THE VARIATION OF THE GRADING ENTROPY DUE TO SOIL DEGRADATION IN SOME LABORATORY TESTS

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ABSTRACT

The grading entropy of a soil [*S*] is derived in terms of the more general concept of statistical entropy. It consists of two terms: the base entropy [S_o], arising from the difference in the width of the statistical cells in the conventional grading curve, and the entropy increment [ΔS]. The goal of the research is to study which grading entropy plays the role of the "true" entropy in a thermodynamic sense (i.e. undergoes an increase during the crushing process being considered as an irreversible thermodynamic process): the entropy increment [ΔS] or the sum of the base entropy and the entropy increment [*S*]. The soil samples are subjected to some crushing tests and direct shear test. The grading curve and the grading entropy are determined before and after each test. It is found that only the entropy increment [ΔS] increases in the tests.

INTRODUCTION

The grading entropy of soils can be calculated on the basis of the formula known from theory or probability or from theory of information (Lorincz [1], [2]). The grading curve is a statistical distribution curve where the probability is in the function of the diameter [*d*] of the particles. The fractions are the grains "passing through one hole size, but retained by the next". The following equality can be written for the measured relative frequencies x_i of the fractions:

$$\sum_{i=1}^{N} x_i = 1; x_i \geq 0 \tag{1}$$

where N is the number of fractions comprised between the finest and coarsest ones.

The sieve hole diameters are usually incremented by a multiplication factor of 2 (e.g. 0.5 mm, 1mm, 2mm 4mm etc) since d may vary across several orders of magnitude.

The minimum grain diameter [d_{min}] is equal to the height of the SiO_4 tetrahedron, 2^{-22} mm (Imre [3]). The fractions are numbered by increasing integers starting from 0 (Table 1). The limiting *d* values for the *i*-th fraction in terms of d_{min} can be calculated as follows:

$$2^{i+1} d_{min} \geq d > 2^{i} d_{min} \tag{2}$$

Table 1. Properties of the fractions

Fraction	0	...	22	23	24
D [mm]	2^{-22}-2^{-21}		1-2	2-4	4-8
S_0 [-]	0		22	23	24

The derivation is ended in the sum of two terms: the base entropy S_0 and, the entropy increment ΔS due to the mixing of the fractions:

$$S = S_0 + \Delta S \qquad (3)$$

$$S_0 = \sum_{i=1}^{N} x_i S_{0i} \qquad (4)$$

$$\Delta S = -\frac{1}{\ln 2} \sum_{i=1}^{N} x_i \ln x_i \qquad (5)$$

where S_{0i} is the eigenentropy of the i-th fraction (Table 1). The grading curves can be represented by a single point in the following normalised coordinate system:

$$A = \frac{S_o - S_{o\,min}}{S_{o\,max} - S_{o\,min}} = \frac{\sum_{i=1}^{N} x_i (i-1)}{N-1} \qquad (6)$$

$$B = \Delta S / \ln(N) = \left(-\frac{1}{\ln 2} \sum_{i=0}^{N} x_i \ln x_i \right) / \ln(N) \qquad (7)$$

where A is the relative base entropy, B is the normalised entropy increment. The admissible points form a compact set in the 2D space of A and B. The aim of the ongoing research is to examine the entropy path of some laboratory tests in this graph.

METHODS, FIRST RESULTS

In the first part of the research (Lorincz et al, 2004) some soil samples were subjected to successive crushing treatments, the grading curve and the grading entropy were determined after each treatment. It was found that only the entropy increment (ΔS) increased monotonically with an increasing number of crushing-treatments. Therefore, in the ultimate state - characterised by maximum entropy increment (ΔS) - the relative frequencies of the fractions are equal.

In this part of the research some crushing and direct shear tests are made and, the grading curve and the grading entropy are determined before and after the tests. Two examples are shown in the following.

Crushing test, wet compaction

Results are shown in Table 2, Figures 1, 2. According to the results, the normalised entropy increment B increases, the relative base entropy A decreases.

Table 2. Entropy coordinates in the crushing test

	A [-]	B [-]
initial	0.77705	1.067783
final	0.701289	1.194772

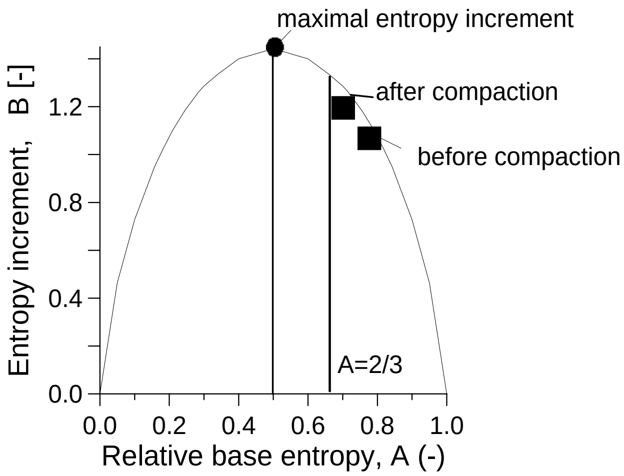

Figure 1. Entropy coordinates in a crushing test

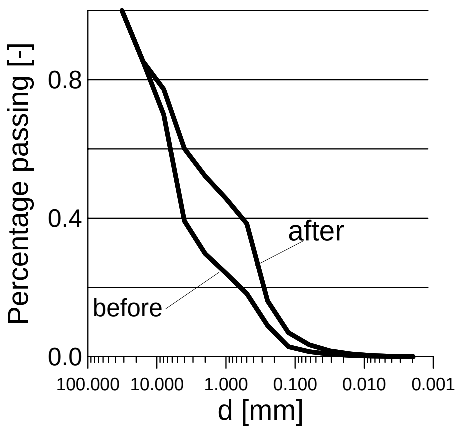

Figure 2. Grading curves in a crushing test

Direct shear test:

Results are shown in Table 3, Figures 3, 4. According to the results, the normalised entropy increment *B* increases, the relative base entropy *A* decreases.

Table 3. Entropy coordinates in a direct shear test

	A [-]	B [-]
initial	0.719	1.247
final	0.398	1.300

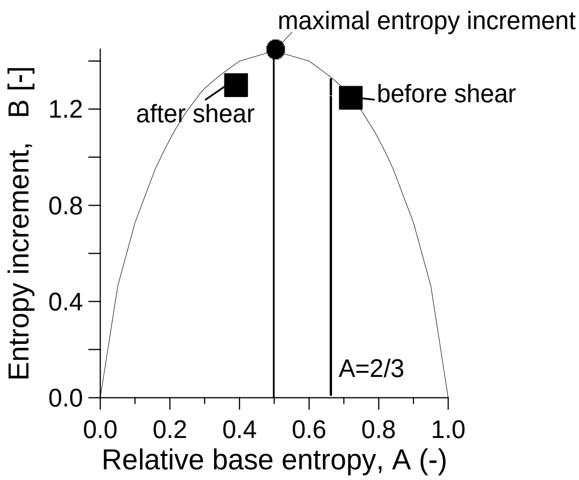

Figure 3. Entropy coordinates in a direct shear test

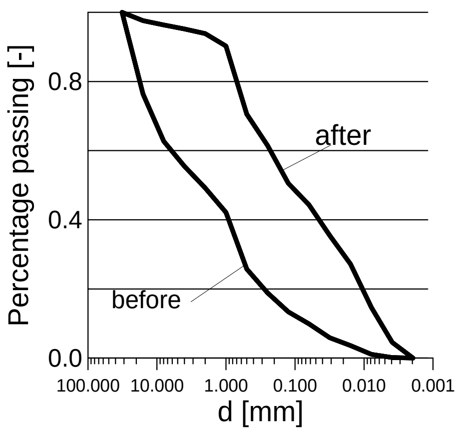

Figure 4. Grading curves in a direct shear test

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