Challenges to Teach Modern Hydraulics and Water Resources Engineering in Brazil

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Introduction

Brazil is a country where hydraulic engineering has occupied a prestigious position. The distribution of water resources throughout the country and the increasing urbanization process that took place during the last three decades required the construction of reservoirs, hydroelectric projects, water distribution networks, irrigation systems and other hydraulic systems. Some of these, such as the Itaipu project -- the greatest hydropower project in the world -- became well-known worldwide.

During the decade of the seventies this process of developing infrastructure reached its peak, mainly due to international financial credit which was readily available at that time. Since then a progressively distinct scenario has been taking place. As a result, the more modest recruitment of young engineers resulted in the decreasing interest of students in studying the traditional areas of hydraulics. On the occasion of a national meeting of Brazilian professors of hydraulic engineering, held in Campinas, Sao Paulo State in August 1995, this lack of interest primarily in research activities based on experimental work, was fully recognized,

We have knowledge of the occurence of a similar process in Europe (Carstens[1]). We understand this process there as mainly having for saturation point for infrastructure works, thus requiring the majority of hydraulic engineers to work in the operation and maintenance of such infrastructure systems. In Brazil, nevertheless, the absence of a hydraulic infrastructure is evident and it is becoming a major public concern in several areas such as hydropower generation (only 25% of the total potential has been exploited), urban flood control, sanitation works, fluvial navigation, etc. Therefore, we have other reasons to explain the decline of traditional hydraulics in the Brazilian context.

Firstly we think the impact of informatics was a major factor in shifting move students and professors from the laboratory to computers. The pace of this movement towards computers modelling was accelerated by two simultaneous factors: (a) the scarcity of financial funds for research, mainly those requiring higher magnitudes (e.g., hydraulic physical modeling); (b) the decreasing cost of personal computers, nowadays accessible to a great majority of graduate and undergraduate students. Older professors are watching this-movement with apprehension since they think the students may miss the physical sense of hydraulic phenomena. On the other hand there are new professors who have been following the most recent advances concerned with the applications of computers to hydraulics, from the computational hydraulics stage up to the so-called hydroinformatics phase. Engineering courses usually have good computational support (hardware) for developing research and teaching computational hydraulics. But there are few commercial packages (software). available for the teaching of hydraulics.

A second important factor is concerned with the role of ecological engineering. During a first stage up to the middle of the 1970's, environmental concerns were dealt with as simple restrictions in Brazilian hydraulic projects. Nowadays they area major criterion on the same level as cost and other technical factors. Thus the hydraulic phenomenon is now being treated as a component of a multi-disciplinary modelling process. Besides the need for a broader education, this new scenario requires an improvement of the synthesis skills of engineering students. Therefore, the curriculum has been shifted from a traditionally oriented emphasis on hydraulics as a specialized discipline to a broader scope including several subjects in water resources engineering.

These two issues will be discussed in greater details in the following sections

The Impact of Informatics on Hydraulic Engineering

Hydraulic engineering has been a field with a large number of successful applications of computers and associated numerical models. The symbiosis of man and digital machine now extends to every aspect of human activity, so it also extends to the area of hydraulics. As was pointed out by Abbot[*], the hydraulician enters into a symbiotic relation with the digital machine, and it is in this symbiotic relation that he, in turn, relates to society as a whole. The same author introduced the term *Computational Hydraulics* to cover the symbiosis between hydraulics and digital computing, and more recently, introduced the name of *Hydroinformatics* to cover the symbiosis between the hydraulician and information technology in general, as this relates in turn to society as a whole.

Based on the previous definitions, the current stage of development of hydraulics in Brazil is located at an intermediate position between *computational hydraulics* and *hydroinformatics*. In a general scope, we realize the principal and pragmatic aspect is that hydroinformatics comprehends all applications of information technology to the aquatic environment. It is thus concerned with measuring and recording devices, including remote-sensing facilities; with data and knowledge structuring, coding and transmission; with a variety of kinds of buffer memory devices; with domain knowledge encapsulation in models of both logical and numerical varieties; and with man-machine interfaces and other graphics facilities. Besides these new devices available to hydraulicians, the new fast processing technology poses interesting issues for engineering students, professors and professionals.

Taking the problem of water distribution network as an example, we see significant progress since the older application of the Hardy-Cross method, followed by the Newton-Raphson method and the linear network theory. Before the advent of digital computers, the network analysis was essentially based on the Hardy-Cross method, by which initial estimates of flow rates are successively corrected within each closed loop in turn. The more recent approaches converge considerably more rapidly than the "Hardy-Cross type" solutions since corrections are made to hydraulic parameters over the whole network at each iteration. However, they are only suitable for digital computer application and where the facility to solve large numbers of simultaneous linear equations with a high degree of accuracy is available. As was pointed out by Koelle[3], besides the capability to include the effects of pumps, reservoirs and valves along the network, some current computational models based on the Characteristic Method coupled with the Shimada[4] technique can solve a problem of a complex water distribution network, spending only 0.36 minutes using a AT386-2 (33 MHz) microprocessor. In 1980 this same problem was solved by a XT (12 Mhz) microprocessor in around 88 minutes execution time (without the

Shimada technique). Thus, the reduction of computational time obtained due to software and hardware development reached the surprising proportion of 250 to 1.

Therefore, it is clear that nowadays hydraulicians face a new paradigm concerning information management. This new hydroinformatics phase has distinct effects on teaching and research activities, as well as on the professional working environment. As was previously stated, a fascination with informatics was a major factor in shifting students and professors from the laboratory to computers. This movement happens in hydraulics as well as in hydrology, where, at least in developing countries, it is difficult to develop research programmed with a scientific basis derived from regular measurements in an experimental river basin. Laboratory and field research requires a longer duration to be undertaken. Furthermore, it demands greater financial support, and the time spent from the research proposal period to the stage when the first results are obtained is considerably longer than that based on computational. modelling. We think these aspects contribute to inhibiting interest in experimental research in the areas of hydraulics and hydrology. An additional factor is concerned with the limited resources for automatic data acquisition and processing available in Brazilian hydraulics laboratories. Thus, with few exceptions, students and researchers are not enthusiastic about developing traditional research using those older approaches and devices traditionally adopted in a hydraulic laboratory.

Hydraulicians and Environmental Concerns

The activities of hydraulic engineers affect nearly all aspects of a society, and sometimes have a lasting influence on it. It is true that the history of hydraulics does include some past mistakes. Dam projects are usually presented as a potential threat to the environment. A well-known international case is the Aswan Dam, which has received criticisms-since it was built in Egypt 25 years ago. But, as pointed out by Carstens[1], by now, after Egypt has escaped the droughts and hunger that have hit her neighbors time and again, it should be clear that Lake Nasser was needed and has proved its worth. This statement is supported by a man well known for his critical attitude towards mega projects and concern for the environment, the Director of the United Nations Environment Programme, Mr. E. K. Tolba: "the real question is not whether the Aswan High Dam should have been constructed, but rather what steps should have been taken to anticipate and address the adverse environmental impacts, and to ensure that they were reduced to an acceptable minimum." The Balbina hydroproject is another case of a dam, constructed in a tropical forest (Amazonia region), which was heatedly discussed by the Brazilian and international press due to the associated environmental impacts. Despite the valid issues concerning the small hydropower outputs, 10 years after the darn was built, monitoring data showed that several predicted impacts did not occurred.

Based on cases like those that have occurred worldwide, hydraulic engineers and, hopefully, environmentalists have learned significant lessons. Of course, the interactions between man-technology-environment should be regarded in all respective measures and activities. More than in other fields of engineering, responsibility for the natural environment will be ranked highly during professional education

The need for the use and analysis of hydrologic data, as well as the need for assessment of the chemistry of waters and of hydro-biological processes makes it clear that scientific foundations related to various natural sciences are an indispensable component of a future-oriented engineering education. Whatever their actual field of activity, hydraulic engineers may work at initial planning, feasibility studies, preliminary and final design, the execution and supervision of construction work, water resources management, or in administrative positions at various levels. As suggested by Drewes and Romisch[5], with the integrated planning and construction of large projects, civil engineers--and in this case hydraulic engineers--often have to assume the role of generalists in the sense of coordinating and integrating the multiple and detailed tasks. An ability and readiness for interdisciplinary cooperation is thus highly necessary. This anticipates the receptivity of hydraulic engineers to a close cooperation with biologists, chemists, ecologists, landscape planners, economists, etc.

The previous issues bring challenges to a variety of professionals for assuming critical attitudes coupled with prudence. The main subject for hydraulic engineers, water in its numerous forms, is one of the most precious resources on earth. Therefore, a major concern for a hydraulic engineer is to ensure a stable and sustainable water supply with reasonable water resources management by controlling the quantity and quality of water suppllied. On the other hand, hydraulicians need to improve their communications skills to convince other professionals of the need to mantain the role of engineers as producers of infrastructure alternatives. Water infrastructure, like public health, will always be a societal need.

The proper way and pace for considering the challenging issues mentioned above will depend on local conditions existing in each country or region. It is always difficult to deal with environmental issues from a global perspective, because individual expectations about the environment vary widely. They are affected by, among other things, a country's standard of living, the state of its economy, the age and extent of its infrastructure, and even ethnic and religious differences. Some countries embody concern for the environment in legislation, and others let market forces determine the pace of environmental progress. In many countries, individuals can influence key decision makers in government and industry through the democratic process as voters or as shareholders. However, mainly in developing countries like Brazil, identifying what people want and how this can be supplied by engineers and builders in a environmentally sensitive way can become very complicated. It will certainly require an emphasis on educational change from basic school up to the college level,

Conclusions

This paper presented some challenging issues in the teaching modem hydraulics, specially considering current international trends and the reality of the Brazilian context. The impacts of informatics and environmental sciences are understood as key variables, which explain the recently changing scenario in which the hydraulic engineer works. Based on these issues, we realize the following aspects to be taken into account in a future-oriented education of hydraulic engineers in Brazil:

1) The requirements of the practice of hydraulic engineering are subjected to accelerating changes, such as those that ocurred during the last 15 years. The trends of these developments can not be predicted in detail, considering the technological innovations usually carried out by developed countries and their fast impacts on less developed countries. The unpredictable future scenario are exacerbated in Brazil due to social, political and economic conditions that are open to unforeseen changes in direction, thus creating additional difficulties in planning long-term policies for engineering education. Environmental concerns must be properly and prudently considered to avoid extreme positions which could carry over as greater delays in supplying the increasing infrastructure deficit;

2) The state of the art in some special areas such as computer applications and simulation theories advances so quickly that it is impossible to design educational programmed for the duration of an entire professional career. Thus, professors must be aware of advising students of the need for engaging in continuing education programmed after conclusion of their undergraduate programs.

3) The dramatic change in social values affects the valuation of work done by people in general, and engineers in particular. The learning process that occurred at larger consulting companies (with senior and young engineers working together on a project) has been dissapearing and is being replaced by the small office with a few engineers in each. The recent institutional contextual shift towards a private hydro market constitutes a new paradigm that will bring uncertainties to the engineering practice.

Even though the complex aforementioned issues could make us become sceptical, they also bring us new opportunities for changes. This new broader education for hydraulic engineers may result in students who are worried not only about the traditional ability of engineers concerning *how* to get things done, but also with *what* should be done, and, more importantly, *why* it should be done (Mark and Carver[6]). In other words, students and engineering faculty should understand that engineering is for people, and that society sets demanding goals and constraints for the practice of engineering. Conscious of this mission, we can hope to graduate hydraulic engineers potentially prepared to assume future leadership positions in society.

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ABSTRACT

Like occured in many other countries the traditional role of Hydraulics in Brazil has been changed from a prestigious position to a more-modest importance during last decades. Basic research in laboratory is declining, and-so is consulting in traditional engineering fields, such as hydropower, coastal and habour. In these areas the need for the traditional hydraulic engineer is decreasing, and this carries over to teaching institutions. Recognizing this process the paper brings to discussion some underlying issues related to the subject. The impact of Informatics and Environmental Sciences are understood as key variables to explain the process. Furthermore, the scarcity of finantial finds to support long term research programmed and also the crisis of governmental investments in infrastructure works entails new difficulties to keep that old Hydraulic scenarios. The discussions take into account the international trends concerned to the training of hydraulic engineers, from which, some special issues are presented considering the brazilian context.