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NEWSLETTER OF THE DIVISION OF GEOTECHNICAL ENGINEERING.

SOUTH AFRICAN INSTITUTION OF CIVIL ENGINEERS.

CORRESPONDENCE: RESEARCH UPON SWELL PRESSURES AGAINST RETAINING WALLS

The Editor,

At the National Building Research Institute we have recently begun a study of swell pressures against retaining walls, and we are presently searching for a structure which would be suitable for instrumenting. It occurred to us that, by publicising our need in Ground Profile, we might locate such a structure.

There have been retaining wall failures due to expansive clay in many countries with arid climates, but there is no design method available to combat the problem. In South Africa, Professor Jennings has recommended K values of 1 for walls in the Orange Free State goldfields, and this value was reduced to 0,8 in practice. However, the majority of walls in clay must have been designed on the basis of normal active pressures.

The key to the problem appears to be the need to predict equilibrium moisture conditions. In building design it is usually assumed that the soil will be fully saturated at equilibrium but for retaining walls, conditions could vary considerably. If one could be sure that construction would not cause wetting-up of the soil, then to design on the basis of active pressures would be acceptable. In the Vereeniging area, for instance, the natural moisture conditions in the profile are usually constant, with medium to high suctions at all times. These suctions could reduce lateral pressures to values less than active.

The first aim is to instrument a full-scale structure and measure the moisture and stress changes, and displacements. These measurements will be complemented by the results of environmentally controlled field tests. We also hope to use an available probing device, or develop a new one, for in the situ measurement of lateral pressures in natural profiles and, hopefully, adjacent to structures.

The wall we seek should be a free retaining or basement wall, built in at least three metres of unsaturated, expansive clay. The wall should be in the design or early construction stages.

Yours sincerely,

(Signed) IAN BRACKLEY

for DIRECTOR, N.B.R.I.

MINI-SYMPOSIUM ON SLIMES DAMS

Of the four presentations at the Symposium the following two are published here. Professor Jennings' will be published in other journals and Professor Blight's contribution is far too good and long for this newsletter.

SLIMES DAMS - LAND ASSET OR LIABILITY

Past practice in slimes dam construction developed on the basis that, in general, slimes dams are a useless by-product of mining and industry and their presence was a price we had to pay for economic and industrial development. However, with due forethought and the adoption of suitable, not necessarily major, design and construction techniques, slimes dams could be distinct land assets, sought after as areas of township development.

Residential and industrial development has taken up much of the available space between slimes dams and mine dumps in certain areas of the Reef. Increasing land values make it inevitable that developers will look closely at the possibility of exploiting the open areas atop and on the sides of slimes dams. An estimated seventy-two square kilometres of slimes and tailings dumps occur on the Reef; the value of this undeveloped land, if it could be developed and sold for an average of R30 000 a hectare, would exceed R200 million.

The most important factors that affect township development fall into one of three categories, viz.: engineering or physical factors; environmental or ecological factors; and economic factors.

With regard to the engineering factors the following subdivisions bear consideration: geometry, stability, erosion, distortion and corrosion.

The geometry of a slimes dam is simple. The dam comprises a toe region, side slopes and a top. The toe region does not yield geometric problems. The upper surface is usually suitable for development provided it is sufficiently large for it to be a feasible economic proposition to provide access. Development of the side slopes would generally require terracing to enable them to be used.

Slopes formed at one vertical to one and a half horizontal (35°) are such that very little horizontal surface can be formed without expensive retaining walls. At one vertical to three horizontal (18°) approximately half of the surface area of the slope could be developed without expensive retaining walls. The adoption of 18° side slopes is also preferable because of erosion and aesthetic considerations.

The stability of a gold slimes dam² is controlled by the fact that the slime behaves as a granular material with an angle of internal friction of about 35° . For dams with slope angles of less than 35° failure occurs only as a result of water pressures or poor foundation conditions.

The subject of surface erosion by wind and water has been the subject of considerable research in South Africa and elsewhere. It is difficult to stabilize slopes steeper than 34° . Slopes with angles between 26° and 34° require considerable continued maintenance. Slopes flatter than 26° are relatively easily stabilized and require only moderate maintenance.

Erosion due to seepage and piping is far more difficult to control than surface erosion. Clearly, development over such areas cannot normally be considered and such erosion must be cured before development is considered.

Slime deposited in a slurry is in a loose (high void ratios) state. As the water table falls the effective weight of the material is controlled, not by the buoyant, but by the total density which may be a hundred percent or more greater than the buoyant density. Consequently the loose slime settles or consolidates considerably.

In the fines above the water table large suction pressures can develop as a result of evaporation. Such suction further increases the effective stress in the slime with a consequential consolidation and settlement. Such consolidation is accompanied by increases in the shear strength.

Areas which have consolidated, for example, near the side of the dam, are therefore usually stable with regard to such settlement. The centre of the dam will continue to settle until the water table stabilizes. Settlements associated with such a fall in the water table are usually large and may cause considerable damage to structures and services placed on the upper dam surface. The major problem is, therefore, to get the water table to fall and stabilize as rapidly as possible.

The rate at which the water table falls is directly proportional to the permeability of the material through which it drains and inversely proportional to the square of the length of the drainage path it must follow. If constructed on an impermeable base, the controlling drainage path is usually from the centre of the dam to the nearest underdrain. If these are placed around the perimeter of the dam, the drainage path lengths may be long and the dam will require long periods to drain. The installation of even a few intermediate drains would reduce drainage periods by orders of magnitude.

My experience with a number of older slimes dams on the Reef is that drainage may have advanced considerably and further distortion as a result of a drop in the water table will not always be excessive.

Usually the water table is low near the edge of the dam and higher near the centre. This suggests that, from a distortion point of view, while the slopes and possibly the outer edges may be suitable for development, some time may still be required for the water to drop in the central section before development can be considered. Under such circumstances the outer edge of the dam could be intensively developed at an early stage. During this period the central portion of the dam could perhaps be used for purposes which are not distortion sensitive such as parks, open storage or flexible warehousing. The central area could be more intensively developed once the water table had fallen sufficiently.

Slimes dams are often acidic and thus inclined to cause corrosion. The acid product may, however, be leaked away by infiltrating rainwater or ground water flow. Thus, investigations on a number of older slimes dams have shown that the corrosiveness of the slimes has been reduced to mild proportions to appreciable depths. Further experience with concrete structures place in slimes appears to indicate that the problems of corrosion are not as severe as predicted. The use of sacrificial concrete on buried concrete components is often a sufficient precaution. Corrosion and particularly electrolytic corrosion of steel, for example water reticulation pipes, often remains a critical problem.

Slimes dams can pollute. The establishment and maintenance of vegetation³ is often the most effective single measure in controlling pollution resulting from the surface erosion by wind and water. Much has been written and said about this. Ground and surface water pollution are often severe, but these are problems which require control regardless of whether the slimes dams are used for development or not.

The aesthetics of dams is seldom considered. Dams are inherently of simple geometric form. The resulting planar surfaces, while they provide vertical relief, offer little variety of slope and aspect. They are therefore aesthetically unattractive areas for residential development. The simple geometric form is a product largely of design and the need to facilitate construction. To vary the dump shape would take a little extra design and control, but would incur little extra cost.

The smooth curved slopes produced at some locations by the Johannesburg Motorway cuttings and embankments are an example of the aesthetic improvements that can be achieved.

It is anticipated that with the implementation of the design concepts mentioned in this article, together with those that are currently considered good practice for pollution, erosion and corrosion control, slimes dams could become definite assets to the communities in which they occur.

ANDY ROBERTSON

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1. H.T. CLAUSEN "Ecological aspects of slimes dam construction" Jour. S.A.I.M.M., Vol. 74 No. 5, December 1973, pp 178 - 182.
2. G.W. DONALDSON "Practical observations and the results of research on the stability of slimes dams for the gold mining industry" Jour. S.A.I.M.M., Vol. 61 No. 3, October 1960.
3. J.R.C. HILL
&
W.F. NOTHARD "The Rhodesian approach to the vegetating of slimes dams" Jour. S.A.I.M.M., Vol. 74 No. 5, December 1973 pp 197 - 208.

SOME BASIC AND ESSENTIAL CONCEPTS RELATING TO THE DESIGN OF SLIMES DAMS

There are those who believe it is not necessary to design slimes dams. There are those who believe that slimes dams are created by habit. That is, of course, quite wrong; every slimes dam is designed, some on the basis of detailed information and others in the absence of information, but naturally the more information available, the more sophisticated is the design.

But design is only the first step in creating a slimes dam. The second step is the construction of the initial earth works to contain the first batch of slime. The final step is the physical operation of the dam. The design is not separate from the operation; it is possible to make the best designed dam fail, as one contractor friend keeps emphasising.

A number of different deposition methods exist. Each has a particular application. Figure 1 illustrates schematically a VALLEY DAM CONSTRUCTION PROCEDURE, which has the lowest running or operating cost.

In Figure 2 is shown an EARTH WALL constructed from waste rock. This is normally associated with open pit mines where an abundance of stripped waste is available.

When a sufficient fraction of coarse material is present, a CYCLONE DISCHARGE system as shown in Figure 3 may be used. As an alternative to cyclones, use may be made of a BEACHING SYSTEM (Figure 4).

A final system that may be termed the GOLD MINE SLIME PRACTICE exists. The slime is distributed from discharge points by open channel flow along the perimeter of the dam. The slime is then trapped in paddocks and allowed to dry out. The drying creates the required strength for wall building purposes. This system is therefore only suitable for use with a fine product.

Accordingly, the following factors influence the choice of operating system adopted: (a) the product size; (b) the topography of the site; (c) the costing preferences, i.e. whether to adopt a relatively high initial capital cost with a corresponding low operating cost or vice versa.

For a specified tonnage a certain minimum area has to be provided to ensure the satisfactory operation of the dam. The smaller the area, the faster is the rate of rise. Two problems thus arise: (a) the material may not dry out fast enough to allow for the raising of the dam wall before further slime is deposited; and (b) insufficient time may elapse for an adequate consolidation of the slime and therefore an insufficient slime's strength may result in slope instability.

The drying process can be accelerated by depositing thin layers of slime, but one is still at the mercy of the weather and the in-situ drainage characteristics. Experience is a necessary ingredient for successful design in these matters.

It is possible to relate the rate of rise and the stability of the slope by using the principle that the shear strength of the slime increases with time as consolidation proceeds.

The ideal topography for a slimes dam is a flat site with only a gradual slope because in such a case a minimum of earthworks provides a maximum volume and yet there is a gradient available to induce drainage.

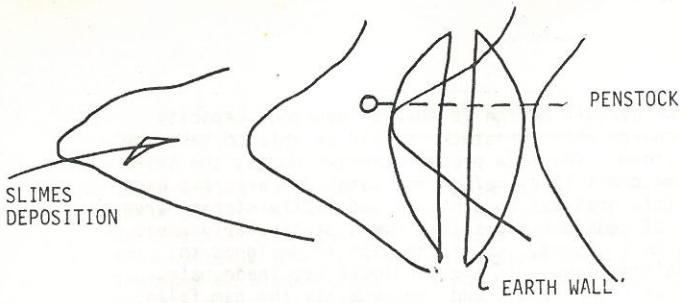


FIG. 1: VALLEY DAM

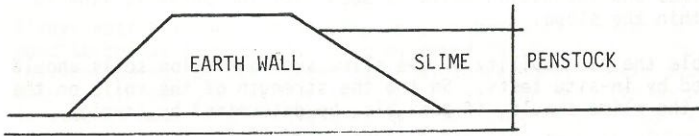


FIG. 2: EARTH WALL DUMP

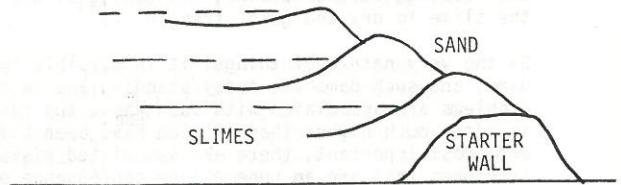


FIG. 3: CYCLONE SEPARATION

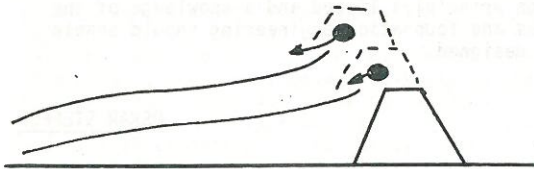


FIG. 4: BEACHING



FIG. 5: CONVENTIONAL GOLD MINE PRACTICE

A critical aspect of the overall design is that of penstock capacity. In addition to the discharge water penstocks should be able to take the one in a hundred year storm. The main problem arises during the initial stages of the slime dam's life, before the total dam area has been covered with slime, little head can be achieved and little storage area is available. Failure of penstock pipes is common, particularly where the dam is situated on soft ground, unless the pipe is designed to cater for inevitable deformations. If the penstocks are inadequate, overtopping of the dam wall can result and consequently the dam fails.

It is important always to consider the possibility of slope instability. Figure 6 shows a number of possible slope failure modes. Most failures can be attributed to water and one of the first objectives in the design of a stable slope should be the control of the water regime within the dam. Underdrains need only be provided when the ratio of permeabilities for slimes and foundation soils is such that the phreatic line is too high within the slope.

Where possible the permeability of the slime and foundation soils should be determined by in-situ tests. So too the strength of the soils on the site and of the slime should, if possible, be determined by in-situ testing.

When slope instability appears, remedial works should be considered. There are a number of conventional remedial works possible, such as buttressing, further drains, flattening of the slope or simply leaving the slime to dry and gain strength.

By the very nature of things, it is possible to build undesigned slimes dams, and such dams are today standing and in operation. However, many problems are associated with such dams, the cost of operating these dams is often much higher than it need have been had the dams been designed, and, most important, there are associated risks of failure attached to such dams that are an unnecessary consequence of such lack of design.

The design principles discussed above are simple and well tried and tested. Each dam is, of course, different to any other and inevitably there are new and different problems associated with each new dam, but an application of the design principles listed and a knowledge of the principles of soil mechanics and foundation engineering should enable most dams to be adequately designed.

OSKAR STEFFEN

PROFILE OF IAN BRACKLEY

Ian Brackley is probably well known to most, not only because of his contribution to soil mechanics, but also because of his achievements in sport in this country. He was born in 1946 in Hastings, Sussex, that historic town in Southern England, and sat his 'A' level examinations at Borden Grammar School. He then went to the University of Nottingham where he graduated with a B. Sc. degree in Civil Engineering in 1967. He joined Roberts Construction Co. in South Africa and was involved for a time with extensions to the Iscor works in Pretoria. In 1968 he joined what was then the Soil Mechanics Division of the National Building Research Institute under Mr. George Donaldson, and is at the present time a Senior Research Officer in what has become the Geotechnical Division.

Always active at work or at play, he has produced a number of very good technical papers which have appeared in the Transactions, or in the Proceedings of the recent Regional Conference. These papers deal mainly with our very active swelling clays. He has also been involved in several major field investigations on research contracts and has contributed to the profession through his hard work on editorial committees. Early recognition of the value of his work came in 1970 when, as a Graduate, he was awarded the annual prize by the S.A. Institution of Civil Engineers as a junior author for his paper on slope instability. In 1971 he received the same award for his joint paper on coal dumps.

He has recently prepared a thesis which was submitted for a doctor's degree at the University of Natal. For this thesis he was capped in May 1976; a well-deserved honour for the young Dr. Brackley. He is at present engaged on a major research investigation into the effects of lateral earth pressures in very active clays, and we look forward with interest to his contribution on this subject. He is already involved in the organization of the coming conference on Partially Saturated Soils, which will be held in 1978.

As mentioned previously, he is active in several fields, and one of his great loves is water sports where the testing of his abilities in full contact with the natural environment gives him a great thrill. He is extremely fit and in his time has won both the Transvaal Marathon championship and the Transvaal Whitewaters championship. He was awarded his Transvaal colours for canoeing in 1972, the same year in which he came third in the Berg River race against strong competition from Austrian and British contestants. For several years he was also secretary of the Transvaal Canoe Union. One of his more daring exploits was the voyage down the Usutu River in 1971, when he and a few companions traversed 500 km down what was virtually an unchartered river.

While there were many episodes with various forms of wild life on the river banks and in the water, his most poignant memories may well be the discussions about important aspects of life with other inmates while he was delayed slightly on his return by his Portuguese friends.

In 1975 he married Ina Vorster who shares his great love for the outdoors. She is well qualified to take care of their future, having a B.A. in nursing with specialist qualifications in midwifery and intensive care. While having such an impressive list of achievements, they both remain a most modest and entertaining young couple from whom we are bound to hear much in the future.

STANDARDIZED CORE LOGGING

At a joint meeting of the AEG and the Geotechnical Division on the 24th May, the draft of a standardized core logging system for rock engineering was discussed.

Copies of the draft may be obtained from The Chairman, Core Logging Committee of the AEG, Private Bag X112, PRETORIA, 0001. Comment on the draft is invited. Such comment should be submitted by the 24th June as the Committee aims to present a second draft at the Symposium on Rock Engineering later this year.

The draft starts out by stating boldly that the aim is to produce a standardized system for the logging of borehole cores for rock engineering purposes. In short, the original aim appears to have been to do for rocks what Jennings, Brink and Williams have done for soils; that is to provide a simple system whereby the person looking at and feeling the soil can describe what he sees.

Unfortunately, the simplicity of this idea which characterises the genius and success of Jennings' system is soon lost in a mass of adaptations, extensions and other possibilities so that it may, for example, be "used for the description of rock masses on outcrops or man-made surfaces".

Of course, such a system would be valuable, but then the proposed draft does not go far enough and is not really sufficiently detailed to give all the information that may be gleaned about a rock mass.

This particular criticism of the code was neatly summed up by Andy Robertson who noted that Professor Jennings wants to cut down the material in the code, whereas Hendrik Kirsten wants to put more in. The one wants a simple system describing only what he can see and assess when looking at a core; the other wants a detailed system for conveying the multitude of information that testing, measuring and inspecting a rock mass can provide. The proposed core logging system sits somewhere in the middle of these two, and thus satisfies neither.

The draft code humbly notes the existence of a large number of descriptive systems for core logging and then justifies its own being by proclaiming that it includes a description of only those parameters which are commonly of interest in rock engineering and uses only qualitative descriptions that depend on a visual inspection or simple mechanical test.

Certainly the draft succeeds in this regard when dealing with such descriptions as colour, weathering, rock fabric and rock type. But when the draft comes to fractures, discontinuities or joints then confusion is spread far and wide.

The draft proposes that the term fracture be applied to describe any naturally occurring break or discontinuity in a rock mass, and thus include as sub-categories bedding spacing, joints or shear zones. Within itself the code ignores this proposal and talks of "thinly bedded, widely fractured" which is a circular serpent of illogical enormity. Andy Robertson claimed that the system of nomenclature is simple; he himself got confused. Professor Jennings was highly critical of the terms and proposed that the word "joint" as he commonly employs it, be used in place of the word "fracture". Finally, the matter was put to the vote and the majority of the meeting opted for the term discontinuity in

preference to either joint or fracture. At least the adoption of the term discontinuity allows for the following description: "The rock displays two forms of discontinuities; a series of alternating brown and red beds, and a system of joints at 350mm on average from each other".

Furthermore, if a discontinuity is any break in the homogeneous nature of the rock then there is no inconsistency in heading the relevant section: DESCRIPTION OF THE JOINTS instead of the present DESCRIPTION OF THE FRACTURES, and thereby satisfying the draft's own proposal that it remain compatible with existing systems of soil and rock classification.

The committee responsible for the draft were criticised for neglecting to provide for a description of the moisture state of the rock or for any mention of a water table. If this is a draft of a pure core logging system, that is, for a description of what one sees in a box of cores, then the neglect of the latter is understandable. The detractors of the committee seemed to feel that neglect of the former was inexcusable.

There appears to be within the system proposed by the draft that germ of insight and inspiration that will provide an MCCSSO for rocks; even if it is only a recognition that one should describe in order the rock mass, the fractures (joints? discontinuities?) and their filling. The document needs much chopping to give it that tightness that characterises a document from the hand of one clever man as compared to a document from a committee of rugged individualists, each eager to propogate his own special chestnut in the bank.

Perhaps the solution to the dilemma is that the draft should be broken into a number of separate but interlinkable documents as Prof. Jennigs suggests. These would cover in order; a system for elementary classification of the essentials to be covered when logging core; those things it would be nice to have; all the other things that make up a very detailed core log; rock descriptions systems for open exposed faces of rock; the testing of rock cores; the storage of rock cores; site investigation and so on.

In view of the number of existing rock classification systems, surely it would be better to adopt a number of systems and then grade them to cater for the variety of levels of complexity that may be required for varying rock engineering jobs. Surely it is better to do this than to promulgate a new untried system with a shoulder shrug that at least it can be revised in the coming ten years to make it good, as the AEG Chairman so cheerfully did at the meeting.

JACK CALDWELL

IMPORTANT NOTICE TO THOSE ENGAGED IN SOIL EXPLORATION

The Geotechnical Division is presently engaged in revising "The Code of Practice relating to the Safety of Men working in Civil Engineering Inspection Pits and Small Diameter Vertical Shafts" (Transactions SAICE November 1960, pp 223 - 227).

It has come to the attention of the Sub-committee dealing with this matter that many people are not aware of the laws governing excavations. Regulations promulgated under Act No. 22 of 1941 (see Government Gazette Extraordinary, Vol. 10, No. 667, 13th December, 1963) are applicable to all excavations; and are definitely applicable to small square test pits and narrow trenches made with back-acting shovels.

These regulations state : "..... no person shall work in an excavation which is more than five feet deep (1,5m) which has not been adequately shored and braced; provided that shoring and bracing shall not be necessary where the sides of the excavation are sloped to at least the angle of repose of the earth or where such excavation is in solid rock".

Strict adherence to the 1960 Code of Practice by the profession has led the Chief Inspector of Factories to condone breaches of this regulation in the case of circular holes only.

OF THIS AND THAT

It is rumoured that the Symposium on EXPLORATION FOR ROCK ENGINEERING will probably be attended by the following personalities:-

Professor Leopold Müller of Salzburg
Professor Charles Fairhurst
Dr. Emmanuel Rocha
Professor Potts
Dr. N. Barton
Dr. Evert Hoek
Dr. H. Voort

The bulletin and registration forms are due to be distributed early in July. Those interested in attending should ensure that they are on the mailing list by telephoning the Symposium Secretary at Johannesburg 22-2751.