# Extreme Vertical Wave Impact on the Deck of a Gravity-Based Structure (GBS) Platform

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**Abstract.** A simple method for solving water impact loads on decks of offshore structures is developed. In the present paper the emphasis is on vertical wave-in-deck loads. The suggested method is three-dimensional and valid for general deck geometries and arbitrary incident wave direction. First and second order wave amplification due to the large-volume structure is included in the analysis. The method is implemented into a numerical simulation program. This tool uses the results from an a priori second order diffraction analysis of the platform hull as input. In particular the wave-in-deck simulation program applies computed linear and quadratic transfer functions from the diffraction analysis as input. The method is validated against experiments. Results from scaled model tests of a gravity-based structure (GBS) are compared to numerical results. The platform was subjected to extreme waves causing water impact on the deck structure. In the present work, only impact from regular waves is considered. Satisfactory results are obtained from the numerical simulations. The theoretical results compare well with the experiment. The vertical loads on the deck are well reproduced both during the water entry phase and the water exit phase. Moreover, the duration of the wave-in-deck event is satisfactorily predicted.

## 1 Introduction

It is common practice to design the lower deck of offshore platforms to be above the maximum predicted wave level. Knowledge regarding wave heights and the variability of environmental conditions has increased over the years, and existing platforms may have been built with lower deck clearance than today's requirements would dictate. Moreover, bottom-mounted platforms initially installed with sufficient deck height may experience that this decreases with time. This reduction can be caused either by settlements of the platform due to its own weight, or by reservoir compaction. Owing to these uncertainties in the safety level, it is important to obtain predictions of the expected hydrodynamic loads on the structure induced by wave impact underneath the decks of existing platforms

In the present paper, a simple method for estimating wave-in-deck impact forces on column-based structures is described. A case study with a fixed GBS structure is used as an example, based on a model test experiment on the Statfjord A platform presented previously in [1]. For such structures, horizontal forces are usually considered to be most critical for platform safety, but the vertical loads may also contribute to the critical responses. According to [1], examples of the critical responses for the Statfjord A GBS are the capacity of the steel plates of the deck to transfer the combined vertical and horizontal slamming load into the shafts, the capacity of the deck to shaft connection and the capacity of the concrete shafts and the shafts to caisson connection. In the actual model tests, possible deck impact forces on the Statfjord A platform in a future late life production scenario were investigated, with focus on the horizontal forces. This subsequently led to the conclusion that the platform can sustain an expected future bottom subsidence and wave conditions. For a broader description of the actual Statfjord A case we refer to [1]. In the following, the focus will be limited to vertical force modelling only, using selected data from the model tests as a validation test case. The present method can also be generalized to study horizontal forces.

For wave impact on floaters, also vertical forces may be critical. Baarholm et. al. [2] showed that impact forces may influence the vertical platform motion significantly.

For jacket type platforms, simple wave impact prediction models exist. A review of some of them is given in [4]. No simple method is available for solving global wave impact loads on large-volume structures where wave diffraction due to the hull is important. So far one has been dependent on model test results exclusively when assessing such impact loads. Simple methods for assessing wave-in-deck loads are welcomed by the industry. The objective of the present work is to make a simple theoretical model to compute the vertical hydrodynamic loads on the deck of a large-volume platform due to impact from extreme waves. Published literature on the subject has limitations. Baarholm and Faltinsen [3] presented a fully non-linear boundary element method for simulating the wave-in-deck event. Good results were obtained for both the water entry phase, i.e. when the wetted area of the platform deck increases, and the water exit phase when the water detaches from the deck. The method is, however, two-dimensional and can thus not be applied to large volume structures. Kaplan [5] presented a mathematical model for determining time histories of impact forces on flat deck structures of offshore platforms. He applied the usual slamming assumption where gravity is neglected: An expression for the vertical wave-in-deck force is found from the principle of conservation of fluid momentum and the impact force can be found without solving the boundary value problem associated with the impact. Kaplan's method is limited to two-dimensional flow and undisturbed flow.

In this work, a method based on a combination of Kaplan's approach and a second-order three-dimensional diffraction analysis of the free-surface elevation and kinematics is proposed. Second-order effects have been observed to add significantly to the maximum crest elevation (see e.g. [6] and [7]) and must therefore be accounted for in the analysis. The method is limited to provide integrated global loads. Pressure distributions are not available from the proposed method.

## 2 Theory

### Exact Boundary Value Problem

In the theoretical description of the wave-in-deck problem, an incompressible fluid in three-dimensional, irrotational flow is assumed. Accordingly, potential flow is applied and viscous effects are disregarded. Moreover, effects of hydroelasticity and surface tension are neglected. A boundary value problem for the total velocity potential $\Phi$ can be set up. The three-dimensional Laplace equation $\nabla^2\Phi = 0$ becomes the governing equation in the fluid domain. Boundary conditions are required to solve the problem. The fully non-linear boundary conditions for the two-dimensional wave-in-deck problem are described by Baarholm and Faltinsen [3]. The exact boundary conditions are imposed in the instantaneous position of the boundaries. They also argue that it is necessary to include a Kutta type condition when the fluid flow reaches the downwave edge of the deck. This condition ensures that the fluid flow leaves the deck tangentially at the downstream end of the deck. For a three-dimensional impact problem, the formulation of the Kutta condition will be more complicated than in the two-dimensional case.

The boundary value problem must be solved as an initial value problem, e.g. with the fluid at rest as an initial condition. A wavemaker (or similar) must be included on the inflow boundary to generate the waves and a numerical beach must be included on the free surface near the downwave boundary. The boundary value problem must be solved at each time step by applying Green's second identity, and a robust time stepping procedure must be used to evolve the solution. When the boundary value problem is solved the force acting on the deck can be found either by direct integration of the hydrodynamic pressure on the wetted part of the deck, which can be found from Bernoulli's equation or by imposing conservation of fluid momentum. If the boundary value problem is properly solved, the resulting force found from these two alternative methods will converge towards each other. This is demonstrated in [3] for a two-dimensional wave-in-deck problem.

To solve the exact boundary value problem of a three-dimensional body in waves with impact included is an extremely cumbersome task that has not been solved yet. Both high temporal and spatial resolution of the numerical scheme would be needed. This will yield extremely computer demanding solutions. It is not within the scope of the present work to solve this problem. On the contrary, we aim to develop a simple method to assess wave-in-deck loads to rogue waves that can easily be used in design of new structures and in re-assessment of existing installations.

**Simplified Boundary Value Problem**

In the following, some assumptions will be made, and a method to evaluate the water impact loads based on a simple von Karman approach is established. Firstly, we let the total velocity potential be written as $\Phi = \phi_{slam} + \phi_{wave}$, where $\phi_{slam}$ and $\phi_{wave}$ are the perturbation velocity potential due to the water impact and the velocity potential of the wave, respectively. The latter comprises the undisturbed incident wave potential and the diffraction velocity potential due to the presence of the platform hull. $\phi_{wave}$ to second order is assumed to be known a priori. A standard second order frequency-domain diffraction program can be used to evaluate this. The computational results are given in terms of linear and quadratic transfer functions that can be used in a time domain simulation of e.g. the free surface elevation and the fluid particle kinematics. The use of the pre-computed quantities in the slamming analysis is described later.

A boundary value problem (BVP) for the unknown slamming potential $\phi_{slam}$ can be set up. The Laplace equation becomes the governing equation in the fluid domain. A typical assumption for slamming problems is that impact occurs over a small period of time, meaning that the acceleration of gravity $g$ is negligible relative to the impact induced accelerations of the fluid particles, and that the rate of change of $\phi_{slam}$ with time is generally larger than the rate of change with respect to the spatial coordinates. Moreover, instead of imposing the free surface condition on the exact free surface, it can be simplified further by applying it on the horizontal plane $z=0$, i.e. the dynamic free surface condition becomes

$$\phi_{slam} = 0 \quad \text{on} \quad z = 0 \tag{1}$$

This condition implies that no waves are generated by the wave-in-deck event. This dynamic free surface condition is widely used for impact problems, e.g. in the classic works by von Karman [9] and Wagner [9], although they solved two-dimensional problems. Similarly, the instantaneous wetted area of the deck is collapsed onto the plane $z=0$ and the body boundary condition is imposed on this. The resulting boundary value problem is depicted in Fig. 1. $S_B$ denotes an arbitrarily shaped wetted area, and $S_F$ denotes the free surface. Both these surfaces are collapsed onto the plane $z=0$. The body boundary condition is described in terms of the temporally and spatially dependent relative impact velocities, $V_R(x,y,t)$. $V_R$ is a combination of the fluid particle kinematics and the platform motions. In the two-dimensional case, the boundary value problem can be solved analytically for simple body boundary conditions. In case of spatially constant impact velocity, $V_R(x,t)=V_R(t)$, the solution is given in e.g. [9]. An analytical solution for a linearly varying impact velocity, $V_R(x,t)=V_0(t)+V_1(t)x$, is given by Zhao and Faltinsen [13]. They used this body boundary condition when studying slamming loads on high-speed vessels. Baarholm and Faltinsen, [15], used the same condition for solving two-dimensional wave-in-deck loads. In the three-dimensional case, an analytical solution is available for water entry of axi-symmetric bodies (see [14]), but analytical solutions are not available for arbitrarily shaped wetted deck areas. In general, the simplified three-dimensional boundary value problem depicted in Fig. 1 must be solved numerically through use of Green's second identity.

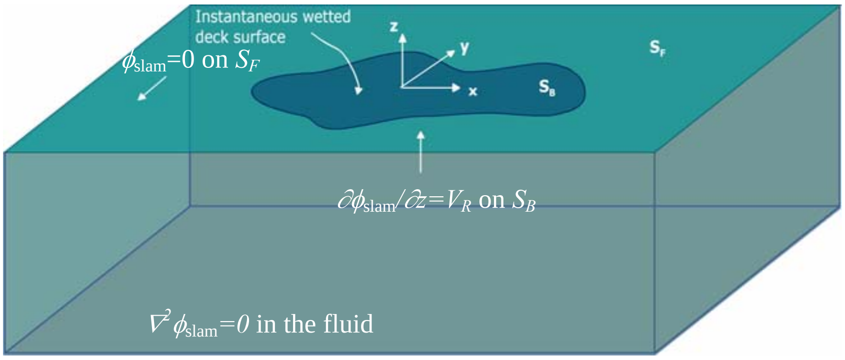



**Fig. 1.** Simplified hydrodynamic boundary value problem of the wave-in-deck event. $\phi_{slam}$ is the impact induced velocity potential and $V_R$ is the averaged relative impact velocity over the wetted deck area.

## Force computations

The main reasons why one needs to solve the boundary value problem is to be able to determine how the wetted area evolves in time and to compute the pressure distribution and the integrated force acting on the platform deck. In this work, the main objective has been to compute the integrated force acting on the deck and the mean pressure, but not the pressure distribution as such. If one assumes a constant impact velocity across the entire wetted area, the boundary value problem yields following simple expression for the vertical impact force

$$F_3 = \frac{d}{dt}\left(A_{33}V_R\right) = \frac{dA_{33}}{dt}V_R + A_{33}\dot{V}_R \tag{2}$$

where $A_{33}=A_{33}(t)$ is the high frequency added mass of the instantaneous wetted deck area and $V_R=V_R(t)$ is the average value over the wetted deck area of the relative impact velocity. The first term on the right hand side of Eq. (2) is denoted as the slamming force and the latter is an inertia force. This formula is well known and used for a large number water entry problems. In addition to the force from the rate of change of momentum, the total deck force will get contributions from hydrostatics and from the dynamic pressure in the diffracted wave field. Here the term diffracted wave field refers to the wave field that is unaffected by the deck impact, but diffraction due to the mean submerged platform hull is included. The latter force is here approximated by a modified Froude-Kriloff force term. The total vertical force acting underneath the deck structure is written as

$$F_3 = \frac{dA_{33}}{dt}V_R + A_{33}\dot{V}_R + \rho\Omega\left(g + \overline{a}_3\right) \tag{3}$$

where $\rho$ is the water density and $\Omega= \Omega (t)$ is the instantaneous volume of fluid in the diffracted wave that is above the lower deck. For simplicity, $\overline{a}_3$ is taken as the average vertical fluid acceleration in the diffracted wave at the instantaneous wetted area. Thus, $\overline{a}_3 = \dot{V}_R$ for a stationary platform. The same type for formulation was used to Baarholm and Faltinsen [15] for two-dimensional wave-in-deck impact. The slamming term is set equal to zero during water exit. This treatment is based on the consideration of vertical momentum transfer only upon water entry and not during conditions associated with water exit. Such treatment is used in ship slamming analysis (see [11]) and is carried over to the present case. The same approach is used by e.g. [5] and [8].

Equation (3) shows that the vertical force due wave impact underneath a platform deck is governed by the kinematics in the wave crest in combination with the platform motions and the evolution of the high frequency limit of the added mass of the wetted deck area. An exact solution for the evolution of the wetted area cannot be found without solving the boundary value problem. Here, however, assume that the instantaneous wetted deck area can be approximated by a von Karman approach. This means that the wetted area is found from the intersection between the diffracted wave field, excluding diffraction effects from the impact potential, and the deck. When the wetted area is known, one can compute the added mass of this. Kaplan used a formula similar to (3) to compute the vertical wave-in-deck force on jacket platforms. In addition to the terms in the above expression, Kaplan also included a drag term in the force expression. He limited his analyses to long-crested head or beam sea waves relative to the rectangular deck. This means that the wetted deck area is rectangular at all times, and that he could solve the problem by a two-dimensional analysis. Moreover, he applied a von Karman type approach when evaluating the wetted deck area, i.e. the wetted area was found as the geometrical intersection between the deck and the undisturbed free surface. Since the wetted area was rectangular, the added mass could be found by analytical expressions. Consequently, the impact loads could be assessed without solving the boundary value problem as such.

The idea here is to generalize Kaplan's approach so that it can be applied for three-dimensional impact problems for which diffraction effects from the presence of a large-volume structure are accounted for. For such a case the wetted area due to impact may have a more general shape, and analytical expressions for the added mass cannot be found. In principle, the added mass must be evaluated numerically for each time step. This can be achieved by a three-dimensional panel method. To omit having to solve such a problem, an approximate approach is proposed. Analytical expressions for the added mass exist for thin rectangular plates and thin elliptical disks. The general idea is to approximate the wet area by one of these basic geometries. This enables us to estimate the added mass with explicit analytical expressions. The feasibility of using the added mass of elliptical disks or rectangular plates has been studied. An extract of the study is presented in [16]. The general conclusion was that one can get good estimates of the added mass of arbitrarily shaped thin plates by applying the added mass of a representative elliptical or rectangular plate. When fitting the general shaped plate to one of the basic geometries it is important to keep the area of the model plate the same as the real wetted area and to use a representative aspect ratio.

**Relative impact velocity and acceleration**

The vertical fluid velocity and acceleration at the deck level are found to second order. In the following the velocity potential $\phi_{wave}$ is split into a first and second order part so that

$$\phi_{wave} = \phi^{(1)} + \phi^{(2)} + O\left(\zeta_a^3\right) \tag{4}$$

where $\zeta_a$ is the amplitude of the first order incident wave. $\phi^{(1)}(x,y,z,t)$ and $\phi^{(2)}(x,y,z,t)$ are the first and second order wave potentials (incident wave + diffracted wave due to the mean submerged part of the hull). By use of Taylor expansion to $O\left(\zeta_a^2\right)$, the relative vertical fluid velocity at the deck can be expressed as

$$w = \frac{\partial\phi^{(1)}}{\partial z} + \frac{\partial\phi^{(2)}}{\partial z} + \eta_{deck}\frac{\partial^2\phi^{(1)}}{\partial z^2} - \dot{\eta}_{deck} \tag{5}$$

where the quantities $\partial\phi^{(1)}/\partial z$ , $\partial\phi^{(2)}/\partial z$ and $\partial^2\phi^{(1)}/\partial z^2$ are to be evaluated on $z=0$. $\dot{\eta}_{deck} = \dot{\eta}_{deck}(x,y,t)$ is the vertical velocity of the deck. This quantity vanishes for a stationary platform. $V_R$ is taken as the average value of $w$ over the wetted area. Similarly, $\dot{V}_R$ is taken as the average value of $\dot{w}$ .

**Validity of second order diffraction analysis**

The free-surface wave elevation and kinematics is disturbed due to the presence of the large-volume structure. The structure in case study below consists of three columns and a large caisson. This is an important factor in the wave-in-deck problem, leading to the input condition of the impact model described above. The prediction of elevation around vertical columns in steep waves, by use of linear as well as second-order numerical diffraction models, has been validated in [6,7]. From these works, it is found that while the use of linear theory can lead to significant under-estimation, second-order models can in many cases work fairly well even in steep waves. The largest discrepancies are observed for high column-to-wavelength ratios ($k\zeta_a > 0.4$), particularly due to over-predictions of the sum-frequency terms. For low $k\zeta_a$-values, the agreement is better, while there are still some discrepancies due to effects beyond second order. Generally speaking, this can lead to under-prediction in the vicinity of the columns, and some over-prediction further away.

## 3 Present Implementation

The theory described above is implemented into a computer program. Below, the main steps in the numerical simulation are described in brief. A priori diffraction analysis of the submerged part of the hull must be performed. In the present work second order frequency-domain diffraction analysis is performed by applying WAMIT (see [12]). Linear and quadratic transfer functions of wave kinematics and free surface elevation at a large number of field points below the deck is evaluated. The computed hydrodynamics are used as input to the simulation program. The field points are distributed in two horizontal layers. One layer is located at the mean free surface with the second layer just below. Two layers are needed to evaluate the *z*-derivative of the computed hydrodynamic quantities. These are needed to extrapolate the wave kinematics above the mean free surface.

In the case of regular waves, the diffracted wave field underneath the deck structure is evaluated for each time step by use of

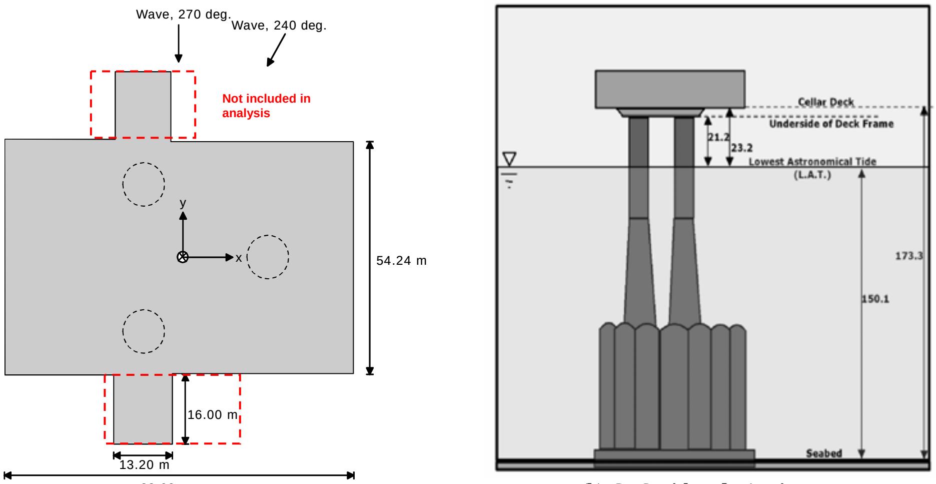
$$\zeta(x,y,t)=\mathrm{Re}\left(\zeta_a\tilde{\eta}^{(1)}\exp(i\omega t)+\zeta_a^2\tilde{\eta}^{(2+)}\exp(i2\omega t)\right)+\zeta_a^2\tilde{\eta}^{(2-)} \qquad \textbf{(6)}$$

where ω is the oscillation frequency of the incident wave. The $\tilde{\eta}$ 's are complex linear and quadratic transfer function values from WAMIT, all dependent upon spatial position although this is not explicitly stated in the expression. Note that the term $\tilde{\eta}^{(2-)}$ is real while the other terms are complex. The superscripts (2+) and (2-) denote second order sum- and difference frequency contributions, respectively. $\tilde{\eta}^{(1)}$ gives the linear contribution. When knowing the diffracted wave field, approximate values of the instantaneous wetted area, $A_{33}$ and wave kinematics can be evaluated. The impact event is stepped forward in time until the wave has completely detached from the deck. Consequently, the vertical force on the deck can be evaluated from Eq. (3).

## 4 Validation case: Wave-in-deck loads on the Statfjord A GBS

A model test program on the Statfjord A GBS was undertaken in the Ocean Basin at Marintek to assess wave-in-deck loads (see [1]). The main objective was to determine hydrodynamic loads from extreme waves on the platform deck at various water depths, to study the effect of estimated future seabed subsidence. Two depths were tested: 150.1m (as-is today) and 151.6m, measured from still water level to the sea bottom. These water depths leave 23.2m and 21.7m air-gap, respectively; from the cellar deck (see Fig. 2). The GBS has 3 columns.

The deck on the Statfjord A platform is 83.60m long and 54.24m wide. In addition it has two extensions protruding from each of the decks long side. The dimensions of these are 13.20m by 16.00m. The measurements covered horizontal and vertical wave loads on the deck structure, air gap at critical locations, local slamming loads and measurements of wave amplification due to the large volume structure. Model tests were run with both regular waves and extreme wave packages. Two wave headings were tested (see Fig. 2). With the coordinate system used here, the wave headings are 240deg and 270deg.




(a) Cellar deck outline from above

*(b) GBS with today's air-gap*

**Fig. 2. GBS model with simplified topside (from [1])**

Further information about the model tests can be found in [1].

## Numerical model

WAMIT was used to perform a priori second order diffraction analysis. The panel model applied in the computations comprised of 5060 panels on the body and 6060 panels on the free surface. A total of 9800 field points were specified for the WAMIT analysis. Note that the field points, which are used when determining the instantaneous wetted area, cover a rectangular area equal to 83.60m by 54.24m. This means that the extensions on each of the long sides of the deck are not accounted for in the analysis.

## Results

The maximum crest elevation obtained by use of the second-order WAMIT model has been validated by comparison to model test measurement. In Fig.3 this is shown for a wave condition H=30m, T=15.5s, 270deg heading. (The actual wave–in-deck load study included higher waves, up to 40m, but they are not included in the elevation study due to the deck interaction effects). Note that the coordinate system is rotated relative to Fig. 2. Results from linear theory, second-order theory and measurements at various locations are shown. Notice that in the present case, the scattering parameter *ka* is as low as approximately 0.1, which means that we are in the range where the second-order theory is found to work reasonably well [7]. Further results from this and other case studies analysis are presented in [7, 17].

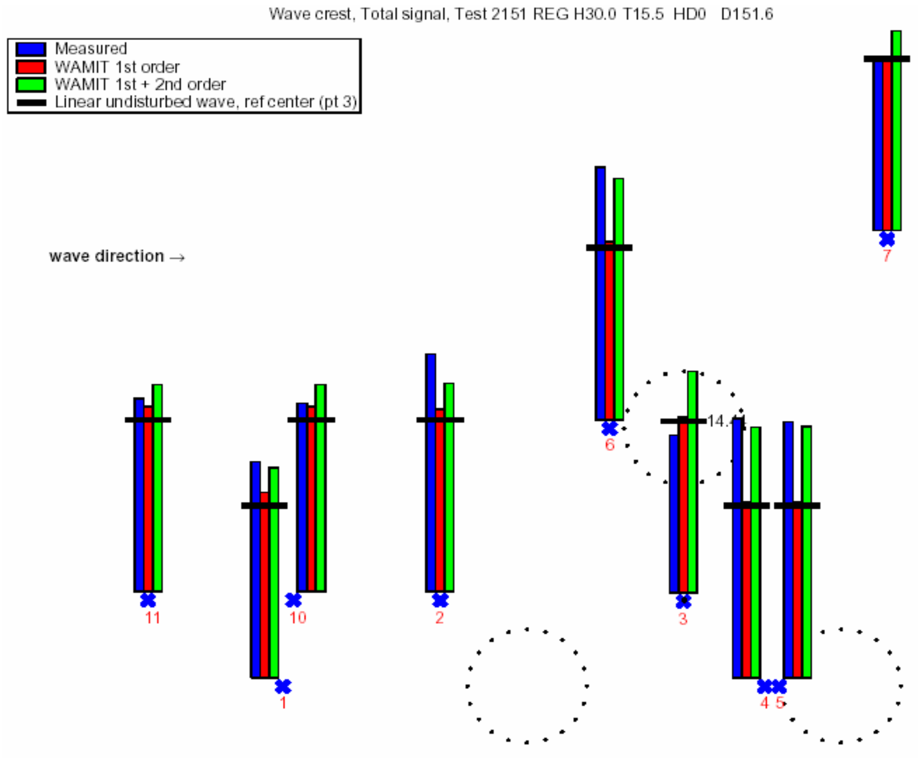



**Fig. 3. Comparison of maximum crest elevation in wave field under the platform**

The numerical load simulation program has been used to reproduce the wave-in-deck events. The analysis is limited to the regular wave tests. In this paper, results are reported for the tests with heading 270deg and with a deck height corresponding to a seabed subsidence of 1.5m. This adds up to altogether 7 test cases. Results from oblique sea computations are presented in [16]. Table 1 presents the main results. Both the maximum water entry force and the maximum magnitude of the negative water exit force from the experiments and the numerical simulations are listed in the table. However, not only the maximum and minimum force were found, the entire time history of the impact force has been simulated for each of the 7 test cases. Example plots of the simulated time series compared to the measured forces records are given in Fig. 4. Plots showing the wetness of the deck at the time instants of maximum and minimum force for case 2 are given in Fig. 5.

**Table 1.** Results from numerical computation of wave-in-deck impact due to regular incident waves. *H* and *T* are wave height and period, respectively. Maximum upward directed force ($F_{max}$) and maximum downward directed force ($F_{max}$) are reported. Corresponding experimental results are included.

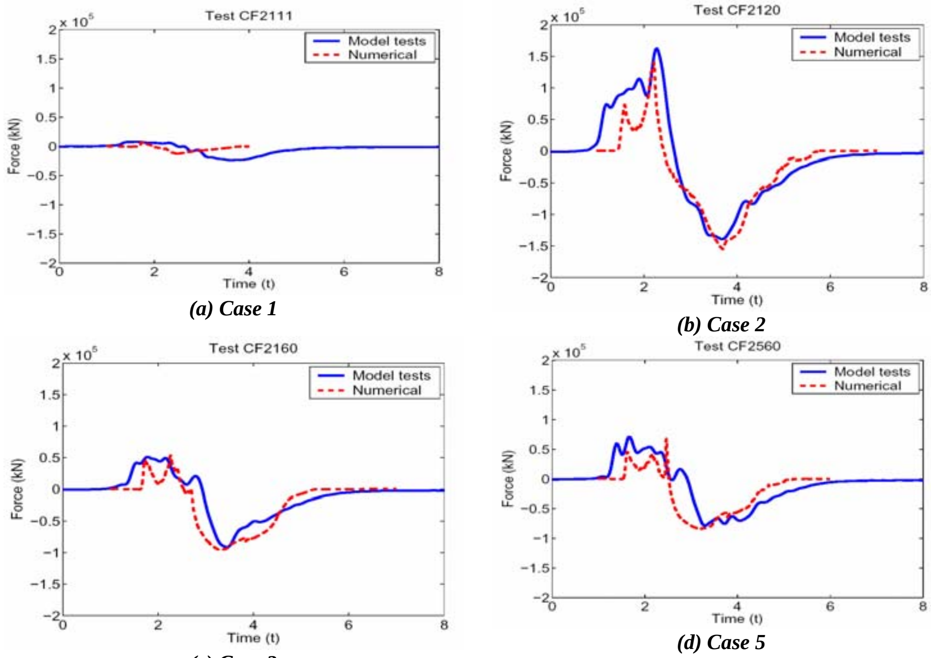
| Case No. | *H* (m) | *T* (s) | Measurements | | Numerical results | |
|---|---|---|---|---|---|---|
| | | | $F_{max}$ (MN) | $F_{min}$ (MN) | $F_{max}$ (MN) | $F_{min}$ (MN) |
| 1 | 34.0 | 17.0 | 7.8 | -23.9 | 7.4 | -12.3 |
| 2 | 40.0 | 17.0 | 166.4 | -131.9 | 140.2 | -153.6 |
| 3 | 37.0 | 15.5 | 51.0 | -91.2 | 53.4 | -95.3 |
| 4 | 34.0 | 15.5 | 15.2 | -23.7 | 16.7 | -23.0 |
| 5 | 37.0 | 16.25 | 70.8 | -78.8 | 67.3 | -84.2 |
| 6 | 34.0 | 16.25 | 7.5 | -18.7 | 9.3 | -17.0 |
| 7 | 33.0 | 14.0 | 45.3 | -30.1 | 8.3 | -23.1 |

## 5 Discussion and Conclusions

The diffracted elevation of the second-order model compares reasonably well to measurements in this case. Furthermore, it can be concluded that use of linear elevation theory may lead to significant under-prediction of both the occurrence and severity of wave-in-deck events. Linear waves would not give impact for any of the 7 cases analyzed.

In general, good agreement is also obtained between the numerical method and the experiments for the loads of hardest water impacts. Both the magnitude of the water entry force and the water exit force as well as the duration of the wave-in-deck event is satisfactory predicted. For the softer impacts, when the wave is barely reaching the deck structure, the relative difference between the measured force and the computed force is greater. This is as expected and in accordance with the experience presented in [8]. When the wave is just reaching the deck, great accuracy in both the wave elevation and the fluid particle kinematics are required to get good correspondence between measurements and computations. Case no. 1 in Table 1 is an example of such a soft impact event. The resulting force for such mild impacts is however small, and the absolute errors in the computed force is therefore also moderate. On the other hand, slight inaccuracies in the generated waves or in the numerical solution of the free surface elevation and fluid particle kinematics will give smaller relative errors for severe impacts. The absolute errors may be significant but the computed results always indicate the magnitude of the impact force.

The experience from [8] would indicate that a von Karman method should underestimate the magnitude of the upwards-directed slamming force. This is also the case here, but perhaps to a lesser extent than expected. The reason why a simple von Karman approach would under-estimate the slamming force is that diffraction due to the deck is omitted and $dA_{33}/dt$ is thus underestimated. Karman approach would underestimate the slamming force is that diffraction due to the deck is omitted and $dA_{33}/dt$ is thus underestimated. The von Karman approach performs well here, but it is



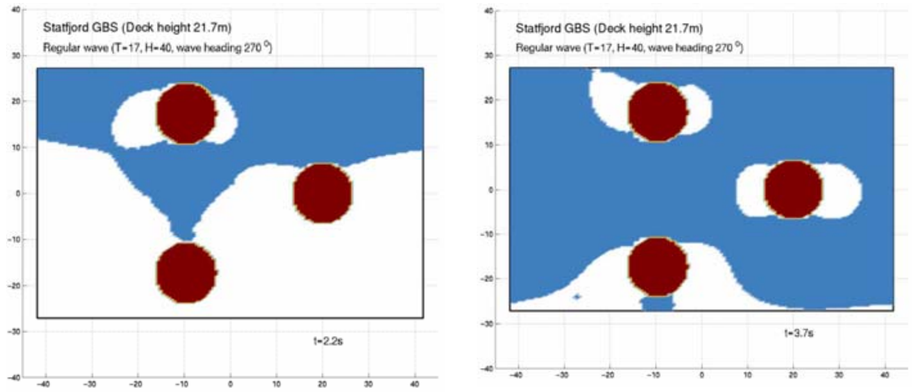

*(a) Case 1*

*(b) Case 2*

*(c) Case 3*

*(d) Case 5*

**Fig. 4.** Vertical impact force time series: comparisons between numerical results (dashed lines) and experimental results (solid lines).




*(a)*

*(b)*

**Fig. 5.** Deck wetness at time instant of maximum upward directed force (a), and at the time instant of maximum downward directed force (b) for case 2 in Table 1.

probably helped by the geometry on the underside of the deck. Large beams protrude from the deck plates. These restrict the jet formation and propagation of the water along the deck, and the wetting process of the deck is probably slower than it would have been for a flat deck. The downwards-directed water exit force is dominated by the added mass of the wetted area. During the wetted area diminishes, the slamming term is set equal to zero. Also the water exit force is in most cases satisfactorily predicted. This indicates that the maximum wetted area is fairly well predicted by the simulations, and, moreover, since the duration is well predicted, this means that the water detaches from the deck similarly in the simulations and in the experiments.

In the present work only impact on a stationary structure is studied. The main reason for this is that the data for the Statfjord A tests was readily available. It is, however, reasons to believe that the method also will be able to predict the vertical water impact loads on a floating structure such as a semisubmersible or a TLP. There are three main differences between impact on a floater and on a bottom-mounted platform. These are: 1) the platform motion contributes to the relative impact velocity and acceleration, 2) the deck height varies in time and space and 3) the impact will to some extent influence the motion of the platform. All these three items should in principle be accounted for. Accounting for first order and sum-frequency platform motion in the relative fluid kinematics and the deck elevation is straightforward. The slow-drift motion of the platform is not an issue in case of regular waves. If the water impact loads are significant in magnitude and duration, they may introduce rigid body motions that cannot be disregarded in the computation of the wave-in-deck load. The impact-induced motion contributes to the relative velocity and acceleration, and it also affects the instantaneous deck height. To solve such a problem properly, one has to solve the impact forces and the impact-induced motions simultaneously (see [2]).

In principle the present method can be used to solve both vertical and horizontal loads on the deck structure, though, it is believed that horizontal forces will be less precisely predicted than vertical forces. One reason is, as discussed above, that one does not take into account for hydrodynamic forces on beams protruding down below the deck structure. This can, however, be accounted for. Kaplan used a component-based model, contrary to the global model used in this work, where he computed drag forces from beams. More critical perhaps is the load from the wave impact on the side of the deck. A von Karman approach will at least for hard impacts, severely underestimate the wetted area and its rate of change. The reason for this is that the foremost contribution to the increase in wetted area is due to diffraction from the impact itself rather than from the diffracted wave field. For the wetting underneath the horizontal deck, the propagation velocity of the wave contributes significantly and the wetting due to the jet flow of the impact velocity potential is relatively of less importance than in the case of impact on a vertical wall.

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