Mooring Design

Introduction

by Adrian Wilkins

The design of moorings and the specification of the components of moorings has been an important part of the EEP committee's work for many years. The original 'Practical Notes' from 1989 provided information on selecting the components of moorings. The Recommendation E-107 then provided a broad outline of the method of designing normal moorings and calculating the loads on the components. Subsequent EEP work highlighted the fact that more guidance was needed on the evaluation of all the environmental forces acting on a moored buoy and the processes needed to design various mooring configurations. This resulted in the Guideline 1066, Design of Floating Aid to Navigation Moorings, in 2010, followed by Guideline, Hydrostatic Buoy Design, in 2013. The latter includes the evaluation of the effect of the loads from a particular mooring on the riding performance of the buoy. The final versions of these guidelines were 'work shopped' at the FloatAid events in Brest where there was considerable valuable input from Industrial Members.

Mobilis were particularly involved in the production of both guidelines and have offered to make their own mooring design software available for use by IALA members. This follows the principals described in Guideline 1066 but offers further sophistication by accounting for movement of the water surface due to wind effects.

The following is Mobilis' report on the project.

CALMAR: chain mooring calculator

by David Henry

IALA proposed in their E-107 Guidelines (1988) an *"Approximate rule"* to determine the chain length for aid to navigation transitional moorings, as an alternative to the more precise and complex calculation methods contained in the Guideline. This proposal was in fact formalizing a fairly common practice of using the famous rule of thumb of having a chain length of *"three times the water depth"*. This has been used almost universally for many years and does go a long way to providing a simple guide to mooring requirements.

Unfortunately many people using it did not read the subsequent reservations in the Guideline, recommending the measurement of water depth *"at highest sea level"* and to *"increase the length"* up to another three times the depth *"where the buoy is submitted to both waves and current"*.

Old habits are very hard to break and many people around the world still use *"three times the depth"*. We still hear and see this almost every week!

This rule of thumb does not take into account the various drag forces exerted on the buoy and mooring by maximum site environmental conditions or the linear mass of the chain, both of which make a considerable difference to the necessary catenary length.

Several other parameters are often not accounted for in the general mooring calculations.

These are:

- absolute maximum depth of water, (Charted Depth plus tidal range plus half the maximum wave height plus eventual surge),
- surface wind generated current (which speed should be added to stream & tidal current speeds),
- current drag on mooring line, (often more current drag load from chain than wind drag on buoy)
- drag force caused by maximum wave height drift,
- increasing drag coefficient due to biological fouling on buoy hull and chain,
- last but most important, buoy immersion and drag both increasing as the mooring load increases, which in turn increases buoy immersion and drag;

Adding all these parameters to the buoy hydrostatic characteristics, analysed for any immersion depth, allows the exact equilibrium of buoy displacement, lifted catenary chain loads and horizontal drag loads to be calculated.

At Mobilis we have realised that many aid to navigation buoy mooring lines are often dimensioned with the 'rule of thumb' and regularly end up as being too short for the maximum conditions on site. We have been calculating moorings using the full analysis method for more than twenty years using our own Excel sheets and often checking them with Orcaflex, a powerful mooring analysis software program.

Since using this method for mooring line calculation, we have not experienced a single buoy mooring line breakage over several thousand buoy mooring specifications.

The only cases where mooring failures were experienced occurred when the mooring recommendations provided by us had not been followed, the chain lengths shortened or because the site environmental conditions or their importance had been underestimated. In almost all cases (98 %) the cause of failure was the installed mooring lines being too short for the site maximum environmental conditions.

Considering that full chain moorings are generally still used for most aids to navigation at sea, MOBILIS decided to develop a general tool, using this calculation method, to very simply and quickly calculate a reliable catenary mooring line for most conditions. This was to be freely available after trialling with their own agents and customers.

This was the origin and aim of CALMAR. ■

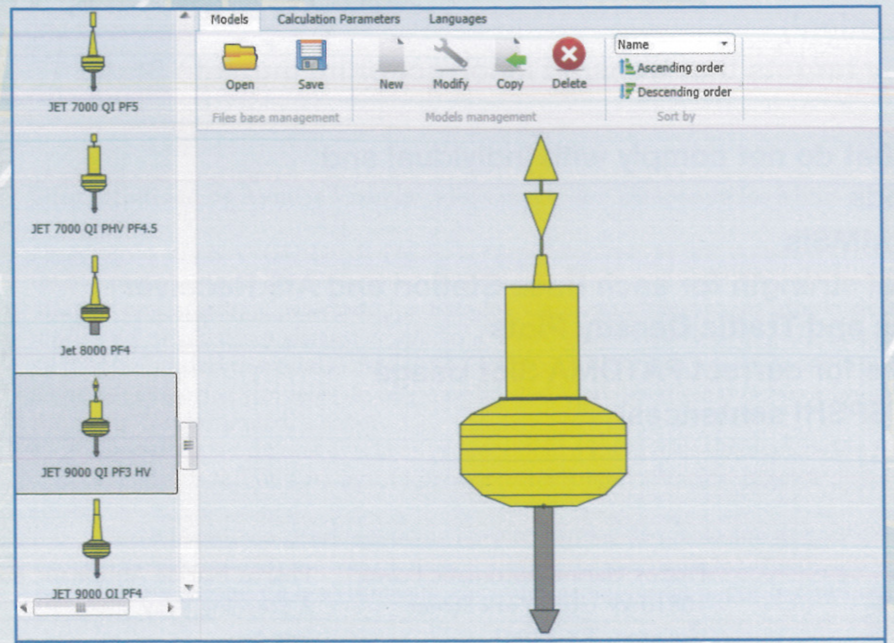
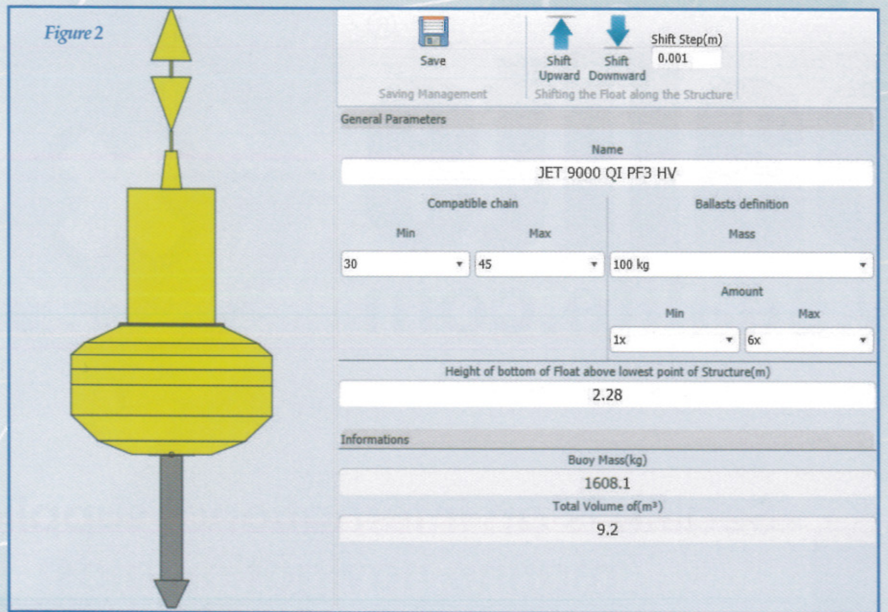
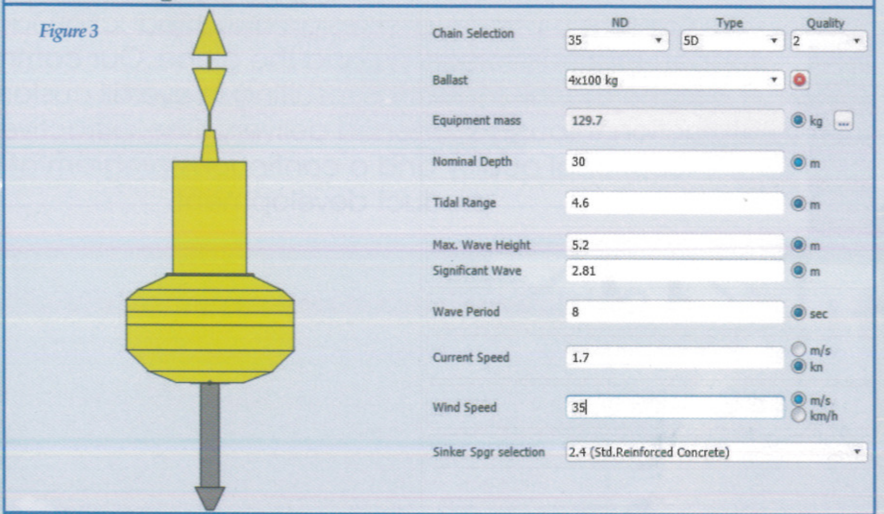


Figure 1 – Calmar model selection: CALMAR provides users with an integrated library of buoy models, allows users to import models from any buoy manufacturer or easily build their own buoy model for calculation





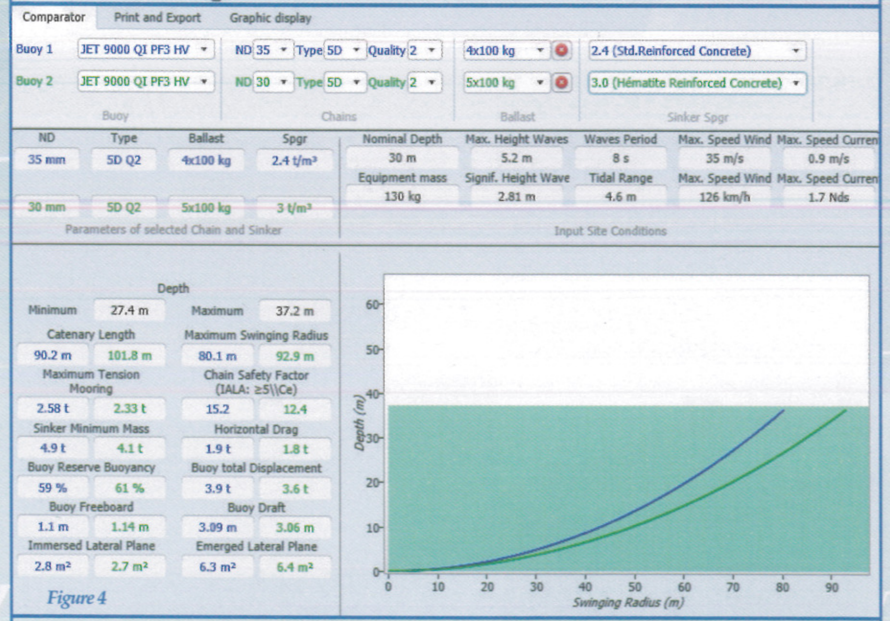


Figure 2 – Calmar model edition: A model editor allows the separate definition of floats, structures, towers and top marks. Facility to stores these elements allows the use of any of them with full modularity.
Figure 3 – Calmar site parameters input: A straight forward screen allows the input of maximum site environmental parameters to be taken into account in calculations and the specification of ballast, equipment, chain types and chain sizes with parametrical variations. Clicking on "Calculations" provides an almost immediate solution on a result screen.
Figure 4 – Calculation results: A simple routine allows the user to easily compare the results between two different buoys and / or two different mooring lines by changing buoy models, ballasts or mooring configurations.
Full facilities to export buoy models, calculation parameters and results in table or graphical form are also available

CALMAR: calculateur de lignes de mouillage

Réalisant que les lignes de mouillage des bouées de balisage sont habituellement dimensionnées de manière empirique, ce qui conduit souvent à des lignes trop courtes pour les conditions environnementales de site, MOBILIS a développé un utilitaire numérique de calcul de lignes caténaires dérivé de ses propres logiciels de calculs de lignes de mouillages. Cet outil prend en compte quelques paramètres de traînée supplémentaires par rapport au Guide de l'AISM 1066 et à d'autres utilitaires existants. Il permet aux utilisateurs d'utiliser ou d'importer des modèles de bouées existants ou de créer facilement un nouveau modèle de bouée pour le calcul. Il permet aussi de comparer deux bouées ou deux lignes de mouillages différentes. Il sera offert en libre utilisation aux membres de l'AISM. ◆

CALMAR: calculadora de fondeo de cadenas

Comprendiendo que las líneas de fondeo de boyas de ayudas a la navegación a menudo se dimensionan mediante una regla general y frecuentemente terminan siendo demasiado cortas para las condiciones de la mayoría de los sitios, MOBILIS ha desarrollado una calculadora de líneas de fondeo con catenaria fácil de usar, originada en sus propias calculadoras de líneas de fondeo. Esta herramienta integra algunos parámetros de carga más que la Directriz 1066 de IALA y otras calculadoras sencillas. La herramienta le permite a los usuarios usar o ingresar bibliotecas de modelos de boyas o construir fácilmente su propio modelo de boya para el cálculo. También le permite al usuario comparar los resultados entre dos boyas diferentes o dos líneas de fondeo de boyas diferentes. Este software será ofrecido para distribución gratuita a los miembros de IALA. ◆

About the author
David HENRY runs his own Naval Architecture and Marine Engineering consultancy which has been working as the Naval Architect for MOBILIS since 1991. He was tasked with providing the method, user interface and calculations and Jean François BOUCULAT, IT manager at MOBILIS, developed and built the software, using Visual Basic DotNet.