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DISCUSSION

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I do want to begin by congratulating our General Reporters on a brilliant task indeed,and moreover I must thank Mr.Chairman for being kind enough in getting rid of me quickly because his comment was well taken.We were indeed somewhat surprised,and I will not say unpleasantly,as I am quite pleased to be here,but we were somewhat surprised at the request that we should participate in this panel.

I take the liberty to bring to you some thoughts which may appear to be diametrically opposed to the very way this subject has been entitled. The subject has been titled "Analysis and Design in Geotechnics";unfortunately,or perhaps it may quite be fortunately,I happen to be working in an area where we have a really tremendous amount of work,and what we normally have to do and I believe most engineers have to do is Design and Analysis.In other words,one really designs first and one analyses to check a design. So in some respects my tone may be a little bit away from a more academic or sophisticated approach and more toward the practicing profession.

It is with considerable elation and some frustration at the same time,that I see in recent conferences the real achievement that has been demonstrated by soil engineers everywhere at mastery of a weapon,at mastery of weapons of mathematics, finite element analysis,and so on. That is really a great merit,the rapidity with which this has been mastered and is being used. But my fear is that we may get too engrossed with the new toy and begin to lose perspective with respect to the difference between the means and the ends.Moreover I'm a little bit concerned at the great number of young people who approach soil mechanics today more or less like the person who suddenly wants to study a new language and doesn't have any access to

a teacher who would begin with a standard phrase like - "I like my house",You like my house","We like my house" and so on. In other words,a teacher who gives you a skeleton on which to build something; and a person not having this access just opens the vocabulary or a dictionary and starts memorizing the language,word by word from a dictionary.Well,we have such a tremendous mass of papers nowadays: The production is nearly catastrophic; forgive my using that word,it is a little bit unkind,but it is a fact. And I feel sorry for young people,because they really don't [too \have/] much of a facility at discriminating between what may be quite right or entirely wrong etc. And,moreover,they don't easily get a skeleton with respect to which they could build up this mass of information. So you will bear with me for a moment,and forgive my getting off into some sort of philosophical approach. I'm going to tell you a little bit about what I feel about the fundamentals of Design; and I will try to exemplify,with a few questions I will throw at some of the papers.The authors will kindly bear with me also. I am not doing that selectively with any criticism; on the contrary,merely to exemplify some questions I feel should be answered,for the purpose of enhancing their really excellent work. Somebody has told me that this is supposed to work.

I offer the following diagram as a representation of the gist of the thoughts I wish to summarize: it may help focus attention on the key words,which,for further memory-aid,are mostly shown to begin with the same letter, D .

The first thought I would leave with you is,that Design,in my way of thinking is really Decision.

Decision Despite Doubts(or uncertainties).There is a mistaken concept in many people,especially some of the older members of our society,that we deal with the socalled exact sciences: so,very frequently we are put in a sort of corner wherein we are supposed to decide on the basis of certainty.

Well design is not an act of certainty ever.

Probability approach portrays that very well. The fact is that no matter how much information you have,you are always really facing a question of decision.Now,secondly let us not harbour any delusions with regard to the deeper drives behind Decision: Decision is a function of Desire plus Data plus a Factor of Safety with respect to Doubts(uncertainties). Well,I put Desire first: subconsciously we want to do something; we may not be quite aware of that,we try to fool ourselves usu-

DESIGN and ANALYSIS in GEOTECHNICS

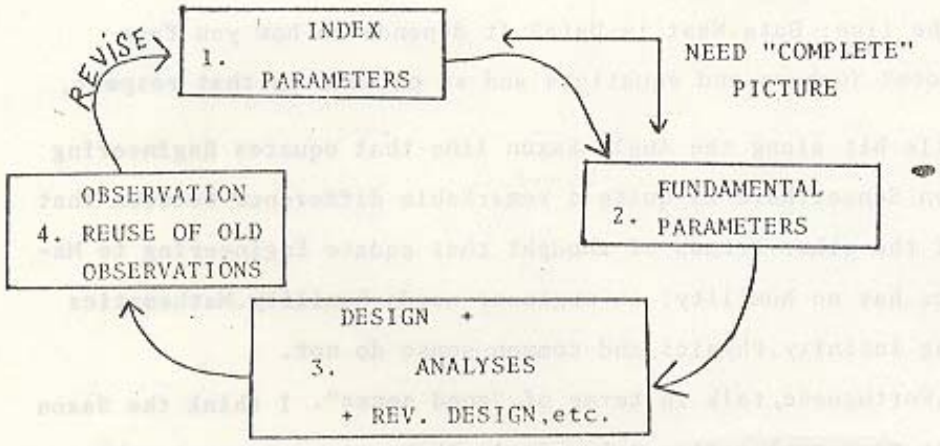
DESIGN = DECISION DESPITE DOUBTS (uncertainties)

(not an act of CERTAINTY)

DECISION = f(DESIRE
+
DATA
+
F.S. w.r.to DOUBTS)

DESIRE ⟶ requires prudence of Devil's advocate
(Society's pressure on professional to test frontiers of impunity)

DATA ⟶ advance by steps as needed and justified.
Engineering = Physics + Common Sense



ally; I am not a psychoanalyst but I psychoanalyse myself quite frequently.I find quite frequently that when I approach a design I either want to do something similar to something I have done,or I want to do something similar to what someone else has done,or most frequently I want to do something better than other people have done. Well,that is always a Desire.Maybe it's a goal: anyway, we've got to be careful about desires because they somehow tend to push us too far.So the indispensible prudence required of the professional,should suggest to us that one should be one's own devil's advocate against oneself. "I want to do this.Why do I want to do this? "So try to analyse your desire.If it is merely to do what everybody else has done,well I'm sorry to say that you are not really a full-fledged professional,because unfortunately professions nowadays,are being pushed by what I call Society's pressure on the professionals to push forward and test the frontiers of impunity.Unfortunately,if you are a professional,I am sorry to

say you are pushed to do better,to build bigger and higher ever.Why? Unfortunately,the biggest gross national product of every country,nowadays,is reproduction. Surprising how very many people contribute in that direction! The fact is that we are pushed,we are continually pushed by the needs of Society:if you have built dams up to 100m high,you want to make them 150.If you have done buildings up to 30 stories high,you want to go up to 40 or 45.If you have used a bearing value of 20 tons per sq. m.,you want to try 25 or 30 and so on. So be careful about testing the frontiers of impunity. And on some of our biggest jobs we frequently find,quite disparagingly,that some of best among us are suddenly caught having gone too far.I could cite case after case of near-failures that will be found to fit into such a pattern of a lack of a devil's advocate,lack of prudence,lack of humility with regard to the uncertainty.

Well to go on down the line: Data.What is Data? It depends on how you face "facts". What are facts? Numbers and equations and so on.Well in that respect, I prefer to be a little bit along the Anglo Saxon line that equates Engineering to Physics plus Common Sense.There is quite a remarkable difference between that viewpoint and some of the other trends of thought that equate Engineering to Mathematics. Mathematics has no humility: an engineer needs humility.Mathematics is capable of thinking infinity.Physics and common sense do not.

Incidently we Latins,Portuguese, talk in terms of "good sense". I think the Saxon word "common sense" is very much better taken.It is that common sense is that which is good. There are remarkable and simple things about the way people think that hint at their being better or worse adapted to a certain specialized social condition,that makes them better engineers or worse enginers.And I think that a person who thinks common sense is engineering is right.You should always check everything that you do with respect to this common sense."Does that sound physically right?"Does it look right":if it doesn't, double check.It may not be in error,but double check before you go ahead.Well,finally to come back down to Data. I request the present generation of younger colleagues(I like to place myself among them)to begin to challenge,to begin to challenge some of the Index Parameters and so on that have served their purpose.I am not criticizing anything that has been done. Everything that has been done has served its purpose,but let us not bow too deeply below certain things that could be reviewed.

As regards Data,I want to insist on the step by step advancing to better degrees of data to the extent desired and justified.In a Design,you start with Index Parameters.

When someone this morning mentioned grainsize analysis or liquid and plastic limits etc.,what are you trying to get as information?I would suggest you always ask the question "so what?".Somebody tells you that a foundation material is a "Devonian clay"...a delightful name and "so what"? as regards probable geotechnical design parameters? Unless you can answer"so what does it mean","what is the practical consequence",I think you should revise.Incidentally,I have been working in consulting boards and so on with practically all nationalities all over the world,and I conclude that soil classification is one of the areas in which we should revise more completely the Index parameters that have been used up to now. Do you know why I should say that?Because I have never seen any soil consultant in any consulting board on a dam,building,subway,or so on,feel satisfied with his understanding of the probable soil behaviour despite receiving stacks of results of routine identification tests.He says"Well this is all very fine,but let me look at the soil,Iwant to feel it".Well if after all you have done,stacks of tests and reports gallore the specialist says "Let me look at one sample",Let me feel it", then there must be something lacking,the index parameter is not sufficient,It has served a first degree purpose but it is not enough.

From Index Parameters you get a first feel of how to design,what really is at stake,and what is the problem.Then you decide whether you want or need to go on to what I call Fundamental Parameters which are of course Strength,Compressibility and Permeability. At least these three. Incidentally,I jotted on the diagram"You need the complete picture",complete in inverted commas: nothing really is complete ever. But at least you need the overall view of the personality. Soil cannot be described merely by one or another of its fundamental parameters; unless you get the feel of its full personality you don't really know how it behaves.It is a terrible pity that one faces so very many papers that deal with just one item,and don't give the remaining information on the personality of the soil under consideration so that you could get a better feel of what really is going on.

Well from that we will move on to what we are discussing today - Design and Analysis,obviously revised design. This is an iterative process.You imagine a certain design,then you analyse,you revise and so.

To what extent is the revision necessary? To the extent to which you don't have experience. To young people who tell me "For Heaven's sake,how hateful to have to have experience",I say,"Yes,how hateful to have to have age".Unfortunately, these two things come together.But don't worry,you'll get both of them.If,however,

you are patient enough to build up on a skeleton.In other words,you have to have a reasoning against which to fill in the data,in order to be able to revise your thinking.

As an Engineer,when I make a design based on SPT,let us say,I decide that for São Paulo clays of SPT blow count 10 I would use a bearing pressure,of let us say, 3 kilos per sq. cm .Well I know from experience that this works alright.Then why do I go to Fundamental Parameters or revised design? Only if my additional work in getting more tests,and more design expenditure,costs less than,let us say,10 or 15% of the economy,that I can make by this subsequent more refined step of analysis and decision.That is where you get to gradually funneling of additional information,thereby reducing the factors of Doubt or uncertainty routinely embodied in the so-called Factor of Safety.But you don't go and reduce factors of uncertainty if it costs much more than what you are going to gain.So that is the step we are discussing today.

And finally,which is very important,we go to Observation to decide on how the soil and design are really behaving.I should like to emphasize to the present company,that you don't have to wait for next building to observe a theory.You can use an old building to "observe",to put your design analysis to cross-examination before presenting it to the public as presumably immaculate.You well know Lambe's discussion about Type A predictions,Type B, and Type C (and I don't know if he has gone further along the alphabet).

If you are honest with yourself,you can transform any Type C or D prediction into a Type A prediction.The honesty is merely the type of honesty that you have to have when you fill out those presumably self-revealing questionaires in weekly magazines. For instance,your self-curiosity seduces you to fill out a questionaire to find out how sexy you are...answer the 42 questions; if you score 150 points you are very sexy,or something like that. Well,if at the time you are answering the questions listed you go to page 72, looking upside down,and try to check the answers which give more points,well then you are fooling yourself.I mean,that's not the way to prove you're sexy within the starting rules of the game.Well,to go back to our building,the fact is that you can honestly put yourself in the case of a past observation as though it were a new one even if it requires filling in some missing data.And if you can't trust yourself,trust a friend.Tell him,"Listen. Keep this data with you.I am going to try out my new theory,and after I've done this,then show me the results".Use a friend.

Unfortunately too many of us keep complaining about the fact that it takes too

long to get observations and it takes too much expense to get observations: it really need not be so. As a first degree,approximation,we don't have to measure settlements to mms ,when we discuss two or five,ten cms which is frequently more than enough. So just a simple stake and a carpenter's water level is enough to give you a first degree approximation feel. Let me summarize for you a case exemplifying how the new generation is losing perspective because of what we call Modernization prior to Development.About thirty years ago a 20-storey building in São Paulo happened to have driven piles upon soft clays that they didn't know were soft,and the building started to settle and tilt. In a square lot of about 25 x 25 sq. m. it tilted,33 cms settlement at one corner,3 at the other corner. The building came out of plumb 90 cm so much so that the road was blocked off, etc.,etc. However,the building was saved.They froze the ground,etc. built new foundations,etc. Incidentally this paper is published in Geotechnique in 1956. About three months ago,as the São Paulo subway was going near a 17 storey building,the building started to settle,tilt. It tilted 3 cms . 4,5 cms . And all the newspapers came out with headlines...this buiding is condemned.It has to be torn down...Why?.Because somebody had quoted or misquoted the paper by Skempton-McDonald saying that 1:200 tilt is too much. And yet I had to point out the 30 year old case nobody knew about any more,and had to call attention to the great number of buildings in Santos that have much higher settlements and differential settlements,some with tilts of 1:80, which nobody thinks of demolishing.Is this then the net advantage to the Subway Company,to have recourse to more modern engineering talents? Young engineers become modernized,and read more avidly what London or New York preach that should be done(for London or New York,mind you),rather than look and learn right around themselves.They feel it is more sophisticated,and it gives them more prestige,if they use for their engineering the more stringent requirements of the more developed and modernized centers of academic engineering. I mean,after all,if you come down to some Project and say that the latest publication in Paris,etc.,says such and such,and you are using that suggestion hot off the press,you become a very sophisticated young engineer.We must guard against that.Engineering methods are in principle the same all over, but each Society has the right and obligation to set,in decision,it's own level of requirements: if we begin to impose(prematurely)on developing countries the most modern levels of requirements of highly modernized societies,we may be doing no more than burdening the Project with higher costs.Development first and modernization immediately subsequent suggest to me a convergent infinite series that leads to a solution,and satisfaction: but modernization prior to development is surely a divergent series that can only lead to frustation,to an ever-widening

gap.

So,we must use and reuse observation of engineering behaviour of our works,in simplest first-degree approximations,to revise our Index Parameters on which 95% or more of our engineering decisions must necessarily be based,if we want to follow the path of development that the advanced nations trailed 30,50 or 80 years ago,and which is the same path we must follow,much as we earnestly want and need to compress it in distance and time and cost.

That is why I insist that what we most need now in Soil Mechanics and Soil Engineering,is to revise thoroughly the Index Parameters that have served their initial purpose,and so the cycle of Engineering progress closes,but spirals up.

Thus,allow me to profit of the occasion to offer some discussion to some of the authors,merely to exemplify the challenge necessary for useful digestion of development's food.

1. Dr.Helenelund's paper is really brilliant,very interesting; but I would personally like to know something about the strength characteristics of that clay. Because the fact that right after loading you get much more lateral displacement is somehow connected with the fact that under any quick loading,you have a lower factor of safety.Then little by little,as the factor of safety increases,you should get principally conditions of volume compressibility.This could possibly be a background sufficient for you to understand.

Unless you understand the information it would become like the word in the dictionary.Well,I would like to understand things so as to be able to remember them easily. So on this paper my request would be for the necessary more "complete" portrayal of the personality of the soil and behaviour under discussion.

2. Another case,for instance. Our illustrious colleagues Dennes and Thomas supply foundation design charts: I notice from their foundation design charts, that two rather interesting results come out.One of them concerns the influence of the water level,which,in the text is said to have been taken into account specifically. The deeper the W.L.,the lower becomes the bearing capacity.Now,that sounds strange. I mean how was the factor specifically considered,if the net result is something absolutely contrary to what "physics" and test information has always indicated.The factor is small but when you want to check on something the trend counts,as revealing correct principles.I should like to ask the gentlemen how they took into account this water level so that it ends up giving this opposite trend. No matter how small. The other factor,of course,which they themselves point out,is the importance of the size.That also yields a result different from presently presumed truths. I am not saying that the existing theory is right but if it is not right,say where it was wrong.So I would plead with these gentlemen to explain just why their derivation leads to different conclusions and how they ex-

plain it physically.

3. Well to move on,for instance,to another case: Dr.Soydemir and Mengi's very interesting analysis. Of course,we know that K_o factors change with time but the mathematical analysis,with its "lack of humility" may sometimes lead us to incomprehensible extrapolations: so we have to stop,and think,and ask ourselves:Well, K_o should change with time,but if those curves come down all the way and then start up again,just why do they stop? Because the graph has stopped? Or how much further would they come again? Is this physically real? Or what is the wrong hypothesis that leads to this...If there is one? Isn't your material really changing? In other words,you are assuming constant Maxwell and Kelvin model properties,and are not these properties really changing as the soil consolidates? So would that be an explanation to give, let's say,a physical understanding to this very interesting figure?

4. Further,I may mention the paper by Drs.Amar et al...with respect to in situ tests using point resistance, pressuremeter, vane,etc. This is the type of problem that is close to the professional engineer. How does one measure strength properties by these various means and how does one check, which one of them really is more or less valid? Now,there again,I would ask these gentlemen why do they accept as a reference,as presumably the correct reference,the laboratory tests (triaxial) and why not one of the others? I have discussed this in some of my earlier State of the Art papers, e.g. Mexico 1969.

5. Finally with respect to a mention that our General Reporter made on Dr.Chowdury's paper. Dr.Chowdury says that there are not many problems in soil engineering that would justify linear analysis.And I would submit: "Well, isn't that strange? over the past 7 years,I have been hearing just the opposite".At least in first degree approximations,we have been hearing,and more and more,proving,that elastic analysis,linear analysis does give you the first degree approximation feel very satisfactorily. Now why does Dr.Chowdury claim the opposite? Is it because of real information or because of intuition? If it is intuition,our general Reporter used the adjectives "more realistic analysis" I beg to question,is that adjective really correct? Is it really more realistic or is it merely more sophisticated? Let's not lead ourselves to the point where sophistication becomes real.
Well, forgive my off-the-cuff comments and I hope that we get some real contributions in discussion, disagreeing with some of the points that I have brought to the floor.