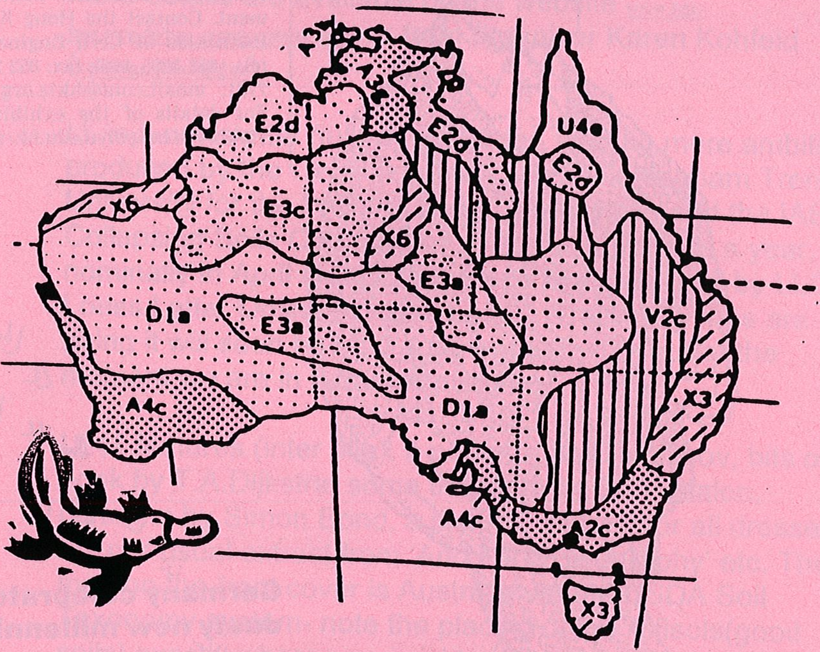
LL44 October 2000 ISSN 0110-7658

LOESS LETTER 44

INQUA Loess Commission
IAEG Collapsing Soils Commission
NTU GeoHazards Group
DIRTMAP 2000

The Nottingham Trent University



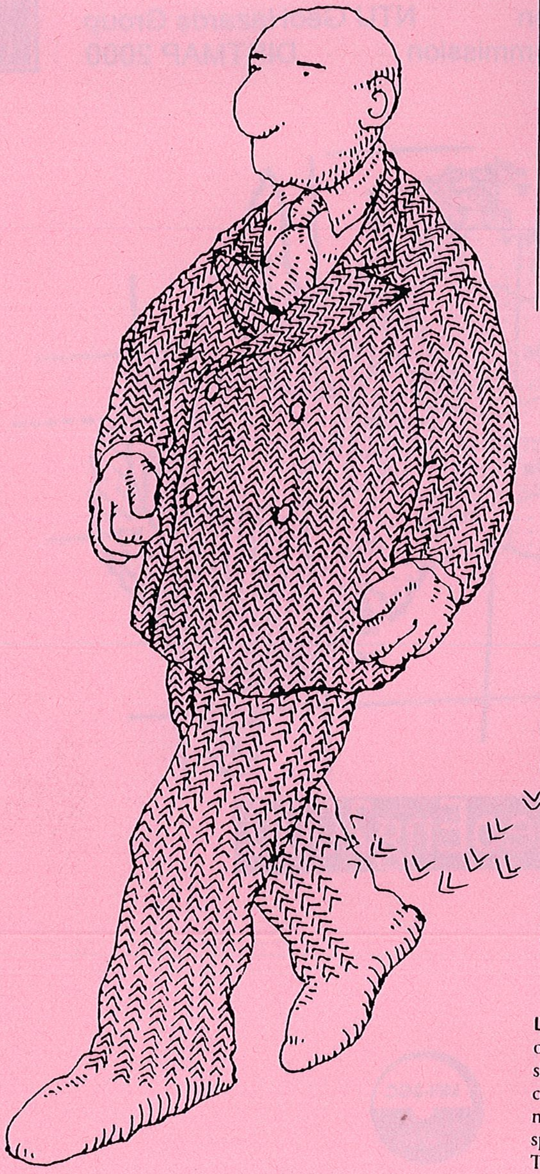
GeoEng2000

MPI-BGC Jena

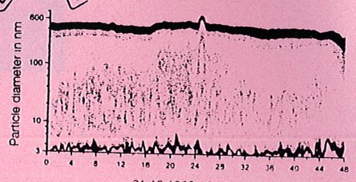
Workshop on the Role of Mineral Aerosols in Quaternary Climate Cycles: Models & Data: Jena, Germany, 7-11 October 2000

First call

Third international conference on soft soil engineering, 6-8 December 2001, Hong Kong. Conference and exhibition organised by the Hong Kong Polytechnic University, The Hong Kong University of Science & Technology and the University of Hong Kong. Main themes are soft material behaviour, monitoring, modelling, ground improvement and settlement control, hazard mitigation, environmental and risk management. Contact the Hong Kong Institution of Civil Engineers, tel: +852 2895 4446; fax: 852 2577 7791; email:conf@hkie.org.hk. For details of the exhibition visit www.cse.polyu.edu.hk/sse3



Germany celebrates a dusty new millennium



Leipzig This dramatic but short-lived cloud of dust particles occurred over Leipzig shortly after midnight on 1 January 2000—coinciding with celebrations of the new millennium. It was recorded by the particle spectrometer of the Institute for Tropospheric Research, which monitors the urban aerosol over the city in eastern Germany. Each particle had a diameter of about 100 nanometres.

LOESS LETTER LL 44: October 2000

LL44 is a special issue supporting the GeoEng 2000 conference in Melbourne, Australia 2-12 November 2000, and the Dirtmap project workshop in Jena, Germany 7-11 October 2000. GeoEng 2000 is a joint meeting of the IAEG, ISSMGE and ISRM. Dirtmap is the "Dust Indicators and Records of Terrestrial and Marine Palaeoenvironments" project. The October workshop is on "The Role of Mineral Aerosols in Quaternary Climate Cycles: Models & Data" and more details are available on the website www.bgc-jena.mpg.de/bgc_prentice/start1.html or from organiser Karen Kohfeld (kek@bgc-jena.mpg.de).

LL is a newsletter (just a newsletter, nothing more ambitious) produced by the GeoHazards Group at Nottingham Trent University for the INQUA Loess Commission and the IAEG Collapsing Soils Commission. It comes out twice a year, nominally in April and October, and is augmented by LLO-Loess Letter Online at www.loessletter.com . The way things are going it will soon be LLO augmented by LL, but at the moment we are in a transition zone.

LL44 features (inter alia): a paper by V.T.Trofimov, bits of a book by T.A.Dijkstra, some thoughts by Dan Yaalon, cartoons by Simon Bond, a picture of an editor all dressed up, our usual extract from 'Arid Land Geography' etc. The map on the front cover is Australia via the USDA Soil Taxonomy system- note the placing of the Alfisols(good soils) exactly where you would expect them (A Alfisols, U Ultisols, V Vertisols, D Aridisols, X mountain soils etc).

Loess InForm- the loess journal published by the Geographical Institute of the Hungarian Academy of Sciences welcomes submissions. LI has been appearing sporadically since 1987 but now more regular publication is intended. LoessFest publications: special issues of Quaternary International and Earth Science Reviews are more or less ready to appear; QI rather in advance of ESR. Selected recent loess publications are listed on LLO.

Addresses, Meetings, etc..

International Association for Engineering Geology & the Environment IAEG. Secretary-General: Dr Michel Deveughele, Ecole des Mines, 60 Blvd St.Michel, 75272 Paris Cedex 06, France(iaeg-sg@cgi.ensmp.fr)

International Union for Quaternary Research INQUA. Secretary: Prof.Dr.Sylvi Haldorsen, Dept.Soil & Water Sci. Agricultural Univ.of Norway, P.O.Box 5028, N-1432 Aas, Norway(sylvi.haldorsen@ijvf.nlh.no)

LL editors: Ian Jefferson, Civil & Structural Eng.Dept. Nottingham Trent University, Nottingham NG1 4BU, UK (ian.jefferson@ntu.ac.uk) and Ian Smalley(smalley@loessletter.com)

LLO website: www.loessletter.com check here for conference reports and random recent loess references.

Collapsing Soils Commentary(for IAEG/C18) website (http://construction.ntu.ac.uk/graduate_school/Research/geohazards/Synergies/default.htm)
C18 Secretary: Ian Jefferson at above address

Dirtmap project: An international project to study aeolian dust; see LL42 for some details; based in Jena, Germany. Contact Karen Kohfeld(kek@bgc-jena.mpg.de) Website (www.bgc-jena.mpg.de/bgc_prentice/start1.html)

GeoEng 2000: Melbourne Australia 19-24 November 2000 (http://civil-www.eng.monash.edu.au/discipln/mgg/geo2000.htm)

IAEG International Symposium on Engineering Geological Problems of Urban Areas. Ekaterinburg Russia 30July-2August 2001(http://www.skyman.ru/~uraltisiz)

IAEG 9th Congress; Engineering Geology for Developing Countries. Durban South Africa 16-20 September 2002 (http://home.geoscience.org.za/saieg/2002.htm)

INQUA 16th Congress: Reno 2003- major loess event

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塔里木盆地边缘山地的黄土沉积*

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提 要 依据在昆仑山北坡若羌、于田和昆仑山西缘塔什库尔干境内的野外工作，分析研究了新疆黄土的分布规律、形成年代、物质成分、沉积环境和沉积区的环境变化。在新疆境内，黄土分布的海拔高度有由南向北降低的趋势，黄土的年龄各地差别较大，在低海拔的部位还保存有"老黄土"，但在高海拔位置只见"新黄土"、全新世和现代黄土。本区黄土虽然颗粒较粗，但矿物组成及化学成分和洛川黄土有相似性。在昆仑山北坡高海拔地区现存的黄土应是在当地较温暖湿润的时期沉积的。

主题词 黄土 环境变化 干旱区 昆仑山 新疆
中图分类号 P535.245 **文献标识码** A

1 引 言

中国黄土的地理分布可划分为三个大区，即西部干燥内陆盆地、中部高原和东部平原[1]。在塔里木盆地和准噶尔盆地黄土分布的总面积分别为34 400km² 和15 840km²，在甘肃河西走廊和青海高原上黄土的分布面积分别为1 200 km² 和16 000 km²。换句话说，我国黄土总面积的17.35%分布于西部干燥内陆盆地及其周围的山地。就黄土状岩石而言，全国总面积的65.67%分布于西部地区。并且在中亚干旱区的其它国家如蒙古、哈萨克等地都有黄土和黄土状岩石分布。所以研究新疆的黄土不仅对于认识当地的地理环境特征而且对于探讨全球黄土的总特点和研究现代尘暴灾害都有重要意义。

2 黄土分布特征

塔里木盆地南侧的黄土主要分布在昆仑山北坡。西段和西南段的黄土已有一些报道，如英吉沙和克里扬一带的[2]。在昆仑山中部和东部地区也都有黄土分布，在阿尔金山当金山口以北、克里雅河上游的普鲁村等地区可观察到大面积连续分布的黄土(图1)。这些地区的黄土堆积过程现仍在进行。白天因为盆地升温迅速，风由塔克拉玛干吹向昆仑山，把大量的粉尘和细砂搬移至山地沉积。在野外工作期间经常体验到，中午时风力变强，所携带的粉砂量大增，空气的能见度变得很小。粉尘被吹到山顶，甚至在冰川上常出现一层黄色尘土层。但这种尘土可能被风力又吹蚀也可能被流水侵蚀掉，因为山坡陡、植被覆盖差，雨水的侵蚀能力颇大。在干旱地区暴雨后河流泥沙的悬移部分含量可高达695g/l[3]。河流在出山口因坡度减小流速减小，所带泥沙则堆积在山前地带。其中的粉沙部分在风力作用下又被搬运到山地或其它地区。所以在塔立木盆地的周围山地上常出现两个黄土带，即在山前地带为黄土状沉积，而在山上为黄土[4,5]。对于昆仑山北坡黄土分布的高度范围，大概是因为观测地点和观测方法不同的原因，看法也差别较大。不少作者在论著中省去了观测地点，所以比较起来有一定困难。实际上，昆仑山北坡黄土分布的上下限也有地域变化。下限多在2 500m 上限区域变化较大。在叶城和民丰之间黄土可达到4 900m 的高山带[①]。需要说明的是，这里海拔较低的位置上的黄土壮岩石实际上就是亚砂土

* 中国科学院资助项目(批准号:KZ952-51-438)
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① 赵兴有:昆仑山北坡黄土沉积环境与气候变化. 见:第七届全国第四纪学术讨论会文摘要汇编. 北京:中国第四纪研究委员会 [illegible]
76~77.

LOESS DEPOSITS IN THE SURROUNDING MOUNTAINS OF TARIM BASIN, NORTHWESTERN CHINA

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Abstract

Loess and loess-like sediments are vastly spread over the marginal mountains of the Tarim Basin and Zhun- gaer Basin in Xinjiang of northwestern China. Around the basins there are often two different aeolian sedimenta- ion belts, which are separately covered by loess, and loess-like deposits. Generally speaking, the loess is more ntensively developed in the southern margin of the basin than in the northern. On the northern flank of Kunlun Mountains, loess is mainly distributed between 2 500m and 3 400m a.s.l.(above see level), and its thickness is eldom over two dozen meters. Small loess patches with a thickness of about 1m may occur even at the elevation ver 5 000 m a.s.l. But in the Tianshan Mountains, the loess is considerably restricted to 950m and 2 400 m a. .l. on the southern flank, and 800m and 2 000m on the northern side.

The samples taken from Tashikuergan to Yütian of the northern flank of Kunlun Mountains show the grain ze of loess tends to increase from West to East. Compared with Loess Plateau, the loess in Xinjiang is generally arser probably owing to its shorter transport distance. The samples from Pulu in the upper reaches of Keriya iver indicate that the percentage of heavy minerals in the loess is 5.5% on average. The content of stable and ry stable minerals is only some 20%. One third of the heavy minerals is hornblende. Besides, the content of idote, iron minerals and black mica is relatively high also.

From the field investigation and laboratory analysis, it concludes that the preserved loess in the surrounding ountains of the Tarim Basin has been deposited mainly in Holocene. There the loess accumulation takes place incipally during the intergalcial periods. Under the more severe climatic conditions of glacial times, the vegeta- n in the present loess zone would deteriorate considerably, and a stronger deflation and sand accumulation uld replace the process of loess sedimentation. But in the northern flank of Tianshan Mountains, several lay- of paleosol are present in the loess section, and both Holocene and late Pleistocene loess is observed.

Key words: Loess, environmental change, arid zone, Kunlun Mountains, Xinjiang

Reno 2003. As this editorial is being composed the next major INQUA meeting is 3 years away. This may seem like a long time but the months click by very rapidly, and we should start thinking about possible loess symposia or workshops for the Reno'03 meeting. Do we discuss the cutting edge of loess research, or take a geographical approach and consider loess deposits associated with deserts, or a continental approach and focus on loess in North America? Suggestions please.

PROCEEDINGS OF THE ASIAN CONFERENCE ON UNSATURATED SOILS
UNSAT-ASIA 2000/SINGAPORE/18 – 19 MAY 2000

Unsaturated Soils for Asia

Edited by

H. Rahardjo, D.G.Toll & E.C.Leong

Nanyang Technological University, Singapore

The Asian Conference on Unsaturated Soils is organised by the NTU-PWD Geotechnical Research Centre, Nanyang Technological University, Singapore, with the support of the Technical Committee on Unsaturated Soils (TC6) of the International Society of Soil Mechanics and Geotechnical Engineering. This publication contains the papers presented at this conference. Although there have been several international and other regional conferences on unsaturated soils, this is the first Asian Conference on Unsaturated Soils. It is appropriate to organise this conference in Asia where abundant 'problematic soils' exist such as swelling soils, collapsible soils and residual soils. Common to these soils is their unsaturated nature and their problematic behaviour that arises when these soils come in contact with water. They are called problematic soils because their behaviour cannot be explained using conventional saturated soil mechanics. Unsaturated soil mechanics has developed to the stage where the theoretical frameworks, the required equipment and measuring techniques are readily available to be put into practice. Therefore, the theme 'From Theory to Practice' is adopted for this conference.

The First Asian Conference on Unsaturated Soils is timely in being organised when Asian countries are actively developing their infrastructures to cater for growth in their populations and economies. Many civil engineering developments involve unsaturated soils that require special consideration, analyses and measurements within the framework of unsaturated soil mechanics. The papers presented to this conference cover a wide range of topics from the fundamentals to practical experiences and from new equipment development to advances in numerical modelling. Flow, shear strength and volume change characteristics of unsaturated soils dominate the discussions of different problems such as heave, collapse, slope instability, foundation failures and contaminant transport. Suction and soil-water characteristics appear to play crucial roles in understanding and solving these problems that are closely related to water flow through unsaturated soils.

We hope that this publication helps to bridge the gap between the theory and practice of unsaturated soils.

A.A. BALKEMA/ROTTERDAM/BROOKFIELD/2000

Unsaturated Soils for Asia, Rahardjo, Toll & Leong (eds) © 2000 Balkema, Rotterdam, ISBN 90 5809 139 2

Damage function and a masonry model for Loess

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ABSTRACT: Natural soils usually have their peculiar structure and their behavior cannot be properly modeled by traditional elasto-plastic theory. In this paper a so-called masonry model is proposed in which a damage function is defined and used in parallel with the yield function to predict the deformation of natural loess during loading and wetting.

1 INTRODUCTION

By introducing suction as a new variable, the Cambridge critical state model has been generalized to model the behaviour of unsaturated soils. According to Alonso et al.(1990), a so-called LC (Loading and collapse) locus is assumed for predicting the plastic behaviour of unsaturated soils due to an increase of load and a decrease of suction. This kind of elasto-plastic model seems satisfactory for many compacted soils, but trouble will be encoun-tered when one deals with some natural soils with open macro pores such as loess which usually has a peak deformation at a definite pressure when wetted under different vertical pressures (Figure 1).

Many natural soils have their structure and exhibit quite different behaviour before and after the damage of the structure. A new kind of constitutive model which takes account of the damage of the soil structure during loading and other mechanical effects has been proposed by the first author as a structural model (Shen, 1998). In the following sections, such a model will be developed for loess.

2 DAMAGE FUNCTION

In classic plasticity theory, the yield function is the key variable in characterizing the evolution of plastic deformation during loading. Usually the yield function is expressed as

$$F(\{\sigma\},h) = f(\{\sigma\})-p(h) = 0 \tag{1}$$

where h is a hardening parameter. Damage function is the generalization of yield function to describe the evolution of the damage of soil structure. In accordance with the two variable approach, the damage function must be a function of both net stress and suction, and its general formulation can be expressed as

$$G(\{\sigma^*\},s,d) = g(\{\sigma^*\},s)-q(d) = 0 \tag{2}$$

where $\{\sigma^*\}=\{\sigma\}-u_a\{\delta\}$ is net stress, $\{\delta\}=\{1\ 1\ 1\ 0\ 0\ 0\}^T$, $s=u_a-u_w$ is suction, d is the damage parameter. q can be regarded as an equivalent stress which causes the structure to be damaged. If an elliptic function for net stress is used as in the Cambridge model, the following expression for g can be suggested

$$g = \sigma^*_m\left(1+\frac{\sigma^{*2}_s}{M^2\sigma^{*2}_m}\right)\frac{1}{1+\alpha(s/p_a)^m} \tag{3}$$

where $\sigma^*_m = (\sigma^*_1+\sigma^*_2+\sigma^*_3)/3$,
$\sigma^*_s = [(\sigma^*_1-\sigma^*_2)^2+(\sigma^*_2-\sigma^*_3)^2+(\sigma^*_3-\sigma^*_1)^2]^{1/2}/\sqrt{2}$.

M, m and α are 3 constants, and p_a is atmospheric pressure. However for better fitting the available experimental data both in the π plane and in the meridian plane, the following new expression will be used

$$g = \frac{\sigma^*_m}{1-(\eta^*/M)^n}\,\frac{1}{1+\alpha(s/p_a)^m} \tag{4}$$

where

$$\eta^* = \frac{1}{\sqrt{2}}\left[\left(\frac{\sigma^*_1-\sigma^*_2}{\sigma^*_1+\sigma^*_2}\right)^2+\left(\frac{\sigma^*_2-\sigma^*_3}{\sigma^*_2+\sigma^*_3}\right)^2+\left(\frac{\sigma^*_3-\sigma^*_1}{\sigma^*_3+\sigma^*_1}\right)^2\right]^{1/2}$$

The curve for η^*=constant is shown in Figure 2 (Shen, 1989). A damage surface in σ_m—σ_s—s space for n =1.2 and m=1 is shown in Figure 3. Equation 4 explains that either increase of σ^*_m and η^* or decrease of s can cause the damage of the soil structure.

The damage parameter d is a measure of damage. A common definition of d is damage ratio, i.e. the ratio of volume occupied by the damaged part to the total volume of the examined element. However, this ratio is unable to be measured, and in the following another definition will be given.

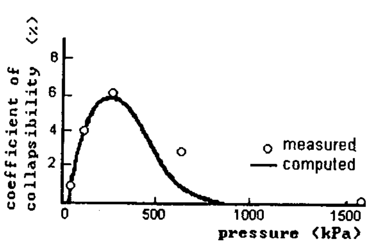

Figure 1 Wetting deformation

Supported by Chinese National Science Foundation (No.19772019)

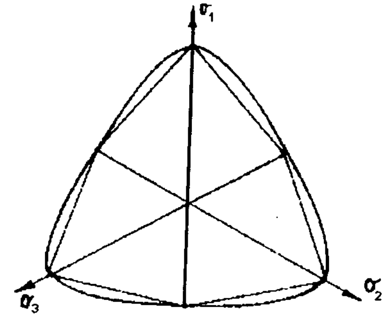

Figure 2 Yield locus

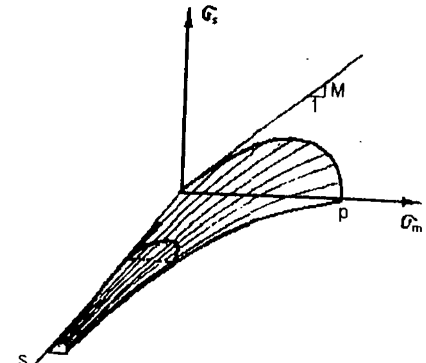

Figure 3 Damage surface

3 A MASONRY MODEL

3.1 *Basic assumption*

Many natural soils exhibit essentially elastic behaviour when loaded at low stress levels. Therefore we can regard the natural soil sample as an elastic body intersected by randomly distributed joints, i.e. like a masonry. When the load reaches a threshold value the weakest joints will break down first making the sample like an assembly of several lumps. When the load increases further, the lumps are crushed again and their size get smaller and smaller. Finally, when all the soil aggregates have been destroyed, a sample with dispersed particles is obtained. Figure 4 demonstrates the process of shear band formation of a masonry sample.

Accordingly, the behaviour of soil after the threshold of loading has been exceeded can be characterized by an assembly of stone-like lumps vulnerable to crushing. An elastoplastic model can be used for it, but an additional term of plastic strain due to the crushing of stones must be added. Therefore, when the associated flow law is adopted the stress-strain relationship in the incremental form can be likely written as

$$\{\Delta\varepsilon\} = [C]\{\Delta\sigma^*\}+A_p\left\{\frac{\partial f}{\partial\sigma^*}\right\}\Delta f+A_d\left\{\frac{\partial g}{\partial\sigma^*}\right\}\Delta g \tag{5}$$

where $[C]$ is elastic compliance matrix, A_p is plastic coefficient due to yielding, A_d is the same coefficient due to damage.

3.2 *Plastic deformation due to yielding*

For the stone-like assembly a yield function similar to that used in Equation 4 will be used

$$f = \frac{\sigma^*_m}{1-(\eta^*/M)^n} \tag{6}$$

Adopting the plastic volumetric strain as a hardening parameter, a hardening rule similar to that of the Cambridge model can be expressed as

$$p = p_0\,exp\left(\frac{1+e_0}{\lambda-\kappa}\varepsilon_v\right) \tag{7}$$

where p_0 is a reference pressure when ε_v =0, λ and κ is the slope of e-ln$p$ curve for virgin compression and rebound respectively. The incremental form of this equation will be

$$\Delta\varepsilon^p_v = \frac{\lambda-\kappa}{1+e_0}\frac{\Delta p}{p} \tag{8}$$

In the case of isotropic compression, $\Delta f = \Delta p$, $\{\partial f/\partial\sigma^*\} = \partial f/\partial\sigma^*_m$
Comparison of Equation 8 with the second term of Equation 5 yields the following expression for the plastic coefficient A_p

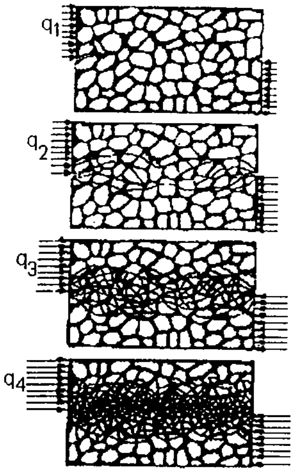

Figure 4 Shearing of a masonry sample

$$A_p = \frac{\lambda - \kappa}{1+e_0} \frac{1}{p\partial f/\partial \sigma_m^{\bullet}} \tag{9}$$

3.3 *Plastic deformation due to damage*

For determinating plastic coefficient A_d we must choose the damage parameter d first. As mentioned above the damage ratio commonly used in the classical damage mechanics will be abandoned here. A reasonable way is taking the size of stone-like lumps as the damage parameter which reduces progressively in the process of damage. But this quantity also cannot be measured. In the following we shall define the parameter d as

$$d = \frac{e_0 - e}{e_0 - e_s} \tag{10}$$

where e is current void ratio, e_0 is its initial value, and e_s is the stable void ratio obtained from compression test of a saturated reconstituted sample of the same soil (Shen, 1996, Figure 5). This definition gives a complete damage (d=1) when $e=e_s$, and no damage at all (d=0) when $e=e_0$.

Now a damage law will be postulated as follows

$$q = q_0 + a\frac{d}{1-d} \tag{11}$$

where a is the initial slope of $q \sim d$ curve. This equation satisfying the following condition: $q=q_0$, d =0 and $q \to \infty$,d=1. From Equation 10, Δd = $(-\Delta e + d\,\Delta e_s)/(e_0 - e_s)$, and accounting for $\Delta e_s = -\lambda\,\Delta p/p$, $d=(e-e_s)/a(e_0-e_s)$ and $\Delta\varepsilon_v = -\Delta e/(1+e_0)$, then for isotropic compression $\Delta p = \Delta q = \Delta g$, and $\{\partial g/\partial\sigma^{\bullet}\} = \partial g/\partial\sigma_m^{\bullet}$

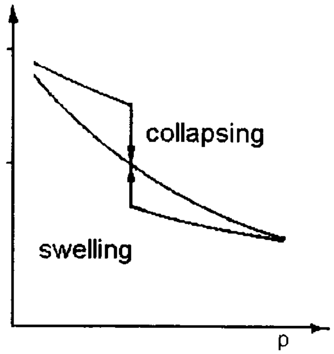

Figure 5 Stable void ratio

the following expression for A_d is obtained from Equation 5

$$A_d = \frac{(e-e_s)/a + (d\lambda_1 - \lambda)/p}{(1+e_0)\dfrac{\partial g}{\partial \sigma_m^{\bullet}}} \tag{12}$$

3.4 *Final expression*

After inserting $\Delta f = \{\frac{\partial f}{\partial \sigma^{\bullet}}\}^T\{\Delta\sigma^{\bullet}\}$ and $\Delta g = \{\frac{\partial g}{\partial \sigma^{*}}\}^T\{\Delta\sigma^{*}\} + \frac{\partial g}{\partial s}\Delta s$ the final expression of stress-strain relationship is as follows

$$\{\Delta\varepsilon\} = ([C] + A_p[C]_f + A_d[C]_g)\{\Delta\sigma^{\bullet}\}$$
$$\{+A_d[C]_g\frac{\partial g}{\partial s})\{\delta\}\Delta s \tag{13}$$

where

$$[C]_f = \{\frac{\partial f}{\partial \sigma}\}^T\{\frac{\partial f}{\partial \sigma^{\bullet}}\},\quad [C]_g = \{\frac{\partial g}{\partial \sigma^{*}}\}^T\{\frac{\partial g}{\partial \sigma^{*}}\}$$

and

$$\frac{\partial g}{\partial s} = \frac{\sigma_m^{\bullet} \qquad \alpha\, m(s/p_a)^{m-1}}{1-(\eta^{*}/M)^n p_a[1+\alpha(s/p_a)^m]^2} \tag{14}$$

4 PARAMETER STUDY

In the above-mentioned Equations, 6 parameters M , λ, κ, α , q_0 and a are encountered. Among them M and λ must vary with the damage parameter, because with the decrease of the size of the stone-like lumps the shear strength of the sample decreases and its compressibility increases. However the rebound coefficient κ will be taken as a constant for simplicity.

M is closely related with the internal friction angle and can be calculated as follows

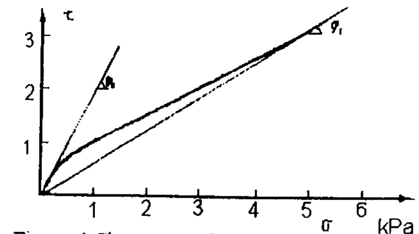

Figure 6 Shear strength envelop

$$M = \sqrt[n]{1+n}\,\sin\phi \tag{15}$$

If ϕ_0 and ϕ_1 is the friction angle for undamaged (d=0) and completely damaged (d=1) sample respectively, the following linear interpolation formula will be used to get ϕ at an intermediate value of d

$$\phi = \phi_0 - d(\phi_0 - \phi_1) \tag{16}$$

$\phi_0$and ϕ_1 can be obtained from the result of tri-axial test of natural samples under low and high confining pressures, (see Figure 6). A similar interpolation formula will be used for parameter λ

$$\lambda = \lambda_0 + d(\lambda_1 - \lambda_0) \tag{17}$$

λ_0 and λ_1 can be determined from the slope of e-ln$p$ curve at small and high stress level respectively as shown in Figure 7. From this figure we can obtain another pair of parameters p_s and p_u for saturated and unsaturated sample respectively, from which the q_0 in Equation 11 and α in Equation 4 can be deduced under assumption that $q \approx 1.2p$ and m=2. Finally, the value a in Equation 11 is obtained by trial and error to obtain a best fit to the experimental data.

5 COMPUTED EXEMPLES

A series of test with artificially prepared loess samples having similar structure with natural loess has been tested in order to determine the model constants and to verify the model behaviour. The obtained constants are: e_0=1.0, s_0=160kPa, w_0=17.7%, λ_0=0.015, λ_1=0.09, sin ϕ_0=0.90, sin ϕ_1=0.52, q_0=30kPa, a=0.4, α =1.4. In addition $\kappa = \lambda_0$ is assumed and $Ei=q_0/\lambda_0$ and ν=0.33 are used for the elastic behaviour of the samples before the threshold value q_0 has been exceeded. The computed results are also shown in Figure 1 and Figure 7.

6 CONCLUSIONS

1. Natural loess has a peculiar structure with open macropores, and its deformation behaviour during loading and wetting cannot be properly modeled by simple extension of existing soil plasticity and introducing only an additional term to take account of suction.

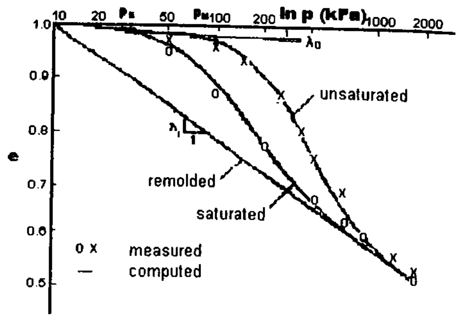

Figure 7 Results of oedometer test

2. The masonry model proposed in this paper regards the soil sample as an assembly of lumps connected with weak bonds which can be destroyed during loading and wetting

3. According to this model the deformation of a sample consists of 3 parts:① elastic deformation of lumps, ② plastic deformation due to sliding between lumps and ③ irrecoverable deformation due to crushing of lumps which can be described by a damage function.

4. The damage function can be defined similar to the yield function, but an extra term with suction as an independent variable must be added to reflect the action of wetting.

5. The preliminary verification shows that the new model might offer an effective way in modeling many natural soils.

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Unsaturated Soils for Asia, Rahardjo, Toll & Leong (eds) © 2000 Balkema, Rotterdam, ISBN 90 5809 139 2

Collapsibility of Egyptian loess soil

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ABSTRACT: The work presented is dealing with experimental research project on the response of circular footing resting on collapsible soil. A special apparatus was prepared in laboratory to measure the collapse settlement of a footing model under the effect of several parameters. Most of the previous researches are dealing with the inundation of collapsible soil starting from the top surface, which represents the case of rainwater, or similar. In this research the inundation starts from bottom of the soil toward the surface which is representing the case of the breakage of sewage pipes and/or rise of ground water table. The used system for inundation enabled to study the effect of dry soil thickness beneath the footing on the value of collapse settlement. The effects of load ratio, initial dry unit weight and the molding moisture content are also studied. Sand cushion is placed beneath the footing as a stabilization method to improve the response of footing and to minimize the collapse potential of soil upon wetting. Comparison between the measured and the predicted collapse settlement using the collapse predictive model developed by Basma & Tuncer (1992) are made.

1 INTODUCTION

The collapsible soils are covering vast areas of several countries. Particularly in Egypt, they are widely spread throughout the Egyptian western desert, especially at Sidi-Baranee, New El-Ameria city, El-Boustan, Borg El-Arab city, the 6th of October city, etc.

Some collapsible soils are deposited in such a way that they exist in a loose honeycomb-type structure at a relatively low density. At their natural low moisture content they possess high apparent strength, but are susceptible to a large reduction in void ratio upon wetting. Some other collapsible soils are generally composed of uniform, silt-sized particles, which were loosely deposited, and are bonded together with relatively small fraction of clay forming the typical loess structure. Normally, loess has high shearing resistance and withstands high stresses without great settlement, when natural moisture content is low. However, upon wetting, the clay bond tends to soften and cause collapse of the loess structure inducing large settlement under low level of stresses. Therefore, it is dangerous to construct on these soils without improving their characteristics.

In Egypt, the formation is very dense; SPT values in the range of 250/300mm blows were recorded. Extensive work on Egyptian western desert collapsible soil was carried out (Abdrabbo & Mahmoud 1988). The authors found that the angle of shearing resistance measured from shear box apparatus, decreases as the molding water content increases, meanwhile the cohesion increases with the increase of the molding water content up to the value of water content corresponding to optimum dry density, then decreases again. The authors also, found that the western desert soil exhibits collapse potential at initial void ratio bigger than 0.45.

Unstable collapsible soils have relative density ranging from 0.1 to 0.9, but for many stable soils they have relative density of 0.70 (Dudley 1970). But, it is misconception when thinking that all soils of low density will exhibit tendency to collapse (Jennings & Knight 1975). The U.S. Bureau of Reclamation (Gibbs & Bara 1967) demonstrated that if the soil exists in void ratio higher than that would exist at the liquid limit, the addition of water would result in collapse settlement. The post-soaked ($\Delta e/\Delta p$) values are independent of initial void ratio, but the pre-soaked values are dependent (Mahmoud & Abdrabbo 1992). The factors affecting the collapse potential of collapsible soil were reported by Abdrabbo & Mahmoud (1988), Mahmoud & Abdrabbo (1992), Houston et al. (1988) and Dudley (1970).

Many researchers reported serious damages that occurred to different types of structures due to collapse settlement (Capps & Hejj 1968) and (Rollins & Rogers 1994). Houston et al. (1988) modified the procedure of double oedometer test developed by Jennings & Knight (1975) to estimate the magnitude of collapse settlement by conducting only one oedometer test. Many researchers made comparison between the output results of implementing the double and single oedometer tests in calculating the collapse settlement of a foundation; general agreement was found (Ismael 1988), (Lawton et al. 1992) and (Basma & Tuncer 1992). Houston et al. (1995) introduced an in-situ collapse test, which is called down-hole collapse test. The test results were used to develop stress-strain relationship of soil.

Basma & Tuncer (1992) developed the following equation to predict the collapse potential (S_c) as,

$$S_c = 48.496 + 0.102\, C_u - 0.457\, W_i - 3.53\, \gamma_d + 2.8 \ln P_w \qquad (1)$$

where C_u = coefficient of uniformity of the soil; W_i = initial moisture content, %; γ_d = dry unit weight in kN/m^3 ; and P_w = pressure at wetting in kN/m^2.

2 TESTING EQUIPMENT AND MATERIALS

A soil bin, used to contain the soil, was made of transparent plastic (perspex) plates; 345 mm side length, 400 mm height and 10 mm thickness connected together using a mixture of perspex powder and chloroform and tied together using steel ties at two levels as shown in Figure 1. The base of the bin was made of a square perspex plate; 365 mm side length and 20 mm thickness. The soil bin was placed on a square steel plate; 340 mm side length, 12mm thickness, which rests on two steel rings; 300 mm diameter, 450 mm height filled with compacted sand. The two rings were placed inside a cylindrical steel rigid container; 750 mm diameter and 600 mm height filled with compacted sand, in order to insure the stability of soil bin during running the test.

A calibrated proving ring, 49 N accuracy, recorded the load applied using a frictionless lever and guiding system. The displacement of the footing was recorded by two dial gauges; 0.01 mm accuracy fixed rigidly to reference beams using magnetic bases. During loading tests, the difference between readings of the two dial gauges, were kept to be within 1 % of the mean value, to accept the test results. The model footing 100 mm in diameter was machined from a steel plate 10 mm thickness. The loads transferred from the lever to the footing, were checked by the principles of static using the lever arm ratio. No appreciable difference what so ever were deserved between the calculated and the measured values. A circular water tank of 200 mm diameter was used to supply the soil bin with water through four plastic pipes. The water was controlled using four water valves, each of 10mm diameter, made from brass, and connected to the bottom side of soil bin symmetrically at equal distance.

The collapsible soil was obtained from New Borg El-Arab city, 60 km to the west of Alexandria city. The soil was dried in an electrical oven at 110 °C for 24 hours then, sieved on 0.425 mm B.S. sieve, the passing material was used. The main characteristics of the soil are shown in Table 1. The laboratory tests on soil are carried out in accordance with ASTM.

The soil bin, Figure 2 was placed and centered at its position with respect to the loading system. Fine gravel layer; 50 mm thickness acts as a filter, was placed and compacted to reach a dry unit weight of 17.56 kN/m^3 and then, covered with a sheet of felt to separate between collapsible soil deposit and the filter layer. The collapsible soil was prepared in six layers, each 50 mm thickness. The weight of dry soil was determined for each layer and compacted to achieve the desired predetermined dry unit weight.

After placing and forming the soil, the footing was placed accurately on the top of soil surface and loaded incrementally up to a predetermined percentage of the failure load. The load was kept constant, and the water allowed to flow to the soil via the four water valves. After water had reached the required level, the water valves were turned off. The water level in the water tank was held constant during the inundation process. The rise of water through the soil was recorded with time, if possible, before and after turning off the water valves. The collapse settlement due to wetting was also, recorded with time during this stage. The load was held constant for 24 hours until full collapse settlement takes place. The vertical load was then increased incrementally using the same procedure before soil inundation up to failure. For each load increment, the settlement of the footing was measured up to the rate of settlement becomes less than 0.005 mm / 20 min for three successive readings. A reference-loading test was conducted on similar soil having zero water content, but without inundation to determine the ultimate load (P_u) of footing-soil system. The ultimate load was defined as the load corresponding to abrupt change in the slope of the load-settlement relationship; presented in logarithmic drawing.

Table 1. Main characteristics of collapsible soil

% passing no 200 sieve	76 %
Effective diameter, D_{10},	0.008 mm
Uniformity coefficient, C_u	5.5
Coefficient of curvature, C_c	2.23
Liquid limit, W_l	30 %
Plastic limit, W_p	21 %
Plasticity index, I_p	9 %
Specific gravity, G_s	2.59
Maximum dry unit weight, γ_{dmax}	16.87 kN/m^3
Optimum moisture content, w_{opt}	21 %

5 COMPARISON OF RESULTS

A comparison between the measured values of collapse settlement from footing models, and the predicted values using the collapse predictive model, developed by Basma & Tuncer (1992) was conducted. The results of this comparison are shown in Table 4. The relationship between R (the ratio of measured collapse settlement/predicted collapse settlement using Equation 1) and (h_d/B) is shown in Figure 8. From this figure, it was found that, the measured collapse settlement is, in general, less than the predicted collapse settlement. But, this ratio increases with the decrease in the dry depth under the footing, and is closer to the measured values when $h_d/B = 0$, i.e. the collapse predictive model developed by Basma & Tuncer is more applicable when the inundation of collapsible soil starting from top surface of soil.

Table 4. Measured and predicted values of collapse settlement

P/P_u	h_d/B	R = measured value/ predicted value
	1.80	0.44
	1.20	0.55
	0.70	0.68
0.25	0.20	0.69
	0.00	0.69
	0.00	0.71
	1.80	0.42
	1.25	0.46
	0.80	0.82
0.50	0.20	0.84
	0.00	0.85
	0.00	0.99

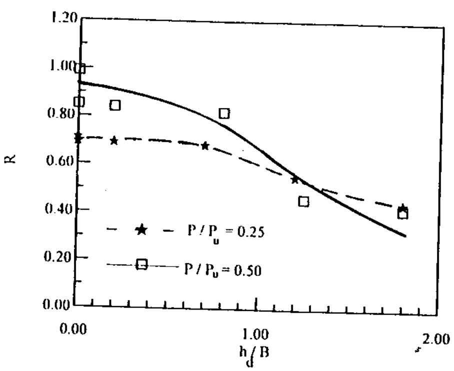

Figure 8. Variation of ratio (R) with (h_d/B)

6 CONCLUSIONS

The following conclusions were drawn from the course of investigation:

1.The collapse settlement increases as the thickness of inundated collapsible soil increases; the load ratio increases and the initial dry unit weight decreases.

2. The collapse settlement at load ratios 0.25 and 0.50 is equal to inappreciable value when the depth of dry soil under the footing is equal nearly to two and half times the footing diameter.

3. Using a sand cushion with thickness equal to twice the footing diameter decreases the collapse settlement significantly.

4. Basma & Tuncer predictive model over estimates the collapse settlement of circular footing resting on collapsible soil and inundated far from foundation level.

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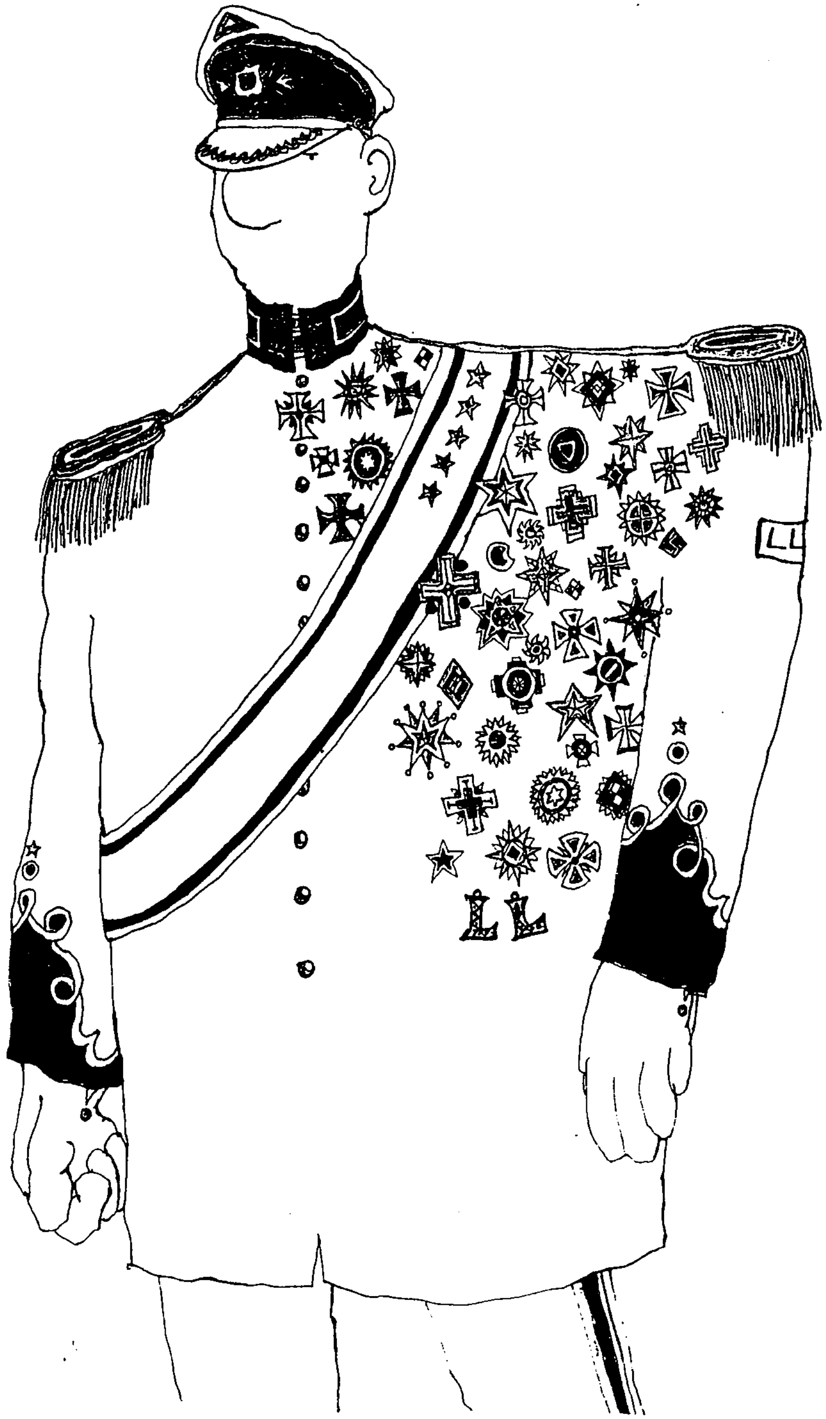

LOESS SLOPE INSTABILITY IN THE LANZHOU REGION, CHINA

INSTABILITEIT VAN LOESS HELLINGEN IN DE LANZHOU REGIO, CHINA

(MET EEN SAMENVATTING IN HET NEDERLANDS)

NEDERLANDSE GEOGRAFISCHE STUDIES / NETHERLANDS GEOGRAPHICAL STUDIES

269 T A DIJKSTRA Loess slope instability in the Lanzhou region, China -- Utrecht 2000: Knag/Faculteit Ruimtelijke Wetenschappen Universiteit Utrecht. 208 pp. ISBN 90-6809-292-8, Dfl 59,50

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DOOR

TOM ANE DIJKSTRA

GEBOREN OP 12 DECEMBER 1962, TE DIEREN (GEM. RHEDEN)

Structure of the thesis

The research project was carried out as part of a larger team endeavour and dissemination of the results has therefore led to the publication of multi-authored papers. A selection of these has been used to form the main textual body of this Thesis.
In **Section 1** the location, research framework and geomorphological problems encountered in the Lanzhou region are introduced.
In **Section 2** the first group of publications focuses on loess as a material with a meta-stable structure and its position among the range of other soil types distinguished by pedologists and engineers. This is illustrated by a short publication that formed one of three presentations at the First International Symposium on Engineering Characteristics of Arid Soils, held in London in July 1993.

Smalley, I.J., Dijkstra, T.A., and C.D.F Rogers (1994), Classification of arid soils for specific purposes, pp. 145-152. Reprinted from: Engineering Characteristics of Arid Soils - Proceedings of the 1st International Symposium, London, 6-7 Jul 1993. Fookes, P.G. and R.H.G. Parry, eds, 90 5410 365 5, 1994, 25cm, 450 pp. EUR. 93.50 / US$110.00 / GBP66.00. A.A. Balkema, P.O.Box 1675, Rotterdam, Netherlands (fax: +31.10.413-5947; e-mail: sales@balkema.nl).

he two following papers approach the meta-stable nature of loess deposits from a ıcking perspective. The first of these forms a literature review on loess collapse, scussing in detail the most influential contributions and identifying the major problems ıd research strategies that are associated with collapse mechanisms of loess deposits. In e second paper the concept of open packing formation is presented and the transitions ɔm random loose to close particle packings are emphasised.

Rogers, C.D.F., Dijkstra, T.A. and I.J. Smalley (1994), Hydroconsolidation and subsidence of loess: studies from China, Russia, North America and Europe. Engineering Geology, 37, pp. 83-113. Copyright (1994), with permission from Elsevier Science.

Dijkstra, T.A.. Smalley, I.J. and C.D.F. Rogers (1995), Particle packing in loess deposits and the problem of structure collapse and hydroconsolidation. Engineering Geology, 40, pp. 49-64. Copyright (1995), with permission from Elsevier Science.

:tion 3 comprises a short introduction and three research publications that deal with broad geomorphological framework, paying attention to geomorphological :sholds, landslide distribution and classification, and neotectonic influences. The first er was presented at a meeting of the British Geomorphological Research Group ion at the Annual Conference of the Institute of British Geographers at the University Sheffield in 1991. It serves as an introduction into the physical geography of the on, the range of loess mass movements and their effect on human activities.

'erbyshire, E., Dijkstra, T.A., Billard, A., Muxart, T., Smalley, I.J. and Y.J. Li (1993), hresholds in a sensitive landscape: the loess region of Central China. In: Thomas, D.S.G. ıd R.J. Allison, eds., Landscape sensitivity. Copyright John Wiley and Sons, pp. 97-127. eproduced with permission.

The second paper of this section was recently presented at a conference in Xi'an on landslide hazard mapping and analysis and has a section that deals with landslide classification and distribution. It is only this particular section (pages 44-55) that has been reproduced here.

Derbyshire, E., Meng, X.M. and T.A. Dijkstra (1997), Landslides in the Lanzhou region, Gansu Province, China. In: Sassa, K. (ed.) International Symposium on Landslide Hazard Assessment. International Union of Geological Sciences publication, Kyoto University, Japan, pp. 41-55. (Reproduced with permission).

In the final paper of this Section the geological framework of the Lanzhou region is discussed and a series of examples is given of major loess mass movements triggered by earthquakes. This paper was presented at a Quaternary Research Association meeting at the Geological Society in London in 1992.

Dijkstra, T.A., Derbyshire, E. and X.M. Meng (1993). Neotectonics and mass movements in the loess of North-Central China. In: Owen, L.A., Stewart, I. and C. Vita-Finzi, eds., Neotectonics: Recent Advances. Quaternary Proceedings, 3, Quaternary Research Association, Cambridge, pp. 93-110. Copyright John Wileys & Sons Limited, reproduced with permission.

In **Section 4** the three selected papers discuss in greater detail the geotechnical properties of the Lanzhou loess as determined through both *in situ* and laboratory tests. The first contribution is adapted from two chapters (5 and 7) from a book, only very recently published, that provides a comprehensive overview of the results obtained during the European - Chinese joint research project. Together with the Engineering Geology publication, these two publications discuss in detail the results of the geotechnical testing programme providing some evaluations of the importance of these findings for the analysis of loess slope instability. The Section concludes with a paper on the analysis of particularly common types of mass movement in the Lanzhou region: cutslopes and terrace edge failures.

Dijkstra T.A., Rappange F.E., van Asch T.W.J., Li Y.J. and B.X. Li (2000), Laboratory and in situ shear strength parameters of Lanzhou loess. In: Derbyshire, E., Meng, X.M. and T.A. Dijkstra, eds., Landslides in the thick loess terrain of northwest China: Mechanisms and mitigation. Copyright John Wileys and Sons, Ltd. Chichester, 288p. Reproduced with permission.

Dijkstra, T.A., Rogers, C.D.F., Smalley, I.J., Derbyshire, E., Li, Y.J. and X.M. Meng (1994), The loess of north-central China: Geotechnical properties and their relation to slope stability. Engineering Geology, 36, pp. 153-171. Copyright (1994), with permission from Elsevier Science.

Dijkstra, T.A., Rogers, C.D.F. and T.W.J. van Asch (1995), Cut slope and terrace edge failures in Malan loess, Lanzhou, PR China. Proceedings of the XI ECSMFE conference, Copenhagen 1995, Volume 7, pp. 61-67. (Reproduced with permission)

Finally, **Section 5** concludes with summaries of the thesis in English and in Dutch.

Environmental Geoscience, Vol. 2, No. 1, 1999, pp. 92–100.

SOIL AND ROCK ENGINEERING

The Maximum Thickness of Collapsible Loess Rocks

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Received December 5, 1996

Abstract—The analysis of new experimental data indicates that the maximum thickness of collapsible loess rocks reaches 50–55 m. The upper five or six cycles of loess massifs can show collapsible properties. Loess horizons, buried soils, and pedocomplexes are collapsible in this massif section.

INTRODUCTION

Collapsibility is the characteristic engineering-geological property of loesses, defined as their deformability on wetting under load when affected by natural or engineering factors. The present-day concept implies that rocks of various genesis may acquire this property either immediately during accumulation and recent subaerial diagenesis of silts under arid conditions (syngenetic collapsibility) or in the course of progressive lithogenesis of young deposits under subaerial conditions and hypergene (including cryoeluvial) decompaction of rocks of different age and origin (epigenetic collapsibility) [13, 14].

As is noted in a number of reviews [3, 6, 8, 10, 12], the thickness of collapsible loess massif does not usually exceed 10–30 m in Northern Eurasia. In the great bulk of the regions in Russia, Ukraine, and Kazakhstan, it reaches 10–15 m. The massifs with thicker collapsible zones (up to 35–40 m) are found in a number of areas in Central Asia and Ciscaucasia.

Kriger, who generalized the data on the loess collapsibility and the cyclic structure of loess massifs, noted that "in Central Asia, Ciscaucasia, the Russian Plain, and southern Western Siberia, C is observed in rock not deeper than the first fossil-soil horizon (20–25 ka old, the roof mainly occurring at a depth of 10–20 m) and, more rarely, not deeper than the second fossil soil (80–100 ka old, the roof lying mainly at a depth of 20–35 m)" [7].[1]

The most comprehensive data on the spatial distribution of collapsible loess thickness are presented on *Prediction Map of Collapsibility in the Areas Covered with Loess in the USSR* of a scale 1 : 2500000 [6, 10]. However, this map does not subdivide further the collapsible sediments with thickness exceeding 20 m, although these are the massifs of the greatest interest in respect to this discussion.

LITERATURE DATA ON THE MAXIMUM THICKNESS OF COLLAPSIBLE LOESSES

In the European part of Northern Eurasia, the maximum thickness of collapsible loess massifs is noted in southern Ukraine and Ciscaucasia. In particular, Bykov *et al.* wrote in comments on the above-mentioned map: "However, it should be pointed out that the thickness of collapsible loess can reach 30–40 m and more in many regions, for example, in eastern Ciscaucasia (near Georgievsk and in the Alkhanchurt valley), southern Tajikistan (within the leveled mountain peneplains), and in the southern periglacial plains of European Russia (in the vicinity of Zaporozh'e, Dnepropetrovsk, etc.)" [10].

Galai points to even greater collapsible loess thickness in eastern Ciscaucasia [3]. According to his assessments, the thickness of the collapsible massif ranges from 20 to 60 m within the interfluvial plains of the eastern and northeastern Stavropol region (Budennovsk, Stepnoe, Novozavedennoe, and Otkaznoe).

More comprehensive data have been published on the very thick collapsible part of the loess massifs in Central Asia. Specifically, a great thickness (40 m) is noted within the Gyaur massif [1].

The areas with highly collapsible thick loess have been discovered in the northeastern and eastern Karshi steppe. These areas are described as the "proluvial, rolling, dissected plain composed of the Karnab proluvial loesses.[2] This region includes mainly separate interfluvial zones between the valleys of the Kashkardarya River and the dry channel of the Kumdarya River. The collapsible massif thickness reaches 35–40 m" [9].

Kadyrov published interesting data on the thick loess sediments in the Tashkent region [5]. According to his assessment, the maximum thickness of loesses collapsible under natural load is more than 50 m. "The relative collapsibility coefficient of some samples, taken from a depth of 31–33 m in Tashkent region, was 0.07–7.1.... "According to the data of Shermatov (1971), the relative collapsibility coefficient of loess-

[1] C stands for "genuine collapsibility," defined by Kriger as the capacity of rock to compact on wetting in the natural stress state [7].

[2] These sediments are of Middle Quaternary age.

like sediments occurring near Zarkent (Tashkent region) at a depth of 41 m was 0.0572" [5].

Thick collapsible massifs are also found in the Gissar–Surkhandarya depression. According to the data of Zhumangulov, the Imak, Middle Quaternary, proluvial, loess sediments, collapsible to a depth of 40 m, occur in the adyrs (low foothills bordering the Fergana depression) and high terraces dissected by deep ravines and gullies [4].

Skvaletskii provides more comprehensive and specific data on the thick collapsible loesses [11, 12] found in Tajikistan. He proves that the upper three cycles (up to the third buried soil horizon) of the Dushanbe loess sediments (the upper Pleistocene) are collapsible under the natural load. These sediments are 39–41 m thick at the piedmont trains and high terraces. These collapsible massifs are found in the Yavan valley and on the Alimtai, Urtaboz, and Tashrabad plateaus.

Kriger *et al.* present somewhat higher figures of collapsible-massif thickness in the Yavan valley. "The studies performed in the Yavan valley show that the collapsible massif thickness may reach 40–45 m at a moisture of the stable paragenetic complex" [8].

THE NEW DATA ON THE MAXIMUM THICKNESS OF COLLAPSIBLE LOESS SEDIMENTS OBTAINED FROM THE STUDY OF KEY ENGINEERING GEOLOGICAL SECTIONS

Between 1986 and 1990, the Production and Research Institute for Engineering Survey in Construction (PNIIIS), the USSR State Construction Committee, the Geological Department of Moscow State University, institutes of academies of sciences of the Soviet Union and several republics, many higher institutes of learning, and regional survey organizations in seven republics of the Soviet Union, worked on "Rational economic development (use) of areas covered by collapsible sediments." The engineering geological investigation of the key sections of collapsible loesses in the Soviet Union appeared to be the most significant part of this problem [16].

The new evidence on the thickness of both loess massifs and their collapsible sections was obtained in the course of these studies. The greatest thickness was established for the key sites in the Northern Caucasus, Tashkent, and southern Tajik regions. The maximum thickness of loesses exceeded 100 and 200 m in single sections of the Northern Caucasus (the Otkaznoe key site) and in the Southern Tajik Depression, respectively. The thickness of collapsible loess massifs also turned out to be higher than earlier believed. For example, its maximum value far exceeded 40 m under the natural load in the Otkaznoe key site. The collapsible sediments of similar thickness are observed in the Adyr key site in the Southern Tajik Depression. As was mentioned earlier [16], we consider this fact to be a discovery in engineering geology of loess formations. However, it is not yet elucidated in the literature. Let us compensate for this gap.

The Otkaznoe key site is located close to Otkaznoe in the Stavropol region. It partially occupies the Kuma River valley and the watershed plateau between this river and the Mokryi Karamak and Gor'kaya Balka rivers. The altitudes range from 246 to 156 m. This area belongs to the Terek–Kuma Plain between two major geological structures of Ciscaucasia: the Stavropol Uplift in the west and the Caspian Depression in the east.

The studies performed by Bortnikov, Galai, Fainer, Udartsev, and other geologists between 1986 and 1989 proved that the maximum thickness of loesses in this region reaches nearly 140 m. These sediments overlie the Akchagyl marine sediments with erosional unconformity. Two complexes are distinguished within this massif. The lower complex (45 m thick) includes three cycles, each consisting of silty loam and brown buried soil horizons. Udartsev considers that this loess massif section, which shows the reverse magnetization to the Matuyam rocks, is composed of Eopleistocene sediments. These sediments are currently water-saturated and in terms of engineering geology should be regarded as clays rather than loesses [15].

The 90-m-thick upper complex consists of nine Pleistocene and Holocene cycles, containing 26 loesses and soil horizons, according to Udartsev. They are composed of silty sandy loams and loams (loesses and loess-like loams according to Morozov). The paleomagnetic studies proved that almost the entire complex (the upper 80 m) is characterized by the direct magnetization of the Brunese age.

The data obtained from 72-m-deep C-1 Borehole drilled by the Stavropol TISIZ (Trust for Engineering and Construction Survey) at the watershed plateau on the right bank of the Kuma River (at an altitude of 245.55 m) appear to be of primary interest to engineering geologists. This borehole reveals five loess cycles occurring to a depth of 50 m (Fig. 1). The upper cycle is crowned by the recent soil, and the underlying cycles are overlain by the buried soil horizons (pedocomplexes, as a rule). The first (upper) cycle (of thickness 13.8 m) is composed of the Holocene–Upper Pleistocene sediments. The second (8.5 m), third (9.8 m), fourth (9.9 m), and fifth (above 9 m) cycles are dated as the Upper, Upper–Middle, and Middle Pleistocene respectively. According to Udartsev, these cycles are crowned by the Holocene pedocomplex, the indistinctly pronounced Bryansk buried soil, and the Mezen, Ramensk, and Kamensk pedocomplexes, respectively.

The loess sediments in this section are predominantly represented by the dry, dusty, heavy sandy loam, loess, and loess-dry, silty, light loams, loesses, and loess-like loams. Their study shows that the collapsibility is typical of all elements in the upper five loess cycles, including the buried soils (Fig. 1a, Table 1). The

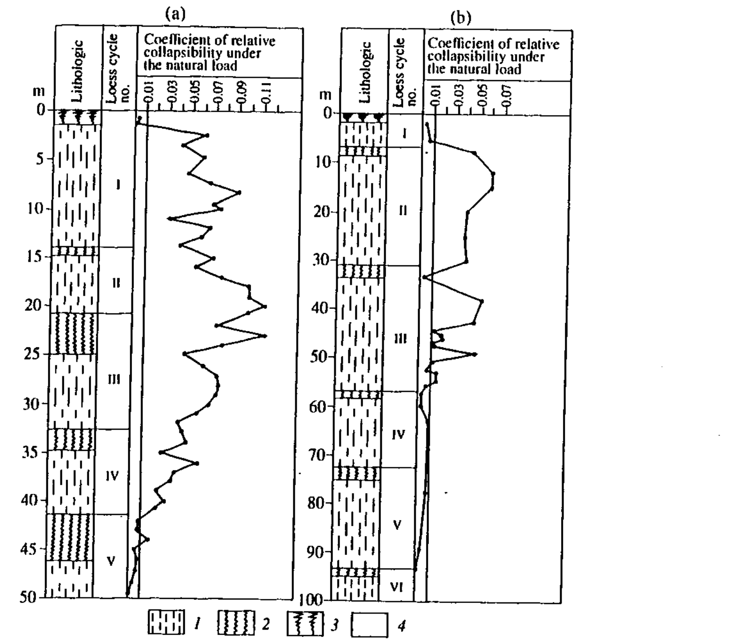

Fig. 1. Distribution of relative collapsibility coefficient of loess sediments in the section of (a) Borehole C-1 at the Otkaznoe site and (b) Borehole 100 M in the vicinity of Budennovsk (the data by Galai): (*1*) loesses, silty sandy loams, and light and ordinary loams; (*2*) buried soil and pedocomplexes of a predominantly loamy composition; (*3*) recent soil of a loamy composition; (*4*) sandy–gravel–shingle.

collapsible loess massif is extraordinarily thick: loesses and paleosoils are *formally* collapsible under the natural load and a load of 0.3 MPa to a depth of 44 (the relative collapsibility coefficient is 0.015) and 30.5 m, respectively; the rated total collapse under natural load is 225 cm.

To a depth of 41 m, the relative collapsibility coefficient under the natural load is 0.021–0.0112 and 0.029–0.112 for the loesses and paleosoils, respectively. Under this load, the maximum collapsibility is typical of the sediments in the first, second, and third cycles. The collapsibility is a maximum (0.09–0.112) in the lower part of the second cycle and in the upper part of the third cycle (the Mezensk pedocomplex). It decreases gradually to 0.021, 0.015, and 0 at depths of 41, 44, and 49.75 m, respectively (Fig. 1a, Table 1).

It is worth noting that Galai also studied the collapsibility of this loess massif to a depth of 62.5 m (at greater depths, the sediments become considerably compacted and moistened). Judging from the unpublished data, which were kindly submitted by Galai, he obtained values of the relative collapsibility coefficient that were virtually the same as those presented in Table 1. The maximum values (0.095–0.112) were obtained at the same depths and for the same structural elements. However, the following significant discrepancy was noted: the collapsible loess sediments allegedly occurred to a depth of 42 m, where the relative collapsibility coefficient was equal to 0.01. According to these data, this parameter was 0.08 and 0.002–0.004 at depths of 44 and 49 m, respectively. As in Table 1, it was equal to zero at a depth of 49.5 m. This value ranged from 0.001 to 0.003 in the interval from 50 to 62.5 m.

The results obtained by Galai for the collapsibility of the 100-m-thick loess massif in the vicinity of Budennovsk (the key stratigraphic section [2]) appear to be similarly timely. As follows from Table 1 and Fig. 1b, the loess is formally collapsible under the natural load to a depth of 55 m (almost to the bottom of the third cycle). At greater depths, in the fourth and fifth cycles, the relative collapsibility coefficient varies from 0.001 to 0.009.

The thick collapsible loess massifs are also found in the Tashkent region (Uzbekistan). There, the experts of

Table 2. (Contd.)

Borehole III-2/C-I						Borehole C-2KU					
Depth, m	Natural moisture content, %	Skeletal density, g/cm³	Porosity, %	Natural load, MPa	Relative collapsibility under natural load	Depth, m	Natural moisture content, %	Skeletal density, g/cm³	Porosity, %	Natural load, MPa	Relative collapsibility under natural load
15.7	13	1.52	43	–	0.106	39.5	15	1.62	40	0.668	0.031
16.0	13	1.50	44	0.31	0.031	40.5	9	1.75	35	0.687	0.033
16.7	12	1.53	43	–	0.056	41.5	7	1.70	37	0.705	0.039
17.0	11	1.48	45	0.33	0.021	42.5	11	1.73	36	0.724	0.017
17.7	12	1.51	44	–	0.090	43.5	13	1.67	38	0.742	0.006
18.0	9	1.46	46	0.36	0.089	44.5	11	1.67	38	0.761	0.008
18.7	11	1.49	44	–	0.160	45.5	13	1.63	39	0.778	0.007
19.0	10	1.41	47	0.37	0.040	46.5	7	1.73	36	0.798	0.008
19.7	9	1.46	46	–	0.138	47.5	10	1.52	44	0.815	0.006
20.0	9	1.47	45	0.39	0.043	48.5	9	1.66	39	0.833	0.007
22.0	8	1.42	47	0.43	0.229	49.5	8	1.69	38	0.851	0.007
25.0	2	1.50	45	0.49	0.129	50.5	8	1.64	39	0.869	0.006
26.0	5	1.64	39	0.51	0.085	51.5	8	1.70	37	0.887	0.006
29.0	2	1.56	42	0.57	0.090	52.5	5	1.66	39	0.905	0.008
32.0	2	1.56	42	0.63	0.106	53.5	7	1.76	35	0.924	0.005
34.0	9	1.62	40	0.67	0.031	54.5	9	1.71	37	0.942	0.005
37.0	8	1.47	45	0.73	0.096	55.5	9	1.64	39	0.960	0.006
39.0	8	1.47	45	–	–						

predominant in this section. Dispersed gypsum is encountered everywhere. The natural moisture of the sediments is 5–8% to a depth of 40 m; lower down, it increases sharply and reaches 22% at a depth of 46 m. The loess porosity is high (45–53%), and it is less than 50% in the lower section (deeper than 35 m).

All four cycles of loess sediments turned out to be collapsible in this massif. The lower boundary of collapsibility under natural load is at a depth of 45 m (the relative collapsibility coefficient is 0.01). This coefficient was equal to zero at a depth of 46 m.

The relative collapsibility coefficient (under the natural load) abruptly rises to a depth of 20–26 m; at greater depths, it falls in a similar way. Both loess components of cycles and buried soils exhibit collapsibility (the relative collapsibility coefficient of the first buried soil horizon (occurring at a depth of 7.1–8.0 m) is 0.046, that of the second horizon (9.3–10.7 m) is equal to 0.047, and that of the third (35.0–36.4 m) is 0.024).

The relative collapsibility coefficient amounts to 0.006–0.036 in the upper cycle (7.0-m-thick). It is equal to 0.020–0.046 and 0.02–0.085 in the second (2.2-m-thick) and third (25.8-m-thick) cycles, respectively, and falls to 0.00–0.05 in the fourth cycle (with an observed thickness of 13 m). This parameter is maximum (0.05–0.085) at a depth of 8–37 m.

The third region with the abnormally thick collapsible loesses is found in the eastern Dushanbe area. The *Adyr key site* is situated within the Southern Tajik Depression (the Dushanbe Depression). It covers the adyr zone at the southern slopes of the Gissar ridge and is bounded by the Tintak aryk (irrigation ditch), Shuroskai Creek, and lower reaches of the Kafirnigan River in the west, east, and south, respectively.

The study of loess sediments in this area, performed by Dodonov, Kim, Oripov, Skvaletskii, and the expert from TajikGIINTIZ, proved that the maximum thickness of this loess massif exceeds 200 m. Two complexes are distinguished within this massif. The lower complex, referred to the Eopleistocene Kairubak Formation, is composed of the noncollapsible compacted loesses with the buried soil horizons. The upper complex includes up to 12–13 loess cycles of the Pleistocene and Pleistocene–Holocene age, each (except for the uppermost cycle) including both loess horizon and overlying buried pedocomplex (or buried soil).

Borehole C-2KU (with initial and final drilling diameters of 426 and 219 mm, respectively), drilled at this key site within the watershed plateau (at an altitude of 1020 m), reveals 12 loess cycles (dated as the Middle–Late Pleistocene) and crowned by the Holocene soil. The geologists from TajikGIINTIZ refer cycle 1 to the Holocene and Upper Pleistocene, cycles 2–5 to the Upper Pleistocene, and cycles 6–11 to the Middle Pleistocene. The underlying loess sediments are dated as the Early Pleistocene. These loess sediments are chiefly of proluvial or alluvial–proluvial genesis.

Lithologically, all cycles are represented by silty sandy loams, loesses, and light or ordinary loess-like loams. The buried-soil horizons are mainly composed of brown silty loams.

The engineering geologists from TajikGIINTIZ studied the collapsibility of these sediments and discovered that the soils of the upper five cycles are collapsible under the natural load. The lower boundary of the collapsible massif is conventionally positioned at a depth of 43 m (with the natural load of 0.73 MPa and the relative collapsibility coefficient of 0.012), although the soils with the relative collapsibility coefficient varying from 0.005 to 0.008 occur below this boundary to a depth of 55.5 m (Fig. 2b, Table 2). Under the additional load, the thickness of collapsible sediments would reach this amazing value.

The relative collapsibility coefficient varies significantly across the section (from 0.001–0.005 to 0.03–0.076) (Table 2). It attains a maximum (up to 0.045–0.076) at depths of 6.5–10.5 and decreases to 0.018, 0.029, and 0.032–0.039 at depths of 16.5, 26.5, and 37.5–41.5 m, respectively. Under the combined impact of natural and additional (0.3 MPa) loads, the relative collapsibility coefficient amounts to 0.012–0.134 in the upper 25 m of the massif.

It is worth noting that Borehole C-4* of depth 130 m, drilled previously by TajikGIINTIZ at altitudes of 830.0 m within the same key site, also revealed the thick massif of the Upper Pleistocene collapsible sediments. At a depth of 36 m, the relative collapsibility coefficient was found to be equal to 0.01 under the natural load, and it varied within 0.003–0.007 to a depth of 40 m. Its maximum values (0.011–0.046) were confined to the upper 20-m-thick horizon.

CONCLUSIONS

The results obtained allow us to draw the following significant conclusions:

(1) The maximum thickness of the collapsible loess massifs can be much greater (up to 50–55 m) than considered previously. This fact appears to constitute a discovery in the engineering geology of loesses.

(2) Contrary to the popular viewpoint [7, 12], the collapsibility is typical not only of the upper two or three loess cycles but also of underlying cycles. The upper five cycles of loess sediments showed collapsibility in the loess massifs at the Otkaznoe and Adyr key sites, and even six cycles were collapsible at the Chirchik key site.

(3) At the key sites studied, both loess and buried soils exhibit collapsible properties. In many respects, this contradicts the opinion widespread among engineering geologists (Sergeev, Minervin, etc.) that buried soil horizons are noncollapsible.

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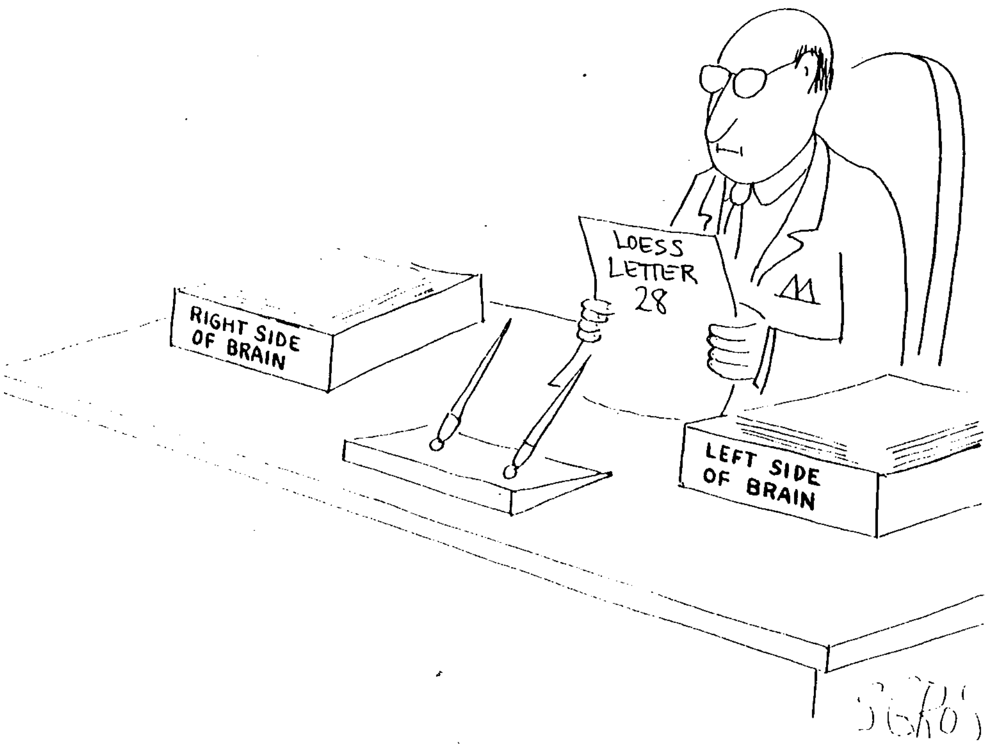

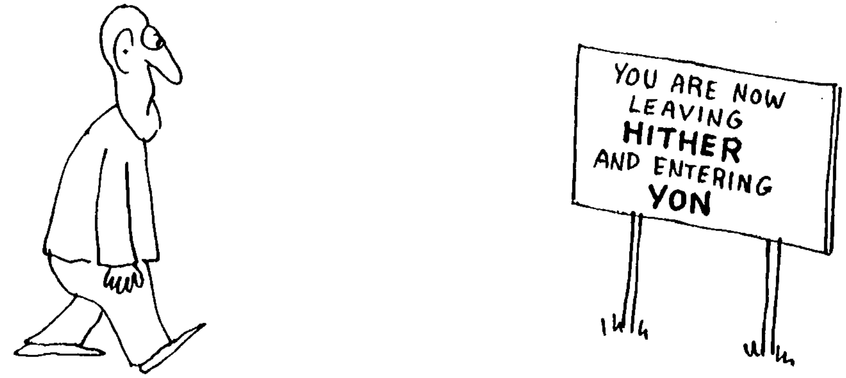

Loess field trip II

S.GROS

ПОЧВОВЕДЕНИЕ

On the Importance of International Communication in Soil Science

D. H. Yaalon

This article is dedicated to the celebration of the 100th anniversary of the founding of *Pochvovedenie*, the first scientific journal entirely devoted to soil science. The year 1899 is also significant for the appearance of the first edition of the textbook *Pochvovedenie* (Soil Science) by N.M. Sibirtzev, presenting details of Dokuchaev's concepts of the genetic soil types and an outline of their classification in Russia. In the United States of America, 1899 marks the beginning of the federally supported systematic soil survey at a detailed scale. A comparison with the current situation is made and the need for better international communication in soil science is stressed.

ПОЧВОВЕДЕНИЕ № 1 1999

Introduction

Soil science and the study of soils had a relatively uncomplicated history without great controversies. It had only a few significant paradigm shifts and was not much in the public's eye, which some recent books attempt to remedy [1, 3, 14]. In books on agriculture written by ancient and classical scholars only a small amount of space was devoted to soils, their characteristics and management. Much later, from the 18th century, more attention was paid to soils, their nature, soil management and fertility, as books dealing with these topics began to appear in several languages in Europe, summarising advise to farmers and developers on the best agricultural practices. During the 19th century scientific observations and analyses of soil began to be published also in almanacs and agricultural journals.

The specific study of soils as an independent object of study in its own right - pedology, including its applied aspects of soil productivity and soil management, is thus a relatively young science. Results of surveys, analyses and research began to be published in scientific journals in the second half of the 19th century. Beginning with the last three decades of the 19th century, the Russian school of V.V. Dokuchaev and his followers has contributed most significantly to the basic concepts of soil genesis [5, 15].

Pochvovedenie, the first journal entirely devoted to current scientific research results in soil science was founded in 1899 and continuously published since, an honor not shared by many scientific journals. Apart from being the main soil science journal in Russia it became a leading international soil journal, now again fully translated also into English. In the following I would like to discuss in a broader context the significance of this landmark and of two other landmark occasions of one hundred years ago, together with some observations and thoughts on the current state of inter-regional communication in soil science and some suggestions how to improve it.

One hundred years ago

The year 1899, when the new journal Pochvovedenie was founded and first edited by P.V. Ototzki, followed for many years by A.A. Yarilov, was remarkable also in two other ways.

The first edition of N.M. Sibirtzev's textbook Pochvovedenie (Soil Science) was published in 1899 (in Warsaw). In it he expounded and systematized Dokuchaev's concept that genetic soil types correspond to a definite combination of soil forming agents (factors) This and later editions of Sibirtzev's book [8], the holder of the first chair in pedology at the Novo-Aleksandrov Agricultural Institute of Agronomy and Forestry in Pulavy (now Poland), became most influential in spreading the new pedological concepts, as Dokuchaev himself did not produce a general soil textbook. Subsequently other, equally pedologically oriented textbooks became influential in training new generations of soil scientists.

In the United States of America the year 1899 is an important milestone in that it marks the initiation by the US Department of Agriculture, Division of Agricultural Soils (later Soil Survey Division of the Bureau of Soils) of federally supported systematic soil surveys on a large scale (1:63,000 or better) with the aim of showing the distribution of local soil types (later 'soil series'), at that time mainly differentiated by texture and geological substrate properties [6, 9, 10]. In subsequent years the Soil Survey Division employed several hundred soil surveyors in all states of America. The soil series concept became refined, including the full soil profile. It permitted a better evaluation of the regional soil inventory, helped to devise a taxonomy based on observed properties and especially enabled improved soil management practices for the benefit of the soil users. Though the preparation of a soil survey inventory is not cutting edge research, it is an essential foundation for it with a high subsequent impact.

Modern earth science is based on collecting detailed and systematic observations, both in the field and in the laboratory, supported by experimentation, followed by data organization and their interpretation, and finally presenting results to a wider audience. Any research is not completed before it is published in a generally available form and eventually, when significant, entering the store of general knowledge in reviews, monographs and textbooks. Thus it seems that one hundred years ago, in 1899, two widely separate countries initiated appropriate and significant examples for three of these major aspects, albeit to be greatly expanded and developed in subsequent years: the collection and evaluation of field data (detailed soil survey), presenting results of research (journal Pochvovedenie), and the spread of syntheses and generalizations (monographs and textbook). Much has been built on and developed from these early foundations.

The current situation

At present over 5000 soil science publications appear each year in a variety of languages, mostly in English (~70%), in a large number of scientific journals and in specific thematic publications covering all fields of soil science. Pedology is indeed recognized as an independent science of soil bodies, closely connected to a number of related basic earth and bio-sciences and significant in various applied sciences besides agriculture [13]. It is taught as such at colleges and universities, requiring continuously up-to-date textbooks listing the most recent advances.

Apart from Pochvovedenie, there is now a large number of national and international journals specializing in soil science [7, 12], about 30 being most important in publishing the more frequently cited research results. Over 100 significant monographs and textbooks related to soil science are being published annually in several languages. Soil surveys are now being carried out on a regular basis in practically all countries of the world. Though generally applying much more sophisticated procedures, the detailed field survey has remained its mainstay.

National characteristics and local or language preferences were always a major obstacle in the international communication of soil science. In the early 1960's, some 23% of all internationally recorded soil research papers were published in the Soviet Union [11]. How this proportion has changed recently has not been estimated. Though Russia continues to boast a number of outstanding soil scientists and Pochvovedenie continues to be among the leading soil science journals, it must be acknowledged that Russia lost its leading role in soil science long ago. During the Soviet period it was mostly because of the politization of the scientific enterprise and forced isolation of its young scientists from overseas contacts [4]. Currently it is strongly handicapped by outdated equipment, inadequate access to foreign publications and the language barrier.

Russian publications rarely cite non-russian research, which unfortunately is reciprocated in American or European publications. We are still largely separated by language and reading habits, just like in Dokuchaev-Sibirtzev and Hilgard times when the landmark pedological paradigms were first published in Russia and the USA, respectively, without sufficient interaction among them [2, 5]. A major effort is needed to overcome this.

The need for better communication

During the last 40 years **Pochvovedenie** was translated first in total, later only selected papers of it, together with other translated research articles in the journal **Eurasian** (previously **Soviet**) **Soil Science**. Because of translation delays and the large costs of overseas professional translation this entreprise was in danger of folding, but was now taken over by a Russian publishing company for simultaneous publishing of the Russian and English editions. Hopefully this situation will endure.

However, it seems also imperative that Russian soil scientists publish directly, like some East European, Chinese, South American and other soil scientists, significant research results in Western language journals which now lead this topic. Since the publication requirements of these are generally high and vary considerably from the Russian practice, young scientists ought to be trained not only in the use of modern equipment and research methodology, but also in the rather strict and demanding ways of presenting research results, separate from interpretations and discussions and fully documented by comprehensive citations of previous and/or relevant literature. At the same time, Russian publications publishing research of more general intererst need to include longer, informative English-language abstracts. The preparation of these abstracts or summaries by the authors themselves is excellent training in concise and clear writing. As a result, non-Rssian authors will hopefully become better acquainted with Russian soil research.

In a world which only recently became conscious of the limitations of natural resources including soils, and the often irreversible damaging effects on the environment brought about by humans, basic and applied studies involving soils will increase in importance. We should aim at, besides the inevitable and needed local problem solving research, to have more soil science communication internationally, accessible and relevant.

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LOESS LETTER 44

INQUA Loess Commission
IAEG Collapsing Soils Commission
NTU GeoHazards Group
DIRTMAP 2000

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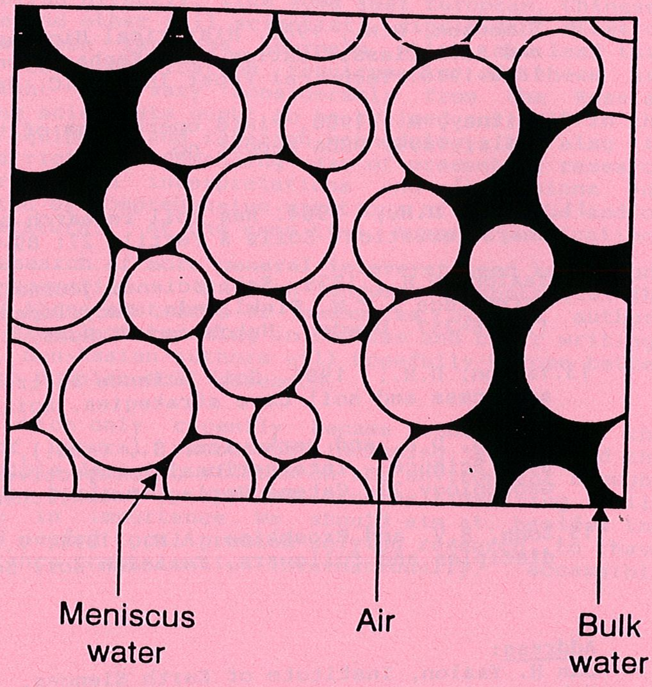

Fig.5: Schematic representation of bulk water and meniscus water within an unsaturated soil (after Karube et al. (1995) and Kato et al. (1995)).

The component S_{ro}, representing the volume