Improvement and Validation of an Analytical Code for Ship Collisions Based on Super-Element Method

Master Thesis Presentation

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- New Hypothesis
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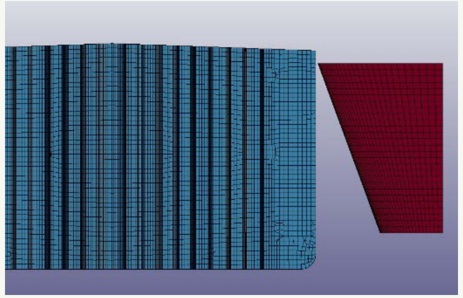
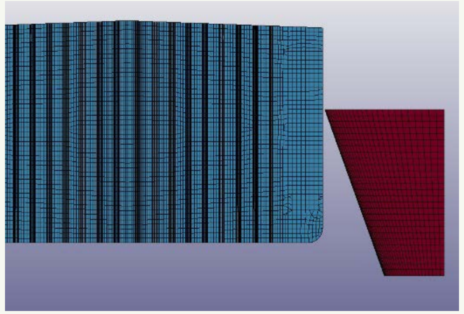
Reminder

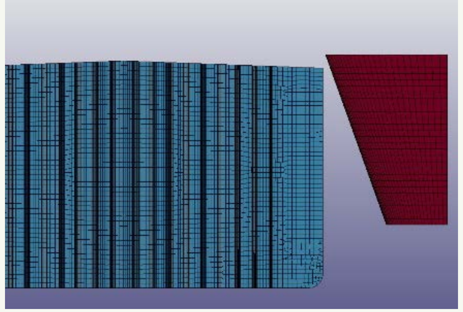
1000-Case	**Deformation Energy [MJ]**
LS-DYNA	5.79
SHARP (Average)	5.03
% Difference	13%



2000-Case	**Deformation Energy [MJ]**
LS-DYNA	4.49
SHARP (Average)	1.05
% Difference	77%

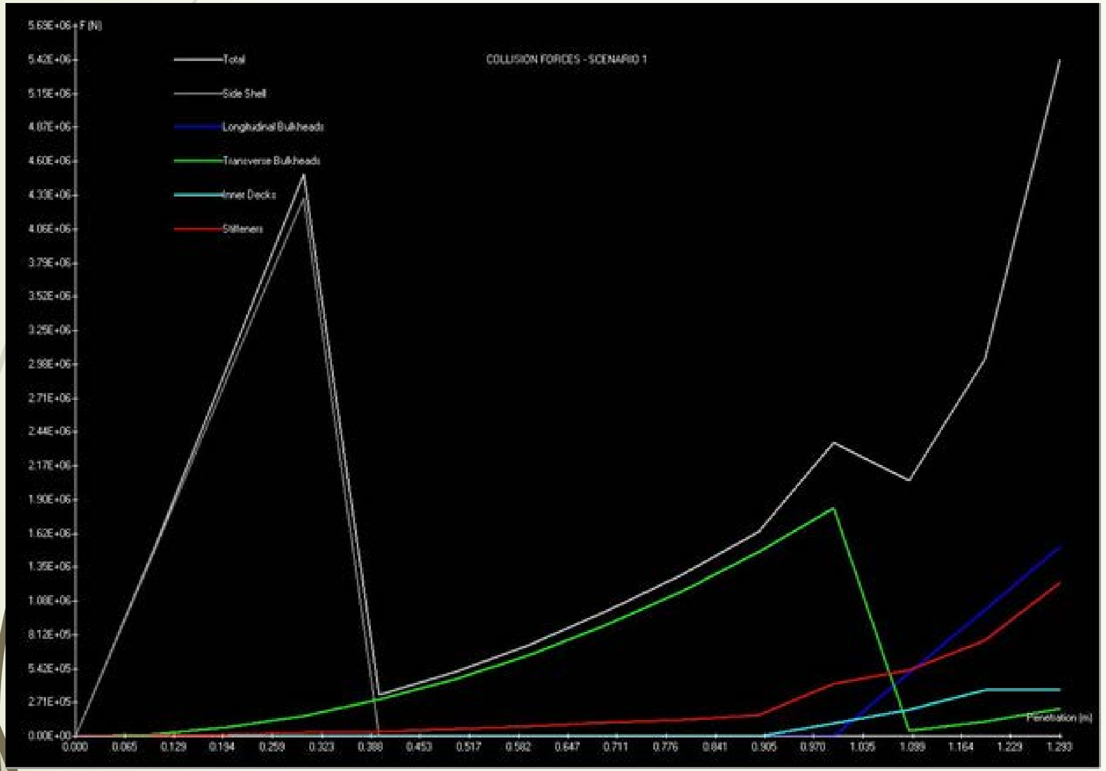


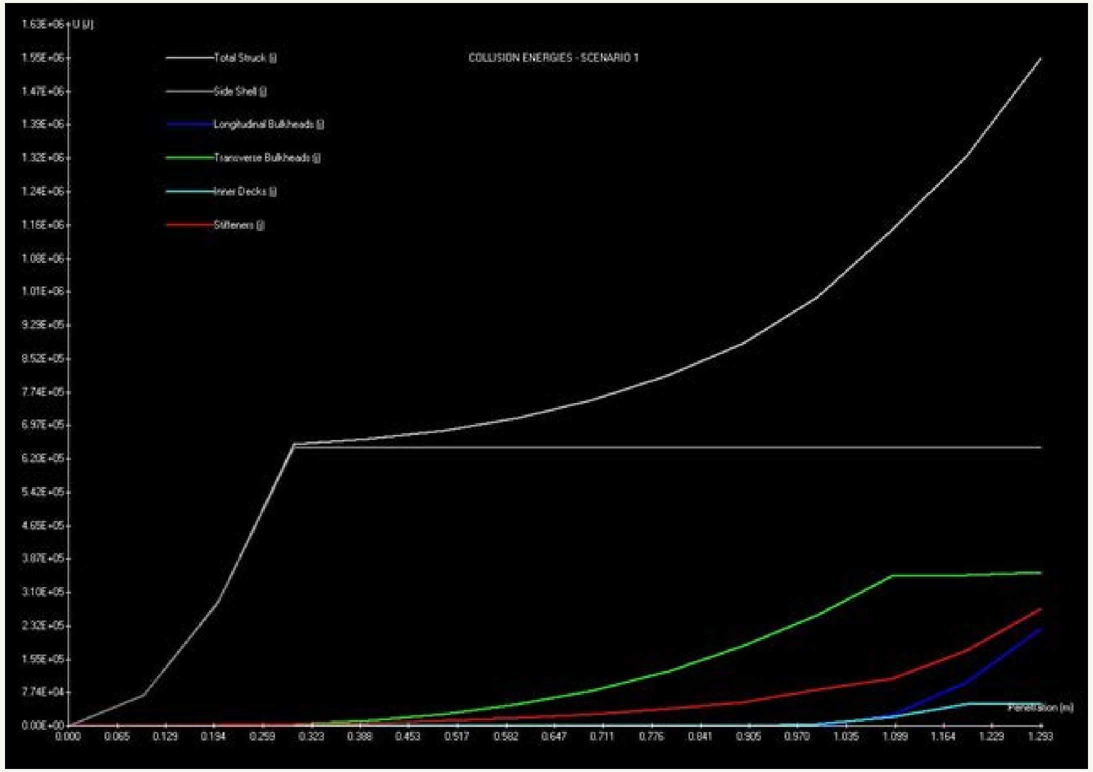
5000-Case	**Deformation Energy [MJ]**
LS-DYNA	6.68
SHARP (Average)	7.21
% Difference	-8%



Main Deficiency

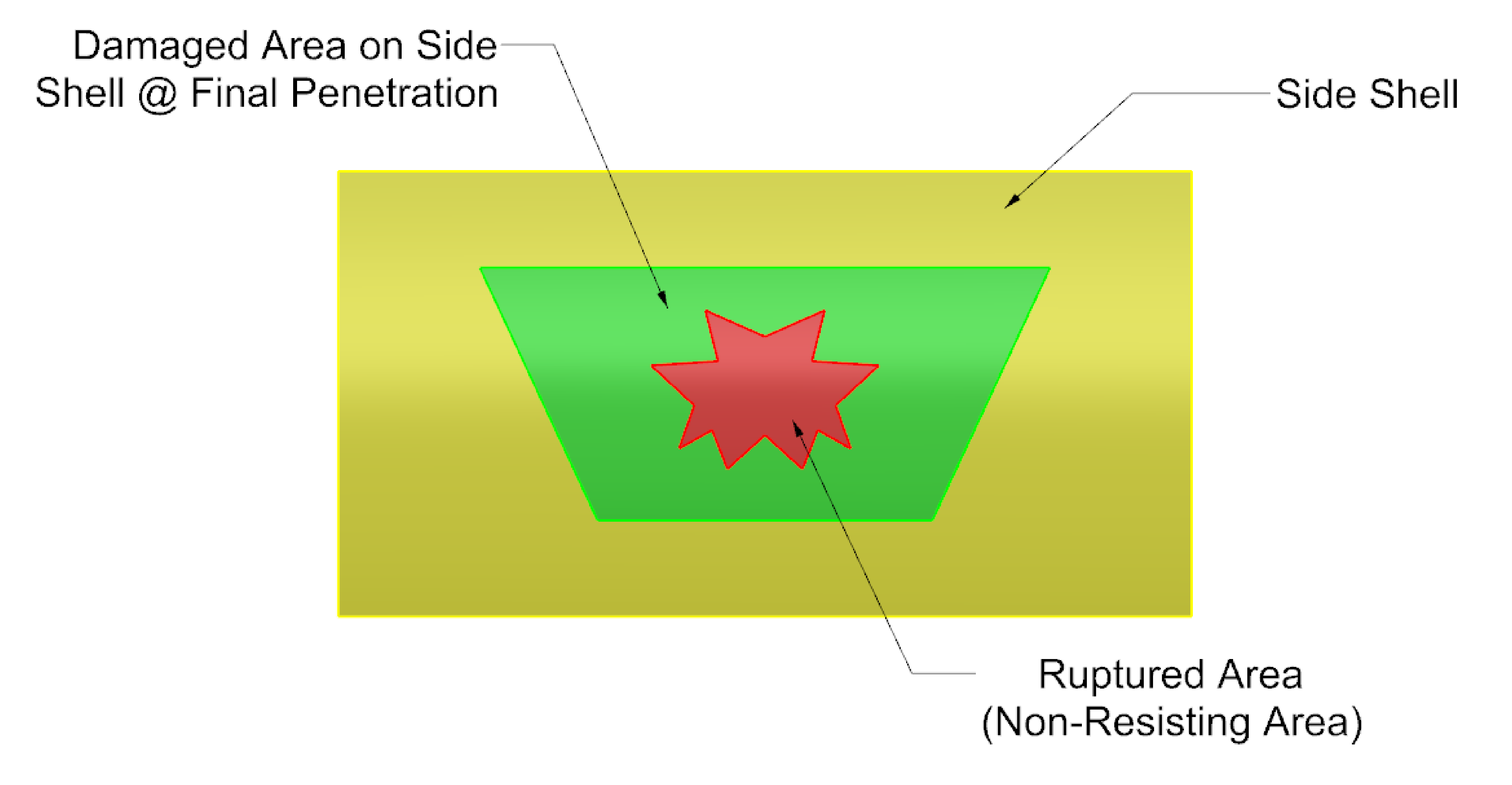
- Lack of post rupture resistance



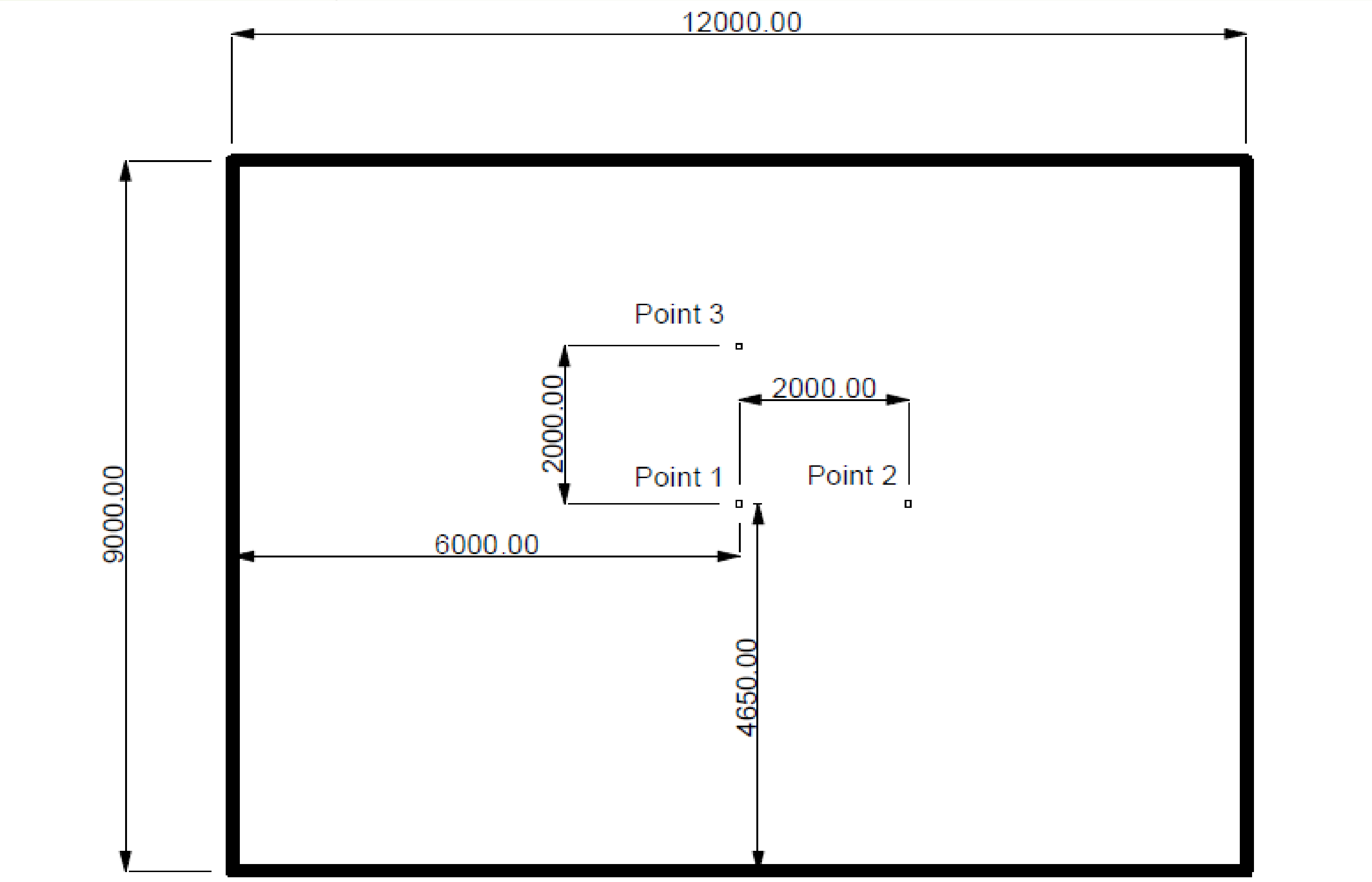


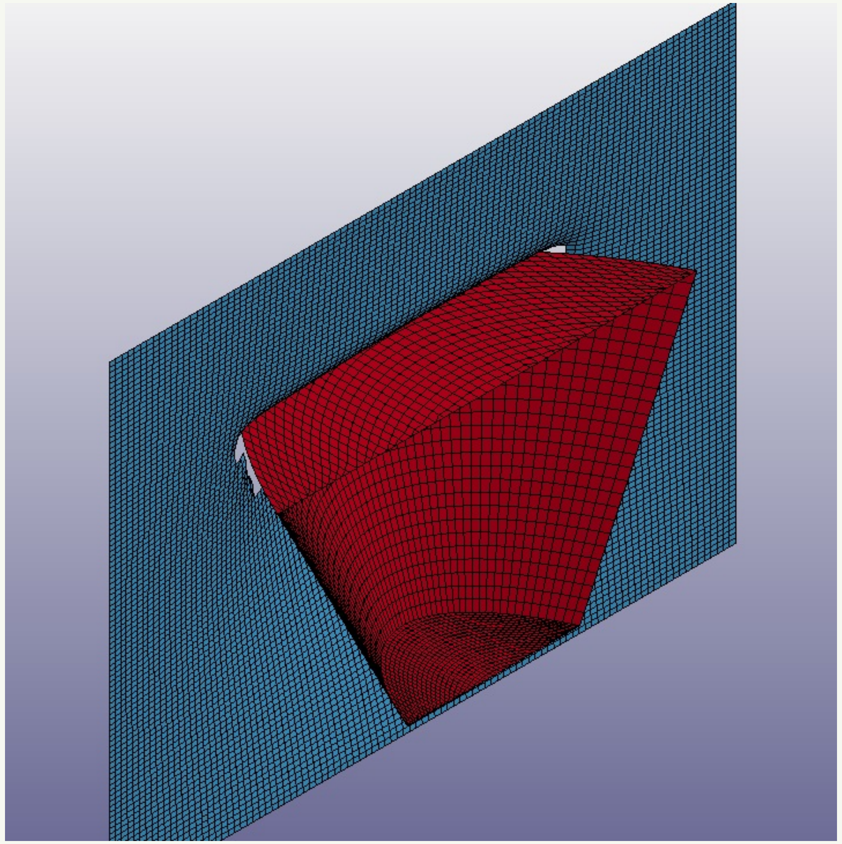
Post Rupture Resistance

$$F = Fmax - \left(Fmax * \frac{Area\ @\ Corresponding\ \delta}{Largest\ Area}\right)$$



Basic Trials with LS-Dyna





Basic Cases

Point 1

Absorbed Energy After Rupture			
By	LS-Dyna	SHARP	Discrepency
Point-1	5.88E+07	5.40E+07	8.23%

Point 2

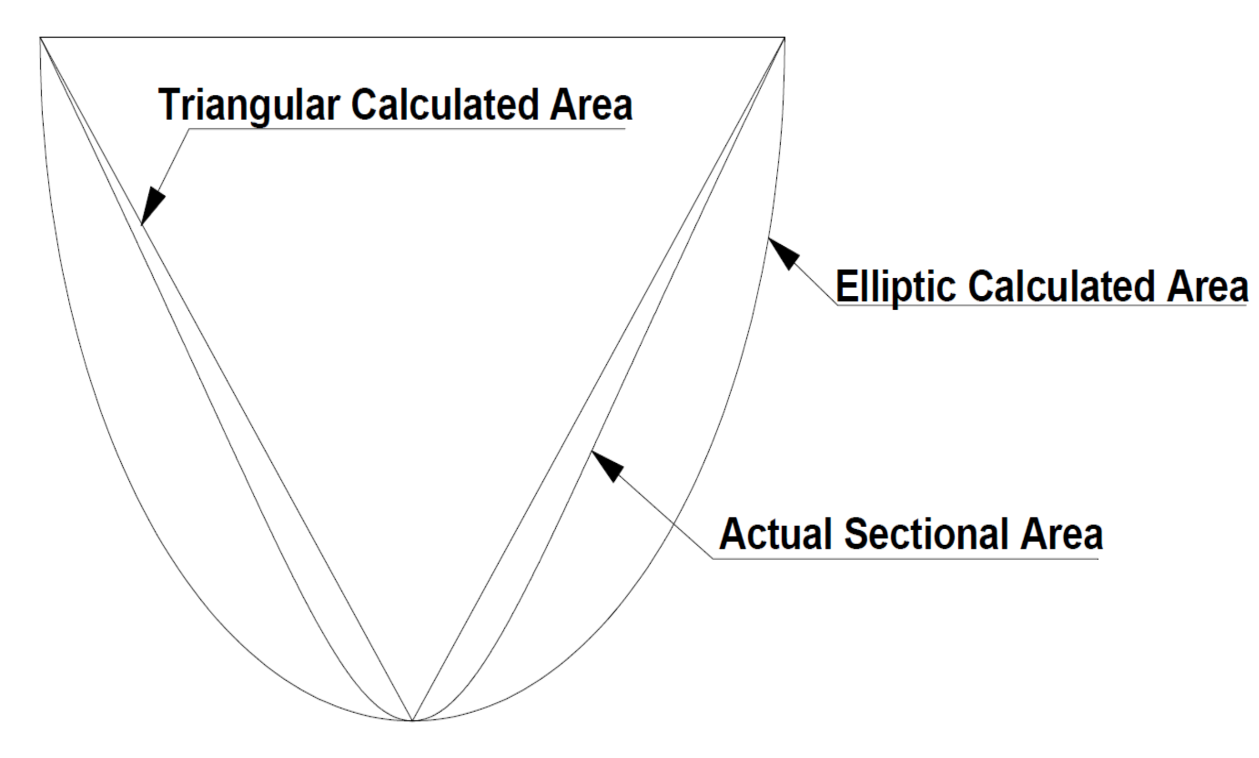
Absorbed Energy After Rupture			
By	LS-Dyna	SHARP	Discrepency
Point-2	5.98E+07	5.57E+07	6.91%

Point 3

Absorbed Energy After Rupture			
By	LS-Dyna	SHARP	Discrepency
Point-3	5.67E+07	5.62E+07	0.91%

Main Gaps of Proposed Method

- Area Calculation



Point 3 –Triangular Area Calculation

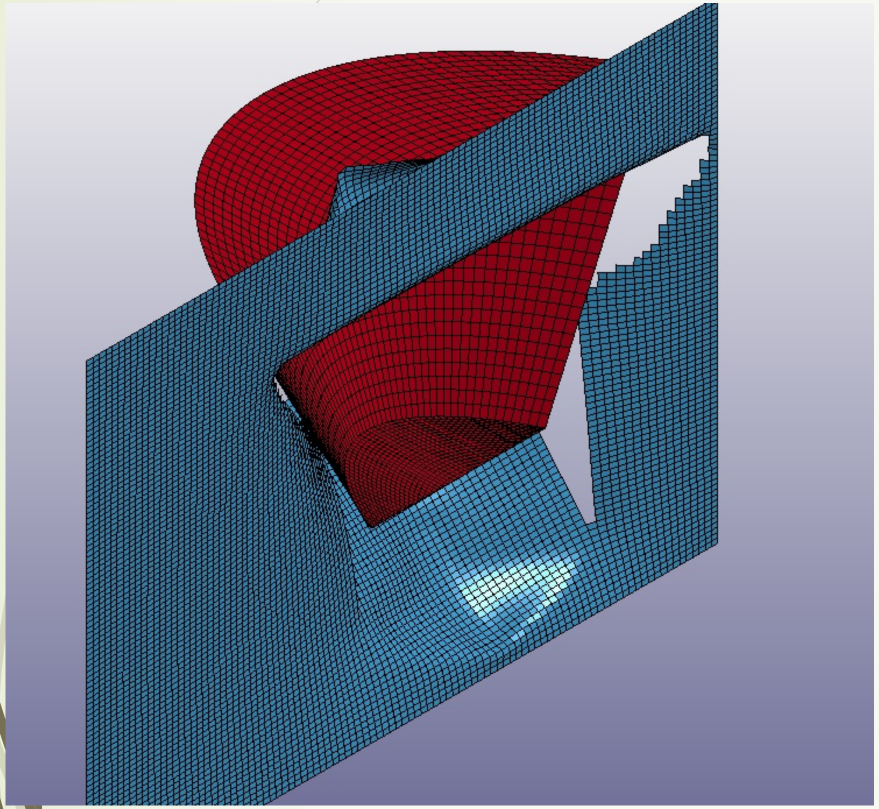
Absorbed Energy After Rupture			
By	LS-Dyna	SHARP	Discrepency
Point-3	5.67E+07	5.72E+07	- 0.91%

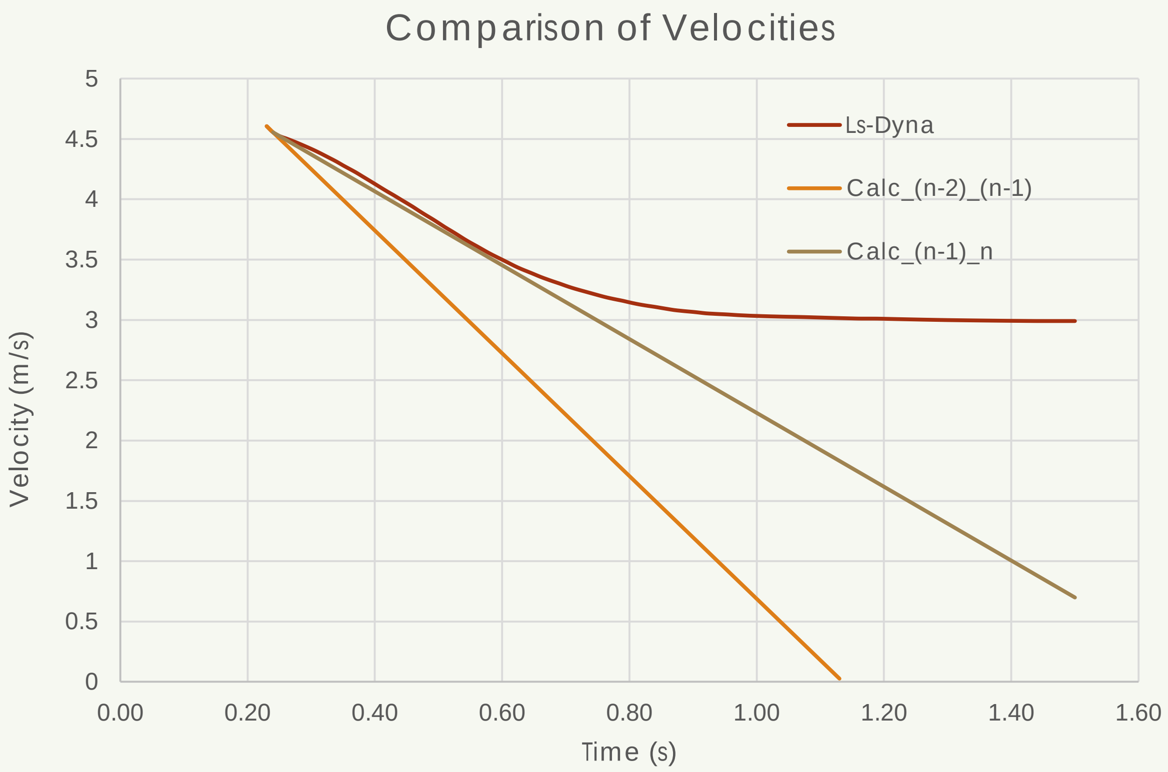
Point 3 –Elliptic Area Calculation

Absorbed Energy After Rupture			
By	LS-Dyna	SHARP	Discrepency
Point-3	5.67E+07	5.20E+07	8.33%

Determining Max Sectional Area

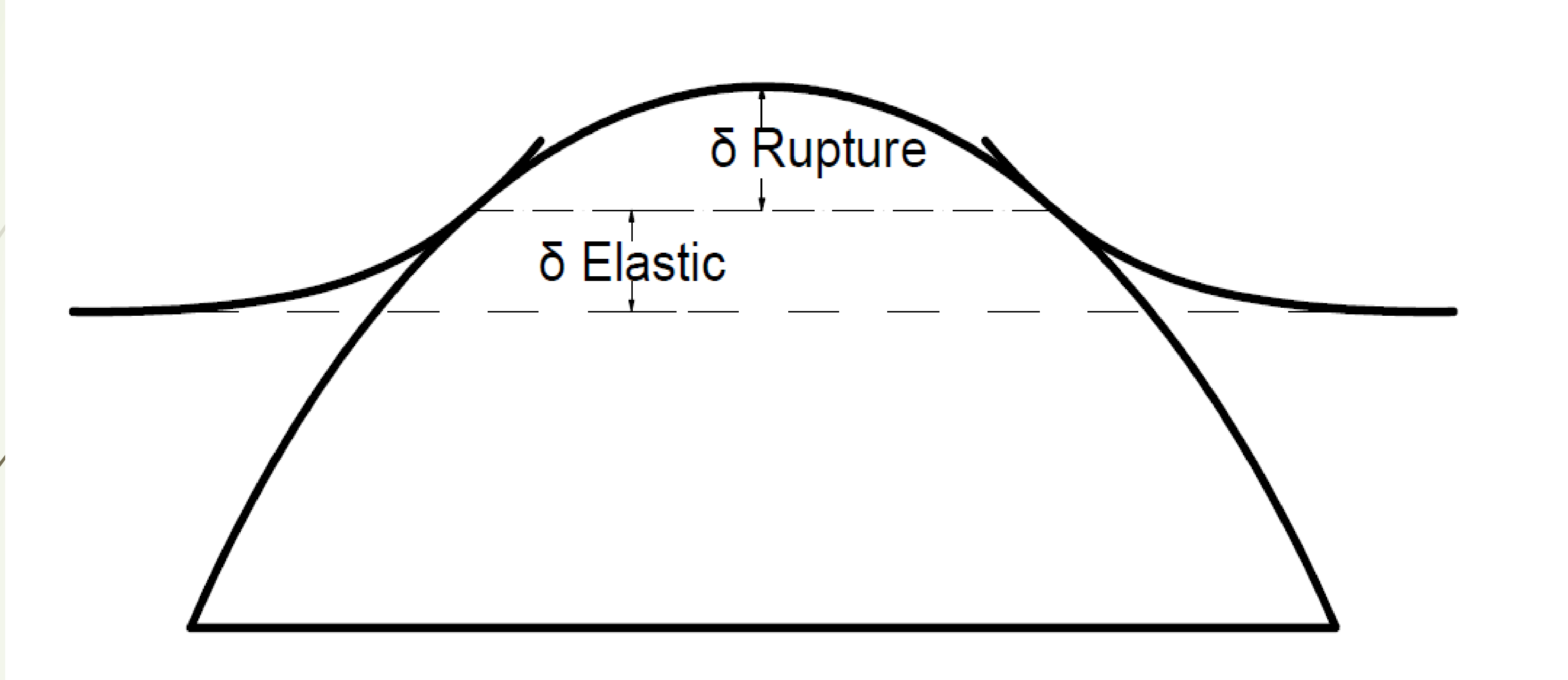
Basic Trials Point 2

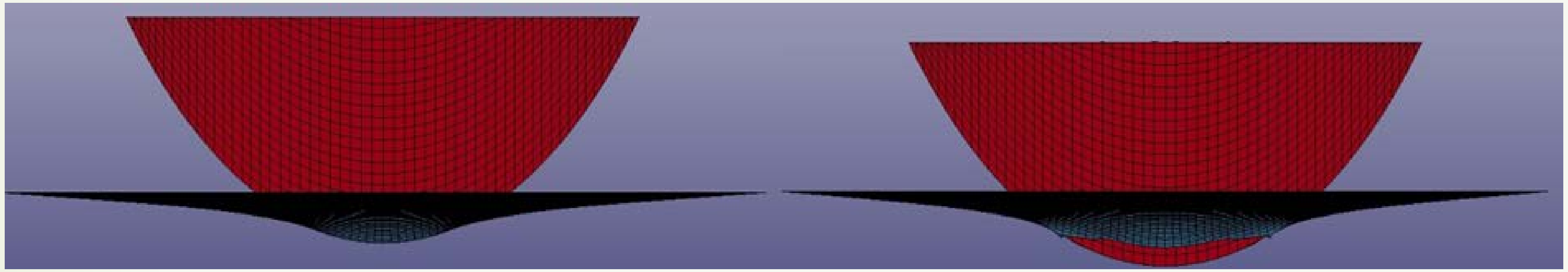




Penetration Terms

$$\delta_{Total} = \delta_{Elastic} + \delta_{Rupture}$$





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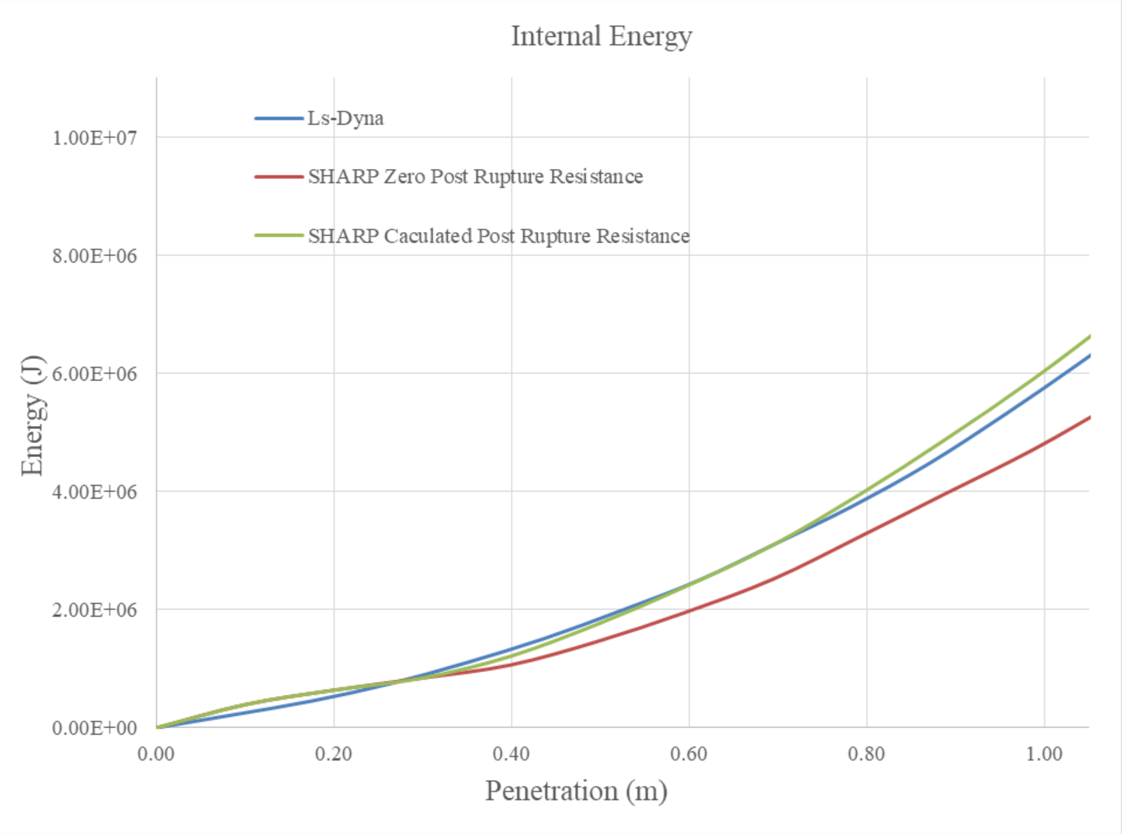
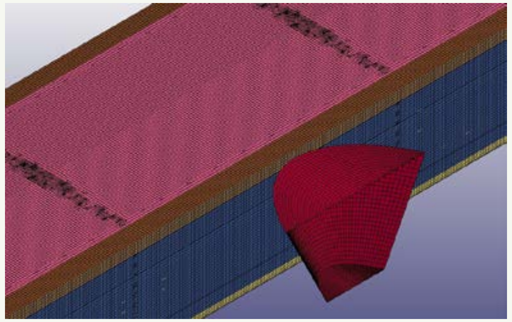
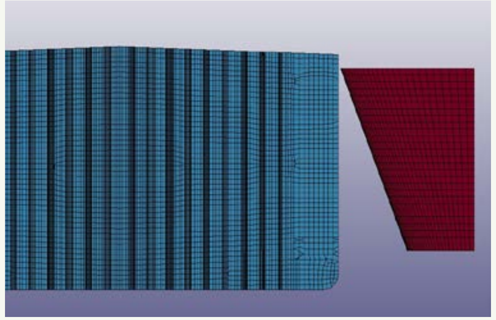
Results – Case - 1

1 m indentation - Average - Triangular- $\delta_{Rupture}$		
		Discre
Ls dyna	5.79E+06	-
SHARP Zero Post Rupture Resistance	5.03E+06	13.15%
SHARP with Calculated Post Rupture Resistance	6.32E+06	-9.18%







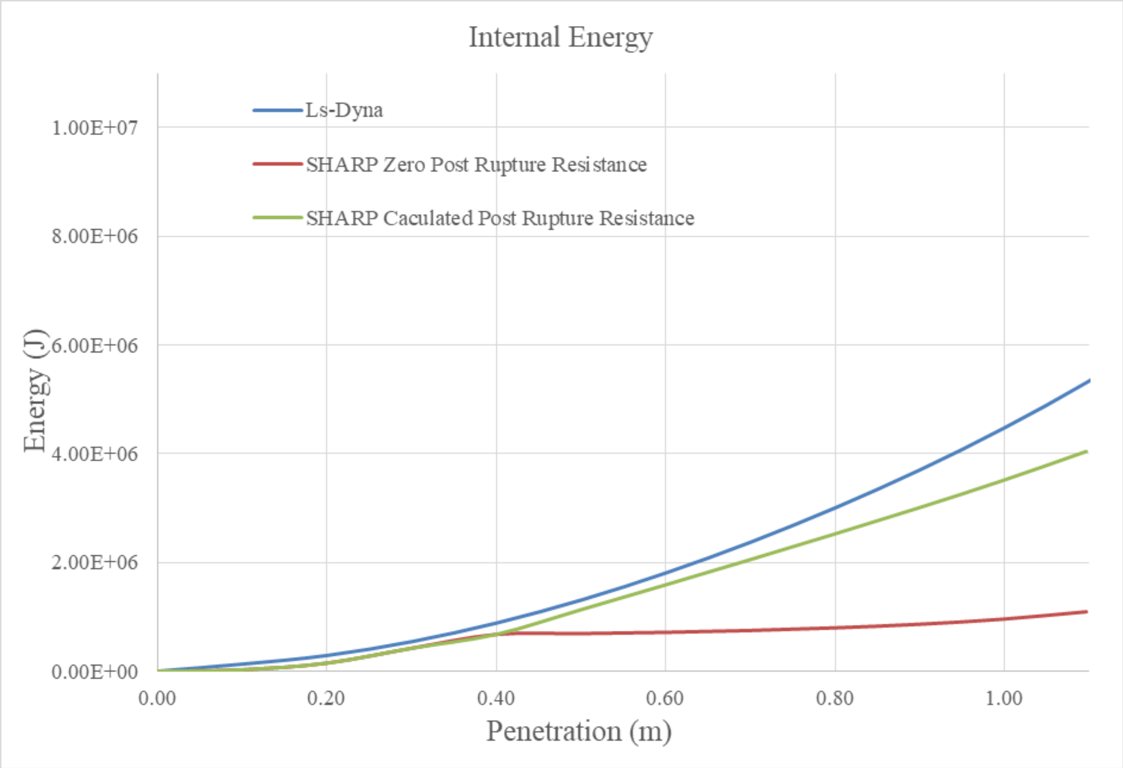
1 m indentation - Average - Elliptic- $\delta_{Rupture}$		
		Discre
Ls dyna	5.79E+06	-
SHARP Zero Post Rupture Resistance	5.03E+06	13.15%
SHARP with Calculated Post Rupture Resistance	6.30E+06	-8.82%

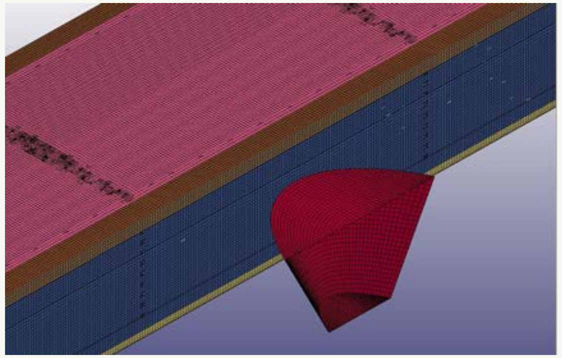
1 m indentation - Average - Triangular- δ_{Total}		
		Discre
Ls dyna	5.79E+06	-
SHARP Zero Post Rupture Resistance	5.03E+06	13.15%
SHARP with Calculated Post Rupture Resistance	6.23E+06	-7.67%

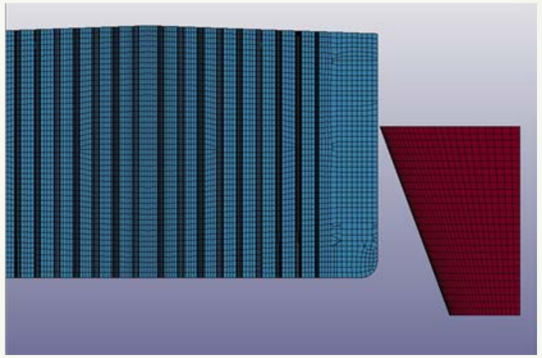
1 m indentation - Average - Elliptical- δ_{Total}		
		Discre
Ls dyna	5.79E+06	-
SHARP Zero Post Rupture Resistance	5.03E+06	13.15%
SHARP with Calculated Post Rupture Resistance	6.16E+06	-6.37%

Results – Case – 2

1 m indentation - Average - Triangular - $\delta_{Rupture}$		
		Discre
Ls dyna	4.49E+06	-
SHARP Zero Post Rupture Resistance	1.05E+06	76.61%
SHARP with Calculated Post Rupture Resistance	3.52E+06	21.60%





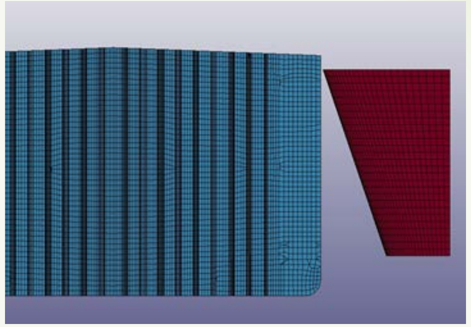


1 m indentation - Average - Elliptic - $\delta_{Rupture}$		
		Discre
Ls dyna	4.49E+06	-
SHARP Zero Post Rupture Resistance	1.05E+06	76.61%
SHARP with Calculated Post Rupture Resistance	3.48E+06	22.57%

1 m indentation - Average - Triangular - δ_{Total}		
		Discre
Ls dyna	4.49E+06	-
SHARP Zero Post Rupture Resistance	1.05E+06	76.61%
SHARP with Calculated Post Rupture Resistance	3.35E+06	25.46%

1 m indentation - Average - Elliptic - δ_{Total}		
		Discre
Ls dyna	4.49E+06	-
SHARP Zero Post Rupture Resistance	1.05E+06	76.61%
SHARP with Calculated Post Rupture Resistance	3.23E+06	28.14%

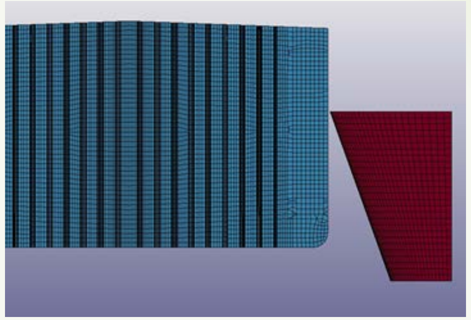
Energy Contributions of Different Elements Case - 1



Parts	Ls-Dyna		Sharp (Wihtout P.R.R)		Sharp (Wiht P.R.R)	
	E (MJ)	%	E (MJ)	%	E (MJ)	%
Total Energy	5.79	1	5.03	1.000	6.32	1.000
Side Shell	$\boxed{2.45}$	42.30%	1.18	23.50%	$\boxed{2.47}$	39.10%
Web Frame	1.81	31.30%	3.80	75.50%	3.80	60.10%
Weather Deck	1.13	19.50%	0.00	0.00%	0.00	0.00%
Stiffners	0.29	5.01%	0.05	1.00%	0.05	0.80%
Others	0.11	1.89%	0.00	0.00%	0.00	0.00%
Penetration	1 m		1 m		1 m	

Triangular – $\delta_{Rupture}$

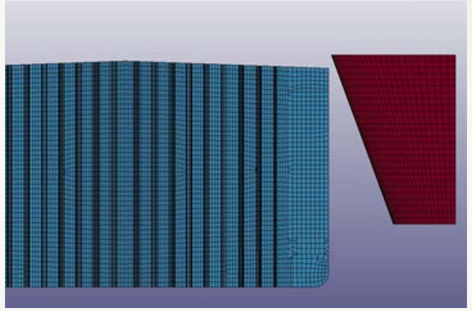
Energy Contributions of Different Elements Case - 2



Parts	Ls-Dyna		Sharp (Wihtout P.R.R)		Sharp (Wiht P.R.R)	
	E (MJ)	%	E (MJ)	%	E (MJ)	%
Total Energy	4.49	1	1.05	1.000	3.52	1.000
Side Shell	$\boxed{2.47}$	55.00%	0.73	69.50%	$\boxed{3.19}$	90.70%
Web Frame	1.12	25.00%	0.23	21.80%	0.23	6.50%
Weather Deck	0.18	4.00%	0.00	0.00%	0.00	0.00%
Stiffners	0.45	10.00%	0.09	8.10%	0.09	2.55%
Others	0.27	6.00%	0.01	0.60%	0.01	0.28%
Penetration	1 m		1 m		1 m	

Triangular – δ_{Rupture}

Contributions of Different Elements Case – 3



Parts	Ls-Dyna		Sharp (Wihtout P.R.R)	
	E (MJ)	%	E (MJ)	%
Total Energy	6.68	1	7.21	1.000
Side Shell	1.40	21.00%	1.92	26.60%
Web Frame	1.54	23.00%	2.61	36.20%
Weather Deck	2.84	42.50%	2.65	36.70%
Stiffners	0.22	3.30%	0.04	0.50%
Others	0.68	10.20%	0.00	0.00%
Penetration	1 m		1 m	

Conclusion and Recommendations

- Proposed post rupture resistance calculation can be considered as acceptable and validated.
- Implementing the method into SHARP's code is on progress. In new version of the software, post rupture resistance will be taken into account and also new version will be tested with all required simulations.
- The coupling effect between different elements such as side shell and deck should now be investigated.
- The reason behind rapid failure of stiffener super-elements should also be investigated. Because of this reason, stiffeners absorb less energy than expected.

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