MECE 6320 – SUBSEA RISER DESIGN

SIZING OF RISER COMPONENTS

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SUBSEA RISER DESIGN

INTRODUCTION:

Risers are a part of the subsea production system which are used to connect the vessel to the subsea well. Riser allow fluids and/or tools to be conducted between the floating vessel and subsea equipment.

Since those early days, risers have been used for four main purposes:

- Drilling
- Completion/ work over
- Production/injection
- Export

In this project, we design a production riser and its components.
Subsea riser components are sized based on input conditions chosen from a set of given conditions.
Using the drift chosen, the internal diameter of the pipe is calculated.

The thickness is calculated by considering the pressure containment case, where in the minimum thickness is calculated for operation under design pressure and the test pressure.

The thickness chosen is the maximum among the thicknesses in design and test conditions.

The input conditions chosen for this project are as follows:

Drift: 10.65”

Riser Style: Welded connectors

NACE Level: NACE

Design Pressure: 10000 psi

Water Depth: 8000 feet

Internal fluid density: 12 lb. /gal

Vessel Offset: 125 feet

Tensioner Type: 6 cylinder

Current Load: 2.7 m/s

Wave loading: 20 ft. wave height / 13 sec wave period

Fatigue Curve: $N= 10^{11.610}*(\Delta\sigma)^{-3}$

1) ***Pipe sizing calculations:*** Calculation worksheet is provided at the end of the report.

Buoyancy: Weight of the displaced water is the buoyancy that is acting on the pipe that is submerged.

Hanging weight of the riser: It is defined as the dry weight of the riser pipe- the buoyancy of the pipe.

Hanging weight =Dry weight of the riser+ dry weight of the fluid- buoyancy of the entire system.

The hanging weight is important to find the tension with which one needs to pull the riser for it to be stable and not collapse under its own weight.

Over pull= Top tension- Hanging weight.

Top tension= Hanging weight top tension factor.*

2) ***Hanging weight calculations***: Calculation worksheet is provided at the end of the report.

Wave forces consists of

- Drag forces (relative motion between cylinder and water)
- Fluid dynamic forces (fluid acceleration)
- Cylinder dynamics forces (cylinder acceleration)

Although the largest horizontal force on the cylinder occurs at the peak of the wave, the largest lateral offset of the riser occurs at a 90 degree phase lag.

F= fluid dynamic force- pipe dynamic force+ drag force.

3) ***Wave and current loading:*** Calculation worksheet is provided at the end of the report.

Since the stroke of the cylinder for this project is less than 25ft, the upstroke and down stroke is taken as 25ft for simulation in Deep riser.

SIMULATION OF THE PRODUCTION RISER USING DEEPRISER

DeepRiser is an integrated engineering application used extensively across the drilling industry. It has been developed specifically to optimize and streamline the design and analysis of drilling risers and top-tensioned production riser systems.

It combines an intuitive GUI (Graphical User Interface), with powerful analytical capabilities, to provide a comprehensive engineering tool for the design and analysis of drilling and top tensioned production riser systems.

DeepRiser was used for the simulation of the components of the production riser and the efficiency and sustainability of the riser is tested. The input conditions provided above are used for the simulation.

The stack up of the riser components in DeepRiser that was used for the simulation is as follows:

Well head

Tapered stress joint

Riser joints (Multiple)

Pup join (Pup joint is a short drill pipe that permit space out of the upper equipment.)

Tension Joint

Surface tree.

The Von-misses stress acting along the length of the riser is shown in the plot obtained from the simulation:

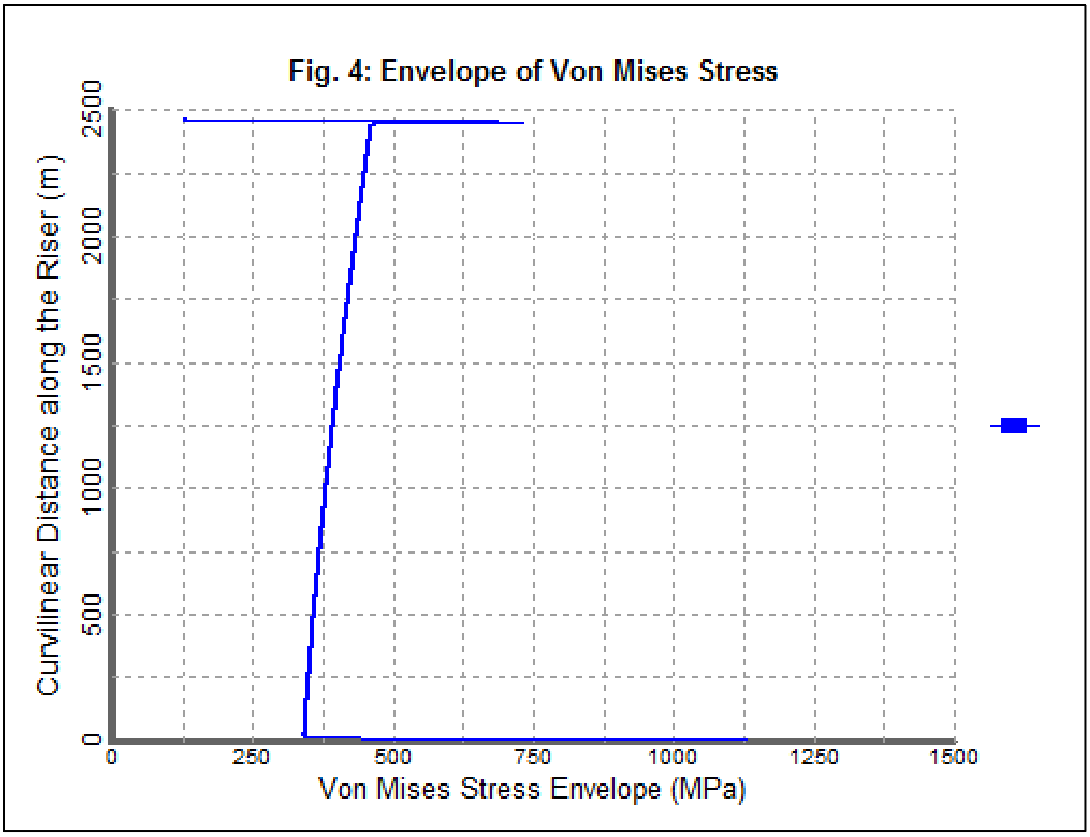

Figure: 1

The above plot indicates that the tension joint and the tapered stress joint are under stresses that are greater than 80% of the yield stress, which is not desirable in real life scenarios.

A riser whose von misses stresses are distributed as shown above cannot be considered ready for installation and effort needs to be taken to optimize the design.

The effective tension along the length of the pipe is shown in the plot below:

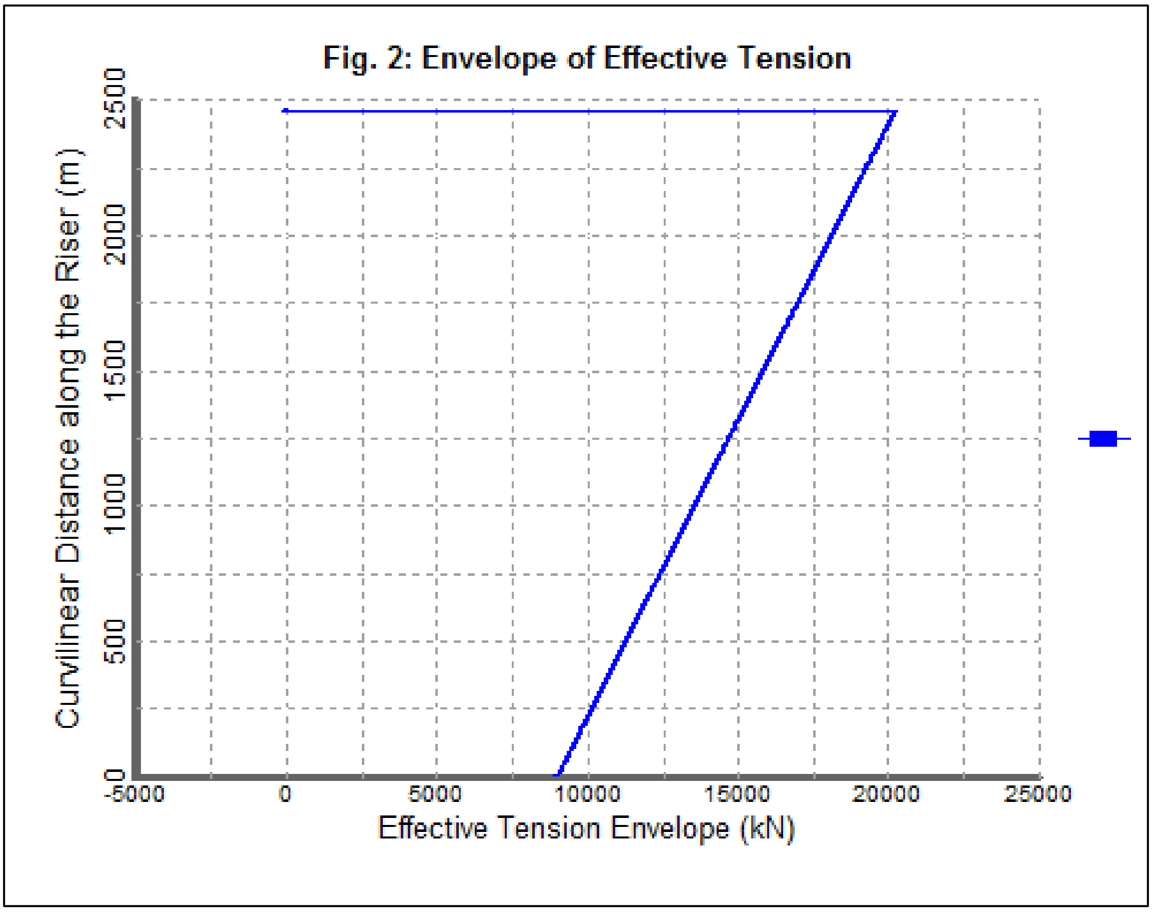

Figure: 2

The above plot shoes the maximum effective tension in the riser and how the tension changes as the elevation increases. This shows that the maximum tension is required at zero elevation and as we ascend the hanging weight of the riser compensates the tension required to pull the riser.

RISER IN THE DYNAMIC VIEWER IN DEEPRISER

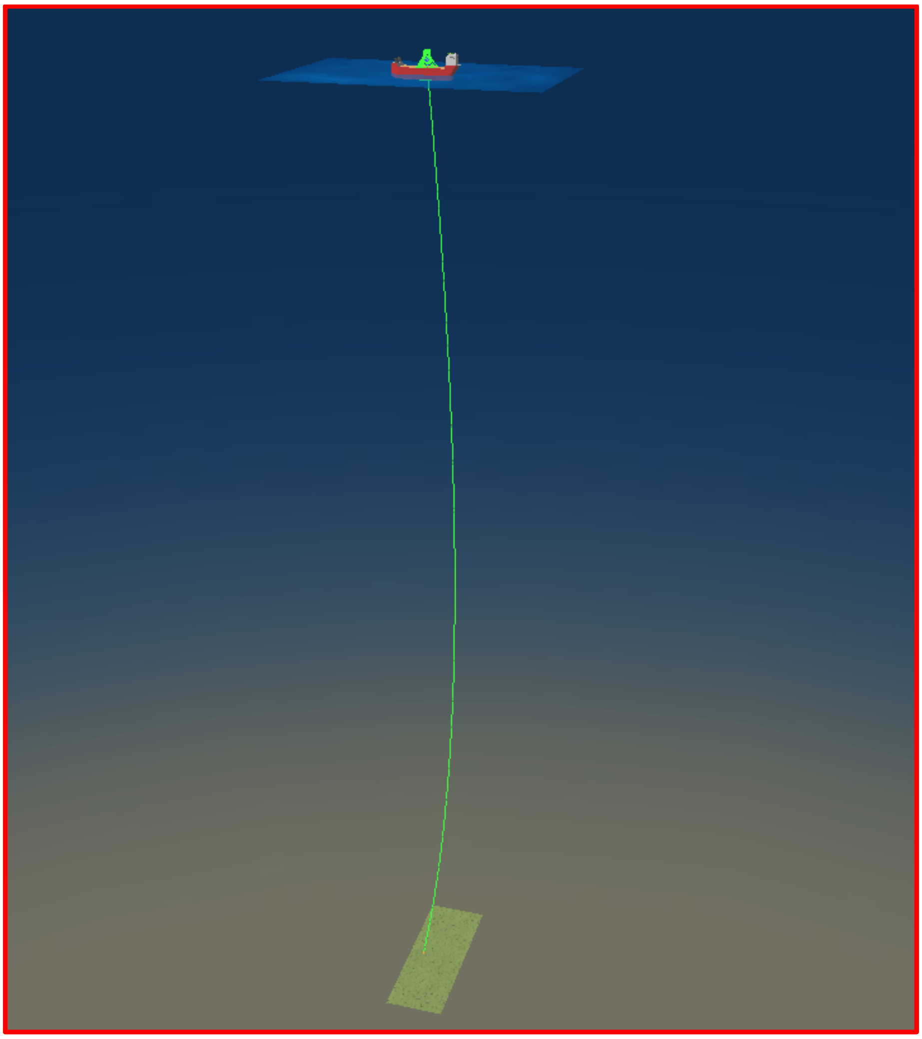

Figure: 3

The above image shows all the riser components together and gives the view of the production riser, under the chosen environmental conditions, at an instance of time.

There is significant bending in the pipe due to the heavy weight and the high current speed chosen.

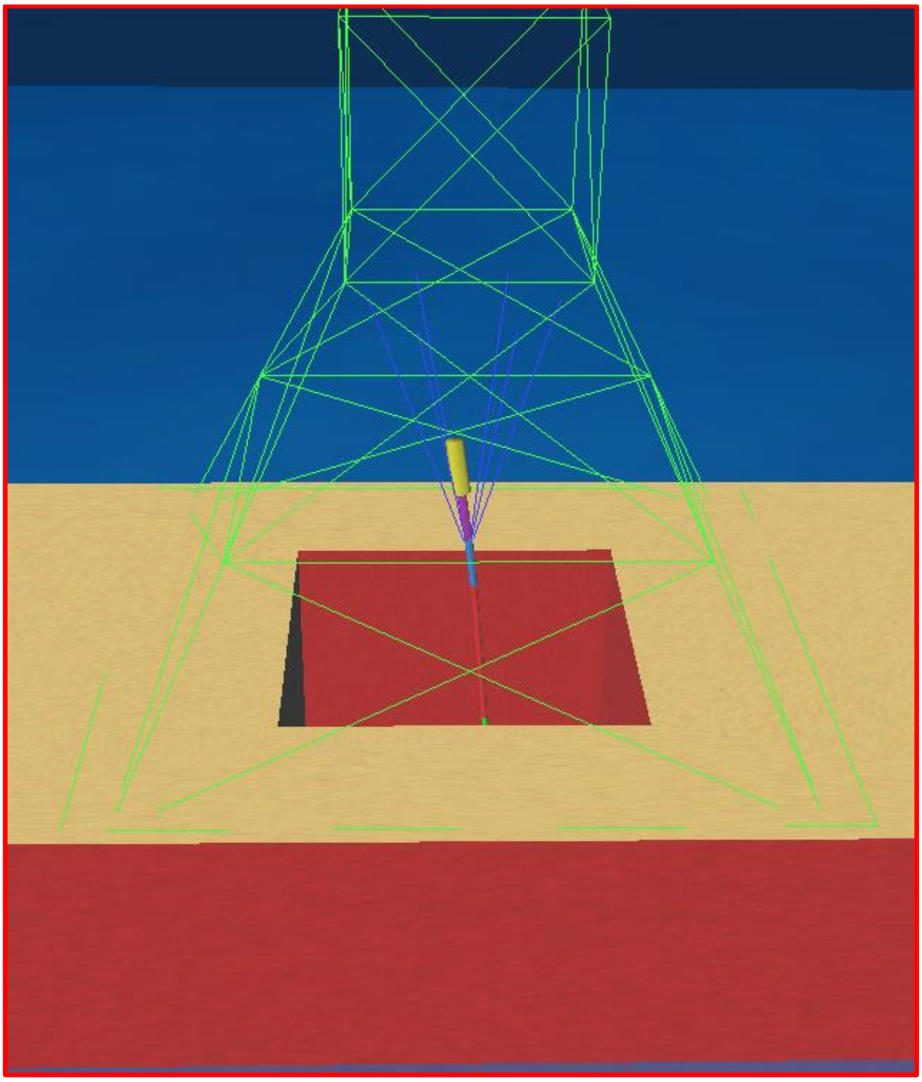

Figure: 4

The above image shows the top most region of the riser which would contain the spool and the tension joint. There are heavy loads on this part of the riser and pulling with a higher tension will straighten the pipe but will increase the effective stress on the riser.

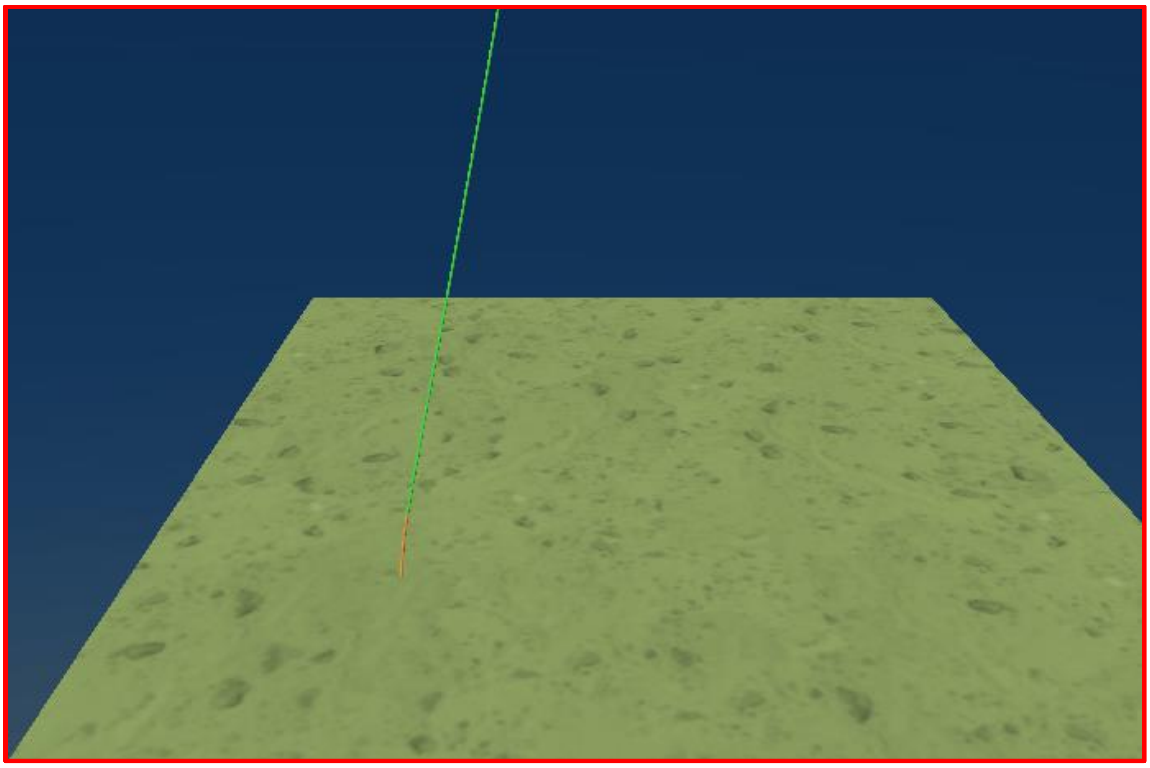

Figure: 5

The above image shows the bottom of the riser, which also is subjected to high amounts of loads. The tapered stress joint is under high amount of stresses in this region and the design of the tapered stress joint needs to be optimum for the riser to withstand the loads at the bottom. The tension with which the riser is pulled needs to be increased for this joint to straighten, but as mentioned, this leads to excessive loading at the top of the riser, which is not ideal.

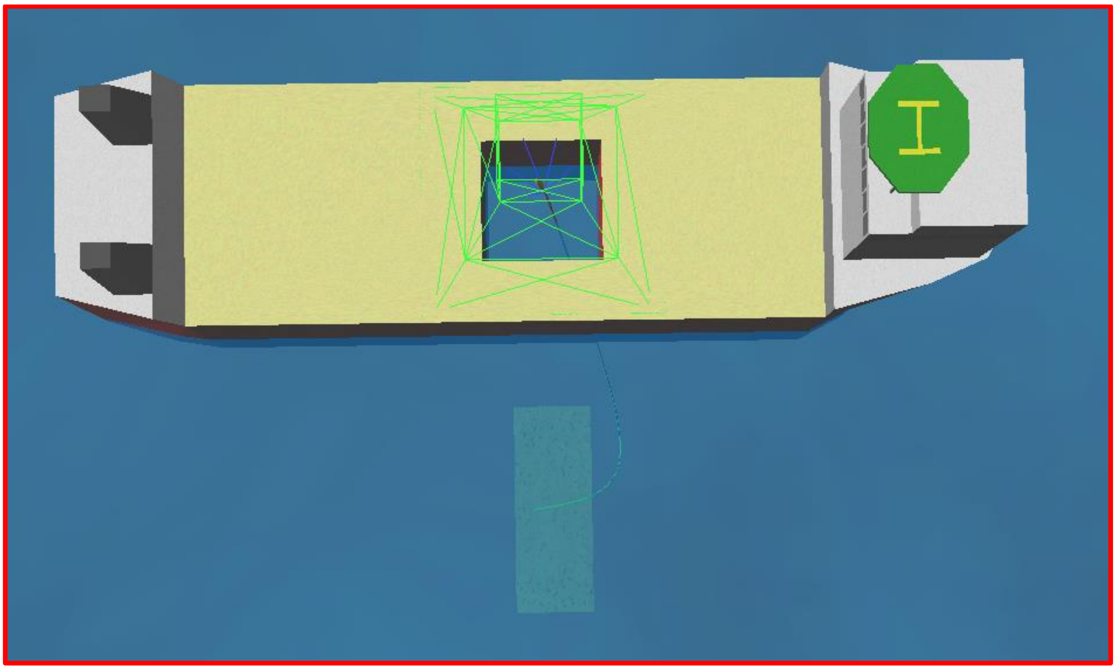

Figure: 6

This figure shows the amount of sag bend in the riser, due to the current speed and also due to the heavy weight of the riser. This image also shows that a 6-cylinder tensioner is used in this project.

CONCLUSIONS:

The water depth is 8000ft deep with a pressure containment thickness of 2.02 inches. The internal diameter of the riser is 10.815 inches which is determined by the drift that has been chosen. The current velocity chosen is 2.7 m/s, which is also on the higher side and results in the sagging of the pipe. It has been derived that the wave and current loading on this riser are very high which provides significant challenges for a safe design.

This riser, under the chosen environmental conditions, is most likely to experience stresses greater than the yield strength, which may lead to the failure of the riser.

The reasons for failure can be attributed to the environmental conditions or the inability of the material used to withstand such conditions or both. Due to the large bore size and the water depth the weight of the riser pipe is very high and very high tension is required for a riser with such dimensions.

RECOMMENDATIONS FOR AN OPTIMIZED DESIGN.

- In this project the environmental conditions are chosen, hence there is a choice of choosing favourable conditions, but if a designer is faced with such conditions in real life then the design must be optimized for those conditions.
- This can be done by increasing the outer diameter of the pipe and by keeping the inner diameter same as obtained due to the drift requirement. This would increase the thickness of the riser, leading to a condition where the thickness will be more than that is required for pressure containment.
- As the customer, in a real life scenario would not be willing to increase the thickness which would lead to increase in the cost of riser, it is the designer's responsibility prerogative that he convinces the customer to increase the thickness as this is essential for a failsafe design.
- The other alternative for an optimised design would be to use a material of higher yield strength at very critical points in the riser like the stress joint. This will ensure that the loads are better distributed among different components in the riser.
- Since a riser has not been designed in such harsh conditions, ensuring a design that is durable and efficient, is a great challenge. Finding a solution to this problem requires a continued effort over a period of time. The optimised solution could not be reached during this project due to constraints of time and resources, but with continued effort, an engineering solution is possible for this problem.