Hydrodynamic Effects on Design of Offshore Platforms (HEDOP) Phases II-A and II-B

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Objective: To reduce uncertainty in load and load effect evaluation and to identify load effects or influences that are unique to deepwater platforms.

Phase II-A

HEDOP II was conducted in two phases, Phase II-A and Phase II-B. Phase II-A of the project focused on the following hydrodynamic loading issues:

a. Load effects in jackets and compliant structures.
b. Low frequency drift forces acting on Tension Leg Platforms.
c. Near surface wave kinematics and forces.

The load effect studies consisted of four somewhat independent studies which examined wave loading aspects on different types of offshore structures. For tension leg platforms (TLP), wave forces generated from a diffraction theory program were compared to those evaluated from the standard Morison equation, and a parameter study of the sensitivity of the TLP response to various changes in wave and wind loading characteristics was carried out. Sensitivity studies were also conducted to identify the effects and relative importance of parameters that influence the response of Compliant Tower Jackets (CTJ) using simplified structural and hydrodynamic models. Finally, the influence of various structural and hydrodynamic parameters on fixed base platform response was investigated using comparisons of analytical models with measured force data from a deepwater Gulf of Mexico platform during Hurricane Fredric.

Low frequency drift forces acting on a TLP were examined by evaluating the statistics of five different TLP model test data sets and reviewing the TLP wave drift calculation techniques.

Numerical simulations of near-surface wave kinetics were compared to high quality data sets provided by the Danish Hydraulic Institute. Kinematics predictions from fluid sheet theory were compared to Wheeler stretching kinematics for regular waves.

Phase II-B

Phase II-B of the project was divided into four main tasks which address the following issues:

a. Shielding and wake effects on jackets and compliant towers.
b. Relative importance of viscous and potential drift forces on TLP and their effects on TLP surge response.
c. Sensitivity of compliant tower response to various hydrodynamic loading and structural characteristics.
d. Comparison between measured and predicted 3-D kinematics.

Wave and current loads measured during wave tank tests were provided by several participants and were used to investigate wake and shielding effects. The wave tank tests were carried out on models of a jacket, a Compliant Piled Tower (CPT), and a fixed base guyed tower. Hydrodynamic loading on a single cylinder model was also measured during the wave tank tests.

The objective of the wake effect study was to develop and verify a hydrodynamic loading model (wake model) that takes into account wake effects. In the wake model, the drag coefficient varies every half wave cycle and is expressed as a function of the flow characteristics of each half cycle. Forces measured in the wave tank tests were compared with the wake model predictions and the optimum wake model parameters that provided the best fit to the measured forces were evaluated. The wake model parameters were optimized using results for regular waves, irregular waves and wave plus current tests (Figure 1).

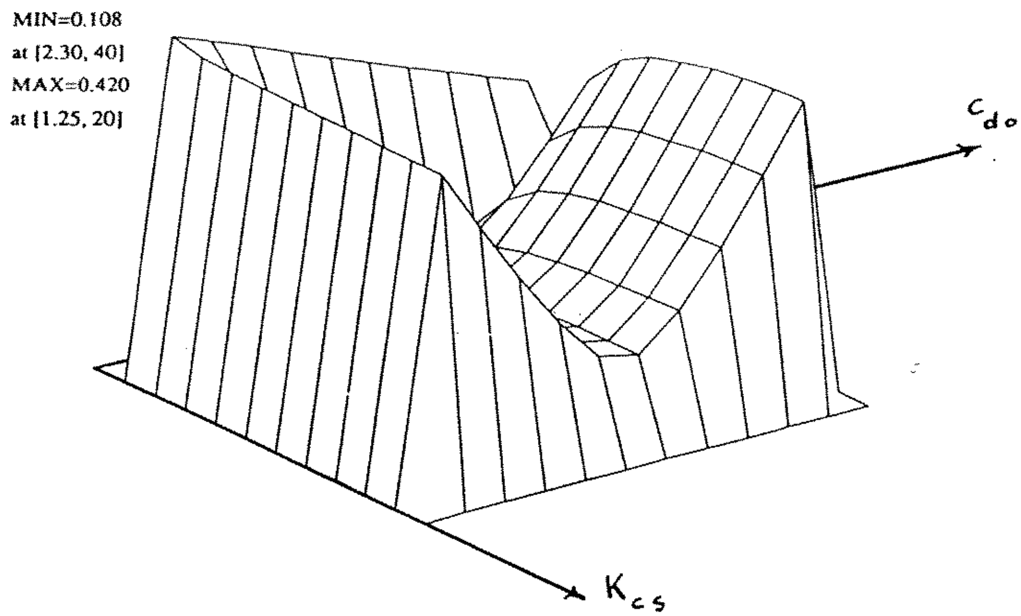

Figure 1—Normalized RMS Error as a Function of the Wake Model Parameters.

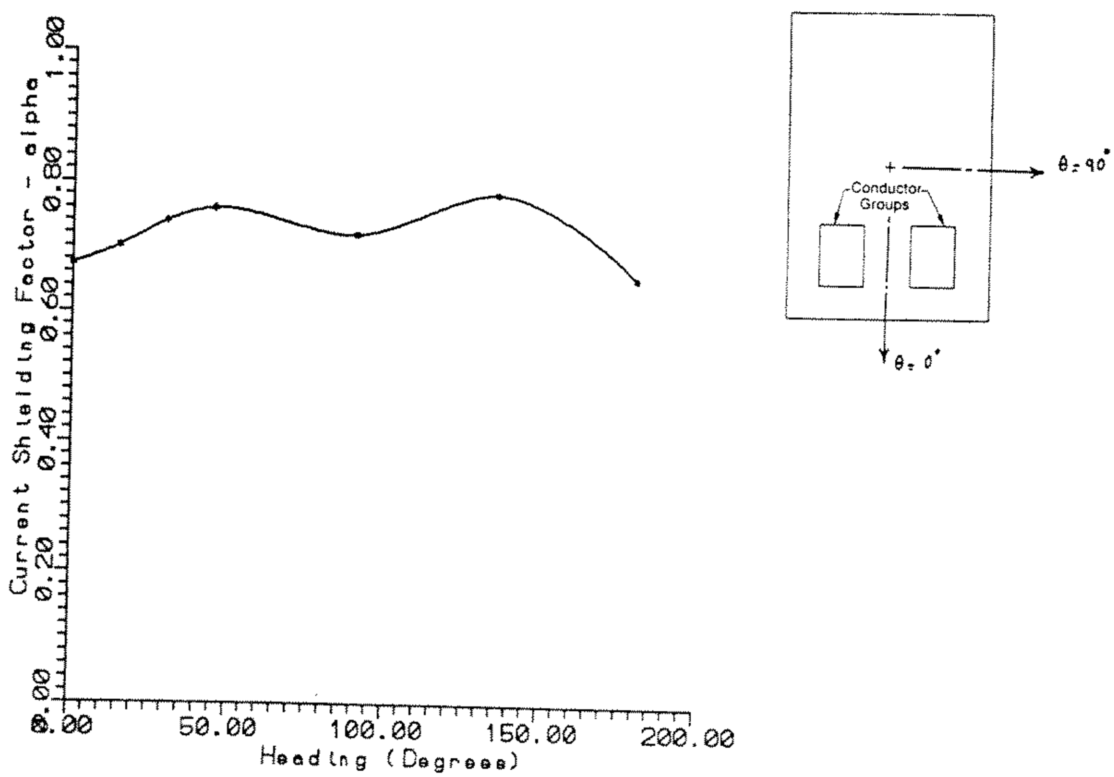

Figure 2—Shielding Factor Versus Current Heading.

Shielding effects resulting from waves and waves plus current were also examined by evaluating shielding factors based on the wave tank test results for current only, wave only and wave plus current conditions (Figure 2). Several shielding algorithms that predict the shielding factors as function of the structure density and geometry were considered during the project. The experimentally evaluated shielding factors were then correlated to the theoretical predictions of the shielding factors.

In the TLP surge response simulations studies, the objective was to distinguish the relative importance of viscous and diffraction effects on the slow drift motion of a TLP. Viscous drift forces are computed using a variation on the Morison equation, and the potential flow force time history is evaluated by means of a convolution integral over the motion time history of the time dependent impulse response or memory functions. Comparisons of the computations with model test results were carried out in order to investigate the effects of the assumptions and simplifications used in the procedure.

The objective of the compliant tower sensitivity studies was to assess the effects and relative importance of the numerous parameters that influence the dynamic response of compliant offshore platforms. This was done using simple but realistic structural and hydrodynamic models of a compliant structure in 2000 ft of water. Responses of the same structure to a number of different sea states were examined and the sensitivity of critical responses to variations in load characteristics were evaluated (Figures 3 and 4). The principal parameters considered in the study were the characteristics of the sea state, stretching schemes used to approximate near surface kinematics, fluid structure interaction and the relative magnitudes of drag and inertia forces. The 3-D wave kinematics study focused on comparing measured and stretched kinematics where in-line, transverse, and total velocities were compared.

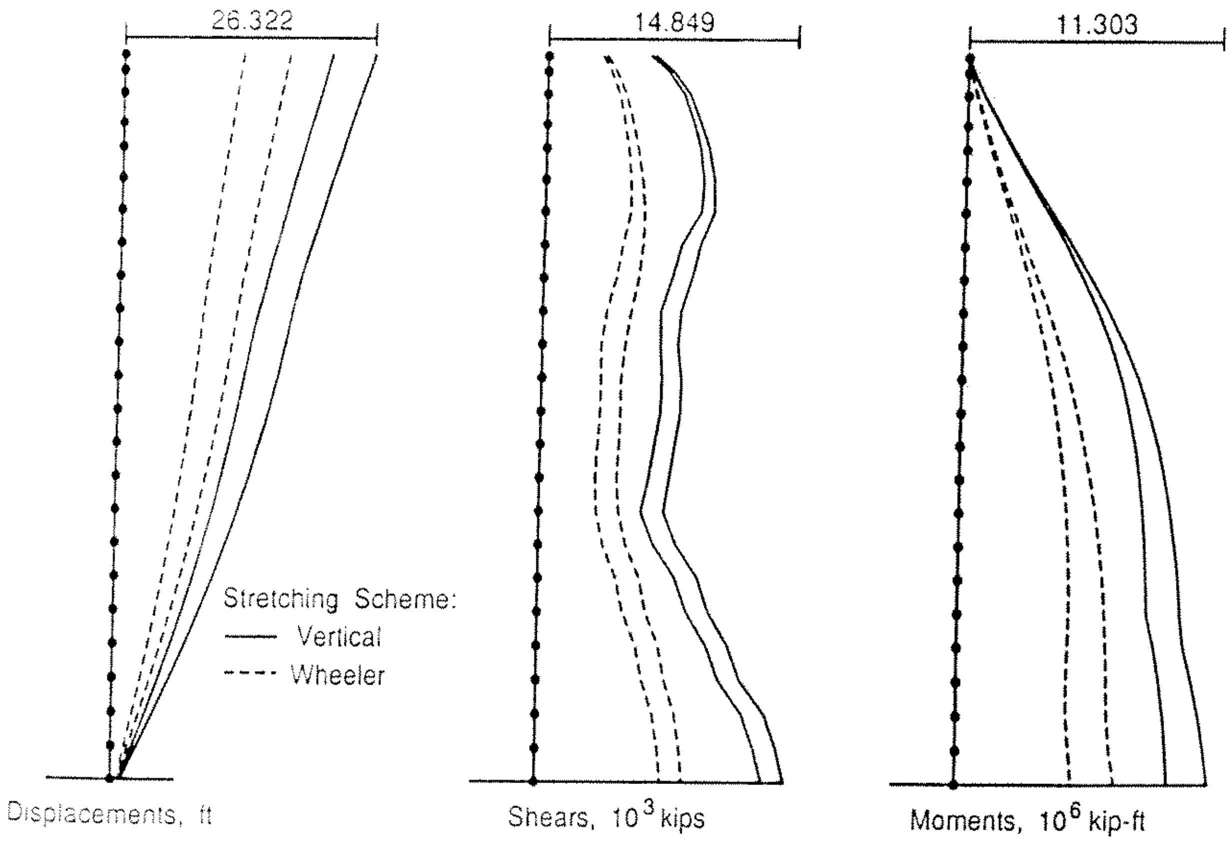

Figure 3—Bounds of Maximum Displacements Using Different Stretching Schemes.

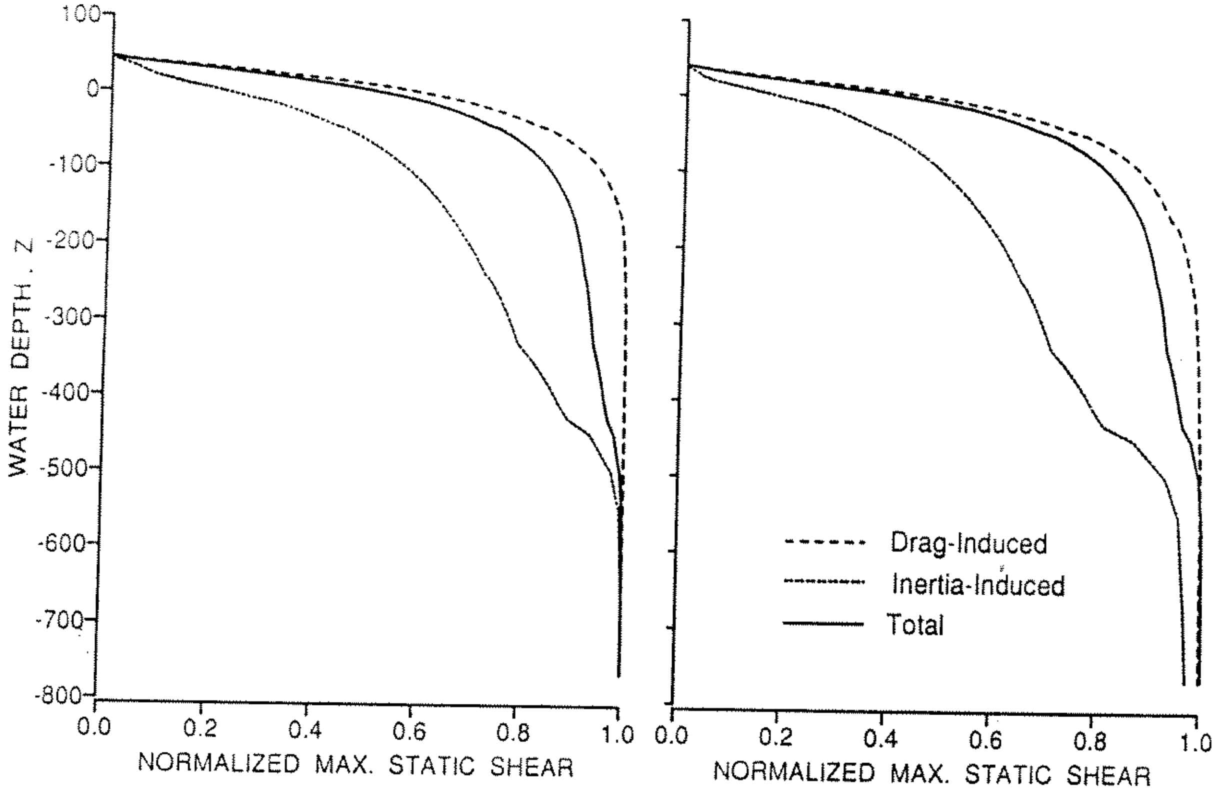

Figure 4—Variation of Maximum Induced Forces With Depth.