No. 35, JULY 1983

GROUND PROFILE

NEWSLETTER OF THE DIVISION
OF GEOTECHNICAL ENGINEERING

QUANTITY SURVEYORS AND GEOTECHNICS

BY B.A. KANTEY

Because of the necessity to have Architects appreciate the special measures required for the design of foundations for structures on expansive soils, the National Building Research Institue in 1950 initiated a programme of articles in various architectural journals, 1, 2 in addition to the Information Sheets distributed regularly. That this programme paid off is evident by the recognition by virtually all firms of reputable Architects that Foundation Investigations and Geotechnical advice is a sine qua non in the teamwork required for important structures today.

Unfortunately the same cannot be said for too many of that group of professionals who form an important part of the team - the Quantity Surveyor. This is more the pity since one of the claims of Quantity Surveyors is that their method of specifying, measurement and payment, reduces the probability for contractual claims. This may well be the case for general construction but the same cannot be said for the measurement and payment for excavations. In fact, as methods of excavation and lateral support become more sophisticated, the opposite seems to be applying. Prime building land is becoming increasingly scarce, development is taking place more and more in geotechnically difficult ground and the potential for claims growing.

This is not to say that the Quantity Surveying profession as such is not conscious of the problems posed. The over-riding problem seems to be the extent to which they are allowed to be directly involved in the teamwork required for modern building practice. Before citing a few examples of the problems that arise, it is very necessary to point out that I could quote as many examples where the Engineer or the Architect was at fault. Such cases are, however, generally sins of commission but it will be evident from the examples given that, in the case of the Quantity Surveyors, the sins are more ones of omission.

CASE 1

A building contract for a major building with basement excavation in rock was put out to tender. A full geotechnical investigation was carried out and a detailed report submitted to the Client and the professional team. Because the Quantity Survey branch of the particular government department had its own "standard" rock classification method, in turn related to measurement and payment items, this "standard" was used in depicting ground conditions on the drawings and in the Bill of Quantities.

A dispute arose as to the classification of "hard" rock as much of the rock encountered could, in real terms, be described as extremely hard which could only be removed by blasting. This dispute could have been obviated if the Quantity Surveyor had stated in his document that a detailed geotechnical investigation had been carried out and that a report was available.

CASE 2

A house was designed and construction supervised by an Architect. Built on a steep slope, the Architect authorised extra-over payment for a limited volume of material which was classified as rock. The builder was not satisfied with the certified amount and sought advice from a Quantity Surveyor. As a result of written advice from the Quantity Surveyor the builder instituted arbitration procedures, claiming a very large amount for excavation in boulders and in material classified by the Quantity Surveyor as rock. A Geotechnical Engineer, called in by the owner, established that the volume of boulders had not been measured but arrived at by visual inspection after excavation had been completed. In addition, there was no material in the excavation which could have been classified as rock, not only in real terms but also in terms of the specification in the building contract. As the Architect, having fulfilled his duties, was no longer involved, the Owner rejected the claim. As a result of informal discussions between Geotechnical Engineer and Quantity Surveyor, the claim was effectively withdrawn and settled shortly before the date set for arbitration but not before substantial costs had been incurred.

CASE 3

A shopping complex was designed on a sloping site, with the lower half of the site requiring up to 3 metres of cut in high water table conditions.

The Engineer managed to persuade a reluctant Client to spend three thousand rands on a site investigation. The subsequent report recommended spread footings, where piles had originally been envisaged, saving tens of thousands of rands. The report also specifically stated that well-pointing would be required where excavations exceeded 1,5 m depth.

The Quantity Surveyor provided no specific item for the well-pointing and furthermore, using a standard clause, stated that no soils report was available. As a result, the Contractor struggled in a morass for weeks, trying to avoid well-pointing, before eventually putting them in and rapidly getting perfect working conditions. Not only was the project behind schedule, but a serious claim situation had arisen.

CASE 4

A six-storey block of flats was designed on a very steeply sloping site in variable transported and residual granite soils and hard rock granite. The Client was persuaded by the Engineer to spend a couple of thousand rands on a site investigation. The report gave precise recommendations on classification of material for payment, including the use of explosives for rock. The Quantity Surveyor, while distributing the report to tenderers, specifically excluded the report from the Contract. His Bill omitted all mention of blasting or explosives for rock excavation, but 300 m^3 of very hard massive granite could only be removed by careful blasting. The contract was delayed 2 months and a claim situation developed.

It should be evident from the above that the necessary teamwork for the successful completion of modern-day structures is not always being carried down to that bottom level of construction, the foundation. It goes without saying that the Quantity Surveyor today works hand in glove with the Architect, Structural, Mechanical and Electrical Engineer even insofar as the design and specification of sub-surface construction. However, the evidence seems to be overwhelming that the specification, measurement and payment for excavations is left to the devices of the Quantity Surveyor alone. This may be logical where no geotechnical investigation has been carried out or where such an investigation has revealed that no problems will arise. But where the report indicates variable conditions, makes specific recommendations and indicates problem areas, it is surely logical that the Quantity Surveyor should make use of the specialist knowledge available in the team to ensure proper specification, measurement and payment. Too often, in fact, the impression is gained that the Geotechnical report was not even read by the Quantity Surveyor, if it ever reached his office.

But surely the first step should be agreement on a comprehensive standard method of classification for excavations. While SABS 1200 D is a reasonable guide, it is not comprehensive enough in its breakdown of rock excavation and there are perfectly adequate classification tests. It is to be sincerely hoped that, in the not too distant future, a committee of Quantity Surveyors, Geotechnical Engineers and Engineering Geologists will be set up to formulate an acceptable classification system as a first step towards reducing the claim potential in sub-surface excavation.

1. The Architect and Foundation Engineering B.A. Kantey S. Afr Arch Record Vol. 37 No. 12, 1952

2. Cracking of Buildings in the Orange Free State. D.M. Calderwood, C.A. Rigby and B.A. Kantey. S Afr. Arch. Record Vol. 38 No. 1, 1953

SYMPOSIUM ON DEEP BASEMENTS
AUGUST 1967

Copies of the above proceedings are available from SAICE, P.O. Box 61019, Marshalltown, 2107. If you would like a copy please apply to Mr. B.B. Venter enclosing your cheque or postal order for R5-00 in favour of the SAICE.

XI INTERNATIONAL CONFERENCE
SOIL MECHANICS AND FOUNDATION ENGINEERING
SAN FRANCISCO 1985

The South African society has been allocated 52 pages for papers. All papers should be 4 pages or 6 pages in length. Odd numbers will be rounded up to the nearest even number in calculating the total number of pages submitted. Authors are therefore requested to attempt to use the space allocated as efficiently as possible.

The final date for receipt of papers is 1st September 1984. Member Societies will be responsible for selecting their own papers for submission to the Conference organising committee.

If you intend submitting a paper please submit your 300 word abstracts to the Honorary Secretary, Geotechnical Division, P.O.Box 221, Rivonia, 2128 before 31st January 1984.

INTERNATIONAL WORKSHOP ON SOIL STRUCTURE INTERACTION
DEPARTMENT OF CIVIL ENGINEERING
UNIVERSITY OF ROORKEE
ROORKEE, INDIA

Date Change Notification

Due to unavoidable circumstances the International Workshop on Soil Structure Interaction will now be held in the Department of Civil Engineering, University of Roorkee, Roorkee, India, from November 28 to December 3, 1983 in place of October 10-14, 1983.

GOPAL RANJAN
Organising Secretary

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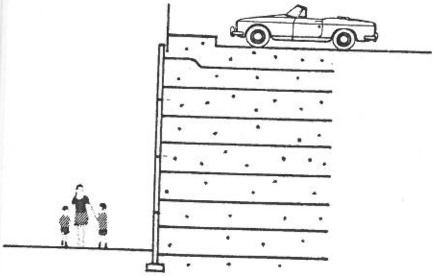
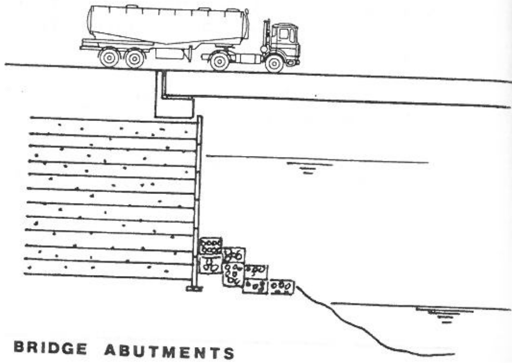
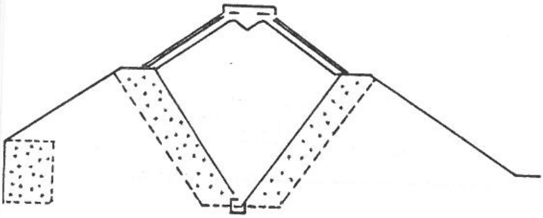
reinforced earth



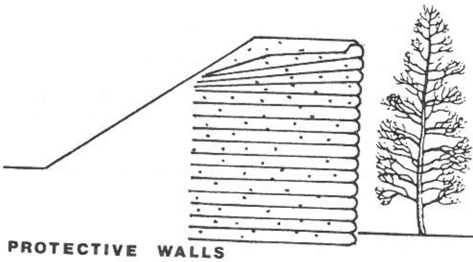
RETAINING WALLS



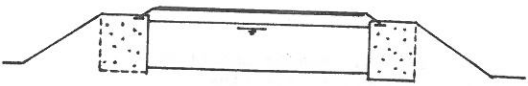
BRIDGE ABUTMENTS



ORE AND MATERIAL STORAGE

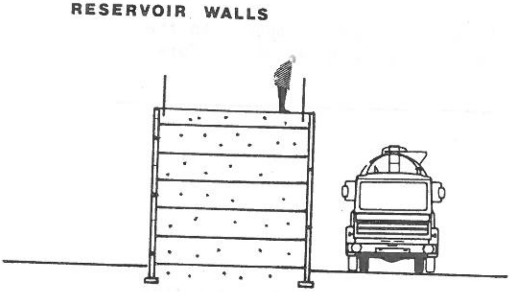


PROTECTIVE WALLS

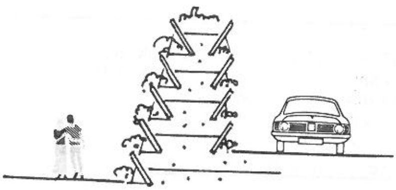


RESERVOIR WALLS

AND MANY OTHER APPLICATIONS .....



BUND WALLS



GREENWALLS©

REPORT-BACK ON SHORT COURSE ON APPLICATION OF PROBABILITY AND STATISTICS IN GEOTECHNICS

given by Prof Dimitri Grivas

Held at Sandton Holdiday Inn
from 6-8 June 1983

Twenty-three participants from as far afield as Cape Town, Durban, Germiston and Johannesburg attended this course which was held under the auspices of the University of Stellenbosch is association with the Geotechnical Division (to help cover the expenses/profits? in bringing Prof Grivas to SA).

A comprehensive set of notes consisting of 152 pages of text, a bibliography containing 166 references and numerous tables was issued to the participants. In his introduction to the course, Professor Grivas gave an overview of the current computer revolution and the emergence of microprocessors and computerised design aids. The development of the computer has brought with it the use of probability theory in Engineering. Probability and statistics in geotechnics is a relatively new field compared to more general application in say structural engineering.

The outline of the course can double as a flow chart for the design or decision making process:

PROBABILITY: (universal)

- theoretical model used to manipulate data (probability is to statistics as geometry is to land surveying)

STATISTICS: (site dependent)

- data gathering
- inference of site conditions and material behaviour

HAZARD ANALYSIS

- evaluation of loads on structure
- determination of possible events of floods, wind, etc.

RELIABILITY ANALYSIS

- objective: to determine the probability of failure of a structure or soil/rock by means of statistics, probability and the hazard analysis to provide the input to the risk analysis.

FAILURE CONSEQUENCE EVALUATION

RISK ANALYSIS

DECISION ANALYSIS

In the overview of basic probability concepts Prof Grivas crystallised this vast topic to the 3 axioms

2 definitions
3 rules,and
2 theorems required to tackle most probelems in statistics. Conditional probability and its application in a monitoring programme (where the

actual behaviour of the structure is compared to the expected behaviour) was briefly touched upon. A lot of time was spent on the basic principles and the determination of statistical moments of various probability density functions (the first night's homework).

Bivariate and regression analyses were dealt with next. Common errors and the bad habits developed by engineers were pointed out where any sets of data are easily approximated by means of a straight line. Particular applications discussed were site characterisation and the determination of special variability of soils. With words like "autocovariance" and "autocorrelation function" etc thrown about, I felt myself wish that I had been a little more attentive when listening to mining engineers talking on geostatistics applied to ore reserve evaluation and the determination of the number of boreholes required (and at what spacing!) to obtain the desired level of confidence in the information gathered. Worked examples made this seemingly difficult topic a little easier (at the time - it is necessary to go through the notes again).

Hazard analysis and failure consequence evaluation are problem dependent and were not discussed in detail during the course. Conditional probability may be used to either update the structure's performance, and if this is reasonably well known, the loading on the structure.

Risk and decision analyses were discussed next to provide the framework in which probabilistic methods in geotechnics are to be presented to the client. Tolerable risk and the method is which decisions are made are based on past good or bad experiences and are dependent on the governing body. The subjective aspects of engineering design are introduced in both risk and decision analyses.

The discussions of the basic probability concepts, bivariate analyses and calculation of statistical moments occupied a large portion of the course for a very good reason. A relatively new technique for performing probabilistic reliability analyses was presented. This involved the use of the point estimate method which may be defined as follows: (Grivas & Stiefel, 1983) "The fundamental concept in the point estimate method involves an approximation of the exact pdf (probability density function) f(x) of a random variable x by a mass density function pi = p(xi), defined at selected discrete values xi. The values of xi, and those of the corresponding mass densities pi, can be determined so as to satisfy the requirement that the discrete approximation pi (xi) has the same statistical moments as the continuous density function f(x), up to a certain order. The value of the latter (eg second, third, etc) in turn determines the degree of accuracy of the approximation".

In structural engineering we have a prallel in the problem of a beam loaded by means of an arbitrarily distributed load. To perform the necessary calculations, this distributed load is replaced by one or more point loads, which add up to the same total load as the distributed load, and are positioned in such a way so as to exert the same bending moments and moments of inertia (second moments) etc on the beam.

The point estimate method makes it possible to make use of a microprocessor or even calculator for probabilistic analyses which would otherwise have required larger computers where say Monte Carlo methods or other simulation techniques are (heavily) employed. The reason why Monte Carlo or other simulation techniques are used in the first functions used in geotechnics are of such a nature that the substitution

The mean of N_γ is therefore calculated as

$$\overline{N}_\gamma = E(N_\gamma) = p_1 N_{\gamma 1} + p_2 N_{\gamma 2}$$

$$= \frac{1}{2}.3,56 + \frac{1}{2}.13,58 = 8,57$$

which is not equal to the bearing capacity factor obtained when the mean value of ϕ is used ($N(\overline{\phi}) = 6,93$).

To obtain the standard deviation of the b.c. factor :

$$E(N_\gamma)^2 = \frac{1}{2}(3,56)^2 + \frac{1}{2}(13,58)^2 = 98,51$$

$$\sigma N^2 = 98,51 - (8,57)^2 = 25,07, \text{ and}$$

$$\sigma N = 5,01$$

REFERENCES

1. Grivas, D A and Stiefel, V G, 1983 : Reliability assessment based on point estimates of probability moments. Unpublished paper in course notes.

2. Lambe, T W and Whitman, R V, 1967 : Soil Mechanics. John Wiley & Sons Inc, New York.

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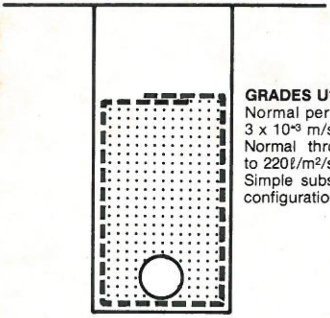
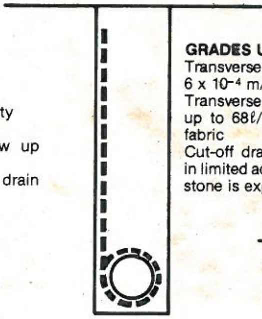
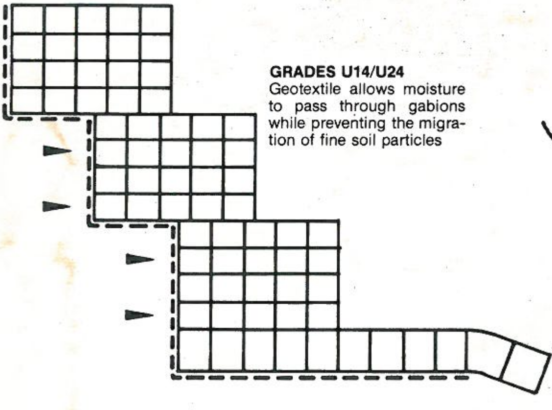


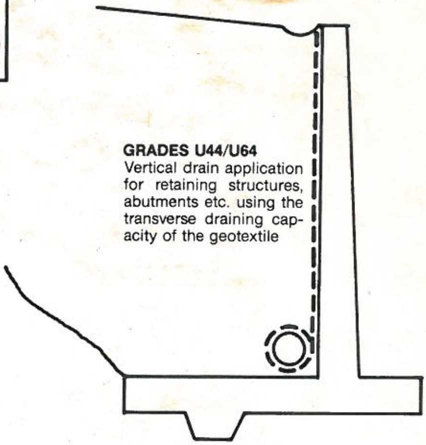
GRADES U14/U24
Normal permeability
3×10^{-3} m/s
Normal throughflow up to $220\ell/m^2/sec$
Simple subsurface drain configuration



GRADES U44/U64
Transverse permeability
6×10^{-4} m/s
Transverse throughflow up to 68ℓ/hr/m width of fabric
Cut-off drain application in limited access or where stone is expensive

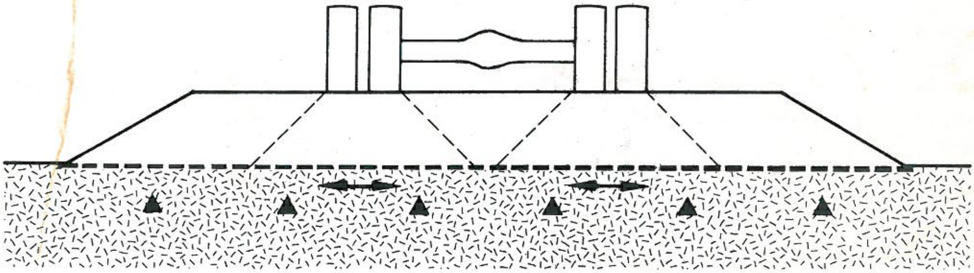


GRADES U14/U24
Geotextile allows moisture to pass through gabions while preventing the migration of fine soil particles



GRADES U44/U64
Vertical drain application for retaining structures, abutments etc. using the transverse draining capacity of the geotextile

GRADES U34/U44
Geotextile used as an interlayer between base material and subgrade prevents contamination of the selected fill while reinforcing the soil interface. Moisture moving upwards due to applied stress is transported away laterally thus accelerating consolidation.



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