

COASTAL ENGINEERING, COASTAL RESEARCH, UNIVERSITIES AND CLIMATE CHANGE

Kamphuis, J. William, Queen's University, Kingston, Canada kamphuis.bill@gmail.com

WHAT WAS COASTAL ENGINEERING?

Coastal Engineering was new in 1950/1960 and at first, it was all about solving urgent coastal problems. There were no recipes, no formulas, no models; nor was there much experience at that time. Inventiveness and ingenuity were the key design ingredients.

Coastal Engineering is a broad subject that is concerned with the interaction between the water and the shore. This involves fluid motion, such as waves and currents and its interaction with a shore that can be anything from sandy beaches to marshlands to highly engineered shorelines, such as found in centres with dense populations. It involves complex hydraulics and fluid mechanics principles on the one hand and complex design criteria on the other hand. It also involves detailed knowledge of the environmental systems where the projects are located. Thus, one obvious need for Coastal Engineering analysis and design is individuals with broad knowledge, interests and background. Such individuals need access to and communication with colleagues in related technical and scientific areas. As a result, much of the early coastal engineering was done at universities.

Coastal erosion and protection were the #1 coastal problem of the early days, followed closely by navigation issues (channels and harbours). Because new design ideas and expressions were developed at the universities, it was natural that these university 'experts' became the first cohort of coastal engineers and coastal consultants. The other major actors in the field of coastal research and design were government sponsored research laboratories.

WHAT HAPPENED OVER TIME?

Field research and hydraulic modeling were the basic tools used to support the early solutions to practical problems and to develop basic, practically useful coastal design relationships. Graduate students in coastal engineering were closely involved with their professors in both the field research and the hydraulic modeling, thus learning directly from their own practical work. Coastal design became more organised as new insights and new expressions were developed over time and shared in the literature.

As it became possible to solve the immediate, urgent problems with more confidence, interest developed in learning more about underlying basic relationships. Soon, the coastal communities in the universities and within the research organizations followed a more-or-less natural progression, shifting research focus from immediately needed design methodology (synthesis) toward greater emphasis on expansion of the knowledge base (analysis), needed for future development of the discipline.

However, within the universities, the gradual drift from emphasis on design (synthesis) to greater emphasis on analysis (science) became a sea change (pardon the pun). The (generally underfunded) universities decided to charge

overheads on incoming research grants, thus creating a major, new source of university income. The sizes and numbers of research grants received by researchers are very much driven by the *number* of papers published. (As time for appropriate peer review of the quality of the research is limited, the most readily available proxy, and often the only substitute measure of the quality of the research and the researcher is the number of publications). Soon the professors began to maximize the number of papers they publish, to increase their status within the university as well as their income, reputation, opportunity of advancement, etc.

However, this drive to produce a maximum number of papers has destructive consequences for engineering education. Engineering disciplines are bi-modal. They must integrally combine a theoretical education with a substantial practical education; combine analysis (theory) with synthesis (design). Unfortunately, maximizing production of research papers focuses research more on advancing the discipline (analysis), and less on application of this knowledge (design), as will be shown below.

Professors, in order to generate large numbers of papers, need to supervise a maximum number of students and must spend time to generate the needed research funding. This comes at the expense of thorough education in practical design and of appropriate supervision and mentoring of students in the practical aspects of their chosen discipline, which is very often the reason why the students chose an engineering education in the first place.

To produce a maximum number of papers the projects must be kept simple, so as not to slow down the publication stream. Hence, there is little interest in the analysis of large, complex problems, which take more time per paper.

In the paper production process, the research papers tend to be analytically-oriented and faculty and graduate students have become less design-oriented. Conferences and publications, where the research results are presented have become analytical enough that the presentations and the publications have become of less interest to practicing engineers. Thus, the enviably close bond between practicing engineers, and the professors and their students is breaking. In the process, research and design are separating.

The losers in this development are the students and the university-based engineering education. Professors, with their time-consuming, analytically-focused background have difficulty finding the time, interest and technical expertise to teach the practical aspects of engineering. And so, the bonds between synthesis and analysis are essentially being severed. The result of these changes is very unfortunate. The profession badly needs broad well-educated young minds, well-educated in *both* theory and practice, both design and analysis - *now*. This need has

become urgent in view of the challenges posed by Climate Change and its resulting impacts, Kamphuis (2019).

Climate has been shown to become generally warmer over the past century (Climate Change; Global Warming). The last few decades have also shown that climate is considerably more variable than was earlier assumed. Therefore, the standard, accepted design methodologies must be updated. These updates must include climate change/impact and other uncertainties. It is for this confusing future that the universities and their professors must provide those bright, broad and well-educated graduates, an exciting, but complicated task.

Unless a university recognizes and faces these practical challenges head-on, it runs a good chance of making its education of coastal engineers practically irrelevant and the profession will go to other universities to find competent, broadly and practically educated employees.

CLIMATE CHANGE

Climate Change research began in earnest with observations that global temperatures have been rising relatively rapidly during the 20th century (Figure 1). Note that there are many fluctuations in the record - the temperature rise is by no means linear or smooth - which means that there will be many uncertainties in the interpretation and use of this record. The record does, however, show an average increase in temperature of about 1° C in the last century, which is a phenomenally rapid rate as shown in Kamphuis (2019).

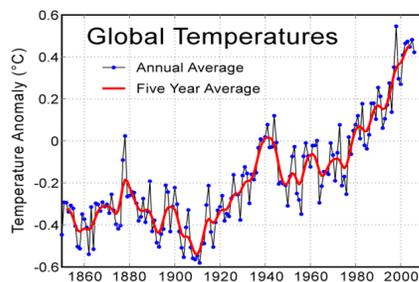


Figure 1 - Recorded Global Temperatures

Ref: NOAA

Such rising temperatures mean there is extra heat in the earth's physical system - the earth's atmosphere, the earth's surface and the oceans. This extra heat adds energy to the earth's weather systems and causes changing and more energetic weather patterns.

The relatively sudden (measured) temperature rise in Figure 1 is disturbing. To learn more about what was (and is) happening, the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO) created the Intergovernmental Panel on Climate Change (IPCC) in 1988. Details about this panel and its results are discussed in Kamphuis (2019).

The combination of greater climate variability and climate change means that coastal design and analysis are suddenly moving from methods based on the assumption that processes are stationary, to a completely new

paradigm: Climate is changing rapidly and is difficult to predict. The design and analysis paradigm has changed from apparent (relative) certainty to great uncertainty. The future coastal analysis and design problems to be solved by coastal/fluvial professionals are no longer simply extensions of past coastal/fluvial methodology. Completely new technology must be developed - *now*. For that, many broadly educated, bright young scientist and engineers are needed and many professors, who dedicate themselves to educating such young people. As discussed earlier, the present university systems will not provide such individuals, unless the university and research culture are changed to facilitate disciplines, such as coastal/fluvial engineering; educating coastal engineers who are familiar with both the theoretical aspects of coastal engineering and design, with both analysis and synthesis.

It must be noted here that Coastal/Fluvial Professionals are not primarily concerned with Climate *Change*. Their main task is to deal with Climate *Impact*. Appropriate response methods to Climate Impact must be developed *now* to improve the safety of millions of people and to prevent massive climate-related migrations, resulting in millions of climate refugees. But what can those response methods be based on? There are few concrete examples, yet, of climate Impact and examples of such impacts are desperately needed to be able to learn. It should also be possible to study similar impacts from recent hurricanes and tsunamis. This is a formidable task and will form a major contribution to future civil order in the response to Climate Impact. This (again) will require many bright minds and much inspiring communication between students, professors and their colleagues.

The main solution to Climate Impact to date has been 'Adaptive' or 'Flexible' design. This makes good sense when the processes are not fully understood, and proper impact responses are still to be developed, but it frightens all clients, governments, permitting agencies, stakeholders and all accountants and lawyers out of their minds. Clients, their advisors and regulatory bodies want certainty. They want to continue with the (relative) certainty of the design methodology of the past, which was based on (apparently) more-or-less solid design criteria, which produced (somewhat) confident analysis of risk. But what is Adaptive/Flexible design? What are the design principles and the design alternatives?

Here lies the crux of the problem. Stakeholders are disturbed by what they perceive as Trial-and-Error Design. Much inspired work is needed by today's and tomorrow's Coastal/Fluvial Scientist and Engineers. Again, bright, all-round people with design skills are desperately needed and as discussed above, the present university systems have difficulty to produce such individuals. But for appropriately prepared graduates and professors, this new world is an incredible and exciting challenge! Let us make sure that we are properly prepared for these future challenges!

REFERENCES

Kamphuis (2019): (To be Published). Introduction to Coastal Engineering and Management", 3rd Ed, World Scientific Press, Singapore.