EDUCATING CIVIL ENGINEERS ON HAZARD MITIGATION AND SUSTAINABILITY

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The scientific field of Civil Engineering is very large, some argue too large. Evolution of technology (e.g. production of new materials) offers new possibilities, but at the same time increases educational needs. The availability of computers and respective software has rendered traditional calculations trivial, but stricter regulations call for development of advanced computer skills. At the same time notions, such as sustainability and hazard mitigation, should find a proper place in civil engineering curricula. As a result, conceptual understanding becomes more and more difficult, in particular when the duration of engineering studies has been officially reduced.

Sustainability and hazard mitigation and their integration in civil engineering curricula

The concept of sustainable development has been defined in the UN Document "Our common future" (1987) as "Development that meets the needs of the present generation without damaging the capacity of future generations to meet their own needs". It may be adapted to most scientific fields, including different branches of Civil Engineering. For instance, structure sustainability could be interpreted as achievement of the predefined goals (e.g. pleasant living space) with minimal consumption of raw materials and energy during the construction and the operation period and with minimal need for maintenance. Sustainable management of water resources on the other hand, aims at meeting water demand using renewable water reserves only.

Hazard mitigation can be defined as any cost-effective action taken to eliminate or reduce the long-term risk to life and property from natural and technological hazards. So, it is relevant to design, construction and operation of small and large scale human projects that could be threatened by natural forces or by human errors and malicious activities. In other words, it penetrates almost every aspect of Civil Engineering. Flood hazard mitigation is probably the most important issue.

After the flood

Source: http://news.pathfinder.gr/photoscope/greece/news/9959.html

Understanding of sustainability and hazard mitigation presupposes grasping of certain closely related or underlying notions and principles, such as:

- **risk analysis**
- **passive safety**
- **resilience**
- **carrying capacity**
- **efficient use of locally available materials**
- **respect of local environment**
- **use of the simplest efficient technology for each task**
- **consideration of non-structural measures for safety maximization.**

Risk analysis includes assessment, characterization and management of risk, and also policies relating to risk. It can be considered as a scientific topic per se, closely related to hazard mitigation.

Passive safety is inversely proportional to the gravity of adverse effects, when technical measures fail. In landfills, for instance, it has to do with the extent and gravity of groundwater pollution in case of liner failure. It depends then on the natural permeability of underlying rocks and the depth of the local groundwater table, namely on landfill site selection. In any case, passive safety is directly related to hazard mitigation.

Resilience

In the framework of strength of materials, resilience can be defined as the capability of a strained body to recover its size and shape after deformation, caused especially by compressive stress. Speaking about sustainability, though, resilience is defined as the ability to recover from or adjust easily to (adverse) change.

By the way, this is a typical case of terminology problems, which are due to the extent of the scientific field of Civil Engineering.

Carrying capacity

The notion of carrying capacity has been initially introduced in Biology, where it can be defined as the maximum equilibrium number of organisms of a species that can be supported indefinitely in a given environment (that includes food, habitat, water and other necessary resources). In the framework of engineering, though, it can be defined as the upper bound of human interference or activities that an ecosystem or an area can sustain without permanent deterioration. For instance, carrying capacity of tourist destinations is a hot environmental issue for the Mediterranean countries. This interpretation of carrying capacity is easily understood by civil engineers, since it is a direct metaphor from statics.

Respect of local environment has to do with adaptation of human plans to locally available resources and climatic conditions. Construction of golf courts in arid Mediterranean regions, for instance, is a clear violation of this principle. Similarly, use of local building materials avoids unnecessary transport energy consumption, sometimes masked by low prices or ignored, due to abundance of funds.

Non-structural measures (e.g. adapting land use to flood hazards or regulating water demand) can play an important role in hazard mitigation and in sustainable development. Traditionally disregarded in construction-oriented curricula, non-structural measures are finding their proper place in modern education of Civil Engineers.

The "high-tech temptation"

Technology offers undoubtedly new possibilities for sustainable development (e.g. new insulation materials that allow reduced energy consumption for the same living standards). While open to innovation, though, engineers should not be lured to use over-sophisticated systems, if the same job can be achieved by simpler systems that could be locally constructed or repaired. Moreover, such systems are usually less vulnerable, users understand their function better, and their use may have positive impact on local economy.

Case study
Department of Civil Engineering, Aristotle University of Thessaloniki

A rather typical example of Greek Departments.
Peculiarity: it offers the largest number of elective courses (around 100).

<u>Sustainability</u>
The terms "sustainability" or "sustainable development" do not appear in any course title.
Inside course curricula these terms appear in 2 courses.
Sustainability principles are presented at least in 9 courses

<u>Hazzard mitigation</u>
The term "hazard mitigation" does not appear in any course title.
The course "Fire protection in structures" (elective) is dedicated to the mitigation of fire hazard.
Different aspects of hazards and mitigation measures are presented at least in 9 more courses.

Underlying notions

Risk analysis: One elective course is dedicated to risk analysis (Systems and risk analysis). The term appears in the curriculum of 4 more elective courses.

The term "passive safety" appears in the curriculum of the elective course "Road safety". It is also discussed at least in one more elective course.

The notions of resilience and carrying capacity are discussed at least in the elective courses "Mathematical models of water ecosystems" and "Regional planning and development II", respectively.

Non structural measures are discussed in the framework of the compulsory course "Irrigation and stream mechanics".

The preceding overview shows that sustainability and hazard mitigation are discussed in many courses, mainly elective. Nevertheless, these notions could be introduced in more compulsory courses. An excuse is that the respective course curricula are already too heavy. It is up to the tutors, though, to make room for these important notions. Introduction of a new course, dedicated to sustainable development and hazard mitigation, or rescheduling of an existing one, could fill gaps and could help students form an integrated picture.

It should also be mentioned that lack of direct reference to sustainability in course titles of the 5-year curriculum of studies, is counterbalanced in additional graduate studies. The Department of Civil Engineering of Aristotle University of Thessaloniki offers a Master's program in "Environmental protection and sustainable development".

The ultimate goal is to prepare our students for a basic future challenge: Safety and satisfactory quality of life for more people with reduced consumption of precious resources.

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