VALIDATION OF A ORCAFLEX OBSEA'S PLATFORM MODEL

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Abstract— Offshore platforms or surface turbines at sea are exposed constantly to the dynamic behavior of the waves, current and wind; it is important to have knowledge about the dynamic response of such structures to wind and waves. We conducted numerical simulations with the help of OrcaFlex software using a small, existing platform with a buoy spar-type, OBSEA, located 4 kilometers offshore Vilanova i la Geltrú coast in a fishing protected area of the Catalan coast of Spain. OBSEA collects data in real time like current profile, waves and wind among other data. This work validates the results of OrcaFlex model via GPS data and give insight to relevant results of the orbit of buoy simulations.

Keywords— Model, Simulation, Moored Ocean Platform, Underwater, Data Acquisition, OBSEA.

I. INTRODUCTION

The installation of mobile offshore platforms for energy in the ocean is a topical issue (see [1] for example). From the floating platform hangs a power cable moored to the bottom ocean that carries up the coast the captured green energy. These observation platforms or surface turbines are exposed constantly to the dynamic behavior of the waves, currents and wind. Many studies exist about dynamic response of spar-type offshore wind turbine to wave and wave excitations [2-4]. OBSEA is a cabled seafloor observatory located 4 km off the Vilanova i la Geltrú coast in a fishing protected area of Catalan coast. It is connected to a station on the coast by a power and communication mixed cable. This marine observatory is located 20 m depth and captures data of waves, currents among others. In addition, there is a buoy moored with three chains that captures meteorological data. All details of OBSEA are summarized in web site www.obsea.es.

In present paper the OBSEA's buoy is modeled. The numerical simulations of this model are carried out with the help of OrcaFlex software, version 9.3c, under an educational license (N1594) [5]. OrcaFlex is a marine dynamics program developed by Orcina for static and dynamic analysis of a wide range of offshore systems. OrcaFlex provides fast and accurate analysis of umbilical cables under wave and current loads and externally imposed motions. It is a fully 3D non-linear time domain finite element program capable of dealing with arbitrarily large deflections of the flexible from the initial configuration. The goal of this work is to validate the OrcaFlex buoy model results giving a comparison of buoy orbit results and real buoy.

II. MATERIAL AND METHODS

In this section we analyze specific OBSEA's data collected on December 16, 2011. The day was chosen to represent typical high wind conditions on the Vilanova coast. The GPS data of buoy is studied taking into account the wind, waves and current time data series. We also summarize different data: averaged values, maximum waves and maximum peaks of wind speed that will be used in section III to model OBSEA's buoy, in OrcaFlex environment, as an input of external conditions of models. The wind speed average is found to be 11.53 kn (5.93 m/s). Waves data have averaged values: 1.37 m of significant height with a mean period of 3.64 s. Wind direction and speed are very variable in time: during night, before 5 a.m., the intensity is smaller than the average and the same occurs with the waves, after 5a.m. the waves and wind are fully developed. With the idea to model the worst scenario, we consider data related with maximum wind intensity as well as data with maximum waves height. At the time of 9 p.m. UTC, a maximum wind speed was found with 11.27 m/s (21.9 kn) and 117º direction of advance, the significant height of wave was 3.05 m, with period of 7.52 s and 17º direction of advance. On the other hand, the direction of advance of current varied in a narrow sector, less than 30o contained in 1st quadrant. This will be the data used for the simulations.

OBSEA's buoy also collects the buoy position with a GPS type AIRMAR, Weather Station PB200. The OBSEA's buoy position is: 41.18ºN, 1.75ºE. The variation of the buoy GPS data comes with seconds. Figure 1 is a plot of the seconds of the latitude and longitude of buoy on December 16, 2011. The green colour differentiate the dynamics of buoy when the wind and waves are developed (after 5 p.m. UTC) compared with the absence of wind (before 5 p.m. UTC), plotted in yellow colour. The displacement of blue cloud to the red one is coherent with the external conditions of wind (to the E) and waves (to the N). To be precise, we find that the buoy median position translates 1.78 m in latitude by 5.23 m in longitude direction (see Table 1), bigger in that direction because the effect of the wind speed on the position of buoy is stronger than the increase of waves amplitude. Table 1 shows some statistical results from these data where the equivalence to meters are also shown (using the Haversine formula, taking 6366 km of Earth radius, we find the equivalence 1"=30.86 m).

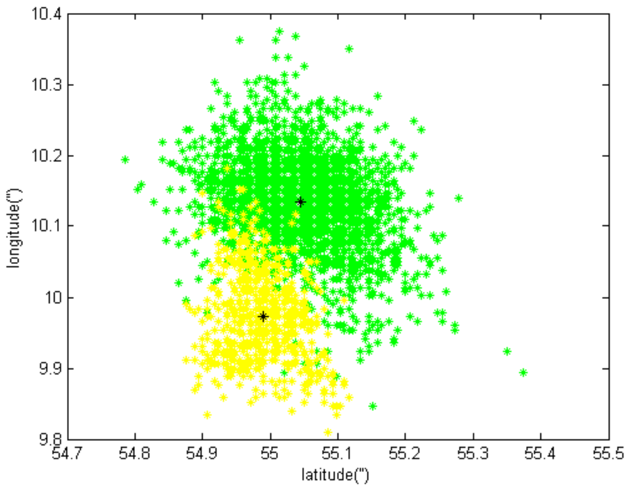

Fig. 1. GPS data, longitude vs latitude of buoy, on December 16, 2011. The units of plot are the seconds ('') of the latitude l=41o10' and longitude L=1o45'. Yelow colour denotes data when there is absence of wind (before 5 a.m.) and green one otherwise (after 5 a.m.), black stars are the median values respectively.

Statistic outputs	before 5 a.m		after 5 a.m	
	Seconds	meters	seconds	meters
rang latitude	0.24	7.407	0.588	18.148
rang longitude	0.372	11.481	0.528	16.296
IQR latitude	0.066	2.037	0.102	3.148
IQR longitude	0.09	2.777	0.078	2.407
Median latitude	54.99	1697.22	55.044	1699
Median longitude	9.972	307.77	10.134	313

Table 1: Rang, interquartilic rang and median of latitude and longitude from GPS buoy (see Fig. 7) in seconds and meters.

GPS data cannot be considered exact because of GPS error measurements and the low accuracy of it, despite of this, the global behaviour and relative differences between latitude and longitude, from a statistical point of view, give important information. The range of movement of buoy do not match with the real range, geometrically it is not possible to have a movement range of 7.4 m latitude by 11.5 m longitude, like we observe before 5 a.m., and this is even worst after 5 a.m., but these values give an idea of the swept area and how it increases with the bad weather. From the statistical point of view the interquartilic range (IQR), that measure the range of variation for the 50% of central values in a BoxPlot graphic, give more valid ranges: a swept area of 3.1 m latitude by 2.4 m longitude is found after 5 a.m. In addition, from figure 1, when the bad weather is fully developed we can observe that the main swept area of the buoy seems to be confined in a regular circular region.

III. ORCAFLEX MODEL

The OBSEA's buoy is moored on the seabed with three chains of 30 m length each one, in a circle of 20 m radius centred on the static buoy position. The chains are equally spaced at 120º. The buoy consists of one cylinder 4 m long and 0.8 m in diameter, and another small cylinder on the bottom that is 0.9 m long and 0.05 m in diameter. It weighs 650 kg in air. At the bottom is a free link to three chain branches 0.65 m long, 0.03 m in diameter and 130º declination, equally distributed.

A model with OrcaFlex environment is done, hereafter Buoy model [6]. This model simulates the real OBSEA's buoy with three chains. A Spar Buoy type on OrcaFlex environment has been selected. In the local axis, North and West are located 10º anticlockwise from x axis and y axis respectively. A chain is located on x axis. Real data of meteorological conditions on December 16, 2011 at 9 p.m., UTC time, are used for the OrcaFlex models, however some restrictions are imposed: a periodic sea wave, a constant wind and a time-constant profile of current.

IV. RESULTS AND DISCUSSION

Dynamic simulations are done with fixed step size small enough to generate results that do not change when the step size is decreased. A step size of 0.05 s is needed in our simulations. Simulations are done from -20 to 600 s to study temporal behaviour. The analysis is focused on last 10 minutes, as the first period of 20 s is considered a transient. We study the relative position (x,y,z) of buoy at the link with chains. The coordinates are measured in meters at the basis of small cylinder of buoy. The origin of axis is on the sea surface without current, wind and waves. In this case the initial position of buoy is (0,0,-3) m, i.e.., at 3 m depth. Table 2 collects a number of significant outputs of buoy orbit from all simulations that are helpful to understand the behaviour of the buoy like the maximum, minimum and range of oscillations of buoy coordinates. There is an additional row results of the Buoy model without current and wind (only waves) that will be used to compare GPS data with simulations.

While the vertical coordinate z oscillates according to the height of waves, in a range of 2.78 meters, the horizontal movement is confined in a circular area of 3.84 by 0.64 meters as can be deduced from Table 2. This result is coherent with GPS data results, where an estimated range (IQR) of movement of 3.1 by 2.4 m in a circular region is found (latitude ~ x, longitude ~ y). The horizontal coordinates translate a median of about (2.7,-2.18) meters with respect to the initial position (0,0) when the waves, wind and current is imposed. To compare with GPS data we need the net effect of wind and current to the waves: in this case the buoy translates 1.18 by 2.05 m meanwhile the GPS data indicates that the buoy has displaced 1.8 by 5 meters, anyway still preserve some proportion. From these results we guess that GPS data do not provide very precise data of longitude (where the wind is stronger).

Finally, the buoy trajectory is found to be regular and circular at every wave period (see Figure 2 (a)), note that the orbit corresponding to one main period is opened but almost periodic as can be seen from Figure 2 (b), so the full trajectory fits a torus.

Measured parameter (m)		Buoy (only waves)	Buoy model
x	minimum	-0.49	0.81
	maximum	3.61	4.65
	range	4.10	3.84
y	minimum	-0.39	-2.50
	maximum	0.13	-1.86
	range	0.52	0.64
z	minimum	-3.98	-3.95
	maximum	-1.06	-1.17
	range	2.92	2.78

Table 2: Minimum, maximum and variation range of relative position of buoy from simulations of OrcaFlex model.

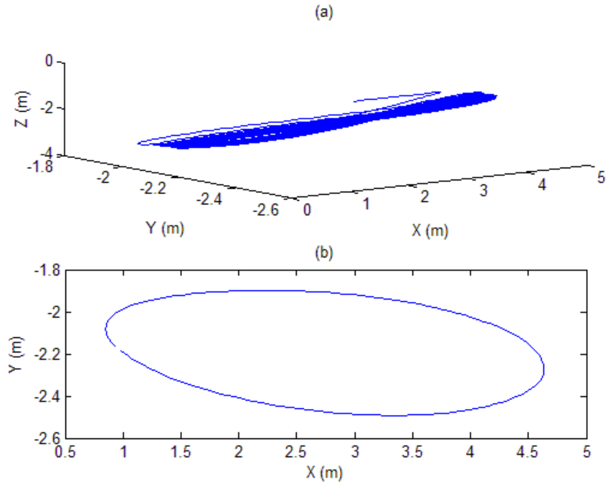

Figure 2. Buoy model. Orbit of buoy (a) from 20 s to 600 s and (b) the horizontal projection view during 1 wave period (7.52 s).

V. CONCLUSIONS

We have validated the OrcaFlex buoy model giving a comparison of buoy orbit results and real buoy GPS data where some proportions and geometry of swept area are preserved when we studied the effect of wind and waves on to the buoy. Still seems that GPS do not provide precise data of longitude (where the wind is stronger), for instance, as we can found from the numerical simulations.

ACKNOWLEDGEMENT

This work has been carried out in part thanks to the project CGL2013-42557-R, Interoperabilidad e instrumentacion de plataformas autonomas marinas para la monitorización sísmica and thanks to the Project CTM2010-15459 (subprograma MAR) Sistemas Inalámbricos para la Extensión de Observatorios Submarinos.

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