Voorstel

Studie "Acoustic Emission" gedrag van verschillende grondsoorten S-80.038

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Proposal Acoustic Emission Studies on Soils, 1981

During spring 1980 the question was raised whether the method of Acoustic Emission (AE) could contribute to the assessment of the stability of Dutch dikes. This resulted in a short memorandum which contained a description of the method and a short literature survey. In the course of preparing the memorandum Prof. R.M. Koerner of the Drexel University, Pennsylvania, USA was contacted.

In the COW-LGM committee meeting of March 27, 1980 it was decided to invite Prof. Koerner for a three day visit as a joint project of COW and LGM. The purpose of this visit was threefold: to introduce the method in the Dutch soil mechanics community, to familiarize Prof. Koerner with LGM, COW and some problem areas and finally to sketch a proposal for further study. The first part was effectuated by discussions on the state of the art between Prof. Koerner, A. Penning (COW) and H. van der Kogel (LGM). Furthermore two lectures were scheduled: one on September 1, 1980 at LGM for an invited audience and the other on September 3 at the Delft University of Technology on invitation of the Dutch Royal Society of Engineers (KIVI). The second part was substantiated by a tour of LGM and a field trip on September 2, 1980 where we visited three problem areas namely "Polder Middelburg", "Boonervliet" and "Gorinchem". The last part consisted of a temporary set up of further work which resulted in the following proposal.

During the discussions and presentations it became evident that the method of AE has been succesfully used to monitor the stability of earth dams in the USA. In fact several agencies adapted the method (see Appendix I). Furthermore during the last ten years a considerable effort has been pursued on the academic level to such an extent that it can be stated that AE are indeed generated by deforming soils (see Appendix II). The work of the Drexel group on AE in soils has been documented with some 37 publications.

Although a wide variety of experiences with AE in USA soils have been obtained, the question remains whether this experience is applicable to the Dutch situation. In other words it is necessary to establish the AE signature of Dutch soils. In the spirit of the above we propose the following studies.

A. Laboratory studies at the Delft Soil Mechanics Laboratory

We propose to test the emittivity of three "typical" types of soil: sand, clay and peat. We will perform a so called frequency analysis in which we establish the frequency content of the emissions and their strength. For this purpose we will use LGM existing triaxial apparatus, install an accelerometer in the bottom plate and buy recording equipment. Tabel A gives more extensive information.

B. Laboratory studies at the Drexel University

Due to non-existing data on "fatty" clays and peat we propose a concurrent series of tests on clay and peat at Drexel. Moreover this action generates a reference point for the at the moment unexperienced personnel of LGM with respect to AE. An outline of the testseries is given in table B.

C. Demonstration experiment

After establishing the signature of the different soils we propose to perform a demonstration in order to show the feasibility of the method in a realistic boundary value problem. The classical plate bearing test seems suitable from the point of view of availability and cost. We propose to measure the AE in a sandy subsoil while measuring concurrently the displacements and the force on the plate until "failure". This generates a displacement / AE count curve, which should demonstrate the relation between trends in AE count and trends towards failure.

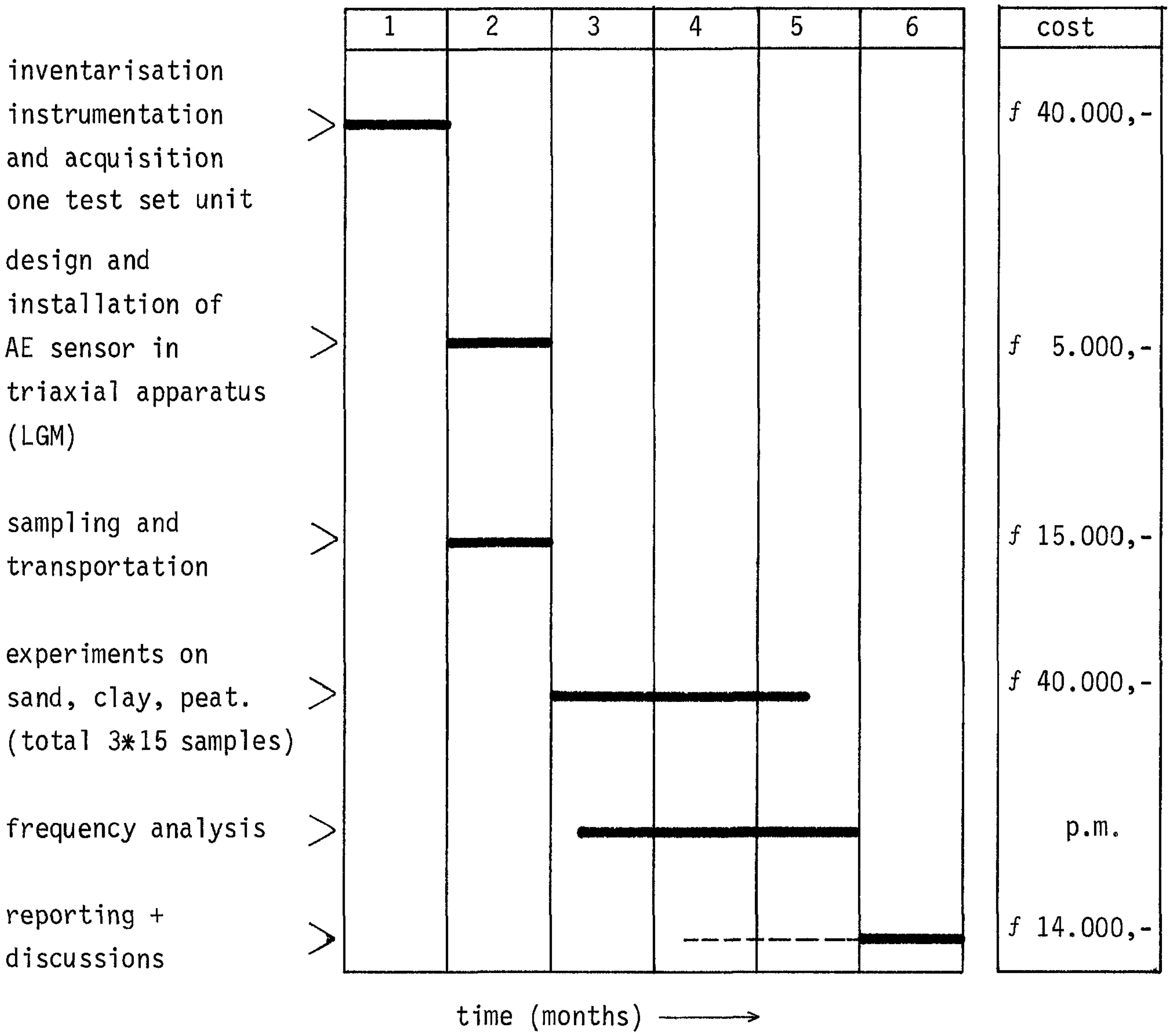
D. Field monitoring

Finally we propose a field monitoring experiment in the problem area "Boonervliet". We will install a wave guide outside the deforming area as well as inside the deforming area. The first one gives us an indication about the background noise, while the second one generates the "signature" of the deforming area. Monitoring the AE over a longer period of time will reveal something about the trends in AE in different seasons, which might be correlated with surface displacement measurements if necessary.

We will try to use as much as possible the existing experience in order to avoid unnecessary duplication. We hope that after the proposed work we will be in the position to either support more practical problems in the Dutch environment (and) or start a research program of a more fundamental nature.

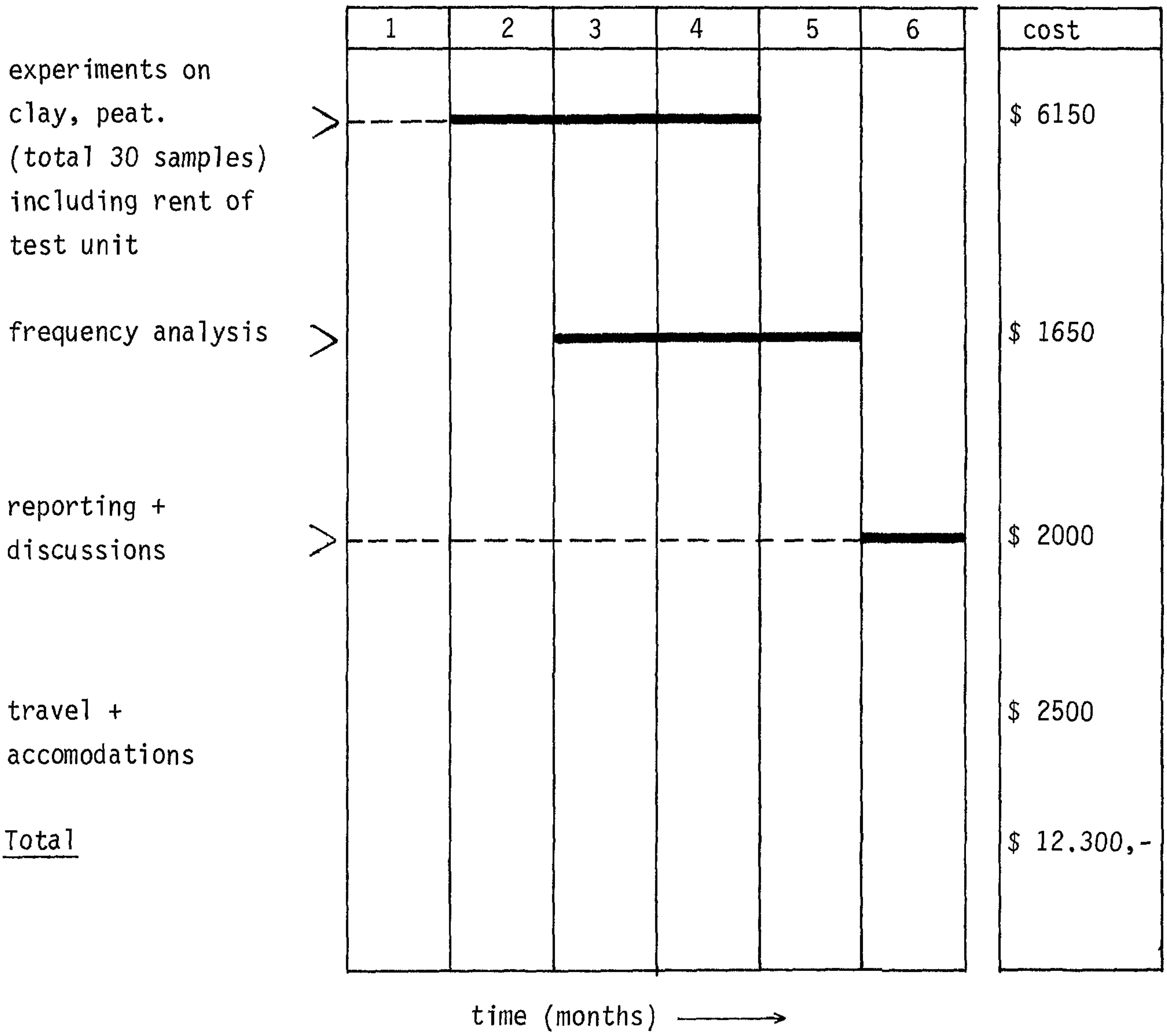
Tabel A

Time Schedule and cost



Tabel B (Koerner)

Time schedule and cost



Demonstration experiment

Cost: (reporting + experiment):	ƒ 4.200,-	+	ƒ 3.000,-
Time experiment:	two days		
"Time" reporting:	14 days		

Field experiment

Cost: (LGM):	ƒ 10.000,-
Time experiment:	one year
"Time" reporting:	one month

U.S. Agencies Using and/or Evaluating the AE Method

- U.S. Environmental Protection Agency (small earth dams)

<u>Contact</u>: Dr. John E. Brugger
Industrial/Environmental Research Laboratory
U.S. Environmental Protection Agency
Edison, New Jersey 08817

- U.S. Bureau of Mines (tailings slopes and mine safety)

<u>Contact</u>: Mr. Frederick W. Leighton
Supervisory Mining Engineer
U.S. Bureau of Mines
Denver Federal Center
Denver, Colorado 80225

- U.S. Department of Transportation (tunnel stability and excavation stability)

<u>Contact</u>: Mr. John R. Salberg
U.S. Department of Transportation
Federal Highway Administration
Washington, D.C. 20590

- U.S. Department of Agriculture (earth dam stability, settlement and subsidenc)

<u>Contact</u>: Mr. Gerald N. Gibson
Soil Conservation Service
U.S. Department of Agriculture
P.O. Box 531
McCook, Nebraska 69001

Summary of A.E. Stability Monitoring of Slope Stability Problems

by

Robert M. Koerner, Ph.D., PE

The acoustic emission monitoring technique has been used for the purposes of slope stability assessment in a number of situations. Table 1 following lists some of these cases. While it is difficult generalize for all circumstances, these past situations have led to the following emission classification stages.

- Soil masses that do not generate acoustic emissions are not deforming and are safe. Such structures are in a state of equilibrium and need not be inspected for a considerable time or until a new loading condition is encountered.
- Soil masses that generate acoustic emissions to a moderate degree (from 10 to 100 counts/min. for the equipment and sensitivities currently used) are deforming slightly and are to be considered marginal. Continued monitoring of such cases is required until such time that the emissions cease or that they increase to the following condition.
- Soil masses that generate large amounts of acoustic emissions, (from 100 to 1000 counts/min. for the equipment and sensitivities currently used) are deforming substantially and are to be considered unstable. Immediate remedial measures are required which, in the case of earth dams, could be to decrease the loading or to add downstream berms until equilibrium is re-established. It is important to note that if acoustic emission monitoring is continuing during these remedial measures, the technique will be functioning as a construction design aid

which gives an instant assessment of the remedial measures as they are in progress.

- Soil masses that generate very high acoustic emission levels (greater than 1000 counts/min for the equipment and sensitivities currently used) are undergoing large deformations and can be considered to be in a failure state. Emergency precautions to assure safety of downstream residents and their personal property should be immediately initiated.

Table 1 - Overview of Sites Monitored by Drexel Group using the Acoustic Emission Method

No.	Designation	Purpose	Height (ft)	Height (m)	Length (ft)	Length (m)	Embankment design & construction	Foundation stability	Acoustic Emission wave guides	Range of AE count rate (Counts/min.)
1	Pa-616	Flood control	30	9.1	2600	800	Excellent	Excellent	20 rods	0
2	Pa-617	Recreation	66	20.1	2500	760	Excellent	Excellent	12 rods	0
3	Neb-200	Flood control	67	20.4	900	270	Excellent	Compressible	12 re-bars	0-200
4	Md-BSC	Ore stockpile	40	12.2	300	90	Good	Poor	2 pipes 1 pipe 1 re-bar	0-20
5	Pa-PIA	Surcharge load	6	1.8	120	37	Good	Poor	1 pile 3 rods	2-750
6	Neb-390B	Flood control	68	20.8	600	180	Excellent	Compressible	6 rods	-
7	Can-LMM	Tailings dam	95	29.0	900	270	Good	Good	3 rods 3 pipes	-
8	Del-COC	Containing dredging spoil	15-40	4.6-12.2	6 mi	10 km	Poor	Good	11 rods	2-10
9	Pa-BOB	Water supply	120	36.6	600	180	Excellent	Excellent	12 re-bars	0-5
10	NJ-NLI	Contain chemical waste	8	2.4	4 mi	7 km	Poor	Very poor	12 rods	0-40
11	Va-KPN	Contain chemical waste	4-15	1.2-4.6	500	150	Poor	Unknown	4 rods	0-3
12	NY-OSW	Contain petroleum waste	8-20	2.4-6.1	450	140	Poor	Unknown	6 rods	2-100
13	Pa-DSP1	Stockpile for highway fill	15	4.6	20	6	Poor	Good	1 rod	10-190
14	Pa-DSP2	Stockpile for highway fill	15	4.6	60	18	Poor	Good	4 rods	2-7700
15	Pa-LN	Seepage beneath earth dam	12	3.6	1200	370	Good	Poor	8 rods	20-480
16	Tex-OC	Gypsum dam	150	45.7	2 mi	3.5 km	Poor	Poor	-	-
17	Ky-WC	Sludge and wastewater lagoons	13 28	4.0 8.5	2 mi	3.5 km	Good	Average	8 rods	0-4
18	Del-CW	Water reservoir	25	7.6	1000	300	Good	Good	1 casing 3 rods	0-40
19	MD-RS	Hydrofracture monitoring	-	-	-	-	-	-	-	-
20	MD-BA	Grout monitoring	-	-	-	-	-	-	-	-
21	VA-R	Hydrofracture monitoring	-	-	-	-	-	-	-	-
22	NY-ASP	Seepage monitoring	3.0	9.1	2000	600	Good	Good	12 rods	-
23	NY-HSP	Seepage monitoring	30	9.1	1500	450	Good	Good	12 rods	0-2000
24	MD-MS	Rock stability	1 20	37	300	90	-	-	2 pipes	0-50
25	PA-MCCT	Foundation stability	65	20	100	30	-	-	1 pipe	-