STATE OF NEW MEXICO
BEFORE THE WATER QUALITY CONTROL COMMISSION

In the Matter of:	)	
	)	
PROPOSED AMENDMENT TO 20.6.2 NMAC (Copper Rule)	)	**No. WQCC 12-01(R)**

EXHIBIT SCOTT – D-12

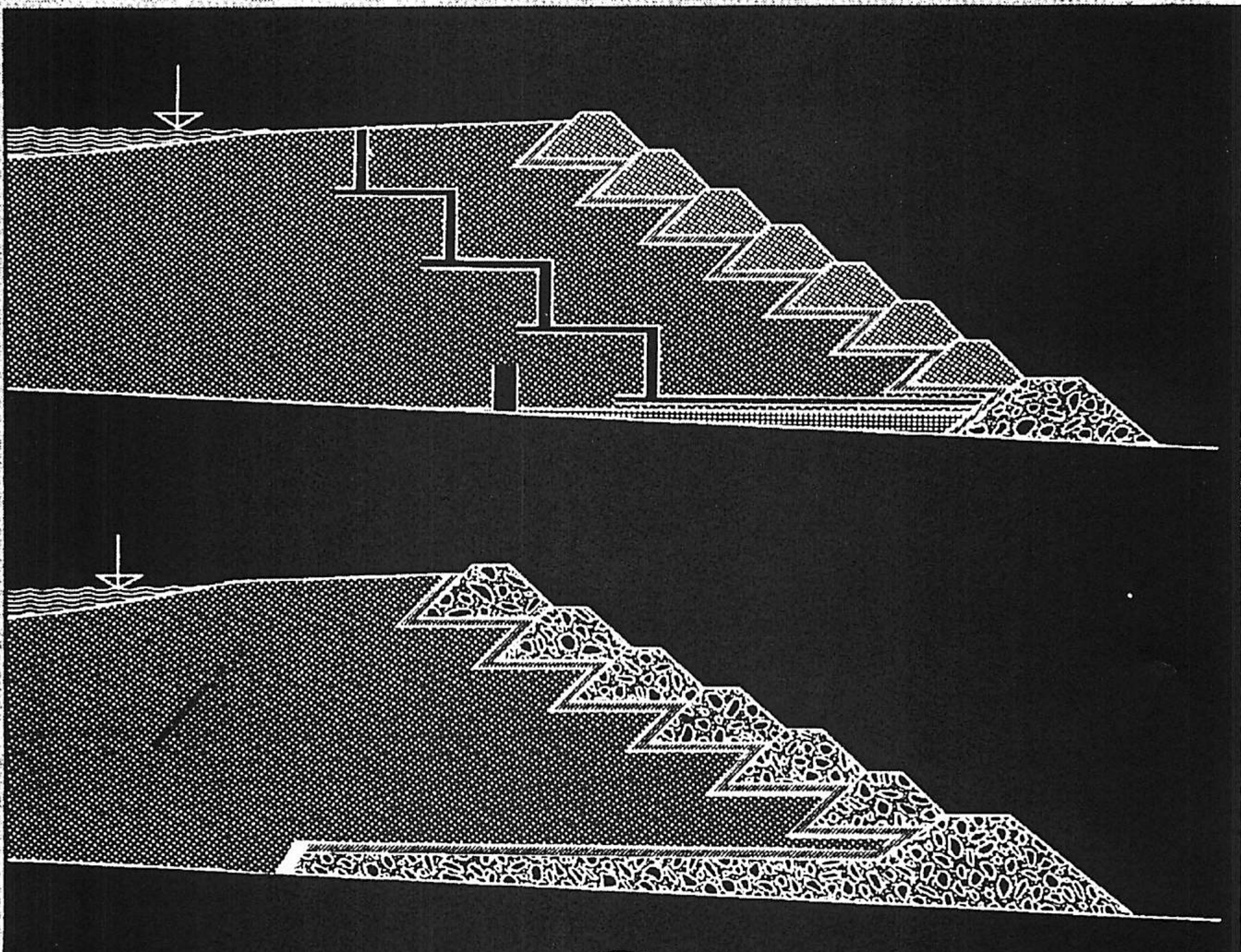
TAILINGS DAMS
DESIGN OF DRAINAGE

Review and recommendations

BARRAGES DE STERILES
CONCEPTION DU DRAINAGE

Synthèse et recommandations

Bulletin 97



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1. INTRODUCTION

Internal drainage is of vital importance to the reliability and safety of tailings dams throughout their whole life including the operational period which commences when tailings are first deposited behind the starter dam.

Although drainage systems in the different types of tailings dams vary extensively, drainage as a major component of the design is the most significant factor in defining the stability under static and dynamic loading. The rate at which the tailings consolidate during construction and the sensitivity of the structure to liquefaction depend almost entirely on drainage. If proper drainage systems are not employed, seepage emerging on the downstream face can lead to erosion and failure. The drainage system must also address the problem of pollution of the environment caused by uncontrolled seepage emerging downstream from the dam.

Well designed drainage is a powerful method for achieving the construction of safe and economical tailings dams. It requires drains to be appropriately located and dimensioned. In addition the drains must be protected by filters at the interface between zones in which the materials have widely different gradings and permeability.

The various types of tailings dams, the main features of the properties of tailings, the purpose and benefits of drainage and the various drainage methods for different dams and foundation conditions are considered and discussed. Recommendations are made in relation to remedial measures for various seepage problems and possible drainage and filter arrangements.

4. PURPOSE OF DRAINAGE IN TAILINGS DAMS

The purpose of drainage in tailings dams is to facilitate the following as efficiently as possible:

a) A Low Phreatic Surface

If a low phreatic surface can be maintained then several favourable effects are achieved: seepage does not emerge on the downstream slope; the hydrodynamic pore pressure (due to the difference of the upstream and downstream water level and determined by the hydrodynamic flow net) is reduced; a large section of the tailings dam is relieved of saturation, thereby reducing the danger of liquefaction under dynamic loading; and saturated material is loaded by the mass of the non-saturated overlying material which provides increased resistance to liquefaction and increases the rate of consolidation.

b) Reduction in Hydrodynamic Pressure Deforming the Flow Net

Drainage decreases the hydrodynamic pressure achieving a flow net in which the equipotential lines are tending toward the horizontal. At horizontal equipotential lines the hydrodynamic pressure is zero even when the phreatic line is high.

c) Reduction in Pore Pressure

The pore pressure that develops due to the deformation of the tailings skeleton loaded by the mass of the overlying material is decreased and the consolidation is accelerated by drainage. Thus, the drainage is designed to both draw down the phreatic line and achieve a flow net in which the equipotential lines are tending towards the horizontal.

d) Control of Seepage and Non-Migration of Tailings Particles

Drainage must be designed to safely remove water infiltration through the tailings dams bodies and their foundation and deliver it to the water reclaim ponds. The hydraulic gradient in seepage flows must be limited, to avoid migration of tailings particles and their passage into drains must be prevented by the use of filters.

As a consequence of *a)*, *b)* and *c)* above, dam stability is improved, steeper downstream slopes can be adopted and an adequate factor of safety can be achieved with a smaller quantity of fill material.

To achieve the most economical solution to drainage of a tailings dam it is necessary to compare various alternatives.

As stated above, filters must be incorporated in the design at the interface between zones significantly different in permeability both within the dam and its foundation.

The first step in designing the drainage system is a careful study of seepage giving special attention to the effect of nonhomogeneity, anisotropy and irregularity in shape of the tailings dam. It is necessary to determine not only the phreatic line but also, and what is even more important, the flow net itself, because drainage considerably deforms the flow net, reducing in this way once again the hydrodynamic pressure.

The flow net is most accurately (and easily) determined through electrical analogy or by means of the finite element method.

Once the flow net is available all the required hydraulic parameters can easily be determined, that is, seepage flow direction, head, hydrodynamic pressure, hydraulic gradients, flow velocity and seepage discharge.

The pore pressure due to deformability of the tailings skeleton and the effect of the drainage on it can be determined by consolidation theory. The peculiarity of the consolidation of tailings dams (gradual dam raising, initial full saturation, low initial density, great deformation and because of that nonlinearity of the mechanical features, large nonhomogeneity and anisotropy) can be taken into account only by using the finite element method of analysis.