These include: Dr J. M. R. Graham of Imperial College, London; Dr Martin Greenhow of Brunel University, London; Professor Makoto Ohkusu of Kyushu University; Professor Paul Sclavounos of MIT; Professor Finn Gunnar Nielsen of Norsk Hydro; Professor Enok Palm of University of Oslo; Dr John Grue of University of Oslo, Dr Bjørn Sortland of Marintek; Siv.ing. Terje Nedrelid of Marintek, Professor Bjørnar Pettersen of NTH and Professor Dag Myrhaug of NTH. Graduate students who have been particularly helpful have been Seung Il Ahn, Rong Zhao, Geir Løland, Jan Kvålsvold, Knut Streitlien and Jens Bloch Helmers. Rong Zhao has done the calculations presented in several of the figures and Vigdis O. Dahl is responsible for the skilful drawing of many of the figures. Marianne Kjølaas has typed the many versions of the manuscript in an accurate and efficient way.

1 INTRODUCTION

Knowledge about wave induced loads and motions of ships and offshore structures is important both in design and operational studies. The significant wave height (the mean of the highest one-third of the waves) can be larger than 2 m for 60% of the time in hostile areas like the North Sea. Wave heights higher than 30 m can occur. The mean wave period can be from 15 to 20 s in extreme weather situations and it is seldom below 4 s. Environmental loads due to current and wind are also important. Extreme wind velocities of 40 to 45 m s^{-1} have to be used in the design of offshore structures in the North Sea.

Fig. 1.1 shows five examples of offshore structures. Two of them, the jacket type and the gravity platform, penetrate the sea floor. At present, fixed structures have been built for water depths up to about 300 m. Two of the structures, the semi-submersible and the floating production ship, are free-floating. The tension leg platform (TLP) is restrained from oscillating vertically by tethers, which are vertical anchorlines that are tensioned by the platform buoyancy being larger than the platform weight. Both the ship and the semi-submersible are kept in position by a spread mooring system. An alternative would be to use thrusters and a dynamic positioning system. Pipes (risers) are used as connections between equipment on the sea floor and the platform.

Ships serve a large variety of purposes. Examples are transportation of goods and passengers, naval operations, drilling, marine operations, fishing, sport and leisure activities. Fig. 1.2 shows three types of ships: a monohull, a SWATH and a SES. The monohull is exemplified by a LNG (liquid natural gas) carrier with spherical tanks. SWATH stands for small-waterplane-area, twin-hull ship and consists of two fully-submerged hulls that are connected to the above water structure by one or several thin struts. Between the hulls there may be fitted fins or foils as in Fig. 1.2. SES (surface effect ship) is an air-cushion supported high-speed vehicle where the air-cushion is enclosed on the sides by rigid sidewalls and on the bow and stern by compliant seals. By high speed we mean high Froude number (Fn). This is defined as $\mathrm{Fn} = U/(Lg)^{\frac{1}{2}}$ (U = ship speed, L = ship length, g = acceleration of gravity). A ship is considered a high-speed marine vehicle when $\mathrm{Fn} > \approx 0.5$. From a

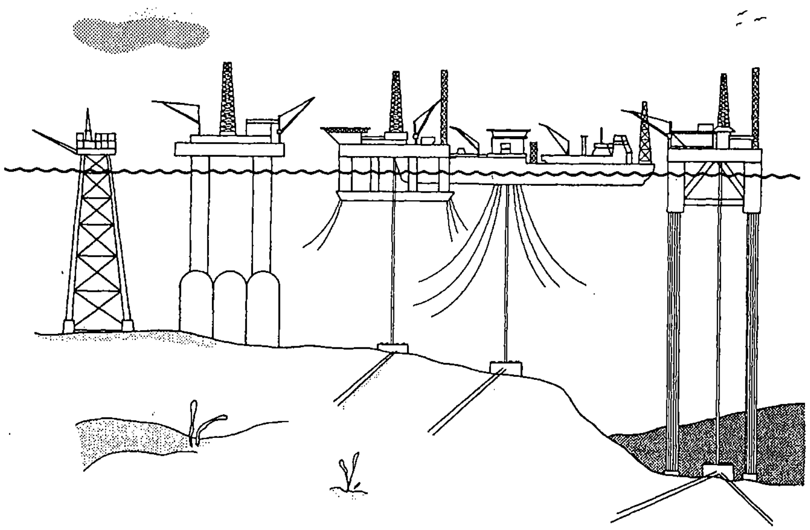


Fig. 1.1. Five types of offshore structures. From left to right we have, jacket, gravity platform, semi-submersible, floating production ship, tension leg platform (TLP). (Partly based on a figure provided by Veritec A/S.)

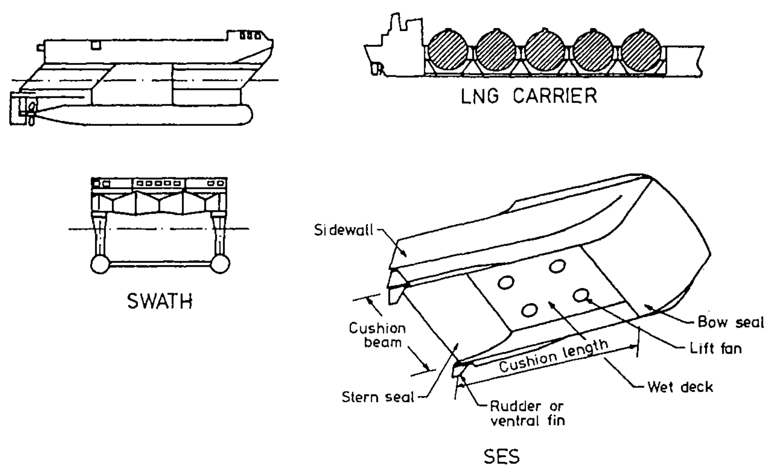


Fig. 1.2. Three types of ships. SWATH (small-waterplane area, twin-hull ship), LNG (liquid natural gas) carrier, SES (surface effect ship).

hydrodynamical view point one can distinguish between ships at zero, normal and high speed. SWATH concepts have been designed for both normal and high-speed applications.

Most of the applications presented in the main text will deal with ships at zero or normal speed and with offshore structures. Applications to high-speed marine vehicles will be given by exercises. We will discuss both wave-induced loads and motions, with motions being the result of integrated hydrodynamic loads on the structure. In the introduction we will give a survey of important wave load and seakeeping problems for ships and offshore structures. Before doing that we need to define the motions.

DEFINITIONS OF MOTIONS

Motions of floating structures can be divided into wave-frequency motion, high-frequency motion, slow-drift motion and mean drift. The oscillatory rigid-body translatory motions are referred to as surge, sway and heave, with heave being the vertical motion (see Fig. 1.3). The oscillatory angular motions are referred to as roll, pitch and yaw, with yaw being rotation about a vertical axis. For a ship, surge is the longitudinal motion and roll is the angular motion about the longitudinal axis.

The wave-frequency motion is mainly linearly-excited motion in the wave-frequency range of significant wave energy. High-frequency mo-

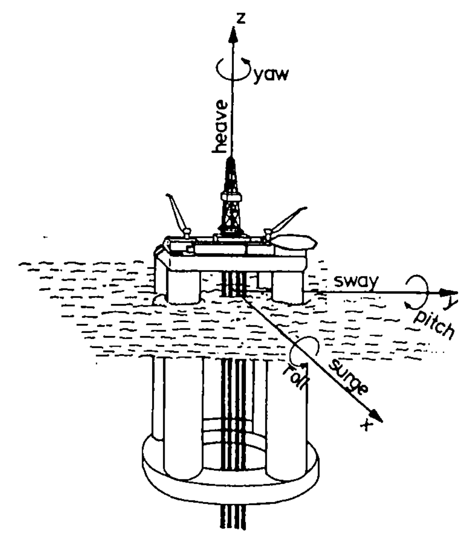
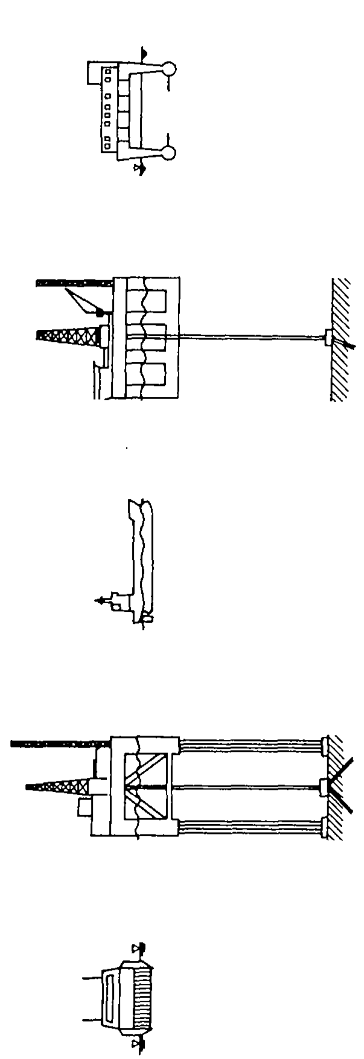


Fig. 1.3. Definition of rigid-body motion modes. Exemplified for a deep concrete floater.

Table 1.1. *Resonant heave oscillations of ships, offshore structures and high speed vehicles*

Vessel:					
	SES (surface effect ship)	TLP (tension leg platform)	Monohull ship Catamaran	Semi-submersible	SWATH (small waterplane area twin hull ship)
Natural heave period:	<1 s	2–4 s	4–16 s[a]	>20 s	>20 s
Restoring force:	Air compressibility	Elasticity of tethers	Waterplane area	Waterplane area	Waterplane area
Dominating excitation mechanism around the natural heave period:	Linear wave forces due to high encounter frequency between ship and waves	Non-linear sum frequency wave forces	Linear wave forces	Swell (long waves)	Linear wave forces due to low encounter frequency between ship and waves
Important damping:	'Ride Control'	Viscous effects	Wave radiation	Viscous effects	Foil control

[a] Rough estimate: $\sqrt{(L/1.5)}$, where L is ship length in metres.

tion is significant for TLPs and is often referred to as ‘rin ‘springing’ and is due to resonance oscillations in heave, pitch an the platform. The restoring forces for the TLP are due to tethers and mass forces due to the platform. The natural periods of these motion modes are typically 2–4 s which are less than most wave periods. They are excited by non-linear wave effects. ‘Ringing’ is associated with transient effects and ‘springing’ is steady-state oscillations.

Similar non-linear effects cause slow drift and mean motions in waves and current. Wind will also induce slow drift and mean motion. Slow drift motion arises from resonance oscillations. For a moored structure it occurs in surge, sway and yaw. The restoring forces are due to the mooring system and the mass forces due to the structure. Typical resonance periods are of the order of 1 to 2 minutes for conventionally moored systems.

Heave is an important response variable for many structures. Table 1.1 illustrates the range of the natural heave periods of different types of marine structures. These include SES, TLPs, monohull ships, catamarans, SWATH ships and semi-submersibles. The table indicates how the natural heave oscillations can be excited. For instance for the SES-hull it occurs due to high encounter frequency between the ship and the waves, while for the SWATH it occurs due to low encounter frequency between the ship and the waves. The table also shows what types of restoring forces can cause heave resonance. For the SES it is the compressibility effect of the air in the cushion. For the monohull ship, catamaran, SWATH and semi-submersible it is due to change in buoyancy forces. This is related directly to the waterplane area of the vessels. Finally we see in Table 1.1 either the most important physical source of natural heave damping or how one artificially increases the damping by control systems.

For the SES it is the heave accelerations and not the heave motions that are important. If no ‘ride control’ is used, acceleration values of $1.5g$ can occur in relatively calm sea. If the natural heave period is 0.5 s, it means the heave amplitude is ≈ 0.1 m.

A semi-submersible is designed to avoid resonance heave motion and the maximum heave motion in severe sea states will be less than half the maximum wave amplitude.

TRADITIONAL SHIP PROBLEMS

Examples of important seakeeping and wave load problems for ships are illustrated in Fig. 1.4. In particular, vertical accelerations and relative vertical motions between the ship and the waves are important responses. Accelerations determine loads on cargo and equipment and are an important reason for seasickness. The relative vertical motions can be used to evaluate the possibility and damage due to slamming and water

Bonjour test dans la page 1

Une autre page avec un autre mot : maison

Et une troisième encore avec un autre mot chien