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Sea Fastening

Related terms:

Lateral Loads, Barges, Fabrication, Crane Barge, Engineering Firm

Vessels and Transport to Offshore Installations

Kurt E. Thomsen, in Offshore Wind (Second Edition), 2014

Maximum Wave Peak Period

How strong is the sea fastening, and how is the seafaring behavior of the vessel? As already described, sea fastening must be laid out to cope with the maximum operating transit criteria for H_s; this is important for the transit criteria. If this is low, the operational envelope is also low. Therefore, the designer—typically the naval architect—will look at the maximum g-force the turbine components will allow in any direction. This will be the governing parameter for the sea fastening. The operational envelope and the maximum g-forces on the components are then determined by the vessel motion and the corresponding maximum sea state in which they occur. This will then be the operational envelope and thereby the design parameter for sea fastening.

Disciplines Involved in Offshore Platform Design

Naeim Nouri Samie MSc Hydraulic Structures, in Practical Engineering Management of Offshore Oil and Gas Platforms, 2016

F Temporary Supports

- Sea fastening supports are used during transportation. They shall be designed/placed in such a way that their cutting is done at the minimum required time and after cutting leave a minimum of debris.
- Rigging platform is used to accommodate lifting slings during offshore transportation. To minimize offshore work, normally slings are connected onshore. Onshore crane access is also much better. They shall be secured in such a way as to be safe against accelerations and movements during offshore voyage, while easily accessible to connect a crane barge hook.
- Barge bumpers are installed but boat landings are transported separately. After jacket is fixed via piling, boat landing is lifted and placed in location.
- After jacket is installed and riser is connected to the underwater pipeline and topside piping, it becomes stable. These end connections act as additional

supports. However, during transportation and installation jacket may require temporary supports. They may be left in place after installation. Normally riser clamps do not provide any torsional restriction. During sea transportation, lifting, or launch it may experience torsion. Riser bend connected to end blind flange is a heavy item. The bend may protrude several meters away from the jacket face and the blind flange will be located at the farmost end point. This may induce a considerable torsion that may only be taken with heavy support elements connected to jacket members.

- J tubes normally have small loads and are closed with a small, lightweight end flange. A diver will remove it and connect the pulling cable attached to it to a subsea cable.

Construction and installation lifting analysis

Mohamed A. El-Reedy Ph.D., in Marine Structural Design Calculations, 2015

Example 7.1

This example calculates the forces in the sea fastening members due to transportation for a deck weight of 50 tons. The input data are as follows:

Steel deck weight, W=50 tons

Length of the CoG from the middle of the ship, LCG=8.4 m

Distance between the CoG of the deck and the vessel center line in transverse direction, TCG=0.0 m

Vertical distance from the deck CoG to the barge keel, VCG=5.0 m

Barge draft=3.65 m

Area of the deck in longitudinal direction=10.0 m^2

Area of the deck in transverse direction=4.2 m^2

Maximum rolling angle, ϕ=20°; Time, t=10 s

Maximum pitch angle, ψ=12.5°; Time, t=10 s

Heave acceleration=±0.2 g

Radius in rolling, R_r=5.0–3.65=1.35 m

Rolling acceleration, $a_r=R_r(\phi\pi/180)(2\pi/t)^2=0.186\ m/s^2$

β=0.0°

Pitching acceleration, $a_p=R_p(\psi\pi/180)(2\pi/t)^2=0.82\ m/s^2$

δ=80.91°

Heaving acceleration, $a_z=0.2g=0.2\times9.81=1.962\ m/s^2$

In the case of rolling, $K_r=1$ $k_p=0.6$ $k_z=0.8$

In the case of pitching and heaving, $K_r=0.6$ $k_p=1$ $k_z=1$

Calculate the rolling force due to transportation vessel motion (Figure 7.16) as

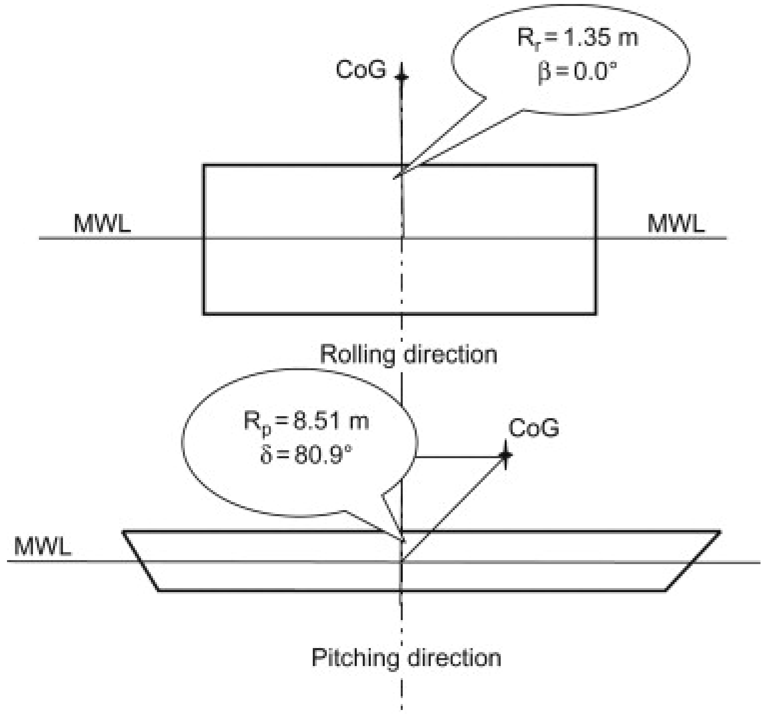

Figure 7.16. Example 7.1.

F_r=(W/9.81)[$k_r a_r$ cos β+sin ϕ(9.81+$k_p a_p$ sin δ+$k_z a_z$)]=21.53 tons

F_w=15 tons due to wind perpendicular to the longitudinal direction of the vessel

Total load=21.53+15=36.53 tons

Calculate the pitching force due to transportation vessel motion (Figure 7.16) as

F_p=(W/9.81)[k_{pap} cos δ+sin ϕ(9.81+$k_r a_r$ sin β+$k_z a_z$)]=13.57 tons

F_w=11 tons due to wind perpendicular to the transverse direction of the vessel

Total load in transverse direction=24.57 tons

Calculate the heaving force due to transportation vessel motion as

F_z=(W/9.81)[$k_r a_r$ sin β+sin ϕ(9.81+$k_p a_p$ sin δ+$k_z a_z$)]=59.82 tons

You have the forces applied on the steel deck CoG, so you can calculate the forces in the supported element.

Project Execution

Kurt E. Thomsen, in Offshore Wind (Second Edition), 2014

Special Equipment

The vessel has a crane, jacking equipment, and sea-fastening equipment onboard, which carry a very high dollar value. This equipment is crucial for the operation of the vessel within the project and must be scrutinized carefully for defects and/or damages. Furthermore, the sea fastening is almost always paid for by the client and therefore the equipment should be in perfect working order. It should be noted that the marine warranty surveyor will be present during the on-hire survey, and some of the main areas of expertise and interest are the special equipment, the certificates, and the general condition of the vessel.

Normally, the on-hire survey is done within a two-day period. This seems short, but the number of tasks that must be performed are planned well in advance, and the focus is on the areas where you would usually—as the experienced surveyor—expect to find problems.

Installation and Vessels

Yong Bai, Qiang Bai, in Subsea Engineering Handbook (Second Edition), 2019

5.5.1 Subsea Structure Installation Analysis

The subsea structure installation procedure normally includes the following:

- Load-out and sea-fastening;
- Transportation;
- Site survey;
- Deployment, typically including overboarding, splash zone lowering, midwater lowering, landing, and positioning and setting (see Figure 5-13);

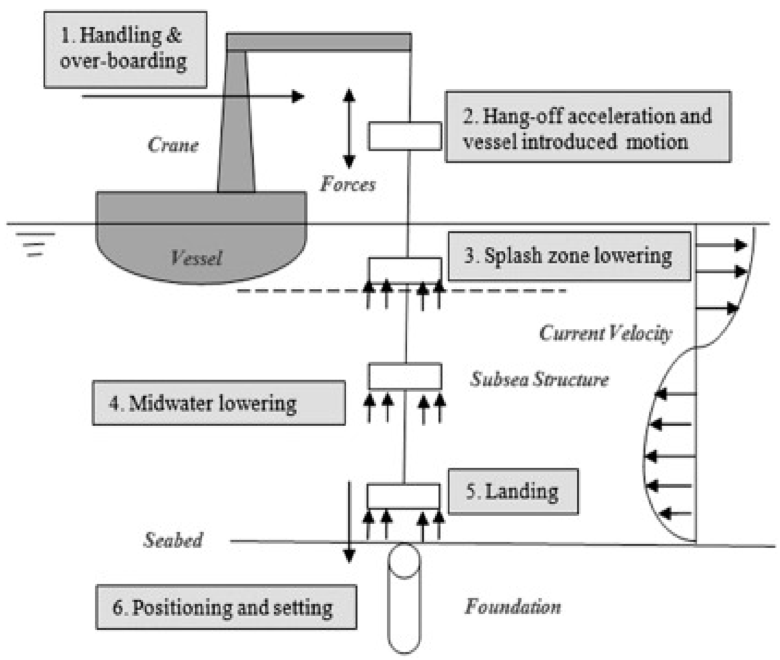

Figure 5-13. Sketch of Analysis Steps for Typical Subsea Structure.

- As-built survey.

This section describe only the structure deployment analysis, which may be the most critical analysis for subsea installation, while other analyses such as barge strength verification for transportation and lifting analysis for load-out, are not included in this section.

Analysis of subsea structure deployment provides the maximum allowable sea states and maximum expected cable tensions and the motions of installed equipment during installation. Finite element software (e.g., Orcaflex) is used for the installation analysis. The objective of the detailed installation analysis is to provide a step-by-step analysis to aid in the generation of the equipment deployment procedure.

The installation analysis can be divided into two stages: static analysis without any environmental loading, and dynamic analysis with environmental loading such as current and wave. The static analysis determines the relationship between vessel position, wire payouts, and tensions for the system in a static state. The dynamic analysis is performed for the system under environmental loads in order to determine the maximum allowable installation sea states and the maximum tension required. The analyses are carried out for a range of wave heights and wave periods.

The analysis model comprises the installation vessel associated with its RAOs, drilling pipe with running tools or a crane with its winch wires, and rigging systems and equipment.

Figure 5-13 illustrates the installation procedures for a typical subsea structure with the forces modeled during each step. For detailed installation analysis of the manifold, refer to Section 19.5.

Fabrication and Installation

Mohamed A. El-Reedy Ph.D., in Offshore Structures, 2012

5.11 Transportation Loads

All structures should be checked for the inertia loads applied during sea transportation. Consideration should be given to the support points used for sea fastening. The following should be considered:

- Structure self-weight
- Equipment and bulk self-weight
- Transportation inertia loads
- Roll, 20º; Period, 10 s
- Pitch, 10º; Period, 10 s
- Heave: ±0.2 g
- Center of rotation is 60% above barge keel at longitudinal midship of the transport barge
- The transportation inertia loads should be combined as roll ± heave and pitch ± heave
- Wind loads for a return period of 10 years (1 minute mean) should be included
- The support points should reflect the support points adopted during load-out

The sea fastenings fix the jacket or the topside (the module) to the barge that transports it from the fabrication yard to its offshore location. Transportation is performed aboard a flat-top barge or, if possible, on the deck of the crane vessel.

The module must be fixed to the barge in order to withstand barge motions in rough seas. The sea fastenings are determined by the positions of the framing in the module as well as by the "hard points" of the barge.

As shown in Figure 5.43, the jacket rests vertically on the barge if it is not tall. Figure 5.44 presents the jacket being transported lying horizontally on the barge. A structure analysis, as discussed previously, will be run again, taking into consideration the fixation points and the movement of the barge. This phase requires cooperation between the installation company and the engineering firm that performed the design. After the engineering office receives the data from the installation company, it runs the structure analysis, and if it is determined that some member will be damaged, it will be changed in this stage. It is advantageous if cooperation between the installation company and the engineering company begins early, to avoid the need for any change in structure configuration.

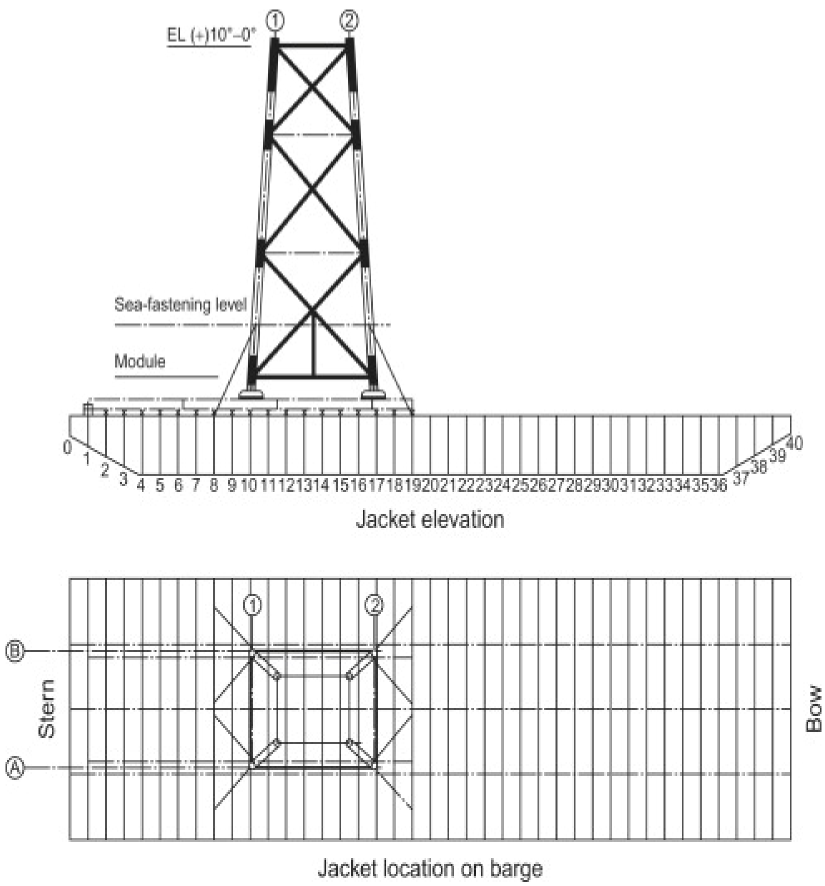

Figure 5.43. Jacket sea fastening during transportation.

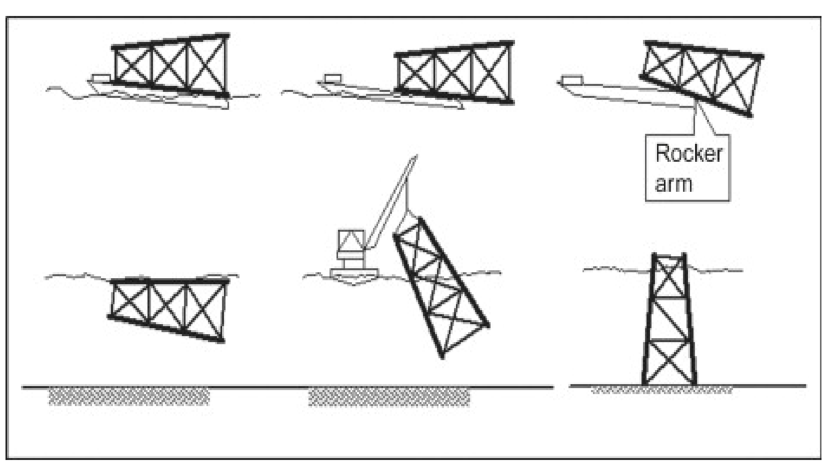

Figure 5.44. Launching and installing a jacket.

Skew load factor (SKL) accounts for sling fabrication tolerance or any other inaccuracy in the sling length. SKL should be calculated based on the DNV recommendations. In the absence of exact information, SKL should be set to 1.25 for a typical indeterminate four-point single-hook lift.

As an alternative to the SKL, the lift weight (hook weight) might be distributed in a 75%–25% split between each pair of slings in turn. All structural members, padeyes, shackles and rigging components should be designed or checked for both load distributions.

For padeye design, an additional lateral force equivalent to 5% of the sling force should be applied at the eye of the padeye, in conjunction with the design sling load.

The criterion of 75%–25% split or SKL of 1.25 is based on the variation in fabrication tolerance ±0.25%. If, for any reason, this cannot be achieved, then the SKL must be modified.

The Basic Organization

Kurt E. Thomsen, in Offshore Wind (Second Edition), 2014

Design Equipment for Project

It seems logical that the individual project will have unique technical challenges and therefore require solutions that are also unique to the project. It could be anything ranging from sea fastening of the components on the contractor's vessel to providing method statements for performing the work or developing the logistical solutions for this particular project.

Here it should be noted that creating the method statements for the individual work processes is a team effort where the QA and, in particular, the HSE departments participate. This is the first event that shows how important it is to have an HSE department as part of the line organization. The development of method statements can only be done in cooperation with the HSE department, simply because this is the only department in the company that has the capability of collecting and interpreting the various national laws and compliance documents relating to health and safety. Therefore, their input is crucial to the process of preparing the project.

SACS Software

Mohamed A. El-Reedy Ph.D., in Marine Structural Design Calculations, 2015

8.10 Sea fastening

After transferring the structure to the material barge, the structure analysis for the structure during transportation on the sea must be performed. The drawings in Figure 8.91 presents a simulation of the structure with additional members for sea fastening. It is traditional for this analysis to release the member ends, which are connected to the barge frames in the rotational degrees of freedom to simulate assuming a guested connection. The model uses the same pullout model but removes the slings.

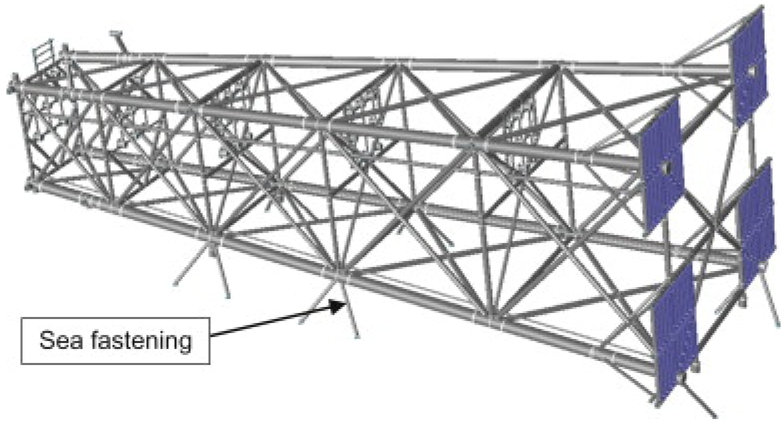

Figure 8.91. Sea fastening structure model.

As an example of the sea fastening of the jacket on the barge is presented in Figure 8.92 with the elevation and plan. Note that the location of the sea fastening and the barge layout are obtained from the installation company.

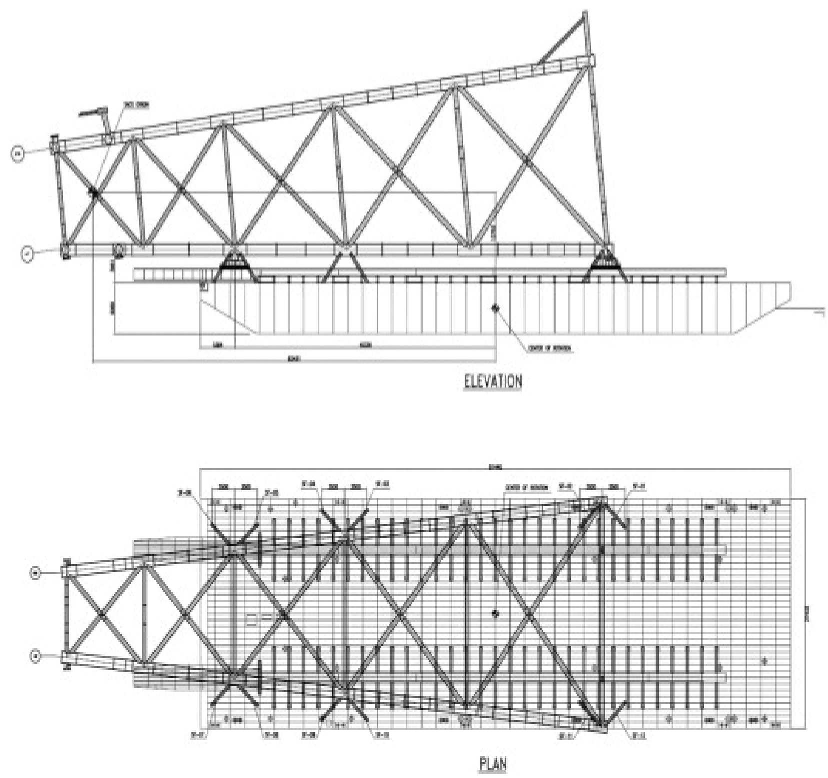

Figure 8.92. Structure model located on the barge.

The computer model is used, and the sea fastening members carry the weight from inertia loads due to rolling and pitching of the barge. In this analysis, consider the weight contingency. The material density will increase around 7%. SACS software through the Tow module considered the modeled and unmodeled element mass to generate the inertia load.

The structure location with respect to the material barge was taken into consideration. As shown in Figure 8.91, this location is defined based on the barge center of rotation, which is the barge's geometric center at sea level relative to the origin of the structure model. The orientation is modeled by aligning the barge's sway and pitch axis with the model's global Y-axis, the barge's surge and roll axis with the model's global X-axis, and the barge's heave axis with the model's global Z-axis.

As per the DNV, the data in Table 8.1 should be considered in design.

Table 8.1. DNV relevant data

Motion	Amplitude	Period (s)
Roll	+20	10
Pitch	+12.5	10
Heave	Acceleration±0.2 g (ground acceleration)	

The effects of wind are assumed to be included in the preceding motion criteria. The center of motion is considered at the barge center of rotation at sea level. The motions in the table are converted by the Tow module into accelerations to generate inertia loads.

8.10.1 Load combinations

Barge motion-induced forces are combined as follows:

- +Roll+Heave
- +Roll–Heave
- –Roll+Heave
- –Roll–Heave
- +Pitch+Heave
- +Pitch–Heave
- –Pitch+Heave
- –Pitch–Heave

The effects of the wind are assumed to be included in these inertia motion criteria. The center of motion is considered to be the barge center of rotation at the sea level. These motions are converted by the Tow module into accelerations to generate the inertia load.

The combination between the gravity load and the inertia load is done by the Combine module in SACS for the following cases of loadings:

- +Gravity+Roll+Heave
- +Gravity+Roll–Heave
- +Gravity–Roll+Heave
- +Gravity–Roll–Heave
- +Gravity+Pitch+Heave
- +Gravity+Pitch–Heave
- +Gravity–Pitch+Heave
- +Gravity–Pitch–Heave

Afterward, choose Data file>Create a model.

The data generator for Tow module is chosen, as shown in Figure 8.93. Example of towing analysis for the first line input file menu as shown in Figure 8.94.

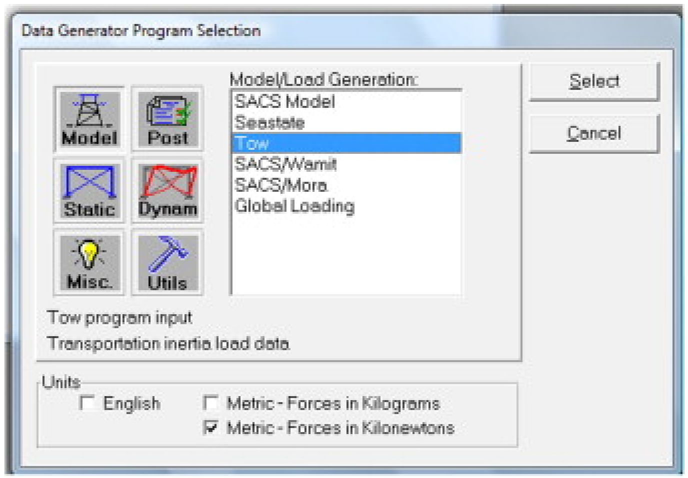

Figure 8.93. Select Tow module.

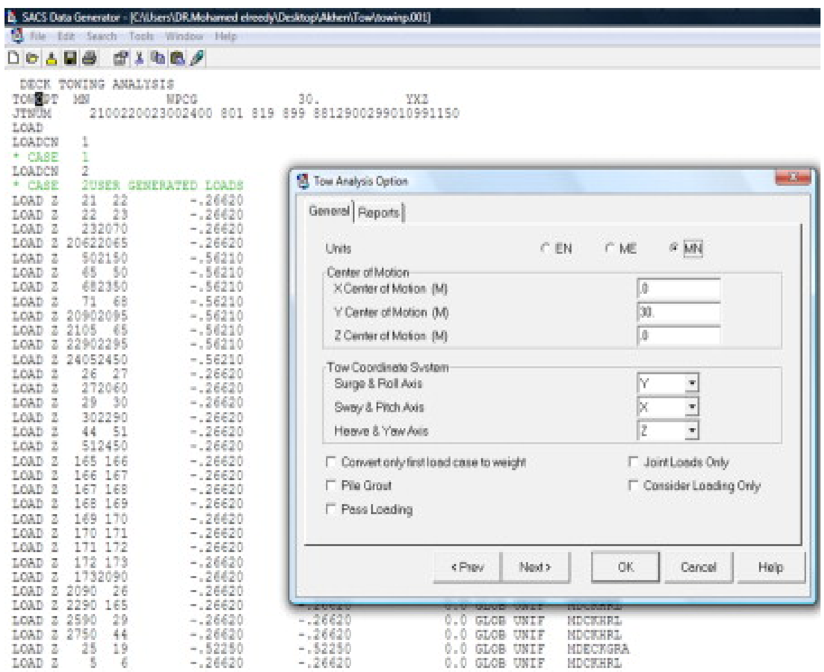

Figure 8.94. Tow module input file.

Start the analysis start by selecting Type: Loadings>Subtype: Sea State Loading (Wave, Wind, Current, Inertia, etc.), as in Figure 8.95.

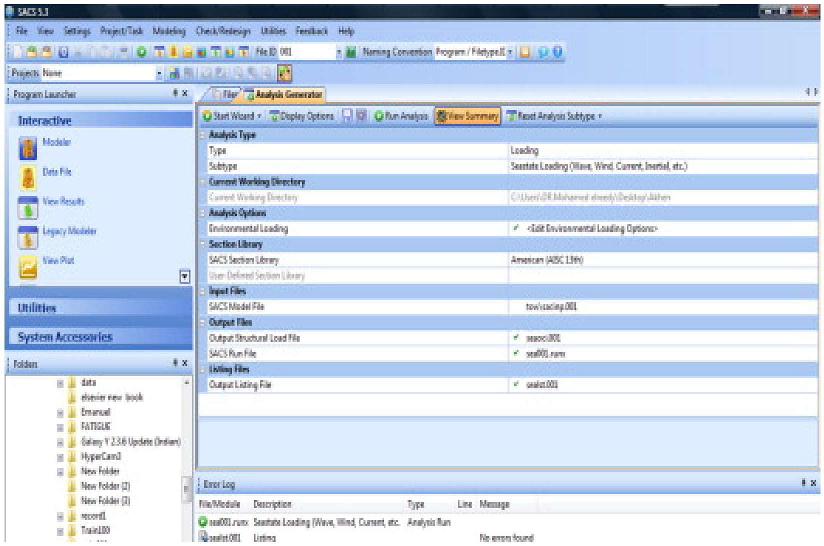

Figure 8.95. Start the Tow analysis.

The input data of the roll, pitch, and heave is as shown for eight load cases, as presented in Figures 8.96 through 8.103.

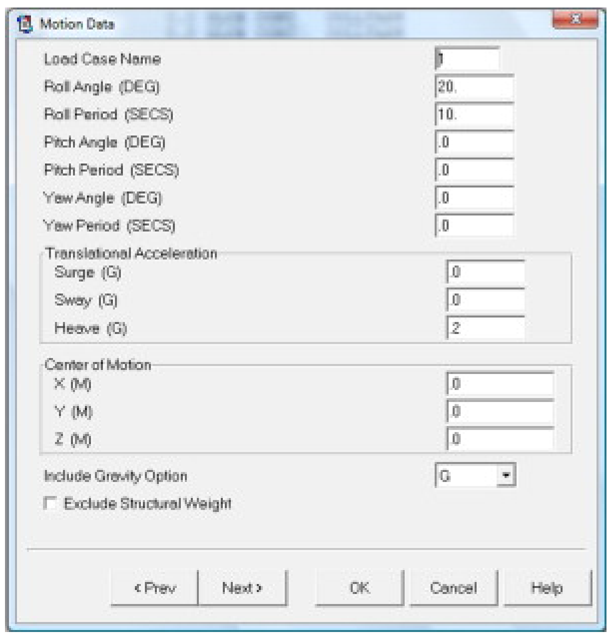

Figure 8.96. Motion input data in load case 1.

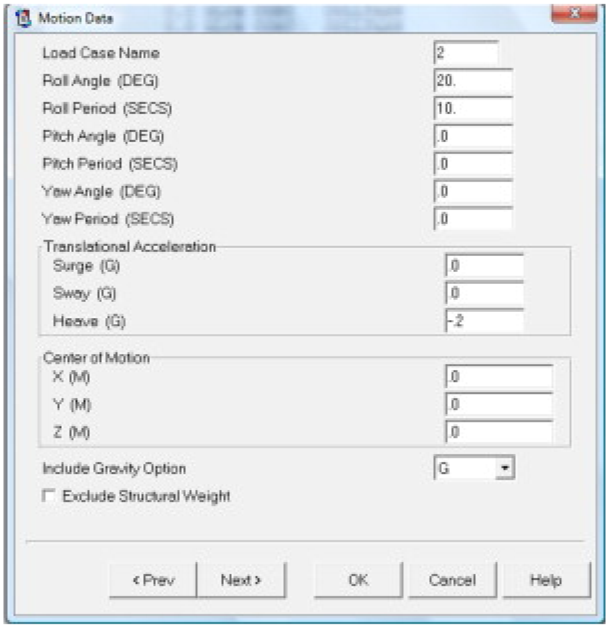

Figure 8.97. Motion input data in load case 2.

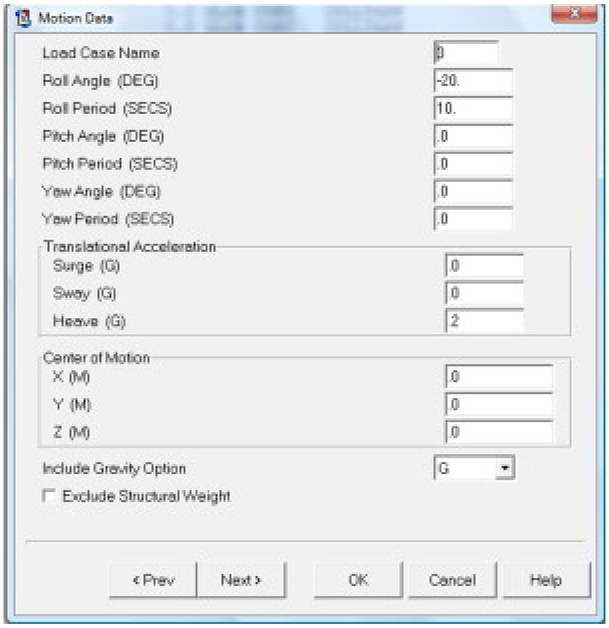

Figure 8.98. Motion input data in load case 3.

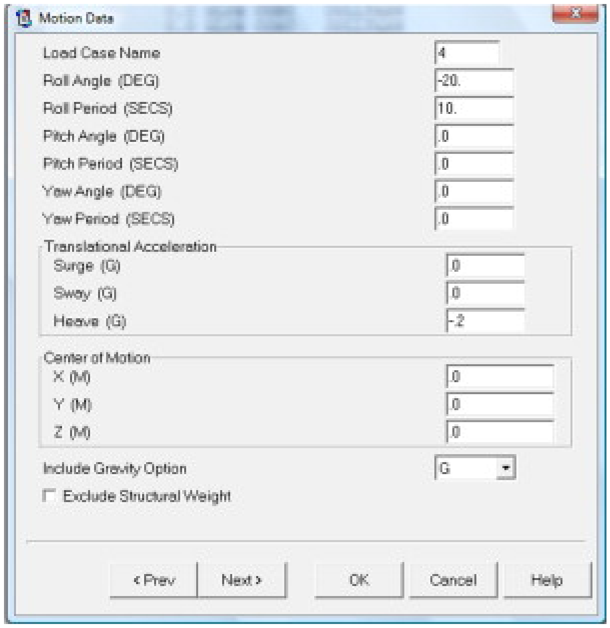

Figure 8.99. Motion input data in load case 4.

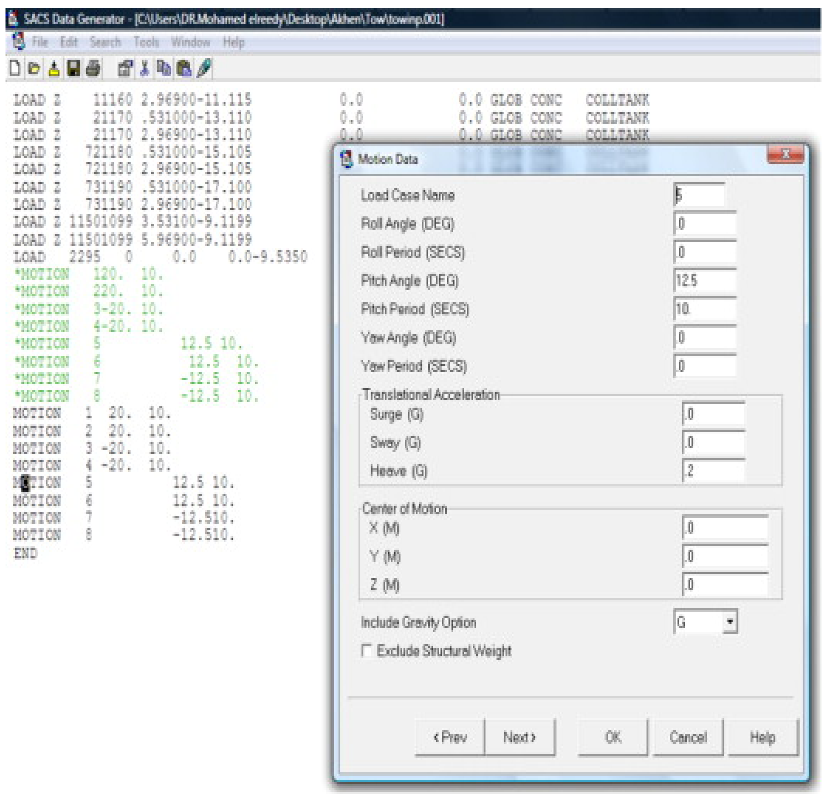

Figure 8.100. Motion input data in load case 5.

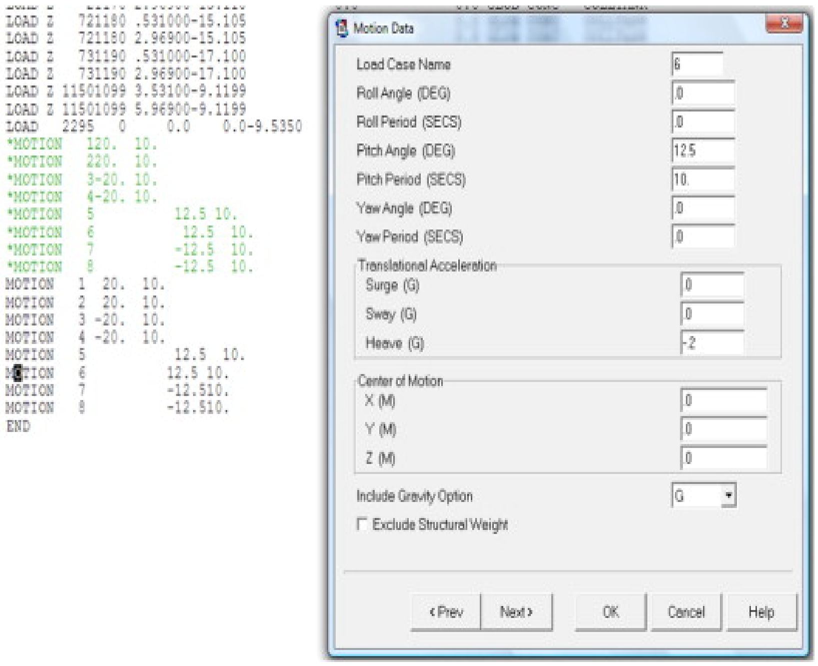

Figure 8.101. Motion input data in load case 6.

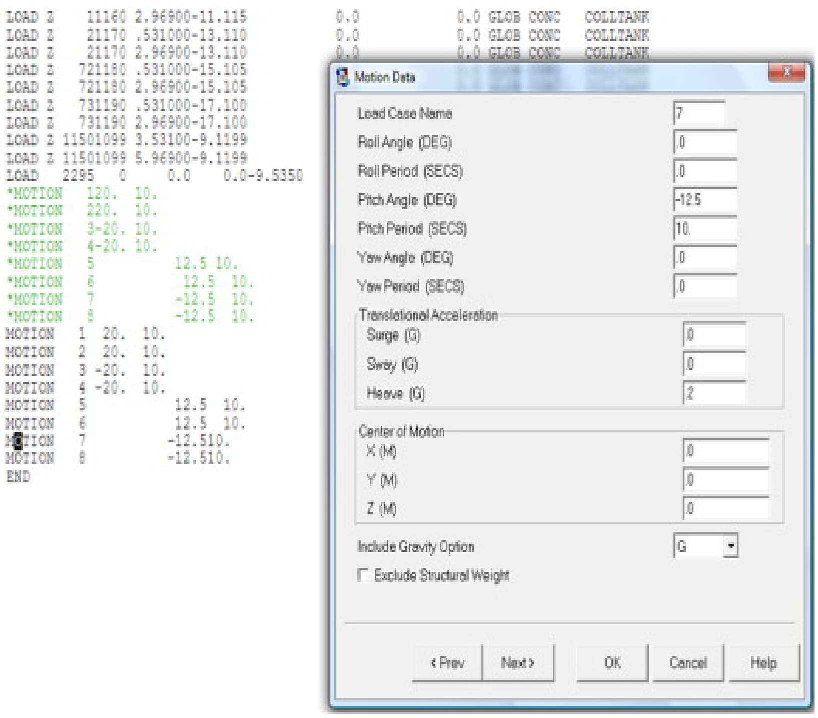

Figure 8.102. Motion input data in **load case 7**.

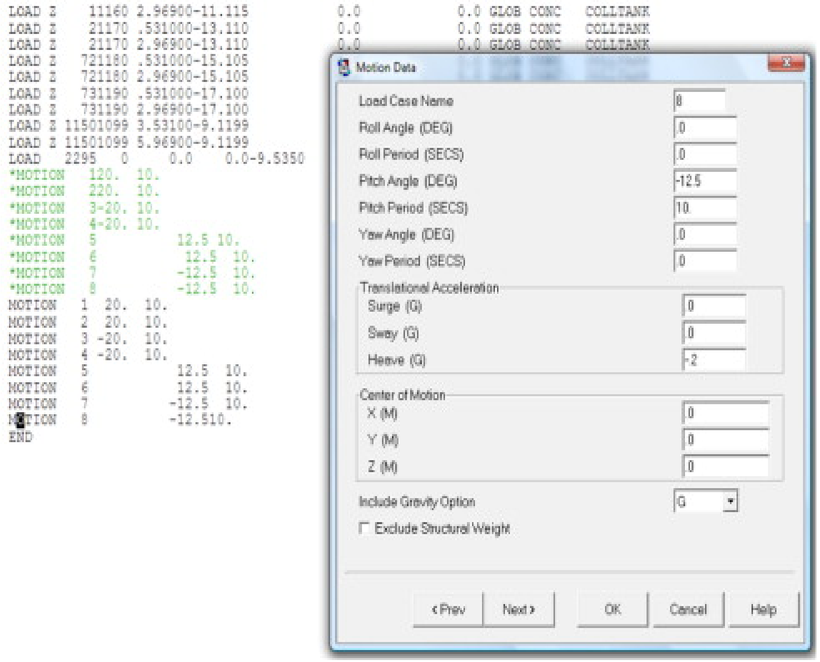

Figure 8.103. Motion input data in load case 8.

The transportation is done in three stages. For stage 1, the analysis under gravity load only, so the sea fastening member carries no load at this stage, as shown in Figure 8.104.

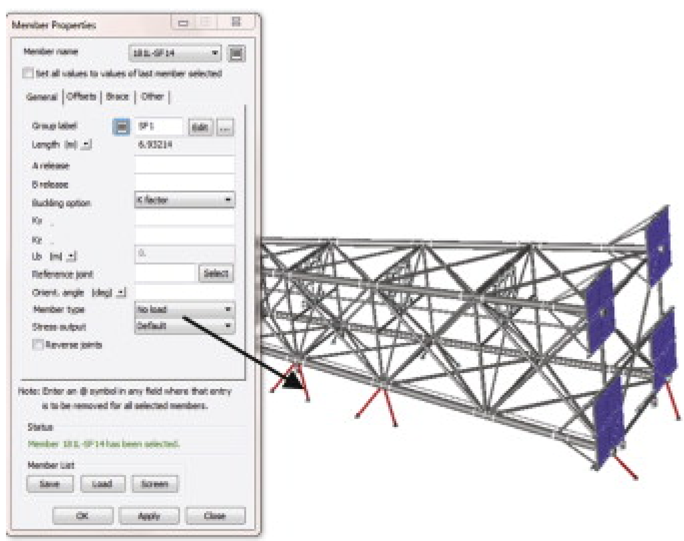

Figure 8.104. Sea fastening member properties.

For stage 2, consider the forces due to transportation, and in this case, the sea fastening members carry the load. The last stage is to have a combination between gravity and transportation load.

Deepwater Metocean Environments

Peter Aird, in Deepwater Drilling, 2019

Angles and Offsets for Floating Operations

Vessel Motions

Vessel motion is generated by a response, i.e., of transfer functions, to passing waves. Vessel motion is important for identifying loads imposed by a mass on or within a vessel's structure and/or its equipment such as:

- Sea fastenings for transporting goods and equipment from port to port, and,
- Specifying and sizing equipment for offshore operations.

Response Amplitude Operator

Response amplitude operator (RAO) refers to the movement of a floating vessel in six degrees of freedom: ***Surge, Sway, Heave, Roll, Pitch***, and ***Yaw*** due to a passing hydrodynamic wave (Ref. Fig. 4.18). RAOs are used as input data for calculations to define the displacements, accelerations, and velocities at any given location on a marine vessel that in turn is used to identify forces imposed on structures and/or equipment. RAO data are also an essential requirement for riser analysis.

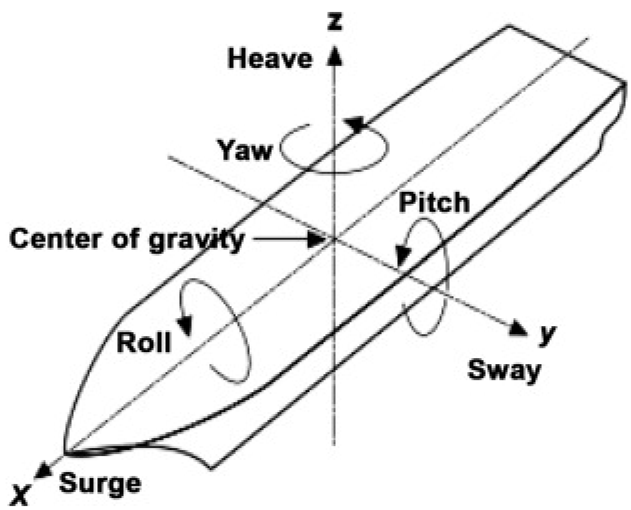

Fig. 4.18. Vessel's six degrees of freedom.

Source: Kingdom Drilling training.

Surge, Sway, and ***Heave*** are *linear movements* in the *x, y, z* directions, respectively, and ***Roll, Pitch,*** and ***Yaw*** are *rotary movements* about the *x, y, z* axes, respectively.

Heave, ***Roll***, and ***Pitch*** are subject *to gravitational restoring forces* (stiffness or spring coefficients), which means that they can be oscillated at a natural frequency, *something to be avoided in practice at all costs.*

Surge, Sway, and ***Yaw*** are not subject to restoring forces, which means that they *cannot be oscillated at a natural frequency.*

The term Response Amplitude Operator comprises two parts:

1. ***Response amplitude*** refers to the degree of movement induced in a floating vessel due to a passing hydrodynamic wave. This movement is absolute (or actual).
2. ***Operator*** refers to a factor that must be multiplied by a specific value, e.g., wave height (or amplitude) to define the absolute (or actual) movement.

Metocean wave height, water depth, and period all affect a vessel's response.

RAO Calculations

RAO calculates response amplitudes in all six degrees of freedom, i.e., those with restoring forces and those without. RAO includes the effect of damping and added mass, which means that the relationship between the response amplitude and the associated wave height is not always linear. Therefore, RAO does not calculate *operators*, it calculates *actual* (theoretical) response amplitudes (RAs) at a given angle through a wave, i.e., you do not multiply RAOs calculated values by a wave height, amplitude, or slope. RAO includes a pictorial demonstration of the vessel's movement in beam, deck, and aft views relative to the profile of the passing wave.

RAO calculations as illustrated in Fig. 4.19 may deliver a pictorial demonstration of the vessel's movement in beam, deck, and aft views relative to the profile of the passing wave.

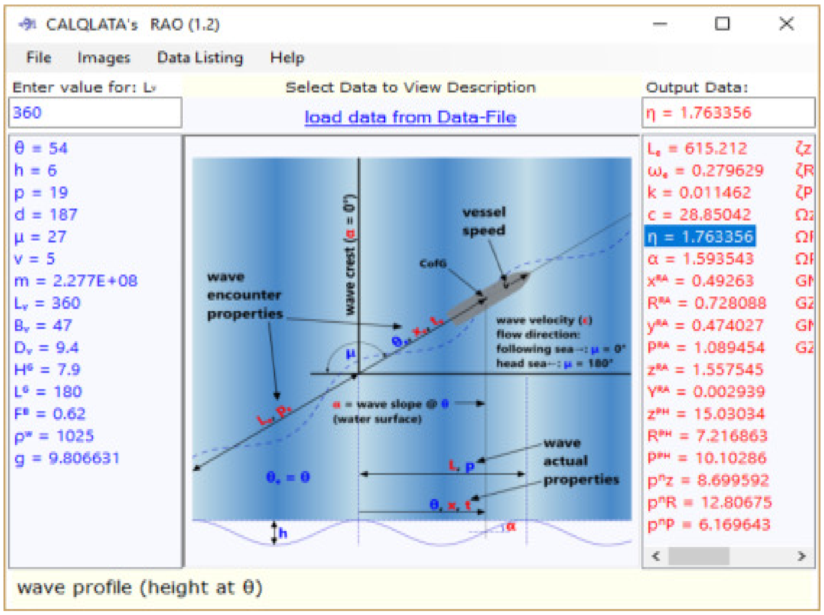

Fig. 4.19. Illustrative example of a RAO set of calculation for a specific vessel and metocean data input.

Source: Keith Dixon-Roche, http://calqlata.com.

Summary

Offshore vessels have unique motion characteristics as defined by RAO. This a key determinant to consider regarding optimum rig selection and operating conditions particularly in offshore deepwater regions, where extreme metocean conditions, water depths, and seabed conditions can limit, restrict or halt moored, dynamic positioning operations. In more challenging and extreme environments, the drilling vessel with the most capable RAO is the one most preferred, i.e., the one most capable to change its heading.