HYDROELASTICITY OF SHIPS

Hydroelasticity of ships

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Preface

Oh will you swear by yonder skies,
Whatever question may arise,
'Twixt rich and poor, 'twixt low and high,
That you will well and truly try?
Trial by Jury

Just as with aircraft, it was quite inevitable that the dynamics of ships would initially be founded on the assumption of rigidity. We now possess a valuable body of theory constructed on that basis. But a ship is not really a rigid structure and, as we show in this book, this has some profound consequences which cannot easily be ignored – particularly when one considers the stresses and strains of the hull in a confused sea.

That a ship is really a flexible structure and might be treated as an elastic beam is not a new idea. This was presumably the underlying theme of a paper published nearly fifty years ago.† But in years gone by the point could not be pressed. The beam being non-uniform, the calculations for the structure were virtually impossible to make before the advent of electronic computers. There was then very little understanding of the mechanics of non-conservative systems. The excitation of the beam by the sea could not be specified with any certainty. Indeed there was no acceptable way of describing the response, let alone of determining it. Even the far more pressing problem of aircraft distortion in flight had not, at that time, given rise to anything like a coherent body of adequate theory.

This book is written in the belief that a return to the fundamentals of ship dynamics is no longer out of the question. Advances in linear structural dynamics, in oceanography, in random process theory, in marine hydrodynamics and in computing appear to have made a big difference. What is more we have concluded that revaluation of existing theories need not lead to a mere collection of proofs, studies and solutions, all produced *ad hoc* as a result of practical demands. It should be possible (we think) to put a thread through this whole subject of Ship Hydroelasticity.‡

† Inglis, C. E. (1929). Natural frequencies and modes of vibration in beams of non-uniform mass and section. *Trans. INA*, **72**, 145–66.

‡ Hydroelasticity is that branch of science which is concerned with the motion of deformable bodies through liquids.

This question of a 'thread' is more important than it may appear. In this book we have given a general treatment, adapting contemporary techniques of structural theory, hydrodynamics and statistical theory for use in it. Obviously progress will be made in these fields, but that progress will not render the general approach useless. New theories too, can be adapted if need be.

This book is essentially one on naval architecture. But it is radically different from any existing book in that field and, in fact, much of the material has appeared only recently as published research. In other words the techniques presented have not yet withstood the test of time. In the circumstances we urge our readers not to regard this as a book of recipes but, on the contrary, to subject it to as many tests as possible. While we have left no intentional errors, it would, we are afraid, be a miracle if none remain. Indeed, having been moved to work in this field almost solely by sheer interest in the subject,† we should regard it as surprising if commercial and/or contractual pressures fail to produce worthwhile improvements.

The fact that this book is concerned with a rapidly developing subject has made it difficult to decide where to draw the line. Our decision has been in favour of presenting only basic theory, together with some specific results for actual ships. In the few months before the book actually appears, studies will be completed on a number of topics. The superposition of slamming responses on steady wave-induced responses has been investigated, additional results have been found for antisymmetric response and several other matters have been examined. In other words, we have decided to restrict this book to the presentation of basic ideas and not to develop those ideas as fully as one might.

The results that are given place greater emphasis on symmetric responses than on antisymmetric. Admittedly this has been dictated by the availability of adequate structural data and by the shortcomings of present-day techniques of estimating antisymmetric fluid loading. Even so this emphasis on symmetric responses hardly makes for artificiality since they are largely responsible for structural damage – notably when slamming occurs. Existing literature on antisymmetric responses is far smaller than that on symmetric responses; but it is to be expected that its sparseness and its known shortcomings will be remedied before long if only because antisymmetric motions are of great importance in questions of safety, and in particular of capsizing.

The origins of this book stem from the decision, reached about ten years ago, to start teaching naval architecture in the department of which we are members. This decision had been reached because it was

† The exception is chapter 9. The Ministry of Defence (Procurement Executive) commissioned the studies on slamming and we gladly acknowledge our gratitude for that support.

agreed that (among others) entrants to the Royal Corps of Naval Constructors should henceforth receive their specialist training in University College London. The RCNC being that body of engineers which is responsible for the Royal Navy's ships, it became necessary to think about the design of high-performance vessels. The then Head of the Corps, the late Sir Alfred Sims, hoped that such thinking would be aimed essentially at the longer term and the writing of this book is one outcome of our attempts to meet the challenge.

We really must say some words of thanks. The exploratory nature of this work has meant that our research assistant, Dr P. K. Y. Tam and, also, in the last stages, Mr P. Temarel and Mr Ö. Belik, have had to get used to our never being quite satisfied, to our perpetual wish to try something else and to our wanting all computer results 'yesterday'. We enjoyed working with Mr C. V. Betts on the particular subject of damping. Jenny Price must sometimes have wondered if the typing of drafts at breakneck speed was entirely compatible with running a particularly lively household and Jane Saffin must occasionally have wondered if the flow of tracings to be made would ever dry up. We are very grateful indeed to them all.

The Ministry of Defence (Procurement Executive), Yarrow (Shipbuilders) Ltd, Ocean Fleets Ltd, Howaldtswerke-Deutsche Werft A.G. and the British Ship Research Association have all helped us by supplying data on actual ships. Finally we wish to acknowledge our indebtedness to the Editors of the *Transactions of the Royal Institution of Naval Architects*, of the *Journal of Sound and Vibration* and of *International Shipbuilding Progress* for permitting us to reproduce material that was first published by them.

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April 1978 W.G.P.