

Review of doctoral dissertation

Title of dissertation: "Experimental exploration of the ship surf-riding in bi-chromatic following seas"

Candidate's name: Mr. Michal Struk, MSc Eng

Institution: Gdańsk University of Technology

Reviewer: Kostas J. Spyrou, Professor
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I have enjoyed reading through the dissertation of Mr. Michal Struk. I find that it is well written, complete and clear. The work demonstrates the candidate's in-depth understanding of the subject, supported by an original and well-suited scientific approach.

The surf-riding behavior of ships in following seas is generally regarded as an advanced topic of ship dynamics due to the presence of strong nonlinear effects which can generate a multitude of peculiar types of ship behavior. Internationally, the general trend in this line of research is to advance from the regular waves condition toward the irregular one which reflects of course more accurately real-world environments. While a few studies based on mathematical modeling and simulation have appeared for this topic in the literature, relevant efforts based on experiments with scaled ship models are very scarce. The main reason is that these experiments are quite unconventional and demanding. On the other hand, they have a very clear scientific objective, that is, to understand how a ship could behave when encountering high waves from astern, and whether scenarios representing a serious safety threat can arise.

The dissertation of Mr. Struk achieves to provide concrete "physical" evidence about surf-riding phenomena in bi-chromatic following waves. The choice of bi-chromatic waves is not arbitrary. It is the first step away from the assumption of periodic (mono-chromatic) waves which has dominated relevant research over the years. One can foresee Mr. Struk's experiments to serve as a stepping stone toward addressing a fully irregular environment, in the years to come.

A scientific theory of surf-riding phenomena for bi-chromatic waves was proposed less than a decade ago. However, this theory had not been validated experimentally. Despite this theory's rigor, it is natural for one to wonder whether the predicted types of nonlinear behavior (which sometimes are quite counterintuitive) would "survive" if the simplifying assumptions of mathematical modeling are removed. That is, whether theory would stand strong against physical evidence. The work of Mr. Struk has shed light on this valuable connection, generating significant insights by means of a two-level experimental effort: first by employing a small and handy physical model in the University's tank; and later, by employing a moderately sized one in a large commercial experimental facility.

His methodology is systematic, rational and effective. Uncertainty issues are inherent in this kind of work. They were effectively dealt with to a good extent; but of course, a few were beyond a PhD student's control. The achieved outcome is significant because it allows to evaluate and, in many cases, corroborate, the theoretical findings.



As a matter of fact, I fully support the award of the doctoral degree to Mr. Michal Struk and, for the reasons outlined above, recommend that it be conferred with honors.

Below are provided a few technical comments, and also, a few very minor grammatical/editorial corrections:

1. In the introduction and elsewhere is mentioned the “front slope” of the wave. This might be vague. It is preferable to identify it as the wave’s downslope.
2. In page 12 is mentioned that ships most likely affected by surf-riding are those moving at high speed. However, in general this is not a feature usually identified with high-speed craft. It is preferable to refer to displacement-type or semi-lifting vessels moving at relatively high speed.
3. At the same page and at several other places: it is recommended not to use the term “high run” for ship behavior in regular waves. Basically, in this case, this is large asymmetric (strongly nonlinear) surging. The concept of high run was introduced as a generalization of surf-riding for a multi-frequency environment.
4. Same page: wave blocking is identified in literature also as bow-diving and there is relevant literature.
5. In Table 1.1 at page 18, I suggest that a few other important experimental works are mentioned:
 - Nicholson, K. 1974. Some parametric model experiments to investigate broaching-to. In: The Dynamics of Marine Vehicles and Structure in Waves (edited by Bishop R.E.D. & Price W.G.). Mechanical Engineering Publ., 160-166, London.
 - Fuwa, T., Yoshino, T., Yamamoto, T. & Sugai, S. 1981. An experimental study on broaching-to of a small high speed boat, 1981/150, 223-231, DOI: https://doi.org/10.2534/jjasnaoe1968.1981.150_223.
 - Thomas, G.A. & Renilson, M.R. 1991. Surf-riding and loss of control of fishing vessels in severe following seas, Transactions of the Royal Institution of Naval Architects, 133, 21-29.
 - DeKat, J.O. & Thomas, W.L. 2000. Broaching and capsize model tests for validation of numerical ship motion predictions. In: Contemporary Ideas on Ship Stability (edited by D. Vassalos et al.), 69-88. ISBN: 0-08-043652-8.
6. In page 25: It would be good to discuss the error of the measurement system for the two models.
7. In Figures 2.6, 2.7 and other, please correct “avarage” to “average”.
8. There is an issue in the definition of primary and secondary wave in the case of bi-chromatic waves: Originally, this was assumed referring to the steeper wave as primary, and to the milder as secondary. Here, the slower wave component is identified as the primary and the faster as the secondary. There is nothing wrong with it since it is a definition, the only issue is that “primary” indicates a dominant component which may not always be identified with the slower component. In any case, it is good that a sentence clarifies the use of the terms and the difference from other literature.
9. In Figs. 3.10 and 3.11 the behavior looks to me like surf-riding which is interrupted at some stage.
10. It will be good to discuss whether water-on-deck and heading changes have affected the obtained surge motion records. In general, surf-riding looks quite oscillatory even in regular waves. What is the explanation?



All in all, as already said, an excellent work.

A handwritten signature in blue ink, appearing to be 'K. Spyrou', written in a cursive style.

Prof. Kostas Spyrou