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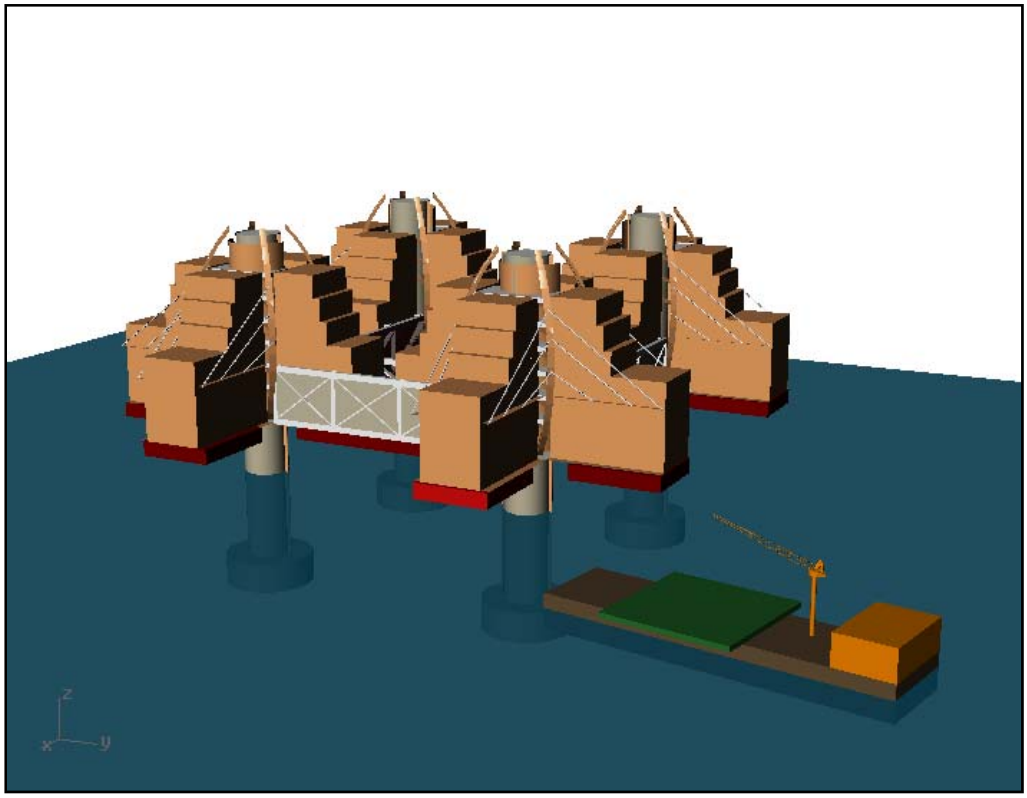
ClubStead Preliminary Analysis: Construction and Commissioning



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1. Summary and Conclusions

The construction and installation methodologies of a floating platform are critical to improve the project economics. The ClubStead is a large structure which only a few shipyards in the world could build entirely. The modular approach described in this document broadens the number of potential shipyards and minimizes the use of heavy equipment.

With the modular method, the ClubStead is built in separate modules at a shipyard and assembled at a nearby basin shielded from the environment. The assembly and welding on the water are the challenging aspects of the installation process. Innovative methods are developed to carry it out. The choice of the assembly site, rather than the size of the shipyard, is critical to the installation process. It must be sufficiently deep and protected.

The 10ft high buoyancy modules under the deck and the large cylindrical footings at the base of the columns are designed to provide sufficient stability during towing to the assembly site (GM>0). The footings also provide increased hydrodynamic stability throughout the operational life of the platform. The buoyancy module adds storage area as well as a fail-safe system to the platform deck, with additional flotation in case of structural failure.

2. Introduction

The ClubStead is a novel type of offshore living facility, focusing on providing a safe and spacious residential haven to communities in the open ocean. The cost per inhabitant is a critical variable to control during the design phase. Various aspects of design affect the cost, and an efficient approach to construction is one way to minimize it.

This document describes the construction and commissioning scenarios of the ClubStead, a 4-column stabilized platform designed to house 200 people. The characteristics of good construction and installation schemes are discussed.

The following points address issues that are found critical in determining the construction and installation method and in minimizing its cost:

- Integrative installation should be favored. It requires minimum intervention of external equipment such as cranes, barges …etc.
- Construction and installation should be performed as to facilitate inspection and intervention at sea.
- Any installation equipment should remain on the platform after commissioning only if it brings added value to the platform in operations.

A construction and commissioning method is devised for the ClubStead and presented herein.

3. Philosophy of the Construction and Installation Plan

3.1. Dimensions of the ClubStead

Table 1 summarizes the dimensions of the ClubStead platform considered for construction and commissioning herein. The ClubStead has a payload of 7,700 st.

Table 1: Dimensions of the ClubStead

COLUMNS			
	Column diameter	41	ft
	Tower Diameter	5	ft
	Hard Tank Diameter	76	ft
	Hard Tank Height	20	ft
	Draft	75	ft
	Airgap	40	ft
DECK			
	Distance column to column	200	ft
	Length of extension	100	ft
	Width of deck	50	ft

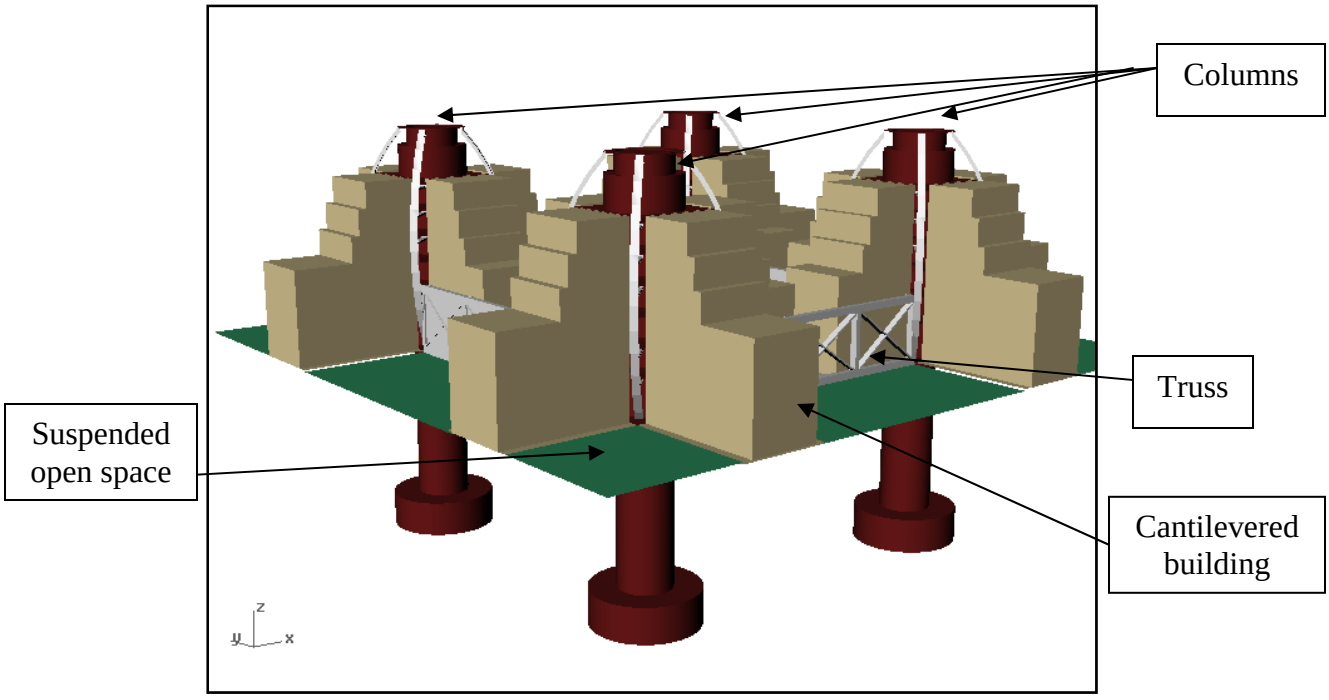


Figure 1: Basic Layout of ClubStead for Construction and Installation

Living facilities consist in 2 to 6-story buildings on the deck between columns. They extend at the extremities as shown in Figure 1. A large truss connects the columns and supports the weight of the buildings. Additional trusses provide support to the cantilevered buildings at the extremities, although stay cables help leverage the latter.

The cables are not represented in Figure 1, but they are necessary to suspend light open green surface areas and buildings at extremities.

The limitations of constructing and commissioning such a large structure are explored in this section.

3.2. Shipyard and Launching Limitations

The ClubStead may be constructed at a number of shipyards throughout the world. Shipyards with smaller capacities may be considered if the platform is built in separated modules and assembled outside of the shipyard.

Building the platform in separate modules has additional advantages. Few shipyards are equipped to launch such a large structure, and a launching would require large and expensive cranes and equipment. The operating draft of the platform, at 75ft, is too deep for many launching basins. If built entirely in the shipyard, the platform would need to be transported to deeper basins for commissioning, at prohibitive costs, or it would have to be stable at much shallower drafts, which may not be possible with all equipment aboard. A potential alternative is to separate modules which can be lifted and transported to the commissioning site at a smaller cost.
For these reasons, the process presented herein assumes the platform is first built in **small modules** which are towed to an **assembling site** in shielded but deep waters within towing distance of the shipyard. The assembly is possible in calm seas only.

To minimize the cost of installation and commissioning, the use of cranes and barges to transport individual pieces of the platform from the shipyard to the assembly site needs to be limited. The transportation of individual parts of the platform to the assembly site may be done by towing rather than on a barge. This requires that these individual components have sufficient self-buoyancy and watertight modules. Such requirements should be considered in the design if it lowers the price of commissioning significantly. Also, the presence of buoyancy modules at the bottom of the deck is an advantage for the safety of the ClubStead at sea, since it may be used as flotation device in case of collapse of the platform in wreckage.

In further designs of the ClubStead, the method used to assemble the platform, including welding of the columns to the trusses and buildings and installation of the cables should be considered with care. The assembly of the platform at sea will be the most challenging technical aspect.

4. Stages of Construction and Installation

The launching and commissioning of the platform is carried out in calm weather in protected basins to avoid relative motions of individual components due to wave and

wind loadings. This section describes in details the commissioning of a ClubStead, from construction of the modules, to final assembly.

4.1. Construction in shipyard

The main components of the structure are built in the shipyards and assembled in modules. The main deck structure consist of 4 modules (in yellow, orange, blue and green in Figure 2). The 4 columns are assembled independently.
All suspended recreational surfaces are built separately and later taken on a barge to the assembly site.

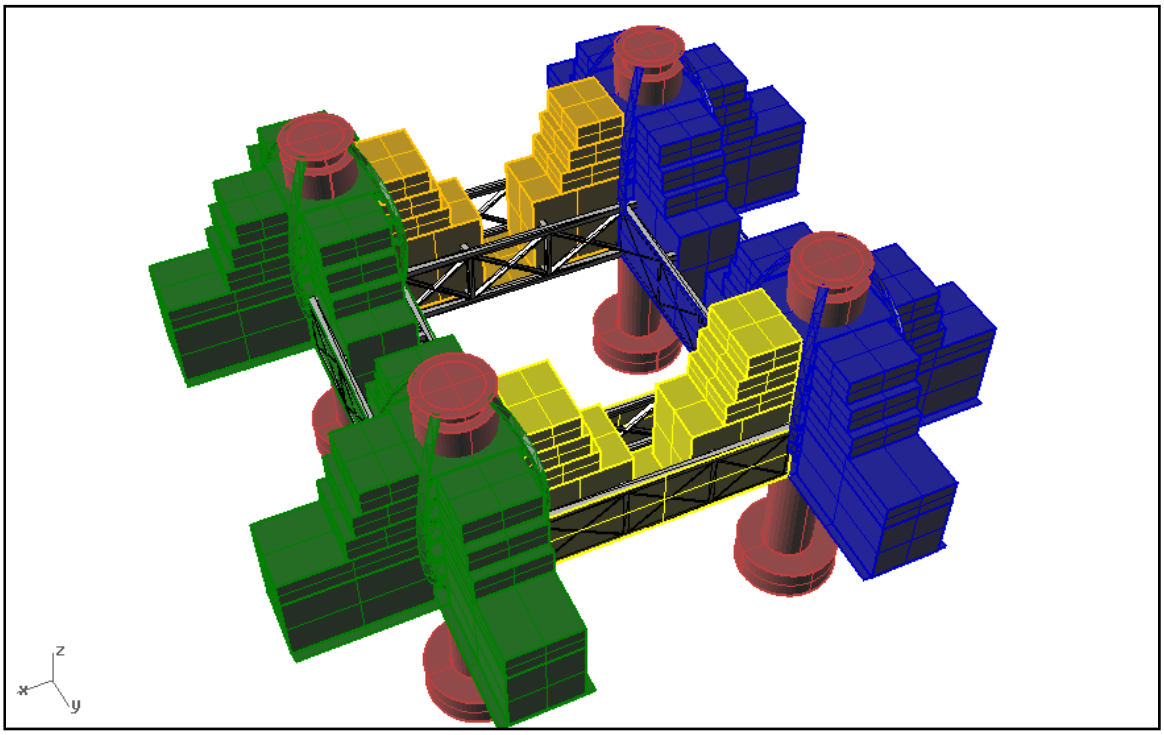


Figure 2: Modules assembled independently in the shipyard

Each module has an integrated water-tight buoyancy part. It is designed to be stable in calm weather.

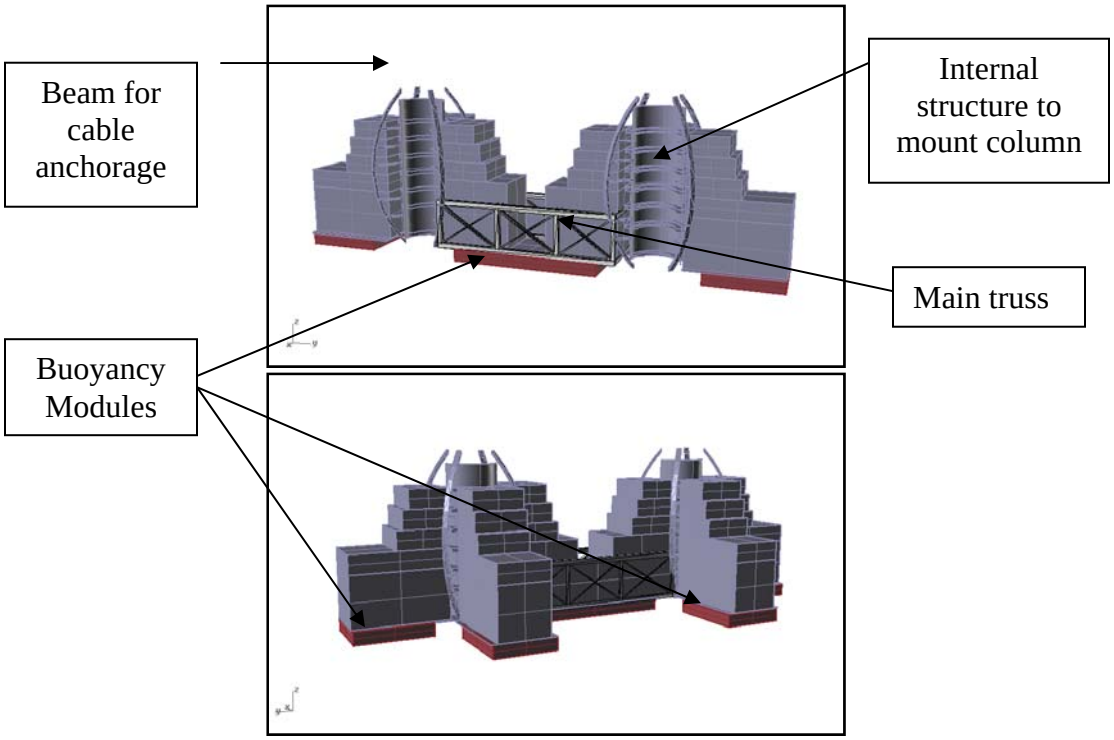


Figure 3: One of the 2 main deck modules after construction in the shipyard

4.2. Launching and towing to assembling site

4.2.1. Deck modules

The deck modules are launched from the shipyard quay:

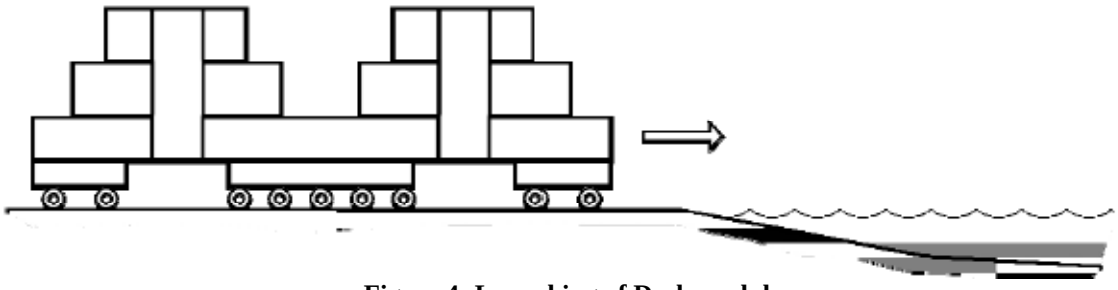


Figure 4: Launching of Deck module

They float on their buoyancy module, with a draft of 5 to 6 ft, depending on module. The buoyancy module is 10ft high with a minimum freeboard of at least 3ft. All modules need to be stable so they can be towed safely. The stability condition is met if the metacentric height of the module is positive. Table 2: Characteristics of each Buoyancy ModuleTable 2 summarizes the mass properties and metacentric height (GM) of each module. To

ensure stability, water ballast is added in the smaller modules (3 & 4). The water ballast will be removed when the modules are assembled with the rest of the platform.

Table 2: Characteristics of each Buoyancy Module

Module Number	**1**	**2**	**3**	**4**
Color in Fig. 2	green	blue	yellow	orange
Draft	5.78	5.78	6.83	6.83
Height	10	10	10	10
Submerged volume	83504	83504	39637	39637
Height of Temporary Ballast in Buoyancy Module (ft)	0	0	1.93	1.93
Center of gravity (KG - above keel)	33.28	33.28	33.28	33.28
Metacentric Height (GM in ft)	**93.1**	**93.1**	**0.6**	**0.6**

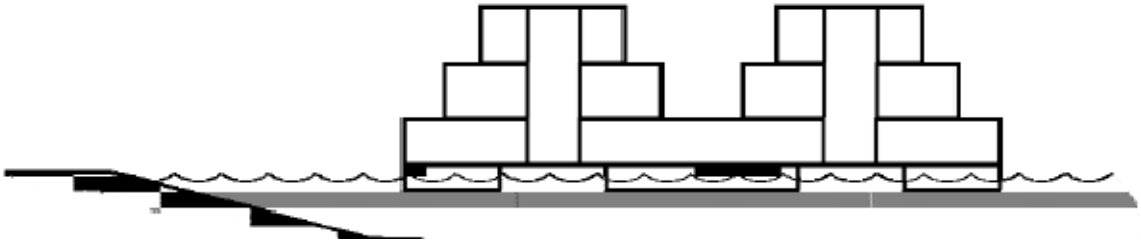


Figure 5: Deck module afloat

A tug boat tows the 4 deck modules to the assembling site where they will be mounted to the columns. The assembling site should be close to the shipyard, in a shielded site to limit the wave and wind disturbances and the water depth should be at least 110ft (draft + airgap on columns) to allow ballasting of columns.

Figure 6: Towing of deck module

4.2.2. Columns

The columns are launched from quayside. A crane may be required to proceed.

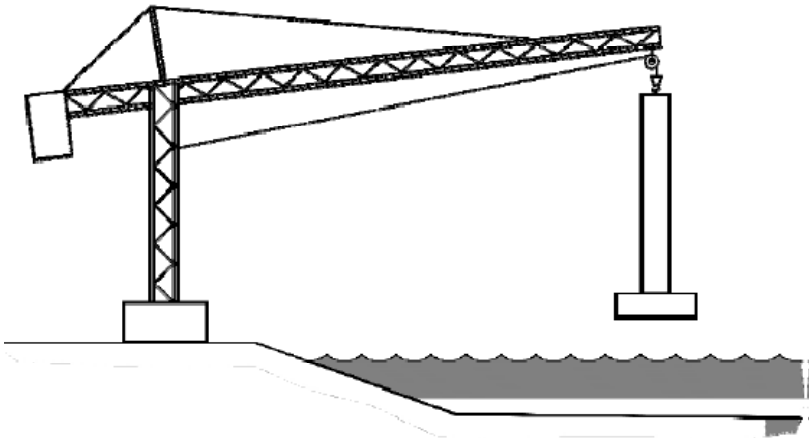


Figure 7: Lauching of columns

The column is designed to be stable on its footing. The characteristics of a column in floating conditions are described below. The metacentric height is positive.

Table 3: Mass Properties and Metacentric Height of Upward floating column

Draft	16.0
Submerged volume	7,596
Weight of ballast (st)	2,091
Center of gravity (KG - above keel)	33.3
Metacentric Height (GM in ft)	**0.7**

A tug boat tows the columns to the assembling site.

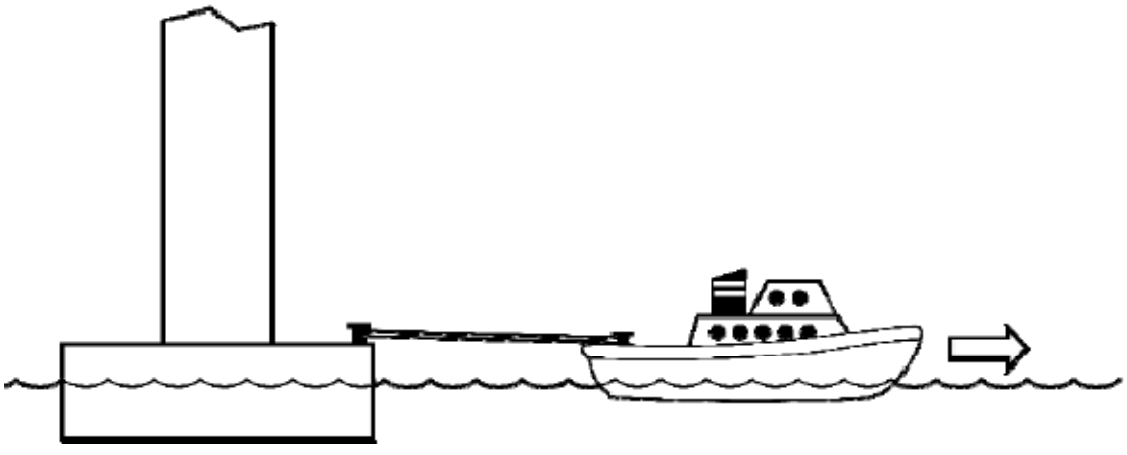


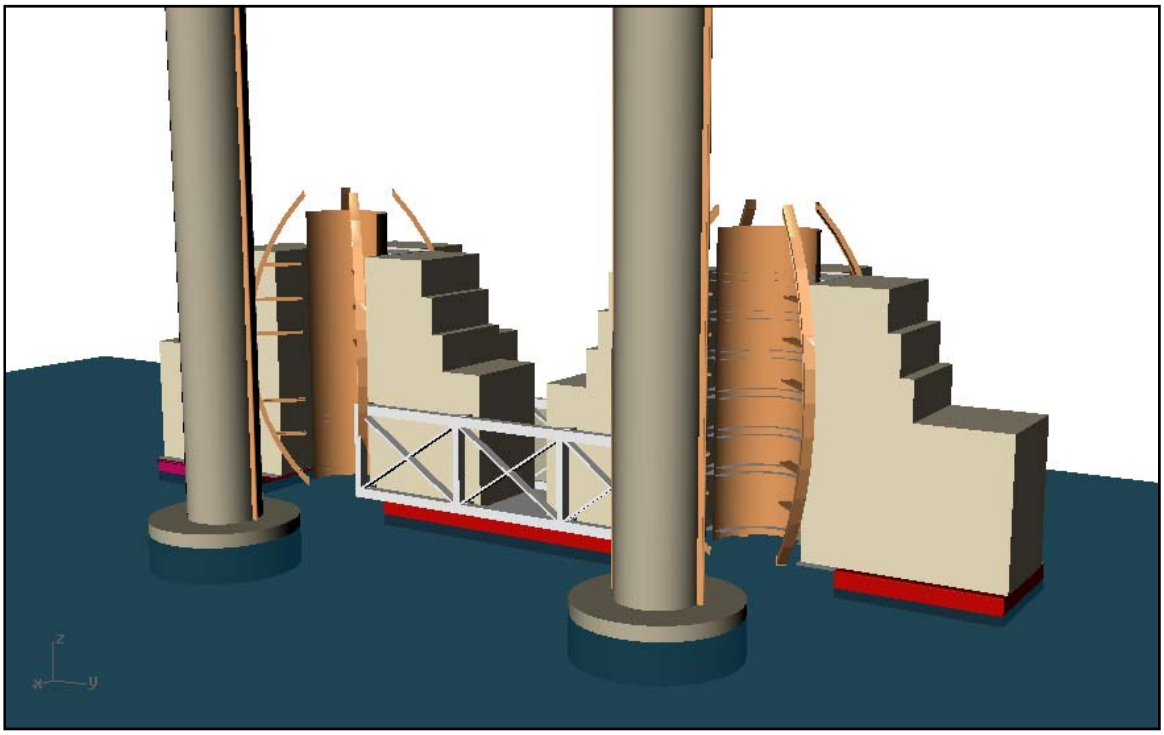
Figure 8: Towing of Columns

4.3. Assembling of columns and half-decks

At the assembly site, the columns are pulled into the large deck modules as illustrated in Figure 9. If necessary, the columns are slightly ballasted to allow sufficient clearance between the top of the footing and the bottom of the buildings on the deck. The buoyancy modules under the deck are designed to allow the full diameter of the footing of the columns to fit between them, with a 4ft clearance.

The structures should be protected with fenders and restrained with tug boats to prevent collisions.

Once they are properly oriented, the columns are restrained with guides, as shown in Figure 10. Two rails run vertically along the columns. At the deck level, a hook is fitted on the rail to restrain the column from moving horizontally and in pitch. The rail will guide the column down during ballasting.



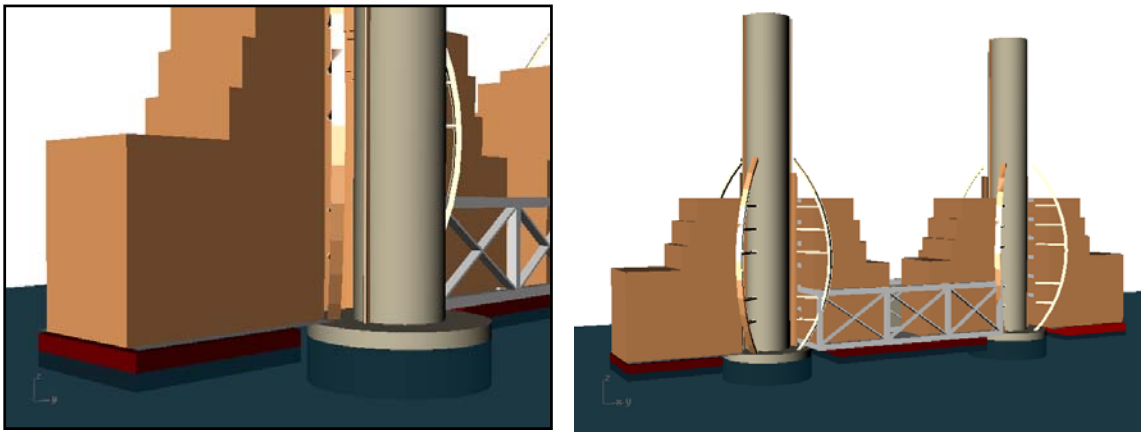


Figure 9: the columns are guided into their location in the deck modules

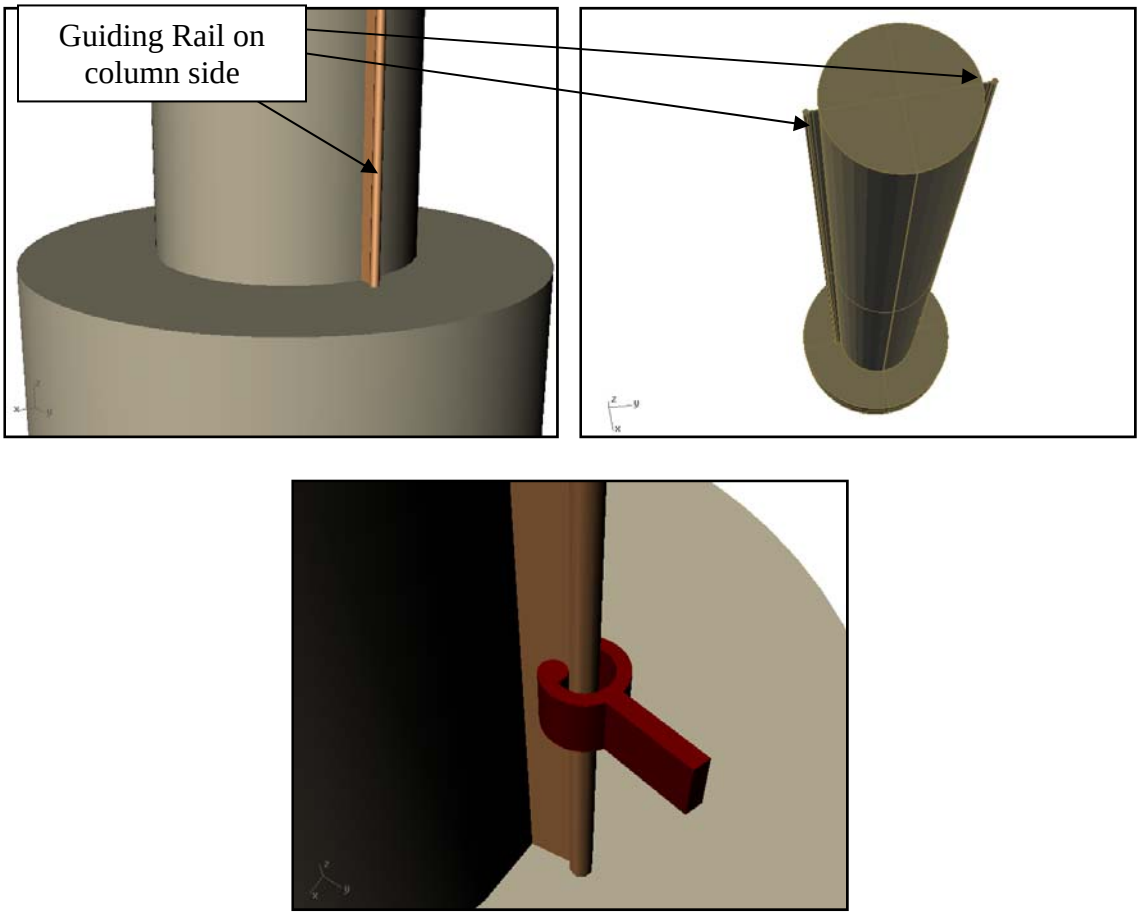


Figure 10: Guides on Columns - Bottom: a "hook" is fit on the guide rail to restrain the column

4.4. Welding and ballasting

Next, the 4 modules of the deck are assembled. Winches and guide ropes may be used to bring the modules together. Fenders and buoys are laid out on the structure to prevent contact and damage. Once the modules are in place, they are welded and/or bolted together.

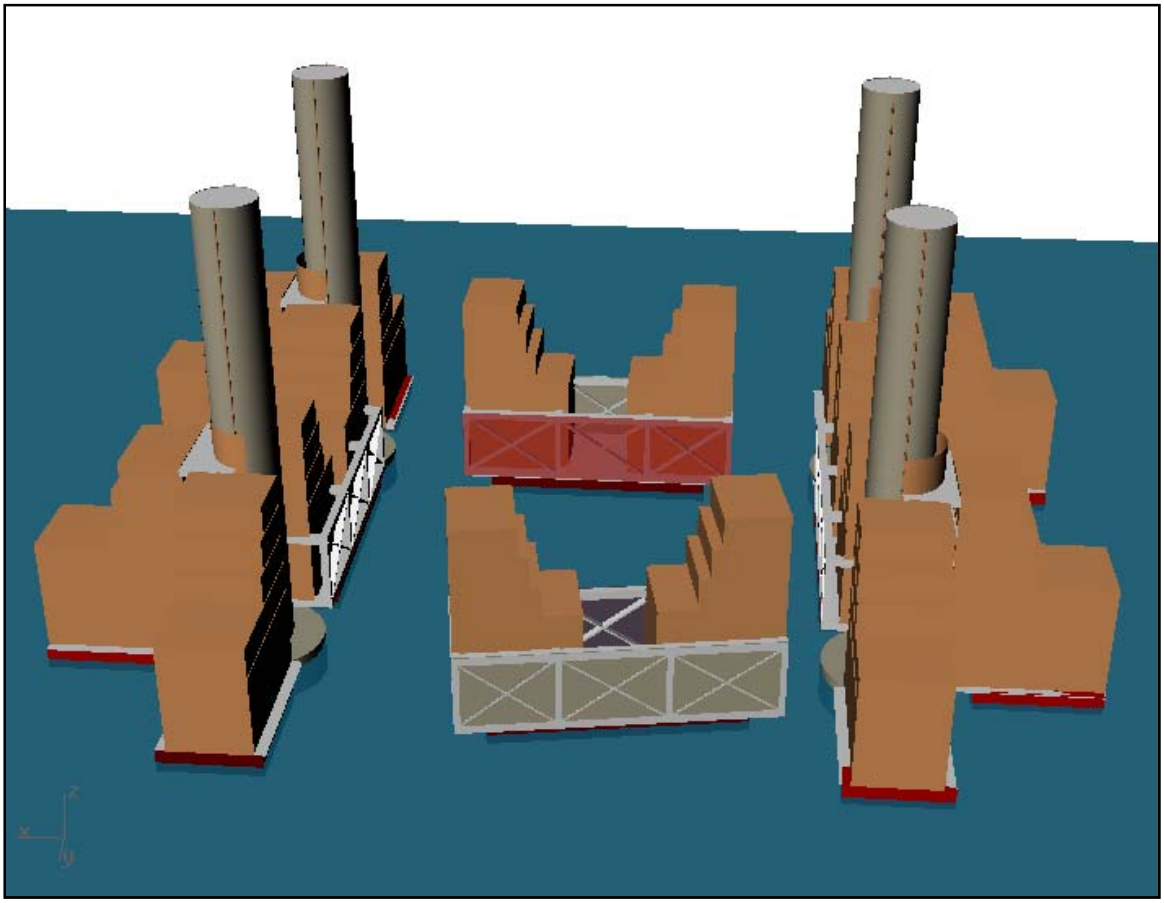


Figure 11: The deck is assembled

Once the deck is ready, the columns are ballasted by pumping water in the bottom compartments until the deck connection on the column is leveled with the deck modules, as illustrated in Figure 12. Then, the columns are welded and/or bolted to the deck modules.

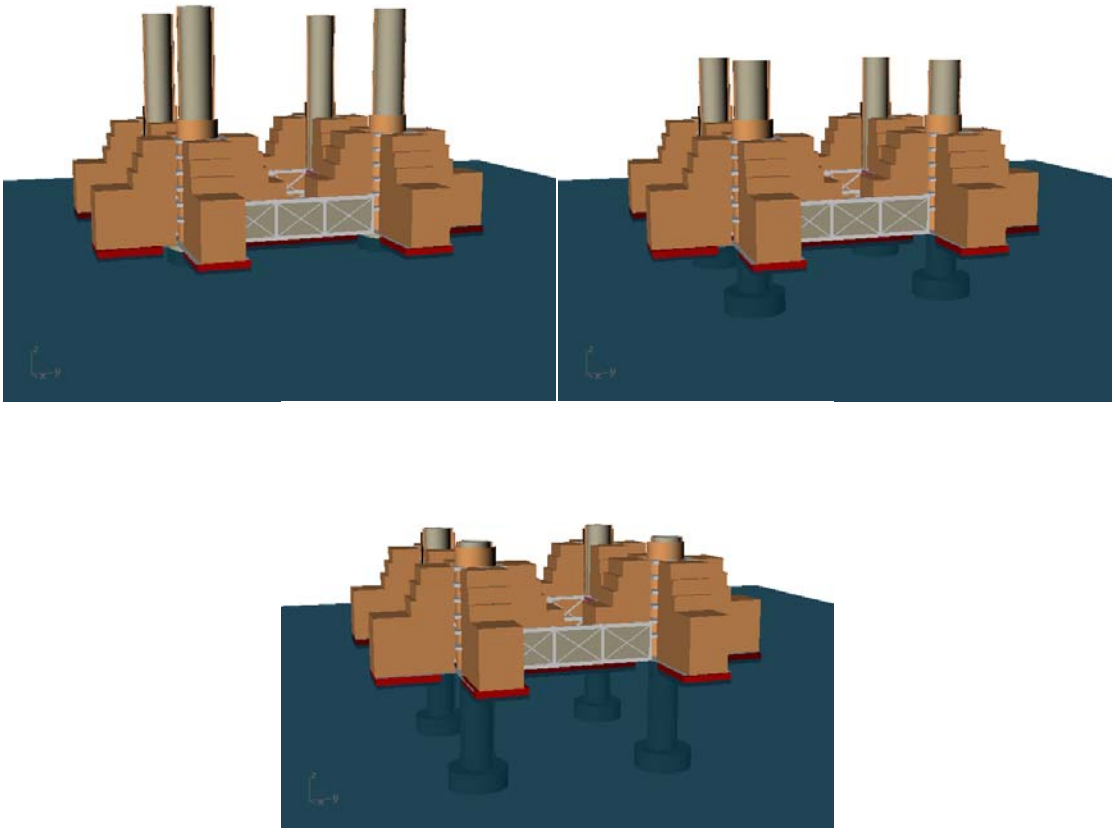


Figure 12: Column Ballasting

4.5. Stay - Cable layout

Cables are used to support the cantilevered buildings at the extremities of the platform. Without the cables, these buildings would not be able to support their own weight once the deck is lifted above water level.

The cables are anchored on the deck with special stay cable anchorage systems. An example of such an anchorage on a bridge is shown in Figure 13[1]. Lay-out methods used on stayed cable bridges may be adapted to install the cables on the ClubStead.

[1] Source: http://groveoz.info

Figure 13: Cable connection

The cables are then drawn upward to the tower. Attachment points have been prepared on the tower. The stay cables may be anchored to the tower in various ways. All cables may be attached at the top of the tower. Alternatively, in the figure below, a special external beam is used to attach the cables; the beam is sufficiently supported at the attachment points to transfer the tension loads to the tower.

A pre-tension is applied on the stay cables using special equipment such as stressing hydraulic jacks. They can be found in various sizes depending on the number of strands to stress and the pre-tension to apply. Light-weight hydraulic jack for single strand stressing can also be considered.

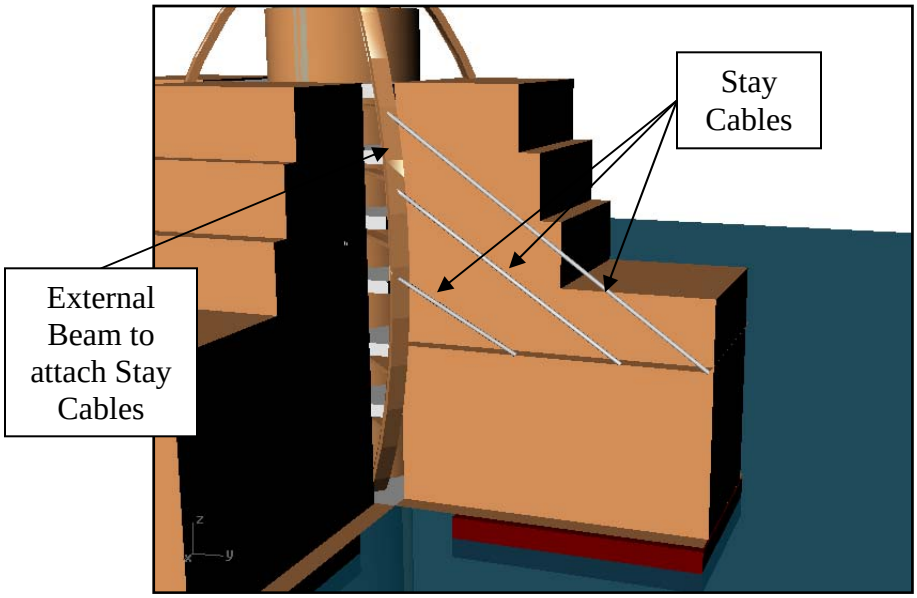


Figure 14: Cable Stay Installation and Tensioning

The last open surfaces are brought on a barge equipped with cranes or lifting equipment. The light weight areas are then lifted to the deck level from the barge. The surfaces are connected to the deck while still supported by the barge.

Stay cables are anchored on the surfaces and tensioned as previously described. Once the stay cables are sufficiently tensioned, they support the weight of the open surfaces; the barge can withdraw.

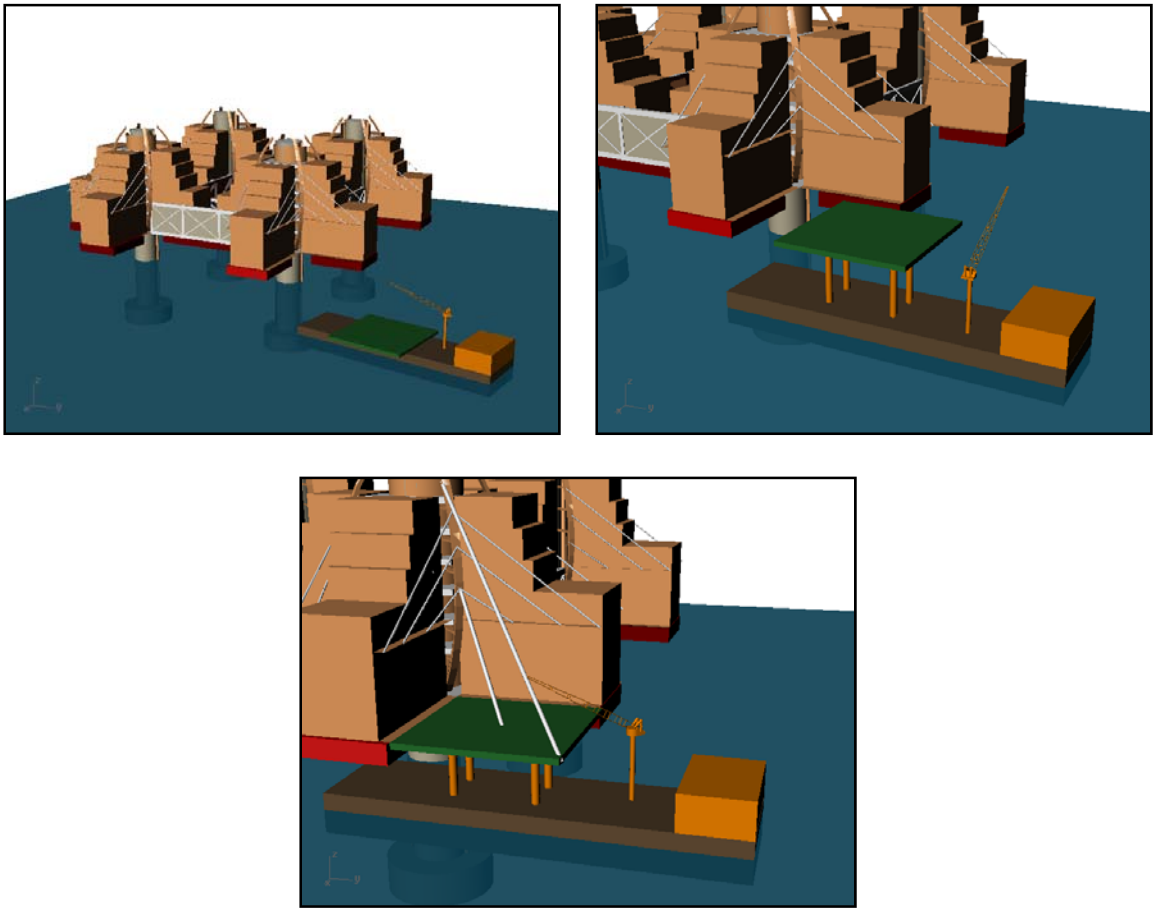


Figure 15: Installation of light-weight surfaces

Once the cables are installed on all the cantilevered extremities of the deck, the columns are slowly de-ballasted by pumping water out, until the ClubStead reaches its operational draft.

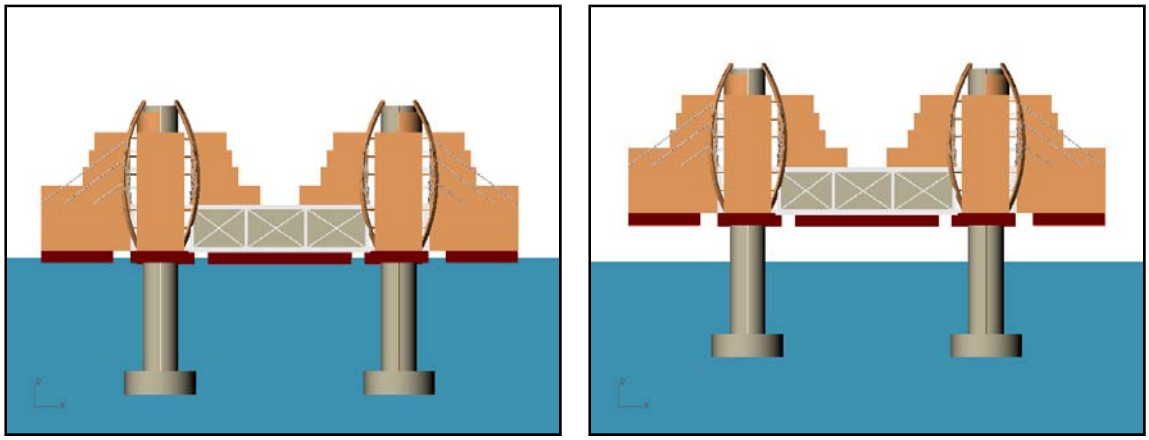


Figure 16: Column De-Ballasting

As the deck modules lose their buoyancy, the cables are tensioned by the weight of the buildings they support to their design target tension.