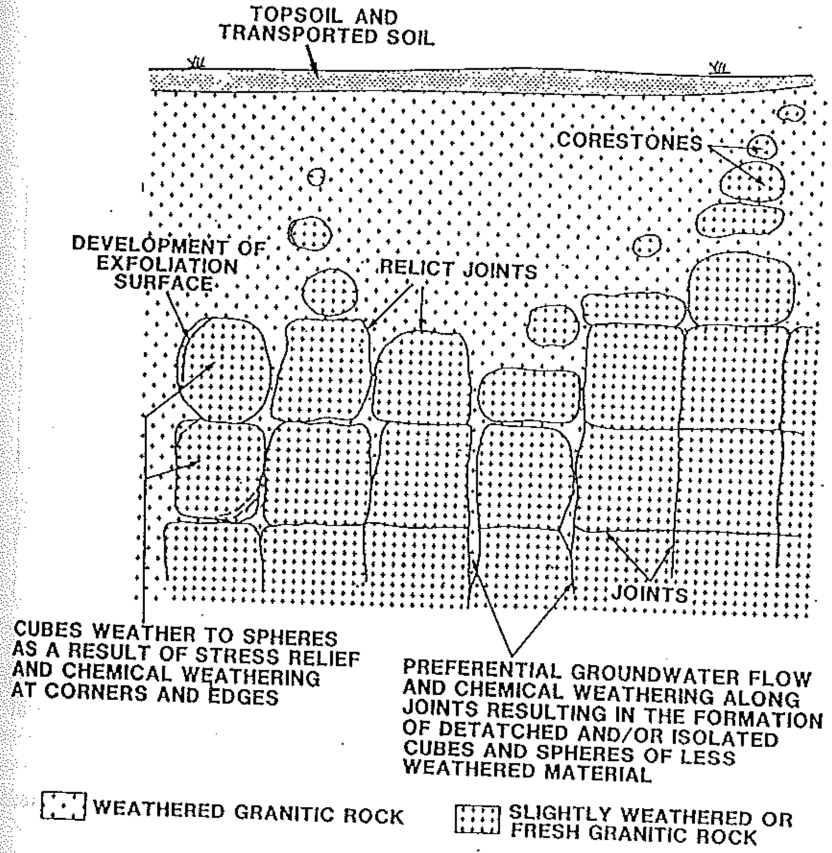

Fig. 5 Development of Corestones within the Weathered Profile

Following extensive testing of various trial mixes, a bentonite-cement slurry mix was designed to have the following properties (Table 1) :

- a deformation modulus equivalent to the surrounding weathered rock to reduce the potential for differential settlement;

- low shrinkage characteristics so that the likelihood of cracking during drying was reduced.

Table 1. Bentonite-cement Slurry Properties

Permeability	less than 1 × 10-8 m/sec at an applied pressure of 150 kPa
Elastic modulus	40 MPa (28 days) ± 10%
Deformability	Triaxial specimens should be capable of achieving a strain of at least 10% under effective wall pressure of 200 kPa at a strain rate of 0.1% per minute or less
Minimum unconfined compressive strength	200 kPa (28 days)

Construction problems anticipated at the design stage

Pre-construction exploratory work identified the following geotechnical issues that would affect slurry trench excavation and performance:

- the presence of corestones of less-weathered material within the weathered rock profile;
- the undulating nature of the less-weathered bedrock surface;
- the relatively high permeability of the weathered rock and residual soil materials;
- the weak, compressible nature of the weathered residual soils.

Based on the information available prior to construction, it was anticipated that the undulating nature of the bedrock surface would prove particularly problematic in relation to "keying" the base of the slurry trench into the underlying bedrock surface. The presence of corestones (Fig. 5) had been identified at various levels of the foundation, however they were not perceived to be a major construction problem at the design stage.

SLURRY TRENCH EXCAVATION

General

A cross section along the centre line of the slurry trench excavation is shown in Fig. 6. Also shown are the prediced levels of the base of the slurry trench, derived from exploratory drilling. Variations in the depths of the individual panels were anticipated in the design.

The actual range in panel depths varied from a minimum of less than 2 m on the right abutment to a maximum of 27 m in the central foundation, which agrees well with predictions from the exploratory drilling. Similarly, the overall shape and extent of the slurry trench agrees well with the design predictions.

Excavation procedure

The cut-off wall was excavated as a series of overlapping panels of fixed dimensions, which when combined, yielded a continuous wall. Primary panels were excavated at 2.4 m spacings (Fig. 7) and backfilled with the bentonite-cement slurry. Following setting of the panels, typically within days of initial excavation, the adjacent secondary panels, 2.8 m wide, were excavated to form a continuous wall (Fig. 6).

Excavation of the panels was achieved using a mechanical clamshell grab, suspended from a track-mounted 30 tonne-capacity crane. The readily excavated materials were removed in this way, the excavation being backfilled with bentonite-cement slurry which also provided support for the sides of the trench as the excavation continued.

Excavation of the trench was preceded by further exploratory drilling to define the underlying bedrock interface in more detail. Additional exploratory drilling was predominantly based on various open-hole methods, however some confirmatory diamond drilling was also performed.

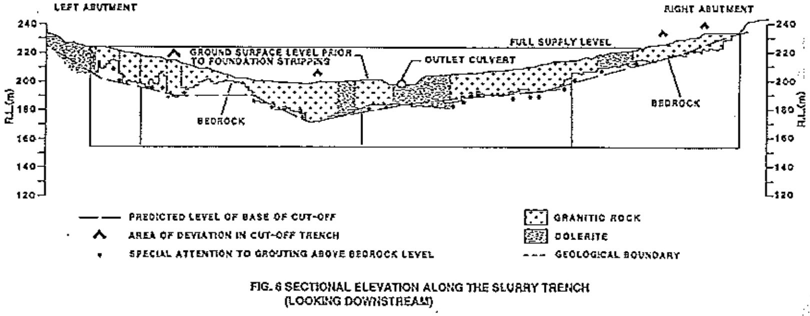

Fig. 6 Sectional Elevation Along the Slurry Trench (Looking Downstream)

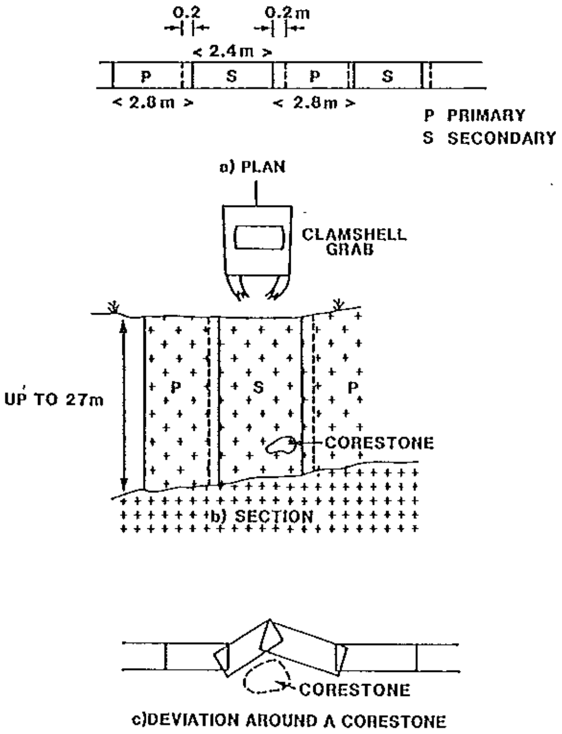

Fig. 7 The Method of Slurry Trench Excavation

INFLUENCE OF GEOLOGY ON SLURRY TRENCH EXCAVATION

Undulations in the bedrock surface

During the design phase it was anticipated that undulations in the bedrock surface would necessitate removal of rock to ensure a subhorizontal base to each panel. It was anticipated that this 'keying' into bedrock could be achieved by using a cross-headed chisel to excavate the rock. In practice, this approach proved impractical. The requirement for 'keying' at the base of each panel was therefore assessed on a panel-by-panel basis. In situations where unsuitable material was inferred to be present, or significant differences in level were apparent on either side of the panel, the following strategies were adopted:

(a) excavation using the cross-headed chisel;

(b) relocation or deviation of the panel (s) (Fig. 7);

(c) additional grouting to ensure an effective seal with the underlying bedrock.

Corestones of less-weathered rock

Where corestones of less-weathered rock were intersected within the profile, they were excavated or treated using one or more of the following four methods:

(a) **Direct excavation by clamshell grab** – Where relatively discrete corestones of restricted size were intersected, they were typically excavated using the clamshell grab. Where corestone size approached the width of the panel, chiselling was often required to reduce the corestone size, or to allow the clamshell grab to pass around the corestone.

(b) **Deviation of the slurry panel alignment** (Fig. 8) – Where the corestone size precluded excavation using combinations of the clamshell grab and/or chisel, a deviation in the slurry panel alignment was introduced. The extent and orientation of the deviation was evaluated using additional closely spaced exploratory drilling.

(c) **Excavation by blasting** (Fig. 9) – Where corestones were more extensive, and if they occurred at a relatively shallow depth, excavation was achieved by blasting. This method was adopted on the upper right abutment.

Fig. 8 A Deviation in the Cut-Off Trench Panel Alignment

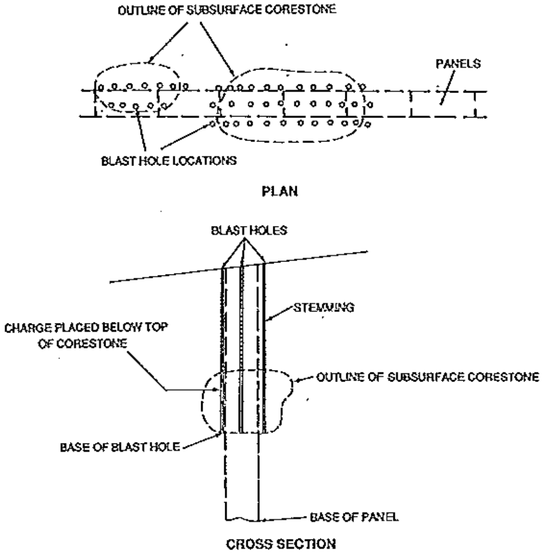

Fig. 9 Excavation of Corestones by Blasting

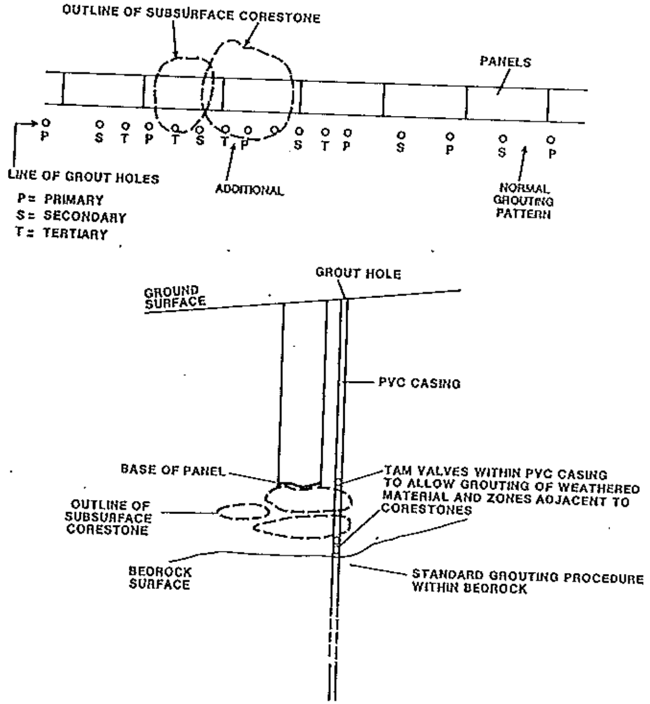

Fig. 10 Additional Grouting Where Corestones Immediately Overlie the Bedrock Surface

(d) **Additional improvement by grouting** (Fig. 10) – In extreme cases, most notably where corestones immediately overlying bedrock occurred at a shallow depth, a locally extensive grout pattern was used instead of direct excavation. In addition to a reduction in grout hole spacing, tube-a-manchette valves (TAMS) were selectively positioned in the PVC casing above the bedrock level to ensure grouting of the weathered zone. This method was adopted throughout the final foundation.

CONCLUSIONS

In general, the extent and depth of the slurry trench excavation was similar to that anticipated at the design stage. However, the following had a significant impact during excavation:

- the locally significant undulations in the less-weathered bedrock interface, which resulted in significant variations in the depths of adjacent panels;
- the presence of corestones of less-weathered rock at various depths in the subsurface profile, which necessitated a variety of techniques to ensure that panels, were excavated to the bedrock surface.

By adopting a flexible approach to the method and sequencing of the excavation, the difficulties posed by the variably weathered rock profile were overcome. Construction of the slurry trench cut-off wall was successfully completed on schedule and within the original budget.

ACKNOWLEDGEMENTS

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