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MODEL TEST UTILIZATION FOR THE DEVELOPMENT OF THE FIRST FULL SCALE RISER SUPPORT BUOY (BSR)

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Abstract. *The first sub-surface buoy for riser support (BSR) will very likely be installed at offshore Brazil. The intention of this device is to support and connect the steel catenary risers that comes from the sea bottom and the flexible jumpers that goes to the floating platform. The BSR is hold in place below the sea level (to be free from the wave excitation) by a set of tethers connected to the sea bottom. Conceptually speaking the idea may be not new, however, it has been never been installed before what stress the importance of this pioneer installation. This paper presents the methodology that has been used for the design and the installation design of the BSR. Particularly, the paper describes the model test installation procedure. Numerical simulations were used to set model test parameters like tensions, displacement grid and accelerations. Some occurrences verified during the model test installation were used to update the prototype design.The work describes the BSR and their main accessories, the experimental environment and the two models in different scales (1:12 and 1:32) that have been used.*

Keywords*: Model test, Subsea installation, Subsea hybrid systems.*

1. Introduction

The offshore oil exploration has been working with continuously increasing water depths. In Campos Basin, Brazil, water depths of nearly 3000 meters are already being considered, and following this scenario, new procedures and new equipment are being needed. Furthermore, present strategies of installation of subsea structures have to be adapted to the new conditions. The engineering problem brings out the need of model testing to estimate the behavior of such structures, requiring some features from ocean basins as new instrumentation, non-conventional tests setups and non-conventional tests procedures

Some examples of such model tests were conducted at LabOceano, Brazil. These tests were carried out for supplying the industry demand on the analysis of various aspects that would be insecure to preview numerically or analytically for the analyzed structures, since the physics have never been formulated and applied before. Some tests considered novel here had been carried out in a joint work between University and Petrobras, the Brazilian oil company. This includes model test simulation of the installation procedure launching of submerged buoys (the BSR or *Bóia de Suporte de Risers* – Support Riser Buoy) and model test simulation of risers installation in the BSR.

This paper will present a description of the BSR and their main accessories, the experimental environment and the two models that have been used. The methodology have been combined a mix of experimental and numerical approach. The numerical approach was used to estimate model test parameters.

2. BSR description

The new concept of submerged buoy, the BSR (Bóia de Suporte de Risers – Support Risers Buoy) (see illustration in Figure 1) could be considered a hybrid system that combines free hanging steel catenary risers - SCRs with flexible jumpers. Both are connected to a subsurface tensioned legged buoy which is intended to serve as the risers support.

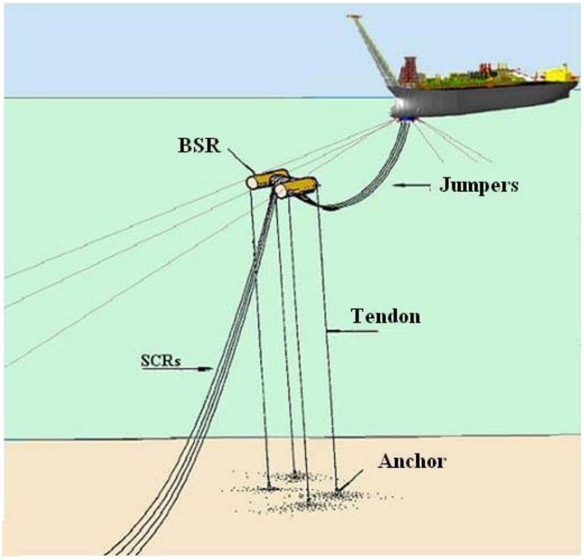

Figure 1. Schematic illustration of a hybrid system with BSR. (Almeida, 2000).

The first BSR prototype developed by PETROBRAS is showed in Figure 2. Their mainly properties are presented at Table 1.

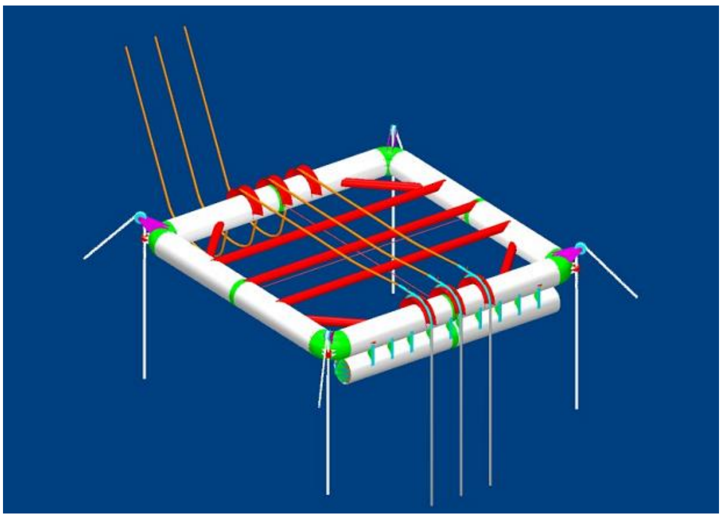

Figure 2. Riser support buoy by PETROBRAS.

Table 1. BSR properties.

Dimensions	27.2 x 27.2 m
Diameter of each cilinder	2.4 m
Weight in air (without ballast)	267.684 ton
Net buoyance	616.068 ton
No. of ballast tank	30
Operational depth	500 m (installed at 100 m)
No. of risers	02
Localization	Barracuda

The next items will present the BSR accessories.

2.1. Chain stopper and chain sheave

Chain stopper and chain sheave (see Figure 3) constitute a passive system used to adjust the tethers. The chain stopper have a flap that restrict the chain in one sense. Then during BSR installation, chain stopper allow BSR to displace only in vertical direction. The chain sheave is a pulley with free rotation to support the installation chain.

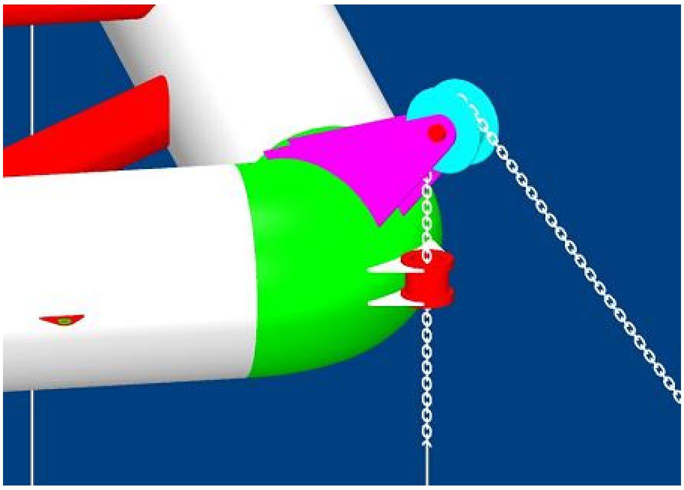

Figure 3. Chain stopper and chain sheave schematic representation.

2.2. Ballast system

The BSR has a ballast system that is used to compound the BSR weight during the installation. Through the model tests at LabOceano it was possible to detect some problems at the first ballast system configuration. The problems were corrected and the improvements implemented at the prototype to be installed at the sea.

2.3. Tethers

The BSR has a set of four tethers, anchored at the soil by an anchor. Tethers are used to assist the BSR installation and once the BSR is installed, they are used like tension leg mooring lines, see Figure 4. Chain and wire rope compounds the tethers. In this text the length of tethers used during the installation are called installation chains.

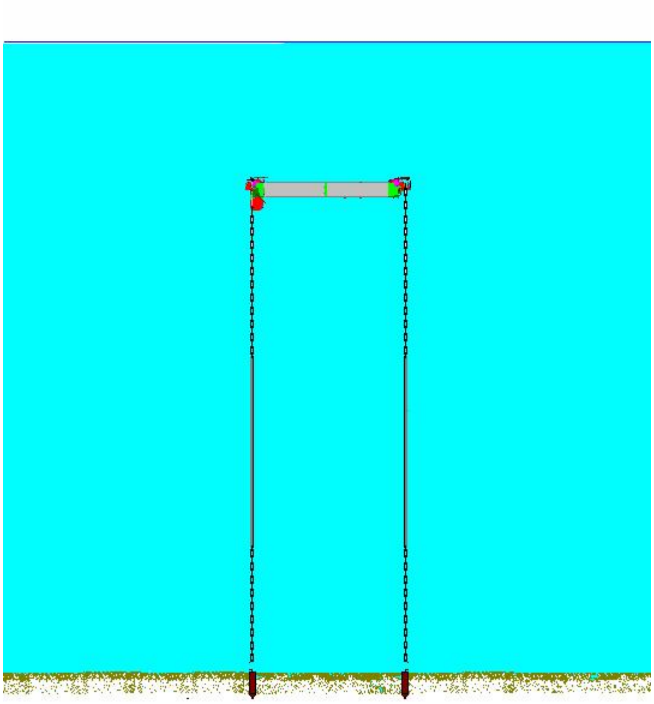

Figure 4. Schematic representation of the BSR installed.

3. Model test

The BSR was experimentally simulated on small scale (1:12 and 1:32). The model tests yielded support the definition of various aspects of a prototype that was constructed by PETROBRAS. The main aspects are:

- Arrangement of the structural and support elements such as the bracings and the risers support.
- Arrangement and conceptual design of the ballast system, which would control the buoyancy of the structure in critical parts of the installation operation.
- The installation procedures of the prototype would be defined based on the model tests results.

A general view of the model being tested at the LabOceano can be seen on Figure 5. A systematic set of qualitative. and quantitative experiments has been pursued for the definition of optimal procedure regarding safety and economic aspects.

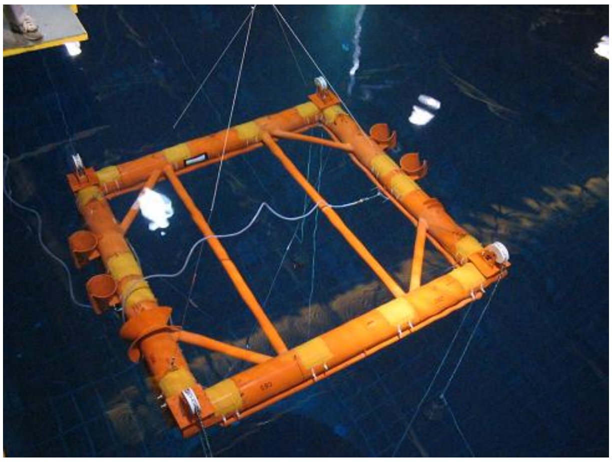

Figure 5. Installation of the model (in scale 1:12) at LabOceano.

The apparatus for the model test at LabOceano is showed on Figure 6. A base was fixed at 21 m water depth. The set of 4 tethers were fixed in it. The following situations were verified at the model tests:

- BSR installation without waves and currents.
- BSR installation with a constant current profile of 1 m/s.
- BSR installation on waves of 2 m height (real scale) and 8 s of period.

- BSR installation with waves and currents.

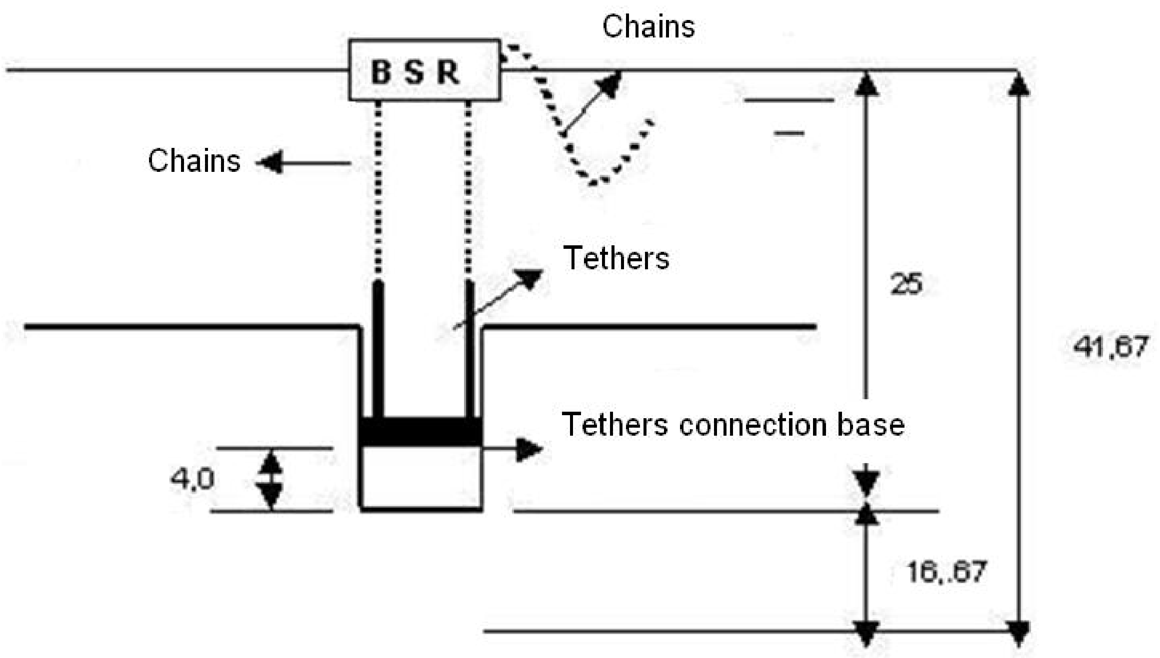

Figure 6. Model test apparatus.

Underwater video cameras, load cells and accelerometers compounds the underwater instrumentation. Due the problems verified to stabilize the buoy, load cells were damaged. The tests were assisted by an ROV and divers.

4. Results

The BSR was experimentally simulated suing small scale models (1:12 and 1:32). When facing a novel problem like the present one, the authors have the strong opinion that it is essential to face the model testing together with numerical simulations. Hence, before the ocean basin experiments a static and dynamic numerical simulations has been performed. This defined the main parameters that should be observed, like the installation weights characteristics, the exact moment to release them, the sequence for ballasting the tanks and the moment to release the chains. Comparisons between experimental and numerical results need to be done in the future.

Figure 7 shows the center of gravity trajectory along the depth. The BSR model is released from 0.5 m below the water surface and it is going down up to 8.0 m. The deviation is considered small assuring the feasibility of the BSR installation procedure.

Figure 8 shows tethers tension numerical results (at a point located at 5 m from the base). The left curve in Figure 7 shows snapshots tensions in the tethers located at the stern and the right curve shows tensions at the BSR bow. The results reflect an inclination of 1 degree towards the stern.

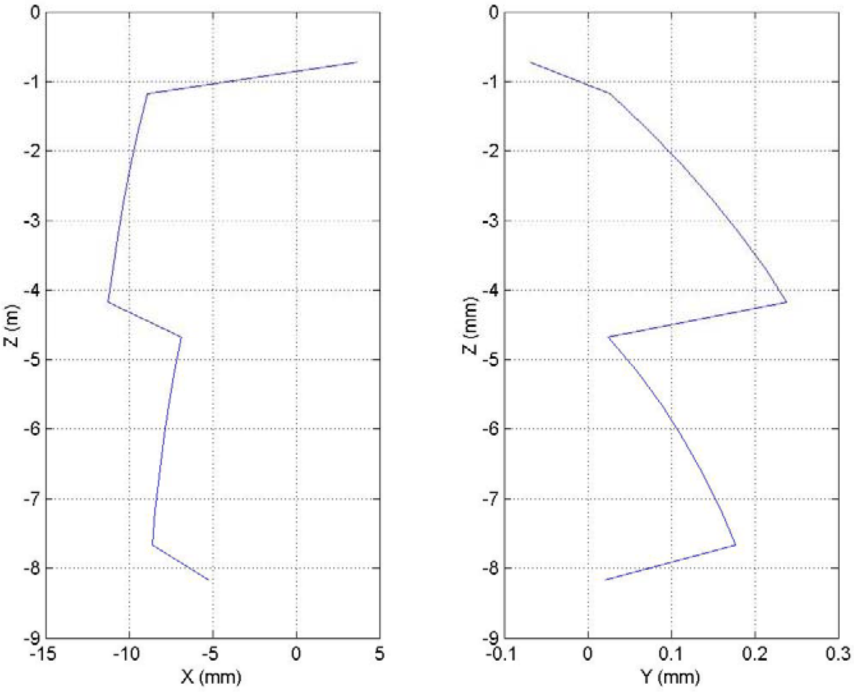

Figure 7. BSR center of gravity trajectory.

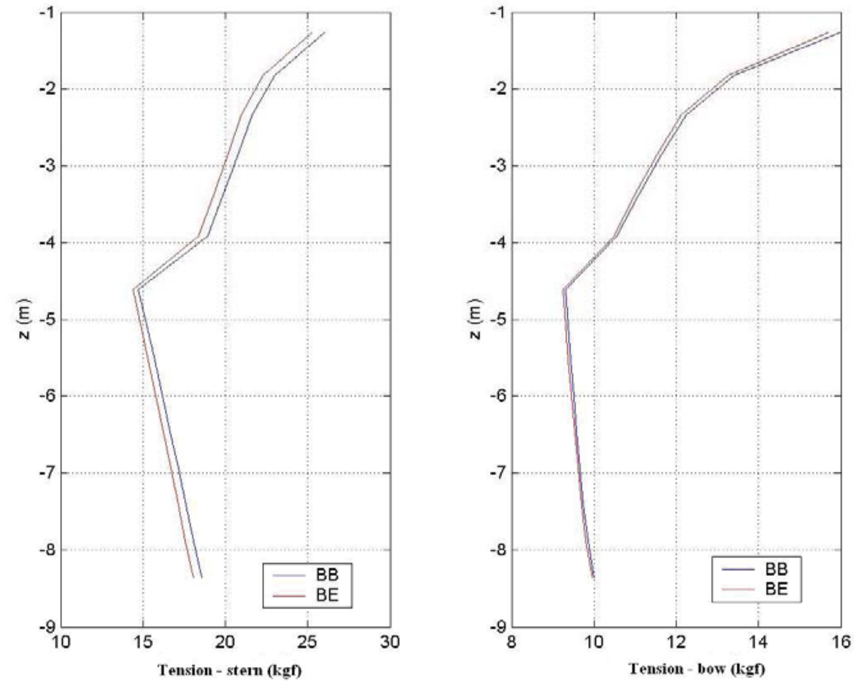

Figure 8. Tension in the tethers.

Besides these quantitative results it is important to list the mains practical results that both changed the design and improved the installation process:

- Definition of new compartmentalization.
- Re-desing of the weights.
- Sequence of chain launch.
- Ballast sequence.

5. Conclusions

A new kind of demand has appeared for the deep water offshore market. This demand was for novel types of model tests like BSR, which required new capabilities and different treatment by the engineers and researchers.

The BSR model test has been resulted in a practical methodology to install the buoy, showing the viability of this new concept. The 1:12 BSR model scale has been contributed to clearly show some difficulties that will be verified during the prototype installation at Campos basin.

6. Acknowledgements

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8. Responsibility notice

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