Ship Global Model Simulation Under Sagging Loading Conditions Using ANSA & META

Bulk carriers are subjected to IACS regulations, concerning the structural integrity of their cargo holds. In sagging and hogging loading conditions the structure of the ship is exposed to maximum values of bending moment and shear force. As a result these conditions are crucial for the determination of the minimum required scantlings, through a global model analysis. This white paper presents the FE model creation of a handymax class bulk carrier and a methodology for modeling realistic, wave induced loading conditions. The whole project has been completed inside ANSA while the FE model was solved in Nastran. ANSA and META comprise the pre- & post-processing suite of BETA CAE Systems.

SUMMARY

Ships inner structure was completely created inside ANSA as a shell model, using the corresponding topology functions. For achieving a perfectly symmetrical model the faces were created as linked. The longitudinal stiffeners were replaced by beam elements having the characteristic L cross section while the element length was chosen to be 26cm, generating a quite fine mesh for a global model analysis. Having the FE model ready, we can proceed to the analysis.

As first step, still water loading conditions were applied in order to obtain the proper weight distribution for the subsequent analysis. The ship is at rest in a state of equilibrium between its own weight and cargo payload and the resultant buoyancy. The weight is calculated in ANSA from the mesh net, the properties of the shell and material characteristics, while the payload is applied as pressure inside the holds, using cargo's density. In this case all holds were considered almost full. The buoyancy is applied as hydrostatic pressure in the elements bellow waterline and varies linearly with water depth. In order to achieve an untrimmed position in the still water loadcase, non structural mass was distributed in three parts of the ship in bow, stern and middle by a special mass balance tool of ANSA.

Having the right weight distribution, sagging loading conditions were applied. An 8m height trochoidal wave was used and the balanced position of the ship was found upon it, by iteratively adjusting the draught and trim until the resultant net force and moment of the ship was ideally zero. It must be noted that because a perfect equilibrium is not possible, some resultant forces were still present. For this reason the inertia relief option of Nastran has to be applied on the model in order to achieve a state of static equilibrium

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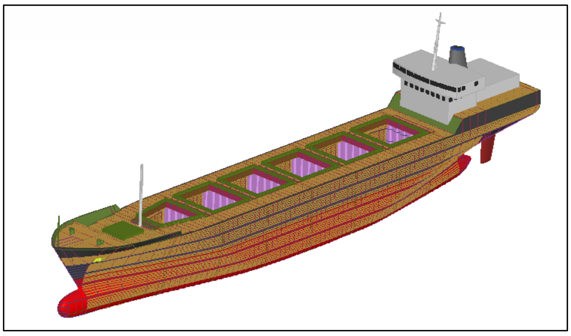
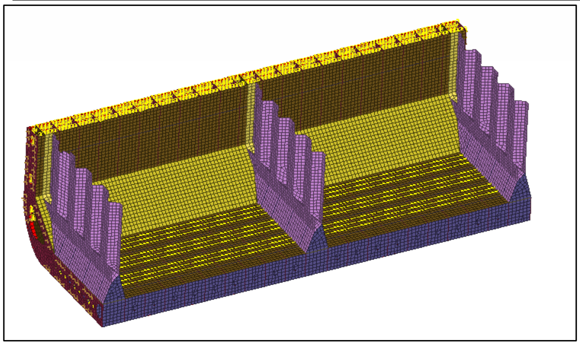
SHIP GEOMETRY

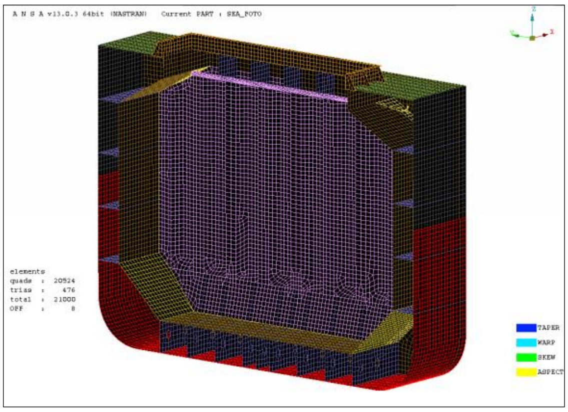


Length (m)	169
Breadth (m)	25
Depth (m)	18
Lightweight Tonnage	9500
Deadweight Tonnage	26000
Number of holds	6
Type of vessel	Handymax double-skin bulk carrier

MESH

Element length (m)	0.26
Total number of shells	595977
Total number of beams	81352
Used Quality Criteria	
Skewness (NASTRAN)	30
Aspect ratio (NASTRAN)	3





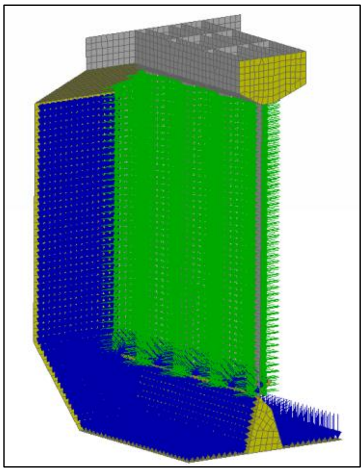
LOADCASE

The holds were considered filled with cargo at a level of 13.9m above the bottom (total height 15.2m) while the pressure of cargo's payload was computed with respect to IACS Common Structural Rules for Bulk Carries.

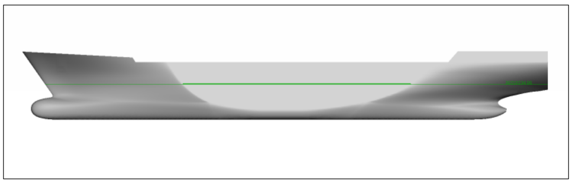
Pcs = p*g*Kc*(h – z)

Pcs	The applied pressure
z	Elements vertical distance from bottom
a	Angle between panel considered and horizontal plane
p	Cargo's density: 0.89 t/m^3
g	Acceleration of gravity: 9.81 m/sec^2
Kc	Coefficient: cos**a**^2+(1-sin(**psi**))*sin**a**^2
psi	Angle of repose: In general equal to 30 degrees
h	Cargo level: 13.9 m

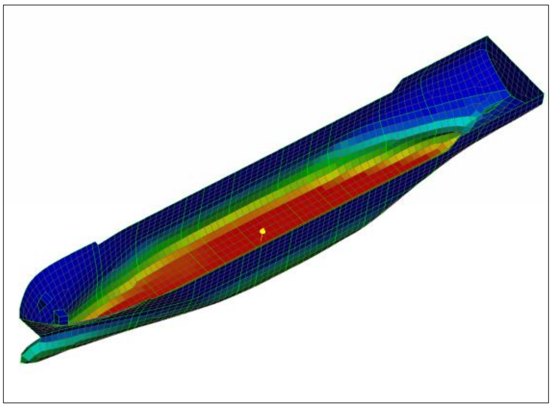
The load due to cargo was distributed as pressure, and the calculated resultant force was found to be equal to 199.5 GN or 20300 tons.



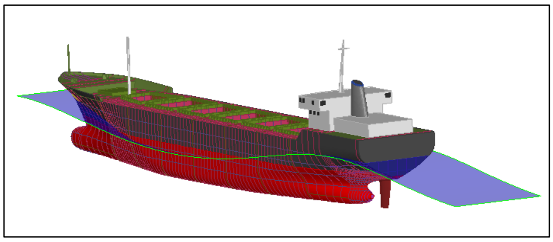
The self weight, meaning the weight of the element net, is 5487 tons. The mass of auxiliary structures that doesn't contribute to ships strength is assumed to be 4000 tons. This results to a tonnage of approximate 29800 tons. The corresponding waterline is calculated using this total weight, at a level of 11.3 meters above ships bottom, using the Tank Tool of ANSA.



The center of buoyancy is calculated and used for the proper non structural mass distribution.



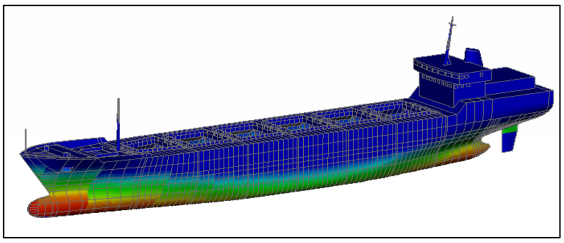
This amount of mass is distributed among three sets at the bow, stern and middle in such portion to achieve balance without having trim angle in the still water load case. This is achieved by moving the center of gravity in such a position in relation to the center of buoyancy that the resultant force produces zero moments along the ships length and width. This procedure can be performed automatically with a special tool of ANSA that adds mass to specified areas of the model in order to achieve a target total mass and a target center of gravity. This procedure results to 850 tons in front 2500 tons in the middle and 650 tons in the aft region.
Next a trochoidal wave was created having the length of the ship and height of 8 meters.



The buoyancy has been calculated from the Common Structural Rules as hydrostatic pressure:

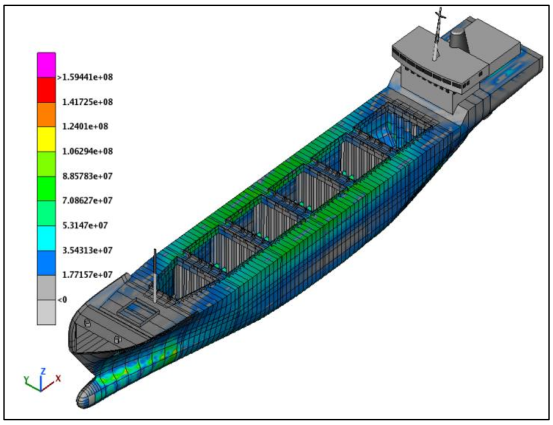
$$Ps = p*g*(Tlci - z)$$

where Tlci is the draught in the considered cross section. The balance achieved in a maximum submergence of 17 meters in the extreme end of the bow and a trim angle of 1 degree.



Despite the fact that a good balance was achieved, the resultant force and moment are not precisely zero. So in order not to have an unrestrained model that can cause problems with Nastran the Inertia Relief technique was used. In this way the resultant forces and moments are balanced by inertial forces induced by an acceleration field.

The model was solved with Nastran (solution 101). The results presented by META post processor, showed that the maximum developed Von Misses stresses in the cargo hold area (about 70 MPa) is lower than materials yield stress (Higher tensile Steel).



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