EDUCATING CIVIL ENGINEERS ON HAZARD MITIGATION AND SUSTAINABILITY

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EXTENDED ABSTRACT

Sustainability and hazard mitigation are two of the rather new notions that attract increasing interest in civil engineering curricula. Sustainable development has been defined as “Development that meets the needs of the present generation without damaging the capacity of future generations to meet their own needs”. Therefore, sustainability is an important aspect of civil engineering projects. 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 this paper it is argued that, together with the introduction of specific courses (usually elective) on sustainability and hazard mitigation, more attention should be paid to some underlying notions or principles, such as risk analysis, passive safety, carrying capacity, resilience, 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. First the aforementioned notions are briefly outlined and then their integration in civil engineering curricula is discussed. The Department of Civil Engineering of Aristotle University of Thessaloniki has been used as an example, typical for Greek Universities. The official bulletin of the Department has served as basis, but informal author’s knowledge has also been taken into account. It has been concluded that sustainability and hazard mitigation are discussed in many courses, mainly elective. Nevertheless, they could be introduced in more compulsory courses, while an elective course, dedicated to them, would be very useful. More discussion of the underlying notions and principles would be useful, too. These results could be considered as indicative of Greek Civil Engineering Departments.

KEYWORDS
Sustainability, Hazard mitigation, Risk analysis, Passive safety, Resilience, Carrying capacity, Civil engineering curricula

1. INTRODUCTION

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 (e.g. Chaw, 2007; Desha et al., 2009). As a result, conceptual understanding becomes more and more difficult (Montfort et al, 2009), in particular when the duration of engineering studies has been officially reduced.

This paper deals with the notions of 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 (e.g. Vazquez et al., 2011). 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 (e.g. Schanze et al., 2006), but current research has focused also on very specific tasks, such as glazing hazard mitigation (Smith and Renfroe, 2010).

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. These are briefly discussed in the following paragraphs.

2. THE UNDERLYING NOTIONS AND PRINCIPLES

Risk analysis includes assessment, characterization and management of risk, and also policies relating to risk. It can be considered as an interdisciplinary scientific topic per se (see for instance http://www.sra.org/, namely the web-site of the Society for Risk Analysis), 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. Another example is road construction, where passive safety is increased by using suitable street furniture (e.g. Passive Safety UK, 2010). In any case, passive safety is directly related to hazard mitigation.

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, or as the property of a material to absorb energy when it is deformed elastically and then, upon unloading to have this energy recovered. 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.

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 topic for the Mediterranean countries (e.g. Tselentis et al., 2006; Christofakis et al., 2009). 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. A discussion of the use of local materials and of other sustainability principles can be found in Glezos et al. (2000).

Technology offers undoubtedly new possibilities for sustainable development (e.g. water saving devices or new insulation materials that allow reduced energy consumption for the same living standards). While open to innovation, though, engineers should not be lured by the “high-tech temptation”, namely the use of 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.

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 (e.g. Simonovic, 2002). Traditionally disregarded in construction-oriented curricula, non-structural measures are finding their proper place in modern education of Civil Engineers.

3. A CASE STUDY

The Department of Civil Engineering of Aristotle University of Thessaloniki is a rather typical example of Greek Departments, its peculiarity being that it offers the largest number of elective courses (around 100). It should be mentioned, though, that this number is going to be reduced.

Despite the large number of courses, the terms “sustainability” or “sustainable development” do not appear in any course title. Inside course curricula these terms appear in: a) the compulsory course of the 2nd semester: “Urban and regional planning and development”, with respect to traditional settlements and historic city centres and b) the elective course of the 9th semester “Environmental impact assessment”. One should not draw conclusions, though, based on direct references only. A closer look at courses curricula reveals that sustainability principles are presented at least in the following courses:

- Building Construction II (compulsory, 4th semester), with respect to energy conservation in buildings.
- Irrigation and stream mechanics (compulsory, 7th semester), with respect to water conservation.
- Special topics in building construction (elective, 8th semester), with respect to energy conservation in buildings.
- Energy-conscious design and use of solar energy in buildings (elective, 9th semester).
- Water resources management (elective, 9th semester).
- Geothermal energy (elective, 9th semester), with respect to sustainable use of renewable resources.
- Coastal structures (elective, 9th semester) with respect to development and protection of coastal zones.
- Solid waste management (elective, 10th semester).
- Environmental and energy policy in the European Union (elective, 10th semester)

The term “hazard mitigation” does not appear in any course title either. Nevertheless, the course “Fire protection in structures” (elective, 8th semester) is dedicated to the mitigation of fire hazard. Moreover, different aspects of hazards and mitigation measures are presented at least in the following courses:

- Groundwater hydraulics and hydrology (compulsory, 5th semester), with respect to floods and drought.
- Soil mechanics I (compulsory, 5th semester), with respect to ground subsidence and its impact on constructions.
- Engineering hydrology (elective, 7th semester), with respect to floods and drought.
- River engineering I (elective, 8th semester), with respect to erosion and sedimentation.
- Geotechnical earthquake engineering (elective, 8th semester), with respect to soil liquefaction.
- Wooden structures (elective, 9th semester), with respect to fire hazard.
- Hydroelectric works (elective, 9th semester), with respect to dam failure hazard.
- Environmental Engineering Geology” (elective, 9th semester) with respect to natural hazards.
- Landslides, earth cuts and fills (elective, 9th semester).

Regarding the underlying notions and principles, one elective course of the 8th semester is dedicated to risk analysis (Systems and risk analysis). The term appears in the curriculum of 4 more elective courses, namely “Engineering seismology and soil dynamics” (7th semester), “Environmental Engineering Geology” (9th semester), “Marine structures” (10th semester) and “Groundwater exploitation and protection” (10th semester).

The term “passive safety” appears in the course curriculum of the elective course “Road safety” (9th semester). It is also discussed at least in the elective course “Solid waste management” of the 10th semester, in relation to landfill site selection.

The notions of resilience and carrying capacity are discussed at least in the elective courses “Mathematical models of water ecosystems” (8th semester) and “Regional planning and development II” (9th semester), respectively. Finally, non structural measures are discussed in the framework of the compulsory course “Irrigation and stream mechanics” (7th semester).

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, such as “Environmental engineering”, which deals with sewage treatment. 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 (e.g. “Environmental impact assessment”), could fill gaps and could help students form an integrated picture.

Regarding the underlying notions and principles, risk analysis is covered in a satisfactory way, but more attention should be paid to the other ones.

Finally it should 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”.

4. FINAL REMARK

The interest in sustainability, hazard mitigation and the related notions and principles discussed in this paper is increasing. Their integration in Civil Engineering curricula is already underway and will help 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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