# A NOTE ON THE ORIGIN OF WET SEAMS IN EMBANKMENT DAMS

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## 1. INTRODUCTION

Concentrated seepage horizons, or wet seams, occur in the impervious zones of many embankment dams, as adequately summarised by Sherard (1). Their presence has traditionally been taken as a manifestation of hydraulic fracture, even when this mechanism is difficult to justify. An alternative origin is suggested below, briefly focussing on the adverse role of calcitic soils and the manner in which they can produce porous horizons in otherwise well compacted fill.

## 2. ANOMALIES OF THE HYDRAULIC FRACTURE EXPLANATION

Some of the significant attributes of wet seams outlined by Sherard include:- the seams develop on first filling, at elevations only marginally below impounding level; trenching in failed embankments has revealed wet seams extending over considerable horizontal distances, sometimes at more than one level; in combination with dispersive soils and inadequate filter protection, their presence can lead to catastrophic failure.

Sherard favours hydraulic fracture as their cause, even in quasi homogeneous embankments, but states that this is because hydraulic fracture appears as the only logical explanation. Uneven foundation profiles are also cited as a cause, although wet seams have been known to occur in dams with smooth foundation profiles. Moreover, at Teton Dam (2), wet seams were traced horizontally well beyond the limits which could be attributed to the influence of profile changes in the foundation.

Hydraulic fracture also runs into difficulties explaining how piezometers installed in wet seams typically record reservoir fluctuations with a minimum of delay, showing the seams to be highly permeable and to remain so even when the head is reduced towards zero. By contrast, extensive hydraulic fracture testing at the Alvita Dam (3) demonstrated that hydraulic fracture occurs only at high pressures, in accordance with theory, and that the fractures seal themselves when the head is marginally reduced below that causing the fracture.

## 3. AN ALTERNATIVE MECHANISM FOR WET SEAMS

In the early '70's, the writer was involved in a supervisory capacity, with a research project into the failure of small earth dams for the Queensland Water Resources Commission, (4). Field inspections indicated that initial failure of some embankments occurred at the level of poorly compacted horizons in the fill. Such porous horizons are, of course, to be expected in farm dams which are often placed dry of optimum and are typically given only nominal machine compaction. On well supervised projects, such horizons are more difficult to explain. Casagrande, when investigating the failure of the Wister Dam (Oklahoma) in 1969 discounted the possibility of poor compaction as a cause and, to judge from the literature since, this avenue does not appear to have been actively pursued.

However, when embankment soils are calcitic in nature, there is a mechanism available to produce porous horizons.

Calcite has the ability to absorb water into its structure and the effect of this can be seen in routine laboratory compaction tests, where the density/water content curve of a calcitic soil becomes displaced to the right of that for an identical soil without any calcite. The optimum moisture content for the calcite rich soil therefore appears as higher, but the additional water is not available to assist in the compaction process, since it is absorbed by the calcite. What then happens in practice, is that control testing for an embankment relies on patterns, using an average range of optimums for the borrow material. However, if zones of the borrow area are rich in calcite, say greater than 10 - 15%, this additional calcite will absorb some of the water artificially added to the fill, or will otherwise draw water out from the remainder of the fill. Thus, the fill will go in dry of optimum, and particle strength at the base of a layer can then be sufficient to resist breakdown under compaction, thereby developing a porous horizon at the base of such a layer. This horizon can extend over a wide area, although control testing records that the material has been put in at the required optimal conditions. It is of interest to note that the selection of borrow at Teton Dam was designed to exclude caliche rich zones, but when wet seams in the embankment were later tested, they showed up to 16% calcite in the wet seam, in comparison to around 9% in the ambient fill.

Wet seams with a calcite origin raise a problem with regard to the long term solution of the calcite. No filter design is adequate to prevent removal of calcite in solution and a situation of progressive deterioration could well exist. It would be worthwhile evaluating the present situation in any existing earth dam built of such soils. For new dams which are obliged to utilise calcitic soils, compaction as wet as can be tolerated appears to be the most practical solution.

## 5. ACKNOWLEDGEMENT

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## 6. REFERENCES

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