Teaching about geosynthetics at graduate and postgraduate level in civil engineering in Romania

S. Manea, L. Batali
Technical University of Civil Engineering Bucharest, Romania

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ABSTRACT: In Romania, about 30 years ago, the first geosynthetic materials (geotextiles) were introduced in the civil engineering works. With every year passed, the quantity of geosynthetics used in civil engineering projects increased, in the last 10 years being also remarked the great diversity of products – geomembranes, geogrids, geocomposites and, of course, geotextiles. The practical aspects, as well as the design ones for the works including geosynthetics have imposed theoretical approaches, laboratory and in situ works. Thus, a useful theoretical and practical Romanian experience was gained, based on the international knowledge and enriched by own projects, direct contacts with the manufacturers and the International Geosynthetic Society (IGS). In this field of geosynthetics applications, the Romanian Civil Engineering School and in particular the Soil Mechanics teachers are especially involved. The paper presents the evolution of the specific courses, teaching and knowledge dissemination methods, for graduate and postgraduate level, as well as for the continuing education of civil engineers.

1 HYSTORY

In Romania, the first geosynthetics (geotextiles) began to appear in the civil engineering works about 30 years ago, at that time a relative reserve being noted, especially related to the lifetime of these products.

After some years of using geotextiles for various applications, once some experience gained, the geotextiles proved their qualities and became today frequently used construction materials.

Moreover, Romania became also a geotextile producer, having 3 geotextile manufactures, which led to the extension of their use in the civil engineering works.

The development of new geosynthetics with various properties and functions or associations of different materials (geocomposites) determined also in Romania, a different approach of the civil engineers, the traditional solutions being replaced by modern ones, including all types of geosynthetics.

For the knowledge and promotion of these materials, especially at the beginning, the Romanian school of civil engineering had a determining role by obtaining information and disseminating them towards the specialists.

The first research, including theoretical and practical aspects, related to the Romanian geotextiles was carried out at the Technical University of Civil Engineering Bucharest (Andrei et al, 1982), using an oedopermeameter.

In the last 10 years, the Romanian experience in this field was enriched by own projects, direct contacts with the manufacturers and the International Geosynthetic Society (IGS).

These evolutions were materialized also by the organization of symposia and workshops under the auspices of the universities, the promoter being the Romanian Association for Geosynthetics, that acquired a prominent part after its recognition as Romanian Chapter of IGS.

2 THE PLACE OF GEOSYNTHETICS IN TEACHING CIVIL ENGINEERING

The first notions about geosynthetics were introduced for the basic engineering teaching within the Soil Mechanics field related courses (figure 1).

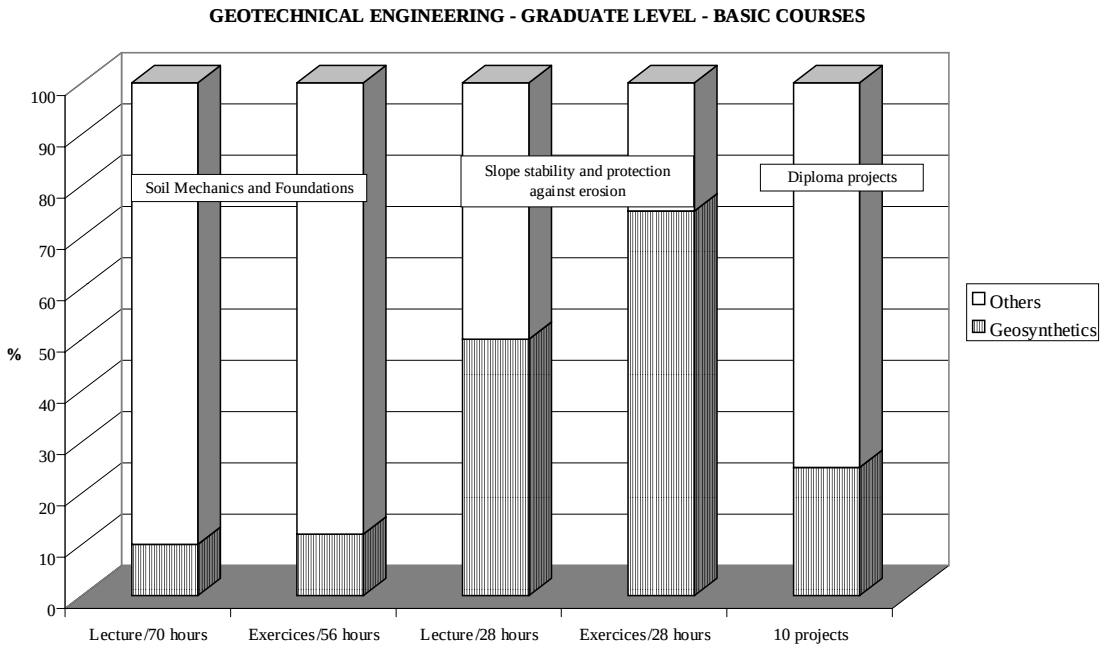

Figure 1. Percentage of the basic courses content referring to geosynthetics at graduate level

So, in the basic courses of “Soil Mechanics” and “Foundations” (IIIrd and IVth year), the elements related to geosynthetics are included in chapters such as: materials used for foundations, water in soils, slope stability and reinforcement, protection of ground foundation.

During the seminars, these notions are detailed, at the Hydraulic Engineering Faculty for example, the students have to design a landfill (liner and drainage systems, cover, stability problems) using geosynthetics.

For the special courses, the number of them referring to geosynthetics is growing. So, the “Slope stability and protection against erosion” course is presenting the design methods for reinforcing works using geosynthetics (geotextiles, geogrids).

A large number of the diploma projects (about 30%) carried out within the Geotechnical Department of the Technical University of Civil Engineering are referring to the use of geosynthetics in civil engineering works. So, at the Railways, Roads and Bridges Faculty, as well as at the Hydraulic Engineering Faculty, have been introduced alternative and definitive reinforcing works using geogrids or geocell mattresses, reinforced earth retaining walls using geotextiles or geogrids, filter and drainage systems using geotextiles, slope protection, liners with geocomposites etc. It was noticed the real interest of students in geosynthetics and their applications, they becoming often “fans” of this field and disseminating further the knowledge.

For the Master degree, it was observed also an increase of courses related to geosynthetics (figure 2). So, for the “Geotechnical Engineering” specialization, the only one from Romania, the course entitled “Environmental Geotechnics” devotes about 75% to notions related to geosynthetics, their properties, applications, engineering works including geosynthetics (landfills, reinforced earth), specific calculation methods. For example, items such as basic principles for landfills, de-

sign of liner and drainage systems, various types of liners are detailed on the base of the international legislation and experience. Are also presented the principles, methods and means of monitoring these types of works.

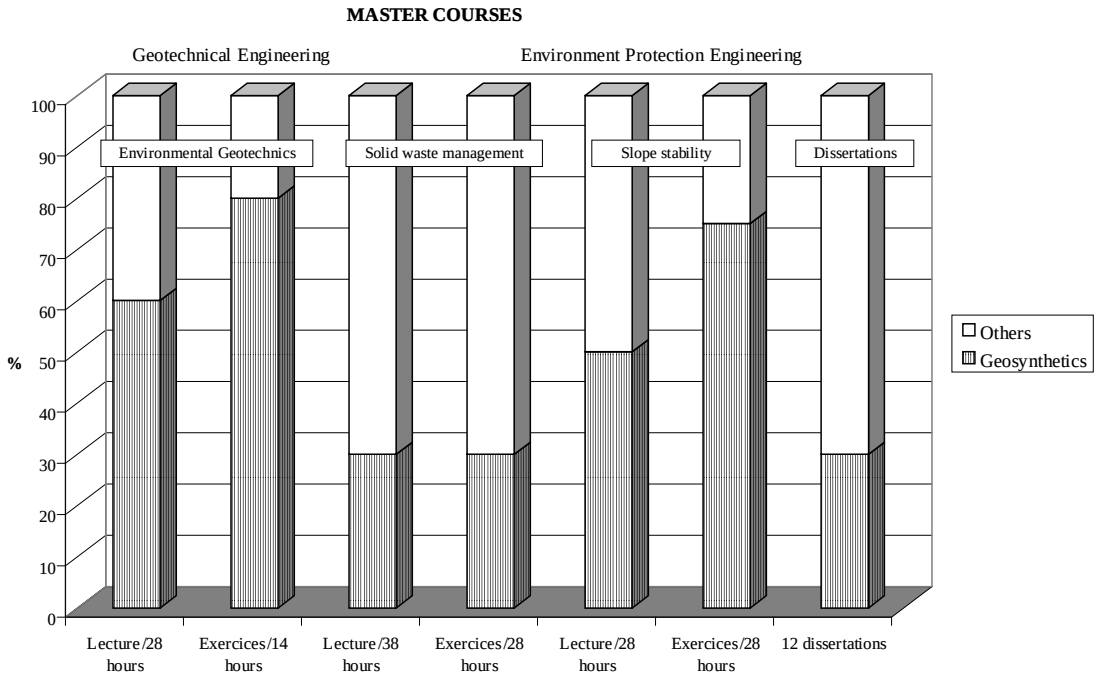

Figure 2. Percentage of the master courses content referring to geosynthetics

Some specific calculation examples, as well as more complex technical projects are used to fix the notions, the students being involved in the choice of alternative solutions using various geosynthetic materials, depending on the ground and waste nature, the landfill type etc.

Another frequently used example is the design of reinforced earth retaining structures, as in the "Slope stability" course delivered to the Master students at the "Environment protection engineering" specialization. In this case, the students have to study classical concrete structures in comparison with earth ones using geotextiles or geogrids. For the same specialization, "Environment protection engineering", the "Solid waste management" course contains about 30% notions related to geosynthetics such as geomembranes, geosynthetics clay liners, geonet, used for protecting the ground.

At the same time, the courses delivered for the Master specialization of "Highway and airport engineering" are presenting ground, roads or platforms reinforcement solutions using geosynthetics.

The impact of these notions on students is reflected in the demand of geosynthetics related research themes for the dissertation (nota bene: for the Master degree a dissertation is needed to be prepared by all students). So, only during this academic year, from a total of 12 students, 4 deal with such problems (2 themes related to liners and 2 others to reinforcements).

As a result of these notions, as well as of the demand on the professional market, some PhD students requested to study the geosynthetics behavior in different situations.

20 years ago, the first PhD thesis had a theoretical character, being based especially on international bibliographic references, some of the materials being obtained very difficultly, by personal effort of some professors.

In the framework of some research carried out at that time, some classical devices have been adapted to determine the physical and mechanical properties of geotextiles (permeability under

various confining stresses, tensile strength, tear strength etc.). The Romanian geotextiles were studied in such equipment in order to compare them with the foreign similar materials.

In the last 10 years, in the framework of the research carried out for the PhD thesis was noticed the elaboration of some new and original calculation methods for structures including geosynthetics (geocomposites, geotextiles, geogrids), using also the laboratory results obtained by the PhD students, especially for modeling the interaction with the soil. In this framework, are to be noticed the results of some shear tests performed on soils (sand, sand + clay, sand + silt) in interaction with geotextiles or geogrids (figure 3).

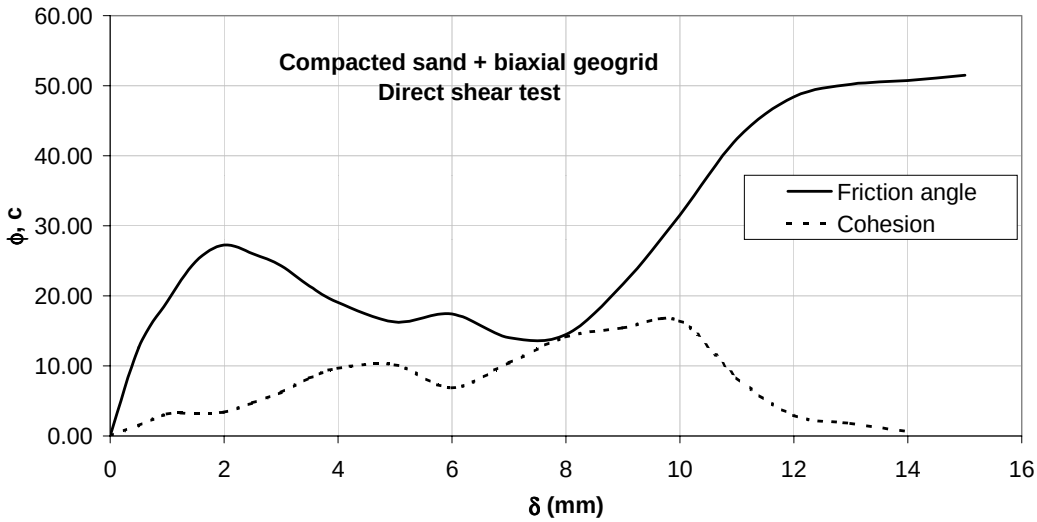

Figure 3. Mobilization of the shear parameters with the displacement during a direct shear test on sand + geogrid

These results, some of them being original, show the necessity to take into account the mobilization of the soil – geosynthetics shear parameters with the deformations, aspect which was turned to account by the researchers for developing design methods.

It has to be mentioned also the preoccupation for teaching about geosynthetics at postgraduate level, in the framework of the continuing education. A TEMPUS program (S. JEP 12468 – CET-TCE – coordinator Prof. I. Manoliu) is in progress in present at the Technical University of Civil Engineering Bucharest aiming to introduce some pilot courses for the continuing education of civil engineers. One of the pilot courses is entitled “Environment - Geotechnical protection and rehabilitation” and contains 4 modules, one of them being devoted to “Application of geosynthetics to environmental Geotechnical protection and rehabilitation”. Its content is presented Figure 4. It is hoped that in the next academic year these pilot courses will be delivered for the first time.

Based on a teaching experience of more then 20 years, one can notice that in the engineering teaching the geosynthetics have a place with an increasing weight. The next years will exist probably courses devoted entirely to geosynthetics and their applications.

It can be considered that it is attribute of the Geotechnical engineers to be involved in this field, the apparition and development of geosynthetics being a revolution in this field.

ENVIRONMENT – GEOTECHNICAL PROTECTION AND REHABILITATION

MODULE 3:

APPLICATION OF GEOSYNTHETICS TO ENVIRONMENTAL GEOTECHNICAL PROTECTION AND REHABILITATION

LECTURE

I. INTRODUCTION
- definition of geosynthetics
- functions of geosynthetics
- applications of geosynthetics in civil engineering

II. PROPERTIES AND TESTING METHODS
- composition and identification
- index and performance testing
- quality control

III. DESIGN METHODS
- hydraulic and separation functions
  - ♦ drainage
  - ♦ filtration
  - ♦ hydraulic barrier

  - ♦ separation
- reinforcement functions
  - ⇒ vertical walls and steep slopes
  - ⇒ slopes
  - ⇒ unpaved roads
  - ⇒ embankments on poor foundations

EXERCISES

- ♦ Design for drainage functions
- ♦ Design for filtration functions
- ♦ Design of liners with Geosynthetic Clay Liners
- ♦ Design of vertical walls and steep slopes reinforced with geosynthetic materials
- ♦ Slopes rehabilitation using geosynthetics
- ♦ Use of geocells for improving embankments on poor foundation
- ♦ Reinforcing of unpaved roads

Figure 4. Content of the pilot course on geosynthetics for the continuing education program

3 METHODS AND MEANS USED FOR TEACHING AND DISSEMINATING THE KNOWLEDGE

New and modern products and solution, the geosynthetic materials imposed the use of specific and modern teaching methods.

Using samples for each material easily performs the first notions and geosynthetics classification introduction. Of a real help are also the presentations of geosynthetics manufacturers who placed them at the University disposal. The students become very interested when they are able to test and try the materials, compare them and to find by their own the specific behavior of geosyn-

thetics related to the water and soil. Some simple models were done in respect to this observation (for drainage or filtration), allowing making comparisons with the traditional solutions (figure 5, Andrei, Manea, 2000).

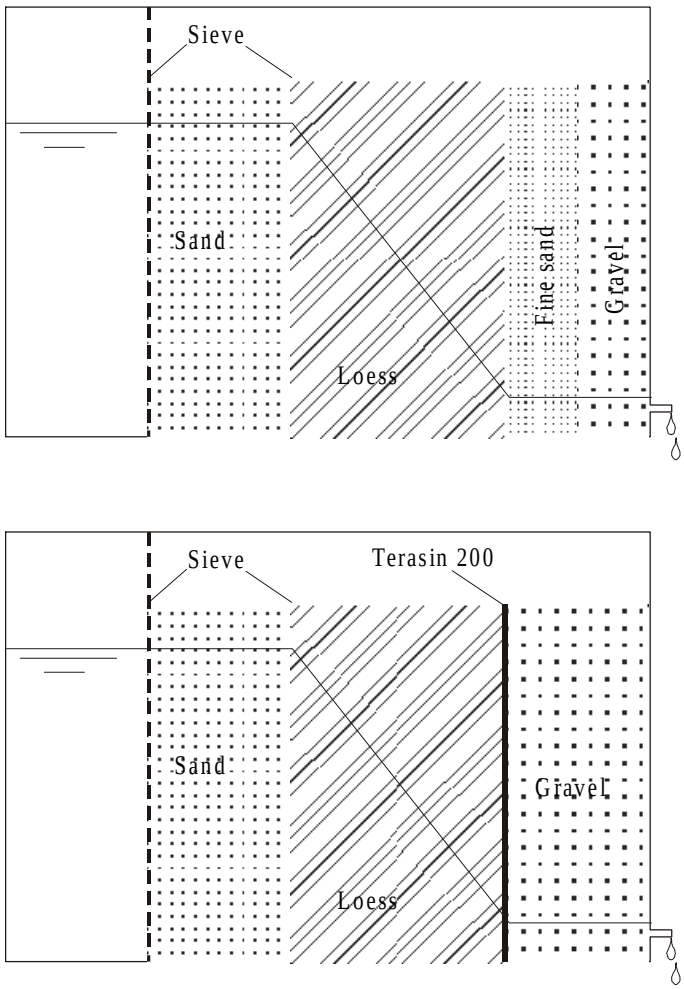

Figure 5. Physical models for traditional and geosynthetic filter

Moreover, during the laboratory hours, the students have the opportunity to work directly with the oedopermeameter in order to obtain the geotextile permeability evolution with the normal stress, the original representation of the results being helpful in understanding the geotextile behavior (figure 6, Andrei, Manea, 1994).

The oedopermeameter is an oedometer whose cell was modified in such a manner that its hydraulic head loss can be neglected during the water flow.

The results are presented in the diagram showed Figure 6, which allows to obtain a straight line log p – V, where p is the normal stress and V is the specific volume defined as:

$$V = \frac{100}{\rho_d} \qquad (1).$$

The relationship between log p and V is defined by the equation (2):

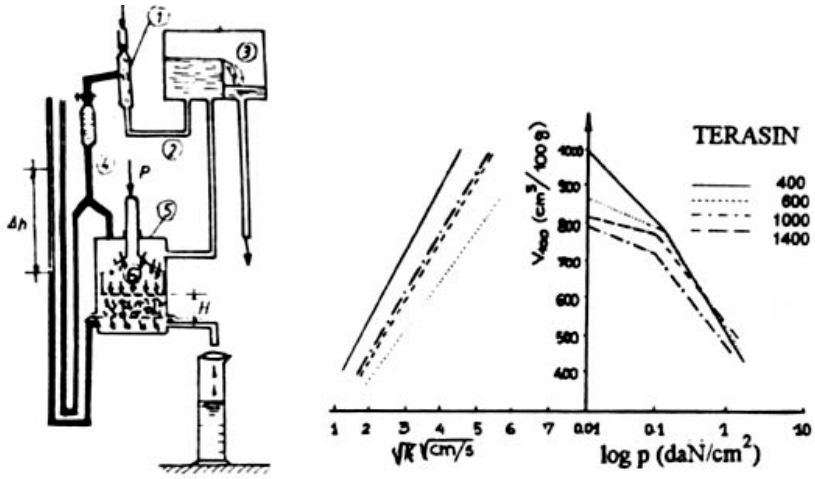

Figure 6. The oedopermemeter and representation of the results

$$V = V_0 - C_c \log p \tag{2}$$

where V = the specific volume corresponding to the stress p, V_0 = the initial specific volume (p = 0), C_c = the compression index and p = the applied stress.

Another correlation can be written between $k^{1/2}$ and V (equation 3):

$$V = a + b\sqrt{k} \tag{3}$$

where a and b are constants and k the permeability coefficient.

From the equations (2) and (3) it results the relationship between p and k:

$$\sqrt{k} = \frac{1}{b}\left(V_0 - a - C_c \log p\right) \tag{4}$$

The videotapes produced by IGS play also a special role, with remarkable results in teachings. The clear and suggestive manner of explanation of the geosynthetics behavior helps to a rapid and easy understanding by the students.

Moreover, other videotapes, disks or CD-ROMs produced by various manufacturers allow going deeply into the notions.

The existence or the elaboration of calculation programs for designing works including geosynthetics allow the students to perform the necessary calculations and to be directly involved in the solution optimization.

Are to be mentioned the various scientific seminars organized by the Romanian Association of Geosynthetics (ARG) in the last 5 years, especially within the Geotechnical Department of the Technical University of Civil Engineering among the participants being included representatives of manufacturers, students, PhD students. The Romanian Civil Engineering School was so put in contact with the newest products and developments in this field.

Moreover, the teachers involved in the geosynthetics field had the opportunity to visit and to study in different universities from Europe.

In order to study thoroughly, to disseminate and to apply all aspects related to geosynthetics, the teachers from the Technical University of Civil Engineering, as well as the Romanian specialists, have elaborate in the last 3 years some teaching materials related to geosynthetics in general, geosynthetics clay liners, geocell mattresses, Environmental Geotechnics (Manea, S. Jianu, L., 1998, Batali, L., 1999, Manea, S., Antonescu. I., Feodorov, V., 1998).

As a results of all these efforts, it can be noticed an increasing interest of students for this field, showed also by the good notations they obtain.

4 CONCLUSIONS

The gradual introduction in the basic civil engineering courses, in the last 20 years, of notions about geosynthetic materials, within the Soil Mechanics and Foundations courses revealed itself as a success.

The students' interest is related to the newness of the materials, to the large application field, as well as to the interactive manner of their presentation and teaching (samples, laboratory research, videotapes, CD-ROMs, work on computer, new and up to date references).

As a result, the specialization courses for the graduate level, as well as those delivered for the postgraduate level referring mostly to geosynthetics are very popular and the diploma projects or dissertations are dealing with items related to them.

In the theoretical research (and not only) field (PhD) it can be observed a constant preoccupation for the geosynthetic materials.

Based on discussions with former students, now engineers involved in the practical problems, we can say that the fruits of the efforts carried out by the teachers can be now picked up. Those who had the courage or the initiative to use once geosynthetics, as designer or constructor, will use them also in the future. The role of the Romanian Civil Engineering School is to keep the old and new generation of engineers well informed about the newest development of the field and to ensure the theoretical basis.

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