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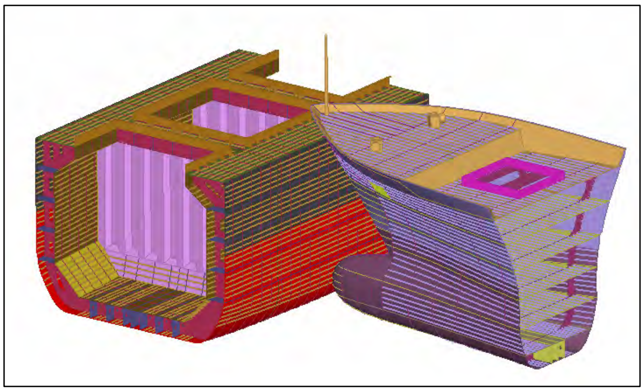
Full Scale Ship Collision Simulation Using ANSA & μETA

The continuous increase in maritime traffic makes the risk of collision greater, especially in the high traffic areas near harbors, channels and offshore structures. Since the consequences of ship collisions can be severe for the environment and the ship's crew, the behavior of a ship's structure subjected to impact loads, must be taken into consideration in the design stage of a ship. Collision mechanics are usually separated into external dynamics and internal mechanics. External dynamics deals with the rigid body global motion of the vessel and the effect of the surrounding water, while the internal mechanics is concerned with the structural failure response. This paper presents a collision scenario between two handymax class double skin bulk carriers, in which the external dynamics have been neglected in order to simplify the analysis and reduce model run times. The finite element model has been created in ANSA and solved in LS-DYNA while the results were presented in μETA post-processor. ANSA and μETA comprise the pre- & post-processing suite of BETA CAE Systems S.A. .

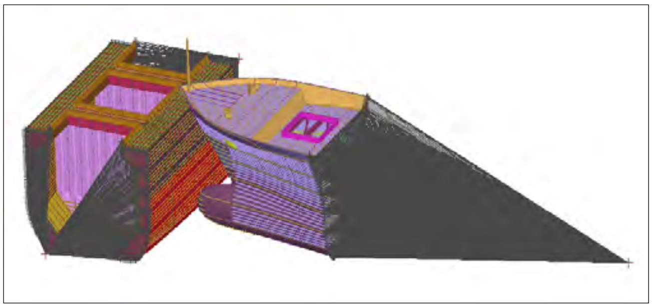
MODEL DESCRIPTION

The collision took place between two identical handymax class double skin bulk carriers with a total tonnage of approximate 27000 tonnes each. In order to observe the behavior of both the holds and the bow, both ships were modeled as deformable bodies. Collision angle was chosen to be 90 degrees and strike location at amidships. These values represent the worst case scenario. The initial velocity of the striking ship was equal to 6 knots while the struck ship was standstill. The external dynamics were neglected in this analysis, so the struck ship was restrained in all degrees of freedom while the striking ship was free to move in the XY plane that lies at the bottom of its hull.



Length (m)	169
Breadth (m)	25
Depth (m)	15
Lightweight Tonnage	9500
Deadweight Tonnage	26000
Number of holds	6
Type of vessel	Handymax double-skin bulk

For computational time reasons, the front and rear sides of the struck ship as well as the rear part of the striking ship can be replaced by nodal rigid bodies. It must be noted that the replaced mass consists of the net mass and the mass from cargo and that the nodal rigid bodies have the same inertia tensors with the replaced structure.



MATERIAL

Material properties were taken from literature. The most critical parameter in material's definition is the rupture criterion. In this study, rupture is assumed to occur when the equivalent plastic strain reaches the critical value of 0.2.

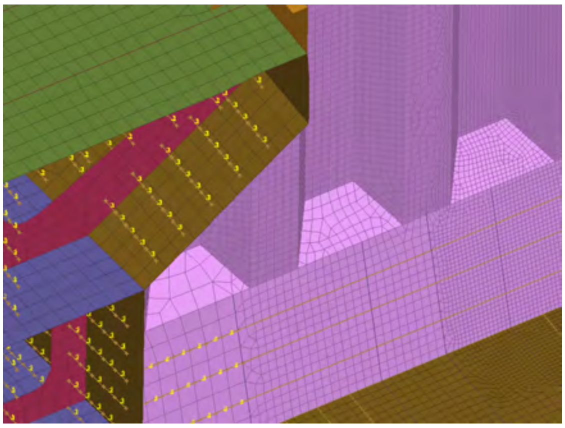
MATERIAL PROPERTIES	
Material type	MAT3 Mat
Density (kg/m^3)	7850
Young's modulus (Pa)	2.1E+11
Poisson ratio	0.3
Yield Strength (Pa)	5.5E+07
Tangent modulus (Pa)	1.0E+09
Hardening parameter	0
Strain rate (C, Hz)	40.4
Strain rate (P)	5
Failure Strain	0.2

MESH

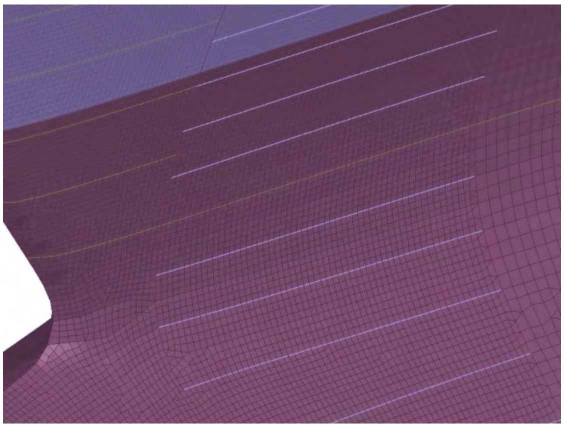
The meshing parameters and quality criteria for the collision analysis are prescribed at the ANSA Batch Meshing Tool. The ships are meshed using three zones. The areas of interest were meshed with a mean element length of 0.07 [m] to ensure accurate results, the insignificant ones with 0.260 [m] and there was an intermediate zone of 0.140 [m].

Since the beams that represent the stiffeners are pasted on the shell elements, a re-meshing action on the shells updates the beams definition. This is an automatic process in ANSA which redefines any entity attached on shells after their re-meshing. At the area of local refinement new beams are created. This technique eliminates the need of redefining the beams in every change of the model mesh.

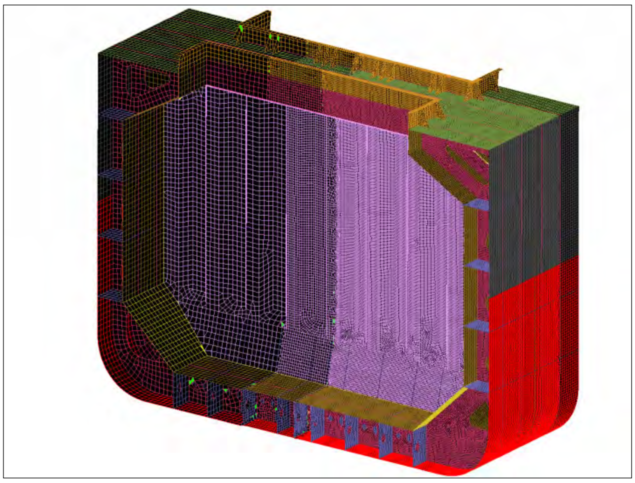
STRUCK SHIP	
Contact areas length	70 mm
Intermediate zone length	140 mm
Remaining areas length	260 mm
Number of shell elements	853114
Number of beam elements	46620

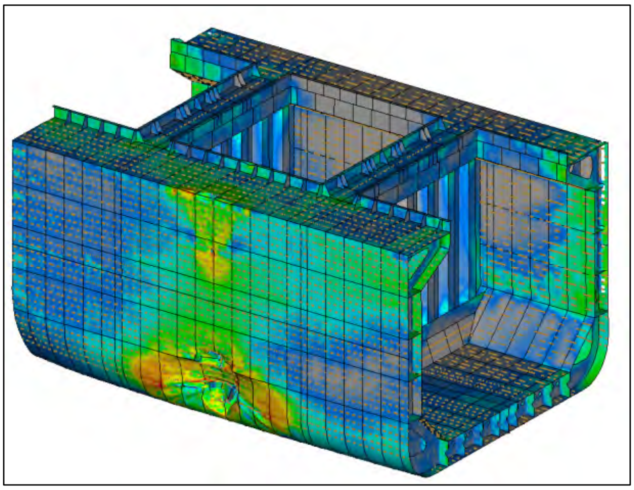


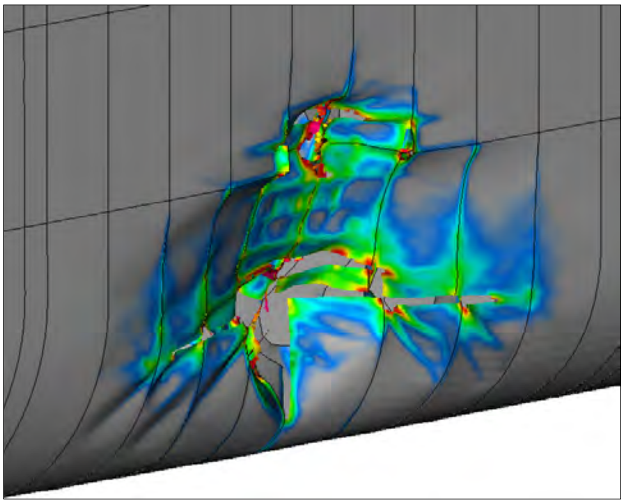
STRICKING SHIP	
Contact areas length	70 mm
Remaining areas length	140 mm
Number of shell elements	473066
Number of beam elements	25355



QUALITY CRITERIA	
Aspect ratio (NASTRAN)	3
Skewness (NASTRAN)	30
Crash time step (sec)	7.0E-06





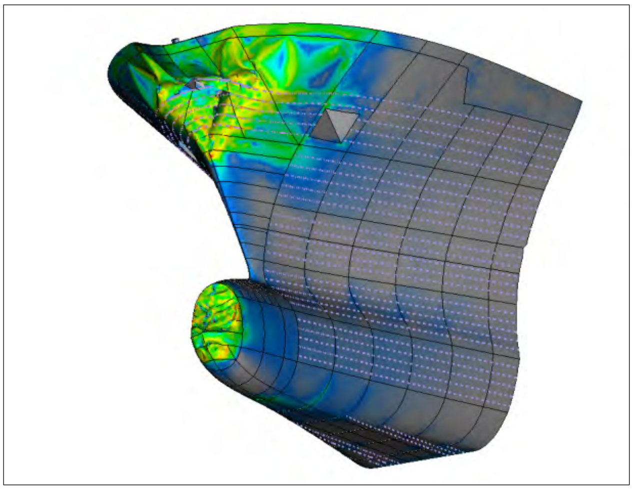


RESULTS

If the external dynamics would have been taken into consideration, the impact energy would have been consumed both in structural deformation and in water resistance. In this study in which only the internal mechanics are taken into account, the whole impact energy is absorbed by the deformable vessels. As result this loadcase can be considered as the worst case scenario.

The results though showed that only the outer hull is penetrated by the bow's bulb while bow's upper edge is severely damaged. The spring back effect started 2 sec after the impact.

The time needed to complete a 4 sec simulation, was approximate 24 hours using a cluster of 16 processors. The excessive CPU time needed for this kind of analysis, limits the number of simulations that can be made during a reasonable time span.



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