

Civil Engineering at the Crossroads in the Twenty-First Century

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Abstract The twenty-first century presents a major challenge for civil engineering. The magnitude and future importance of some of the problems perceived by society are directly related to the field of the civil engineer, implying an inescapable burden of responsibility for a group whose technical soundness, rational approach and efficiency is highly valued and respected by the citizen. However, the substantial changes in society and in the way it perceives the problems that it considers important call for a thorough review of our structures, both professional and educational; so that our profession, with its undeniable historical prestige, may modernize certain approaches and attitudes in order to continue to be a reliable instrument in the service of society, giving priority from an ethical standpoint to its actions in pursuit of “the public good”. It possesses important tools to facilitate this work (new technologies, the development of communications, the transmission of scientific thought...); but there is nevertheless a need for deep reflection on the very essence of civil engineering: what we want it to be in the future, and the ability and willingness to take the lead at a time when society needs disinterested messages, technically supported, reasonably presented and dispassionately transmitted.

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Introduction

That society is subject to continuous evolution, and that in recent years this evolution has experienced historically unprecedented acceleration, is beyond dispute. However, in this process of change, there still remain some old-fashioned structures, both professional and educational, victims of ingrained inertia, that will require a decisive push if they are not to become hidebound organizations, enslaved to the past, with few signs of future effectiveness and efficiency. In this article we shall focus our attention on the specific field of civil engineering, essential in many aspects of city life and which, in the opinion of the authors, must accept a major transformation in its professional—and consequently educational—approaches, in order to be available to deal, with the reliability and effectiveness that it has shown in the past, with the new challenges, new attitudes and new implications called for by twenty-first century society.

Any change that hopes to have a continuous effect in the future must be planned and instituted right from the preparatory stages of future professionals; in other words, teaching acquires, as it surely must, a position of prominence in the design and “training” of the attitudes and skills of the twenty-first century engineer. Problems may arise in the organization of plans and syllabuses with contents and new guidelines, as manifested by D. Lynch and J. Russell (2009); but the desired and desirable goals cannot be relegated or curtailed by the “administrative” or organizational problems that its implementation may involve. The comments of Dr. Morales Manceda may be particularly apposite, when he expresses the need to redirect university teaching, by including among the technical content subjects dealing with ethical aspects and humanistic disciplines: to teach not only the “how”, but also the profound ethical sense which explains “the why and wherefore”. For the ultimate goal to which technology should be directed is none other than the common good of man.

This professional reassessment should go much deeper than simply a closer approach to new technologies or a redefinition of working procedures, or even joining forces with the engineers of newly emerging disciplines. Civil engineering must address a profound reflection on its attitude to society, its active and determined involvement in the major problems of concern to the twenty-first century citizen, its assumption of leadership and ultimately on their its approaches.

In a world too often influenced by the immediacy of results, by economic performance, by political patronage and by a certain laxity of conscience, it is absolutely imperative that a profession so intimately linked to the “public interest” should be capable of leading social proposals and movements from a base of rigorous technical knowledge, of established ethical principles, and from a rational and independent approach.

The Need for the Resurgence of Civil Society

The experience of recent decades in Spain, and dare we say it, in Europe, shows a progressive takeover by what might be called political or business structures, stifling

the cultured, fair and independent participation of the citizens. Too many issues of vital importance to the health and welfare of citizens and to the very future of the planet are managed by interest groups who distort at their convenience scientific theories, data and experimental results, preventing or at the very least hampering participation in the decision-making process by independent professionals of recognized ability, and free from demagogic, unsustainable or biased agendas.

More than ever there is a need for a true social structure. As a condition *sine qua non* this requires independent organizations and intermediate groups (NGOs) to set themselves up as truly representative bodies, with real influence on the taking of decisions which affect what is understood as “the common good”. From this point of view, professional associations, and specifically those which include civil engineers, should develop, and are morally bound to take, a responsible lead in designing processes to help to solve some of the problems that most concern today’s society.

As Professor Valero Matas (2009) puts it: The intermediate bodies may be seen as one of the vital figures in complex societies, being an instrument for the rights and freedoms of individuals. Their nature leads them to solve the problems of society and the demands of private life, articulated as a tool for the critical action of public opinion and political will.

The validity of the important role that civil engineering may play in the design of strategies on issues substantially affecting society depends on the development and strengthening of the structures that bring together individual engineers: the professional associations. This reinforcement of the genuine participation of professional associations has nothing to do with their obvious “corporatism”. Indeed, corporatism occurs when groups are created, managed and oriented towards the achievement of specific objectives that are basically not concerned with the “social good”: on the contrary, professional associations of civil engineers should be seeking optimum solutions in their fields of activity on the basis of dispassionate technical approaches, free of opportunism, with calm and pragmatic reflection; and they must do so with a real capacity to influence decision making.

This will to take the lead, this assumption of responsibility, must permeate the whole field of civil engineering. This means that right from the start of the engineer’s academic training an effort must be made to instill in students the importance of the profession in solving vital problems in the daily life of the citizen, concern for the burning problems that threaten our way of life (sustainability, environmental impact, waste treatment); and all of this based on ethics and honorable behavior.

Remodeling Versus Refounding

The older an organization is and the greater its prestige, the more resistant it is to change. The proud history of civil engineering, the brilliance of a good number of its members, and the social prestige consolidated over the years as a result of work well done, may lead to a certain attitude of complacency, an ambiguous position of detachment and in extreme cases a progressive disconnection from the social field in which the activity of the engineer takes place.

However, the social dynamic, the magnitude of some of the problems that threaten our living standards and seriously compromise the future of coming generations, the media's generation and transmission of opinions that confuse and baffle the citizen, and ultimately the lack of independence and transparency of certain messages sent to society, call for much commitment from the civil engineer. It is no longer just a matter of designing or building, it is a matter of doing so with a much broader vision, a vision of the future, of sustainability, of respect for the natural environment, of responsibility to future generations.

This increasing awareness necessarily implies a profound reorganization of civil engineering, a reorganization that affects both the teaching of engineering and engineering professionals, as well as the associations that bring them together. In our view it is not a question of "dismantling" a structure; for despite its logical weaknesses, it holds a wealth of experience, a responsibility, a body of doctrine and a record tried and tested over its long history. These are in themselves the strong points of the profession, and define its profound values. It is therefore necessary to remodel civil engineering; cautiously, but also with the excitement of finding ourselves at a crossroads from which a new form of engineering should emerge, identifying and redefining the parameters of what the "public interest" will be in the twenty-first century.

We possess very powerful tools: new technologies, the development of communications, the rapprochement of cultures and networks of knowledge can be of great help to the work of the new civil engineering. However, we need to make a profound reflection on the role of our profession in society, about our stance: determined, pragmatic, based on some of the priority issues of our society and that concern us directly in our practice; we need to resolve the question of our access to the communication media.

The Civil Engineer and Society

It is clear that, generally speaking, the civil engineer is held in very positive esteem by society, although in some cases society is not fully aware of how much the engineer's work influences their daily lives. Yet paradoxically society trusts the engineer, sometimes even to excess, so that when an accident occurs, the citizen's faith feels somehow shaken: "that shouldn't have happened", a bridge can't collapse, a dam can't burst, ... This social pressure, which does not accept or understand what we might call "statistical failure", materially conditions the professional work of civil engineers, restricting their initiatives and giving them a heavy load of responsibility that is sometimes hard to bear. We thus come to a remarkable contradiction: a profession whose job is known only in very general terms nonetheless generates levels of expectations and certainty never demanded from other professional groups.

This responsibility to society and the trust that it places in the work of engineers in general, and most particularly of civil engineers, has to a certain extent led to the fact that civil engineering education, certainly in Spain (and as far as the authors know, in other universities in the European Union) has traditionally laid special

emphasis on fostering the technical training of the future professional, sparing no efforts in human or material resources. But everything suggests that the dynamics of the evolution of society in the twenty-first century calls for more than strong technical training for the engineer; other factors come into play, some new and others which, hitherto ignored, may seem so.

There is a need, in the authors' opinion, for a return to what one might call "classic values": prudence, perseverance, ethics ..., supplemented by unequivocal and effective attitudes to the momentous issues of our time: sustainability, respect for the environment, the independence of knowledge, and closer contact with society. Civil engineering, due to the involvement of its work in what is known as the "public interest", should take a much more active role than that which is purely limited to its technical side; it should lead in other fields that, influenced by its activity, are some of the main concerns and aspirations of the social environment.

The Training of the Future Civil Engineer

There can be no doubt that training is the seed that will grow into the future professional development of the engineer; hence the enormous importance that teaching has in outlining the ideal profile that society needs to meet its expectations and to design ways of solving the most pressing problems of our century.

The National Academy of Engineering (NAE) in the United States has published a list of what may be the main engineering challenges in the twenty-first century. This list, prepared by a team of experts from around the world, convened at the request of the National Science Foundation, can be grouped under four key headings for the success of humanity: sustainability, health, reducing vulnerability and the quality of life. There is no doubt of the enormous involvement that the work of the civil engineer has in these matters, and it is necessary for the academic environment where they develop their training instructs to arouse and stimulate the students' concern about these issues; this will undoubtedly condition their future professional work and their vision of the world around them.

Another key aspect is related to the design of the syllabus. On this issue, a variety of authors and scholars within the field seem to agree on the key points that should guide the learning system in the coming years; perhaps, thanks to the clarity of their approach, it is worth reproducing the appraisal of the situation made by Kindelán and Martín (2008):

The rise of worldwide communication networks and information technologies has redefined the concept of education in all fields. In engineering, a new educational paradigm can be glimpsed where the development of generic skills is prioritized. Skills such as the ability to successfully communicate orally and in writing, to operate with a multidisciplinary perspective in decision-making and problem-solving, to work in teams, and to become involved in lifelong learning [...]. The relationship among communication, training and lifelong learning is a key point in the profile of the engineer in this century.

It remains only to comment briefly on another basic question: once the overall objectives, basic concepts, attitudes and skills to be encouraged in the civil engineer in the coming decades have been established, how can we establish specific contents, as far as possible regulated, in university teaching? Trevelyan and Tilli (2007) place special emphasis on empirical methods; this may be so as regards technological knowledge, but we must also encourage in the engineer other attitudes which basically have profound ethical and humanistic roots. In this regard it is interesting to read the reflection made by Samuel C. Florman (1997) on the perception that society has of the engineer, and the need to change it. These are his words:

If engineers are viewed as mere technicians, then the relevance of non-technical studies is called into question. Yet non-technical studies are means by which we hope to change engineers from technicians into true professionals. We must find ways to break this paralyzing cycle.

Having said all this, we would not wish to conclude this discussion without emphasizing, if only briefly, the need to recuperate (for we believe that to some extent they have been lost or diluted) what might be called “classic values”; and of all of these, basically the need to reinforce ethical values. Our famous thinker and writer Ortega y Gasset (2000) said, “To be an engineer it is not enough to be an engineer”. We might add that engineering education should inculcate in students a profound conviction that engineering, to achieve its own objective, the objective that gives it full sense and meaning, must be carried out under certain conditions (effectiveness, efficiency, accuracy ...). These conditions include morality, expressed in many ways (in decisions, procedures, motivations, prediction of consequences ...). and should not only be a moral for life, but should also be considered, pondered, and subject to rational argument: in other words, ethics. In short, excellence in engineering is strictly speaking, although not exclusively, ethical.

As Bilbao et al. (2006) point out:

It is necessary to stress—and today more than ever—an unquestionably social view of engineering activities. And that means basically two things. On the one hand, engineering is developed not only by individuals but also, and above all, by teams of professionals and, more often than not, in the context of organizations. This collective dimension of engineering activity gives it particular moral implications. On the other hand, the engineer’s professional activity is rarely limited to his or her relationship with a particular client or user (whether a physical person or legal entity) but it inevitably has a very significant social impact.

On this point, we may still quote John Dewey’s (1930) thoughts from nearly a century ago:

Engineering schools give excellent technical training. Where is the school that pays systematic attention to the potential social function of the engineering profession?

To a certain extent, the associations that bring together civil engineers are fully aware of the future (already present?) guidelines that should be shaping the profile

of the twenty-first century civil engineer, and the need to take a global view not only of the philosophy that underpins the activity and the attitude of future engineers, but also their values, expectations and their social influence.

In this sense we may, for example, highlight the cooperation that the ASCE (2010) and the Spanish Association of Civil Engineers (AICCP) have maintained for many years, and that has given rise to various programs of joint activities; among these, since they affect the profession, we would single out as particularly important those aimed at strengthening the commitment to ethical values and the fight against corruption in civil engineering, the evaluation and prediction of the future professional and adaptation of engineers, the commitment to sustainable engineering, and participation in training programs.

In view of the time when this article is being written, we may highlight in this context of international collaboration and globalization of approach the presentation in Madrid of the document “The Vision for Civil Engineering in 2025” prepared by ASCE, and which the Spanish AICCP has translated into Spanish, and is committed to its dissemination in Hispanic countries. This document, based on the Summit on the Future of Engineering, is intended to some extent to draw the broad outlines of the position of engineering towards twenty-first century society, its challenges, its responsibilities, its assumption of leadership, and its decisive contribution on issues in fields as sensitive and urgent as the demands for sustainable energy, drinking water, clean air and safe disposal of waste. We would emphasize, in conclusion, two aspects that in some way will mean a clear change in the attitude and social involvement of the civil engineer.

- Civil engineers must be comfortable not only with the quantitative issues of “black and white”, but also with the “grey” areas of political leadership.
- Civil engineers must increase their visibility and become more active, and public policy forums should demand this of them.

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