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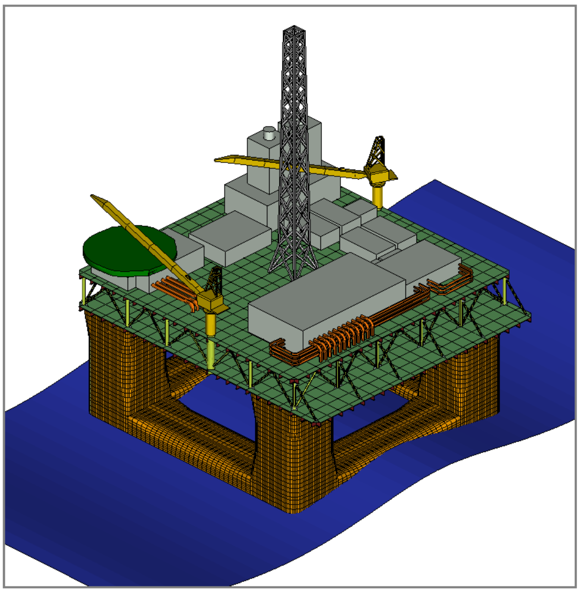
Semi-Submersible Offshore Platform Simulation Using ANSA & μETA

Offshore platforms are large structures designed to withstand extreme weather conditions and have a lifespan of at least 40 years. Million dollars have to be invested for research, materials and equipment for their construction. Any mistake in design or in system operations could lead to dramatic results with effects not only on the platform but on the environment and the personnel as well. Computational analysis and simulations of several load-cases with FE models is a powerful tool for engineers in the offshore industry to help in reducing such risks.

SUMMARY

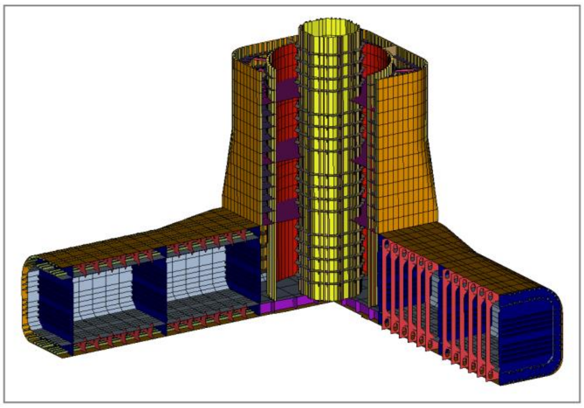


A complete model of a Semi-Submersible offshore platform, also called “SEMI”, was created in ANSA with the help of the related Topology functions. The transformation tool was also used to take advantage of the symmetrical hull of the platform on X and Y axis to speed up the whole process. The whole model consists of shell elements with a variable element length according to the area of interest thus creating a rather fine meshing for a global model analysis. The model is also structurally prepared for further simplification by replacing the longitudinal stiffeners with beam elements.

Once the geometrical model is finished, it is ready to be set up for any specific load-case. As a first analysis, still water loading conditions were applied for a static solution in NASTRAN (sol 101), both for shipping loading and for fully loaded platform. Furthermore, the Semi platform is analyzed in hogging condition with the effect of a 10 meter (height and length) wave -identical to the platforms length- to study the worst case scenario. Accordingly to the loadcase, masses were distributed all over the hull, the deck and the tanks of the platform to simulate the equipment payload, and the ballast production and storage tanks weight. Mooring and riser tensioners forces were applied to the specified hull and deck points. Gravity acceleration was also applied. Finally, buoyancy was applied as hydrostatic pressure in the elements bellow waterline, varying linearly with water depth.

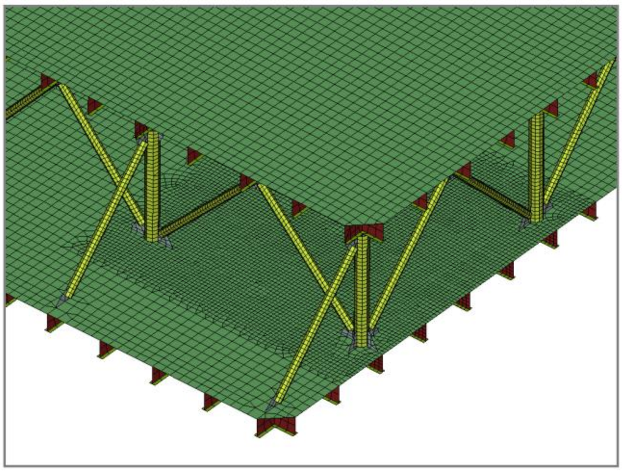
In a static simulation, like this mentioned above, the platform is in a state of equilibrium between its own weight, the auxiliary payload, and the resultant buoyancy. However in order to ideally simulate the equilibrium state the method of inertia relief was used to set the corresponding parameter in NASTRAN. Finally, the results were analyzed with the help of μETA post processor.

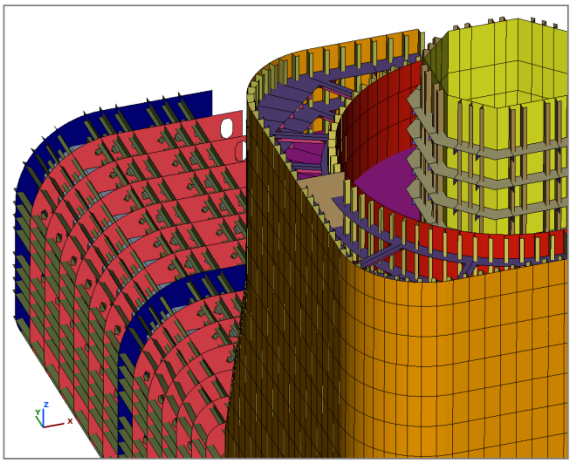
SEMI GEOMETRY & WEIGHT DISTRIBUTION



Some characteristic geometrical data of the model as well as weight distribution data are presented in the table below.

Hull dimensions (m)	72x72x33
Column dimensions (m)	15x15
Total height (m)	43.2
Draft (m)	5.7 ~ 23.4
Lightweight Tonnage	8400
Deadweight Tonnage	42200
Type of platform	Semi-Submersible



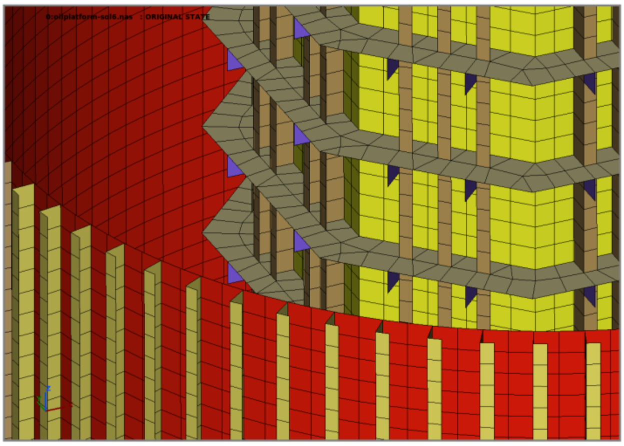


The weight distribution will be more analytically presented in the LOADCASE section.

MESH

The element length varies from 250mm for the hull to 600mm for the deck. Some data regarding meshing and FE model are presented below.

Element length (m)	0.25 to 0.6
Total number of shells	1495932
Total quads	1434839
Total trias	61093
Quality Criteria	
Skewness (NASTRAN)	30
Aspect ratio (NASTRAN)	5



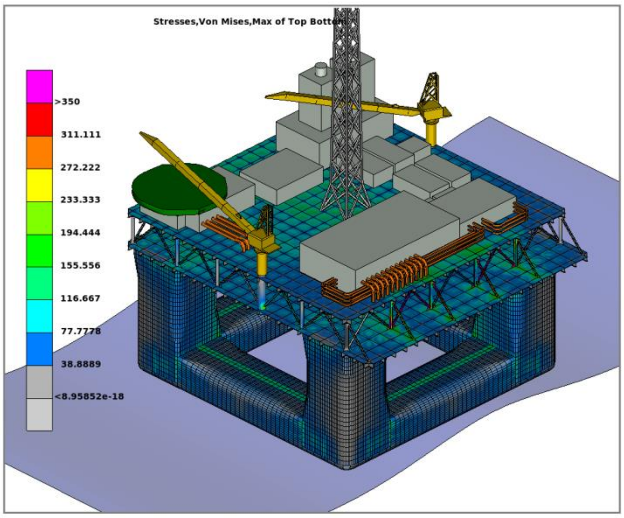
LOADCASES

LOADCASE 1

Net weight of the structure is considered to be 8400 tonnes. This is:

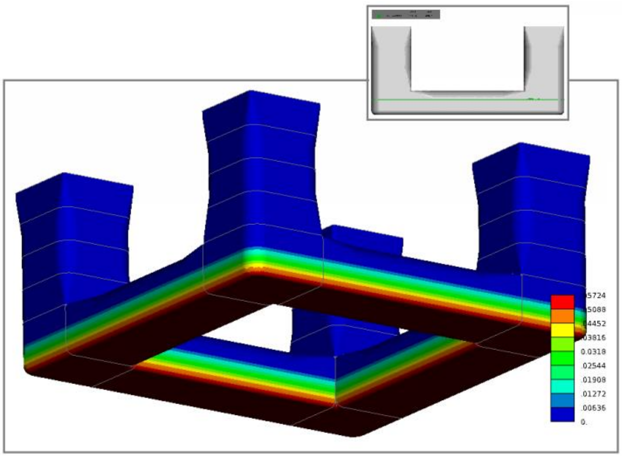
- 6000 tonnes for the hull and
- 2400 tonnes for the deck.

In the first loadcase the platform is considered to be at shipping loading, meaning that storage and ballast tanks are empty in order to achieve minimum draft. As a consequence, masses were distributed all over the deck area to simulate the topsides payload (facilities, equipment). In order to distribute the masses in an effective way the deck is separated in nine smaller partitions and the distribution is done with ANSA special tool “MassBalance” so as the center of gravity of the whole platform coincides with the geometrical center of the hull on X and Y axis. Totally 10800 tonnes were distributed on the deck area.

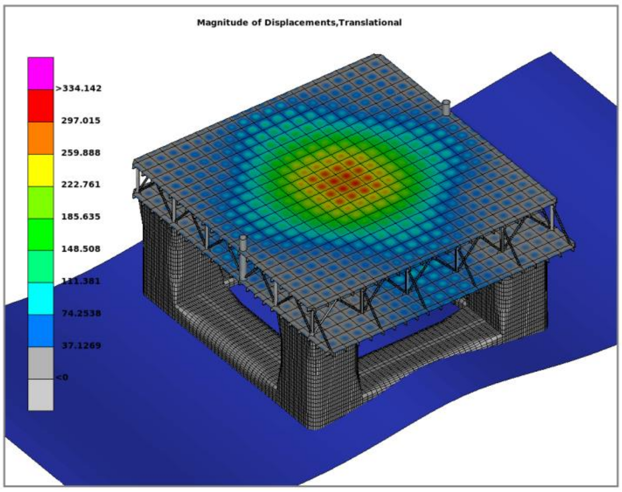


Considering the total weight of the platform at that state to be about 19200 tonnes and using a simplified model to describe only the outer surface of the hull, it is possible to find the waterline using ANSA Tank Tool by calculating the volume that the platform occupies underwater. The sea level is estimated to be 5.7 m above Hull base.

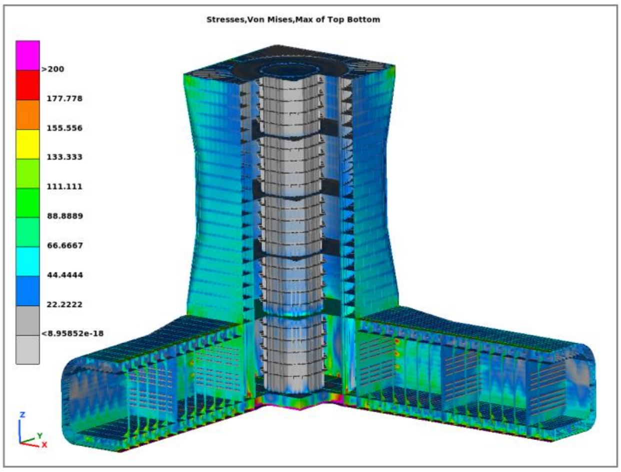
After waterline calculation, buoyancy pressure is applied to every element below that level, varying according to water depth. The results can be visualized through an element pressure graph. The resultant buoyancy force at this stage is calculated at about $19.26*10^7$ N.



Also, gravity acceleration is applied to the whole model. By setting the inertia relief parameter in NASTRAN to -2 there is no need of SPC use in the model and the platform remains unrestrained. NASTRAN will counteract any remaining resultant force or moment by applying inertial forces induced by an acceleration field. In this way, it is possible to have a static solution.



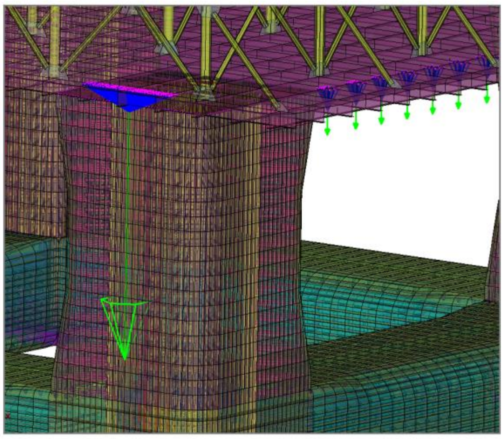
Strains, stresses and displacements are examined then in μETA. Critical areas with high stress values can be identified and further analysis can be done for every case. Some results are presented below.



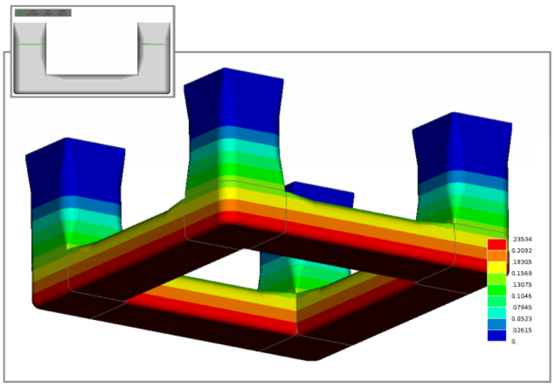
LOADCASE 2

In this loadcase the “Semi” platform is considered fully loaded. Taking the previous model (loadcase 1) as a basis, the ballast, storage and production tanks should be filled up. There are 4 tanks in each pontoon of the hull and 3 tanks in each column adding up to a total of 28 tanks. 12000 tonnes of liquid are considered to be stored and distributed as masses accordingly.

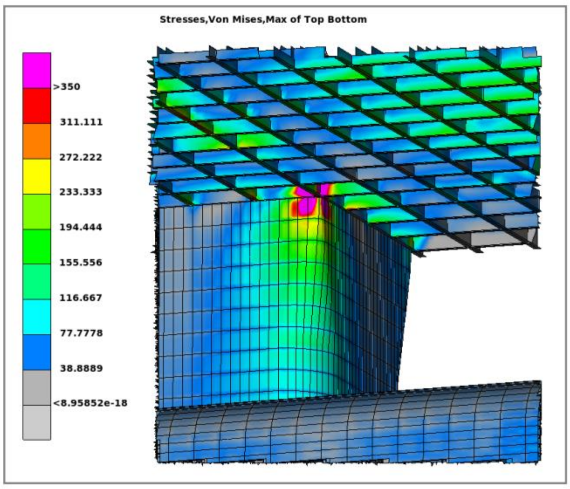
Additionally, at this loadcase mooring loading is applied at each column ($2*10^7$ N each) and riser tensioners loading is applied at deck ($3*10^7$ N total).



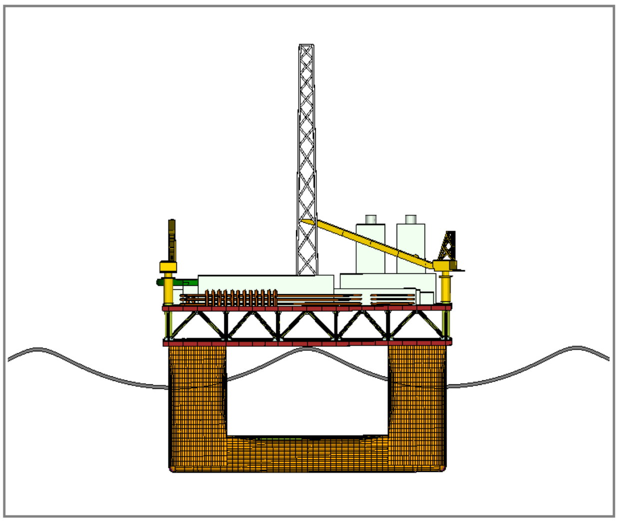
Following the same procedure as previously, the new waterline is calculated at 23.4 m above hull base. Buoyancy pressure is applied again to the new external surface below waterline. The result is a total buoyancy resultant force of $42.06*10^7$ N.



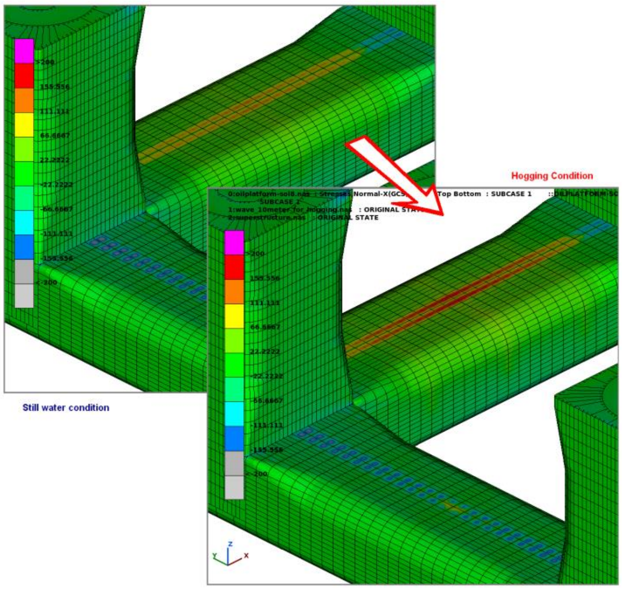
NASTRAN parameters are set in the same way to have a static solution again.



__LOADCASE 3__



In the last case, the platform is simulated at hogging condition. The whole loading of the platform is the same as loadcase 2 but this time a trochoidal, 10 m height wave with length identical to hull's length is used. In order to position the platform on the wave ANSA special tool "BalanceOnWave" is used and then buoyancy pressure is applied again to the new external surface above water.



The CPU time needed for a static solution of this model is estimated to be about 2 hours using 6 cores.

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