HOW TO BUILD AN OCEAN

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ABSTRACT

At Newcastle University, England, a taste for ocean engineering is volunteered through short courses primarily introduced into the syllabi of other subjects. These courses provide an insight into applied oceanography and ocean engineering as an introduction to climatological research and its potential impact on environmental subjects - sneaky, but it works. As such it reaches a very wide audience with extremely diverse backgrounds.

1. INTRODUCTION

A common fallacy in the education of ocean engineers is that their continued training merely requires the imparting of knowledge regarding the transfer of land-based technologies to the sea. Another part of the fallacy is that the student at any level really understands the objectives of the subject that he is facing. A brief census of ocean engineers worldwide is sufficient to confuse the finger of blame; nowhere in particular can it alight. We all share the guilt for proliferating ignorance of the real challenge of the oceans and the way Man might tackle it. Young engineers generally have little real feeling for their environment or the forces at its disposal. They know the words and the techniques to camouflage their ignorance but these are easily exposed for the shallow veneer of intellectual polish that they are. In brief, and, in keeping with many of our land-orientated couterparts, we teachers fail to impart an understanding of the soul of engineering. It is not about machines and techniques; it is about enabling Man to come to equable terms with his environment.

To approach the ocean environment successfully requires a very broad-based knowledge. Apart from the traditional skills of engineering in all its various shades, ocean engineering should include a working knowledge of economics, oceanography, geology, biology, sociology, and a long list of other ologies. The depth of the working knowledge may only extend as far as the name of a guy who has a friend whose mother read a book about it but it is essential to understand the genuine need to have access to this information. Also the understanding should include a real appreciation of the myriad of ways in which the sea represents a different world than the land - there is more in the sea than water.

Civil Engineering was named to distinguish it from its counterpart, and, indeed in earlier strife-ridden times forerunner, military engineering. The distinction was found necessary not so much because the technical content of each subject was substantially different but more because the type of person attracted to the one application was generally found to be a different animal than that to the other. The same now applies to ocean engineering.

Little within the vast range of activities confronting the ocean engineer is not encompassed by an existing discipline. However, the overwhelming influence of the sea requires that the would-be professional ocean engineer comes to regard it as his respectful adversary, always prepared to bend to Man's intervention yet relentless in exposing the shortcomings of those not fully at ease with their environment. In short,novice and doyen of ocean engineering alike must think first environment and then technology.

Ocean engineering could be said to have begun with the earliest faltering steps of mankind to provide a beachhead for maritime intercourse - a hollow log needed to be tethered, an arc would require a launching facility, and, more recently, lighthouses and their like necessitated offshore foundations. However, as a distinct subject, it had to wait for Man to exhaust much of his convenient landbased natural resources so that he was driven to confront the awesome prospect of frequent offshore construction and servicing.

Ocean Engineering at Newcastle University had to wait for the initiative of the University elders to secure the benevolence of "outside" donors to establish a primarily research professorship. The University sought the advice of governmental, industrial and academic sages in order to establish the most appropriate flavour for the subject in the light of its novelty (the Chair remains the only one in the U.K. to enjoy the distinct title of Ocean Engineering). It appears that the recommendation was made that the post should be offered to a progressive researcher endowed with commercial initiative to compensate for the near-absence of university funding, extensive knowledge of and

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sympathy with the many components of the offshore environment, and sufficient technological skills to devise engineering systems to overcome the environmental challenge in the interests of industry. However, the author is pleased to record that the University preserved its prerogative to ignore this sound advice by employing him instead!

Since the establishment of the Chair in 1975 the direction of Newcastle's Ocean Engineering has expanded from its initial concentration on marine geotechnics to encompass the study of the sea itself and indeed the overlying atmosphere. During its six years it has attempted to service a pre-existing engineering master's course in marine technology with dubious success, the reasons for which are open to challenge, but, in the author's opinion, fairly clear and related directly to the central theme of this paper. Engineers, as people devoted to doing for a penny what any fool can do for a pound (to be translated loosely in terms of cents and dollars, etc.), are people concerned primarily with machines and money; marine technology in U.K. is directed primarily towards ships and systems, the design and construction of which is carried out by engineers. Ocean Engineering at Newcastle aims to achieve an equally productive graduate through exposure to and familiarity with the offshore environment per se. Hardcore engineers, directed to excellence in shipping matters in the context of a one-year postgraduate course are not obviously volunteered the facility to "take time off" to extend their horizons to apparently peripheral environmental subjects - after all, one can cross the Atlantic inside a ship without once seeing the sea, let alone the sky or the seabed.

So how could Ocean Engineering, now housed securely in the Department of Naval Architecture and Shipbuilding, transcend the strictures of an overwhelmingly engineering title and powerbase? The answer is to be found in a mixture of enterprise, determination, naivity and downright arrogance, the focus of which the author is content to be. The vehicle through which ocean engineering at Newcastle is being expressed is the direction of the full range of Earth Science subjects, of which ocean engineering is but a small part, towards the solution of a range of offshore (and onshore) technical and socio-economic problems. In short, the author has devised a lecture programme to link geology, the seabed, the sea and the air with offshore engineering under the guise of climate and weather prediction. How and with what measurable success? Read on.

2. THE FOCUS

In the context of impoverished University research carried on without recourse to normal offshore site investigation and sophisticated sampling facilities, there is but one sound way to proceed towards securing engineering design data, i.e. seabed strength and consolidation properties. That way is through correlation[1]. Novice research groups can seldom produce nitty gritty data. However, they can produce index parameters from disturbed samples acquired with borrowed equipment and perhaps these can be correlated with the values required by the engineer.

Correlative index parameters can take many forms from the geotechnical such as plasticity indices, densities and particle size distribution[2] through geophysical data such as ultrasonic wave velocities[3] to the correlation of bio-population grouping with geotechnical zones[4] and beyond to the following paragraphs. Confronted by the seemingly endless range of correlative possibilities the author became accustomed to scanning the literature for any potential correlation.

One particular review took him to a volume of the Deep Sea Drilling Project (DSDP) reports[5] in which he observed a borehole profile of oxygen isotope data (^{18}O) extending to some 560m depth below seabed and describing an approximately stable rate of deposition according to the isotope dating of the core to a limit of about 7 million years. At that time the author was seeking geotechnical correlations and was unaware of the significance of oxygen isotope variation or the potential value of its analysis in this near-true time series. However, he was bemused by the apparent cyclic quality of the isotope data which, by manual curve fitting, he reduced to three sine components and a minor residual. The relation of these components was of ever-decreasing amplitude as the period reduced by a half. The record was insufficiently sensitive to permit finer interpretation than of period 1.2m years so the variation of oxygen isotope values was pursued in other data suites from seabed cores from the Caribbean[6] and the Indian Ocean[7] ranging back to 450,000 years from which the periods of 600,000 years down to 75,000 years were discerned. These led on to analysis of the variation of oxygen isotope values from cores in the Greenland[8] and Antarctic[9] ice sheets with measuring interval down to 200 years permitting a sensitivity of interpretation down to a periodicity of about 1100 years.

At this point, and with a sine series encompassing 13 components, the author confirmed his suspicion that oxygen isotope variation in fact describes palaeoclimate or, more precisely, past temperatures, about which the ocean engineer is generally totally unaware. Such being the case he recognised the possibility of pursuing temperature variation down to periods representing engineering time, i.e. less than a century. At that point Lamb's data[10], relating to temperature variation over eastern Europe interpreted from historical records, came to his attention. This extends back to about 900 AD and permitted a resolution of the sine series down to a periodicity of of about 67 years. In turn, this was found to be consistent with the variation of the instrumentally measured temperature of the Northern Hemisphere since 1881[11] from which sine components with a periodicity down to about 4 years are available to extend the sine series to 21 components. If this progression could be substantiated it would indeed be of immense engineering significance - i.e. a return from environmental fantasy to hardcore ocean engineering.

Before we proceed to the shortterm of this year's offshore programme let us allow ourselves the frivolity of attempting to extend the "fundamental" of the sine series backwards from its temporary foothold at 4.8m years. Such a lighthearted digression should be welcome as it takes us into the area of uncertain dating and data values in which conjecture can so easily become doctrine and opinion replaces the guidance of codes of practice. With tongues well and truly slotted into cheeks let us then drift back. The variation of carbonate compensation depth (CCD) during the last 120 million years across the South Atlantic has been described. The CCD is also related to palaeoclimate and Le Pichon's data[12] can be related to the extension of the sine series to a higher "fundamental" of about 150 million years. Strictly for fun it is interesting to guess why a further extrapolation of the series to a more distant "fundamental" of the order of 4.8 billion years gives rise to the coincidence of predicted ice ages in the Pre-Cambrian (500-900 million years) and the Huronian (2100-2200 million years) with the observation of glacial relicts from the same periods. Once on the trail it is instructive to contemplate the significance of even further flights of fancy in relation to the origins of the solar system and even the "big bang" when stretching the "fundamental" to the order of 38 billion years. And, by the way, is that not beyond the supposed date of the beginning of the Universe - and still only 34 components of the series?

Let us not, however, get carried too far off course. We were about to address the shortterm under four years duration. At this point it is important to recognise that coincidence provides insufficient grounds on which to establish a theory; there must be a reason for the climate variation. Space will not permit its proper description here but suffice it to say that the link between global temperature and atmospheric pressure variation can be soundly demonstrated without recourse to conventional atmospheric dynamics. Local pressure measurements give rise to synoptic charts from which weather can be predicted. Preliminary results indicate that, for example, the significant wave height thus predictable does indeed bear a highly statistically significant relation with the observed record - and that, when determined over periods of weeks, is ocean engineering.

Intriguing, maybe - but perhaps a trifle too fanciful for our budding ocean engineer. However, by now he is captivated, softened up to the prospect of intepreting the high frequency variations in the engineering realm under four years. He is reminded that all that has gone before stemmed from the proper engineering ambition of seeking geotechnical data from a seabed borehole profile. No longer need he expect only boredom in archived data - under any borehole record may lie the key to the Universe! A happy mind - an excited, alive mind - is a productive mind. And how do we know? By trial, by presenting this very series of lectures summarised so crudely here to guinea pig classes of undergraduates.

3. THE TRIAL

Trial short courses in climatology, for that is indeed where this branch of ocean engineering has taken us, have been presented to first and third year undergraduates in Civil Engineering at Newcastle with the forewarning that they would be examined on the subject, asked to compile extra-curricular essays, and invited to comment formally on their estimate of the value of this study to their course leader. The introduction to the study and the return to the engineering timescale provided ample scope for putting over mainstream physical oceanography and ocean engineering. Despite the fact that ocean engineering lies outside the students' anticipated programme and that they were inviting an additional workload, the comments from each class were entirely favourable. A considerable amount of ocean engineering was absorbed on the way to an appreciation of the climatic argument and the author and students alike could not recall more stimulating discussion than during and after the lecture series.

It is planned to extend the introduction of this series of lectures into the curriculae of other undergraduate and postgraduate courses. A preliminary foray into the open lecture series of the Faculty of Agriculture and the Mechanical Engineering Department have already met with similar interest though undoubted scepticism on the part of the engineers. Scepticism need not be a bad thing; in order to be constructively sceptical, one has to come to terms with the meat of the argument and by so doing one absorbs a fair measure of applied oceanography and ocean engineering. Sneaky, but it works. The reader may ask himself whether he too may have absorbed a modicum of information about climatology under the auspices of a paper ostensibly about the education of ocean engineering.

In the meantime, the Ocean Engineering group at Newcastle takes advantage of the interest kindled by these occasional lectures to hold open house for all-comers. Students and external visitors alike from a wide diversity of disciplines thereby come into contact with the peculiar mixture of civil, electronic, mining, hydrological, geotechnical, petroleum and instrumentation engineering, geology, geophysics, oceanography, climatology, meteorology, zoology, mathematics, computing, naval architecture and economics available in the group. As a result the group is able to boast more than its fair share of applicants to undertake post-graduate research.

4. CONCLUSIONS

Necessity, brought about by the need to establish a new research and teaching enterprise in an austere economic climate, has resulted in a novel approach to ocean engineering teaching at Newcastle University. With insufficient teaching resources to provide extensive regular formal coursework the Ocean Engineering research group volunteers lectures to other syllabi in the University primarily under the heading of climatology. This coursework is introduced by using ocean engineering as the goal and applied oceanography and

related subjects as the tools of trade.

The programme is still at an early stage, but the results to date are encouraging. This novel teaching vehicle appears to be both stimulating and constructive while students and author alike have a lot of fun.

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