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Advances in fluid mechanics for offshore engineering: a modelling perspective

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Introduction

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One contribution of 12 to a Theme Issue 'Advances in fluid mechanics for offshore engineering: a modelling perspective'.

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Written by a group of international experts in their field, this Theme Issue provides an overview of the recent advances made by the fluid mechanics community dedicated to offshore engineering, with a specific focus into modelling issues. Although of great importance we have purposely neglected all applications related to 'emerging offshore engineering' concerned with renewable energy extraction (from waves, current and wind) and concentrated our attention on 'classical offshore engineering', i.e. that serving the naval and oil and gas industries. This distinction, which we admit is evident in the applications but vanishes with reference to the physics and solutions, appeared as essential to coherently organize the recent progress made in classical offshore engineering. Other topics that have been purposely neglected are related to internal pipe flow (though that is fluid mechanics of importance for offshore engineering) and the effects that ice has on offshore structures.

In recent years, some significant works have summarized the state of the art in the field (e.g. [1]) and in related topics, such as seabed morpho-dynamics (e.g. [2]), wave impact on walls (e.g. [3]), fluid–structure interactions (e.g. [4]) and freak oceanic waves (e.g. [5]).

However, the continuing and recent progress of the applications—e.g. increasing variety of sea structures and ships involved in transportation, increasing extension of oil and gas exploration areas, etc.—unendingly bring to attention new challenges in the description of the physics and modelling. Hence, the need to update the state of the art in fluid mechanics modelling for offshore engineering.

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This Theme Issue attempts such a task by means of 11 dedicated studies. These can be roughly divided into three classes: (i) studies that focus on floating structures, (ii) works dedicated to structures that pierce the sea water surface and significantly extend downwards (at times reaching the seabed), and (iii) papers devoted to the description of submerged structures. All these papers both illustrate recent progress on typical topics in the field and tackle radically new issues.

For example, with reference to the studies that focus on floating structures, 'Influence of motion coupling and nonlinear effects on parametric roll for a FPSO' [6] investigates classical topics of research in naval engineering. On the other hand, the analysis in 'Wave-induced response of a floating two-dimensional body with moonpool' [7] serves the needs of an increasing use of moonpools to perform marine operations. Finally, the analysis proposed in 'Hydroelastic behaviour of a structure exposed to an underwater explosion' [8] can be regarded as an innovative way to solve an old problem.

The variety of bodies that interact with the sea surface and extend downwards into the sea is very large (e.g. platform legs, mooring lines, underwater cables, etc.). Hence, the need for studies that, though analysing similar oscillatory dynamics, focus on specific matters related to such surface-piercing bodies. The paper 'Resonance of a tension leg platform excited by third harmonic force in nonlinear regular waves' [9] opens this second group of papers by proposing a numerical investigation of the resonance phenomenon of a tension leg platform in Stokes waves. The free vibrations induced by a uniform current on slender bodies is investigated in the paper 'Vortex-induced vibrations of a flexible cylinder at large inclination angle' [10] while analogous dynamics induced by the oscillatory forcing of water waves are examined in 'The interaction between steep waves and a surface-piercing column' [11]. The role of the forcing due to extreme waves is also analysed in the final paper of the group 'Second-order statistics and designer waves for violent free-surface motion around multi-column structures' [12].

Four papers are dedicated to the description of submerged structures. These are, typically (but not only), submerged pipelines, extensively used by the oil and gas industry over an increasing range of water depths and seabed conditions. The paper 'Insight on the design of free-spanning pipelines' [13] proposes a review of the theme and sets the scene for the other more specific papers. Among such papers the analytical investigation in the paper 'A theoretical model of asymmetric wave ripples' [14] is aimed at characterizing the small-scale roughness that influences pipeline stability. Such a stability under extreme forcing is analysed by the work 'Stability of subsea pipelines during large storms' [15]. The fourth study in the category, 'Numerical investigation of flow and scour around a vertical circular cylinder' [16], is dedicated to the flow–structure interactions undergone by a solid structure that extends normally to the seabed, rather than parallel (like pipelines).

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