N°05

A comparison between virtual and actual ROPS testing on agricultural tractors

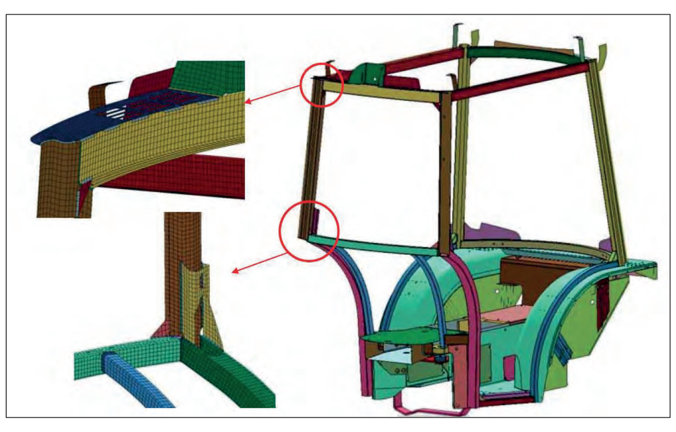
Rationale

The main goal of Roll Over Protective Structure (ROPS) is to provide protection to the operator in case of tractor overturning. The Organization for Economic Co-operation and Development (OECD) for facilitating international trading developed Standardized Codes setting up the requirements in terms of energy and force for the ROPS test. A clearance zone for the driver has to be preserved during the ROPS loadings sequence. Manufacturers nowadays try to minimise the cost in tractor ROPS design and fitment while preserving the fulfillment of the testing procedures. However to maximise cost reduction can cause a ROPS failure in the normalised tests. Ad hoc models can simulate in advance ROPS behaviour allowing to succeed the actual tests.

State of art ROPS designed to be fitted on a BCS vineyard tractor
Normalised ROPS test carried out according to the OECD Code 7 → **Failed test**

Objectives: to optimise the ROPS design both as performance and costs by comparing actual and simulated ROPS tests to check and solve critical aspects in the early stage of the ROPS design phase

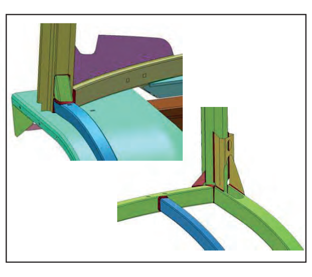
Materials & Methods



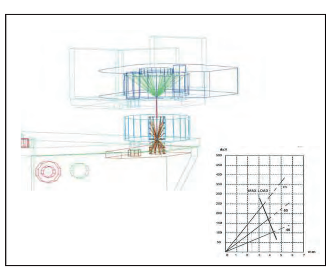
Experimental tests were carried out at the University of Bologna according to the OECD Code 7 procedure - **Numerical simulations** were performed by EnginSoft Group - ROPS cab was provided by BCS manufacturer - Italy

ROPS cab failing the test was made of a steel reinforced tubular frame joined to the tractor chassis by means of the platform. Silent blocks were fitted on the front and rear supports in order to limit noise and vibrations and increase driver's comfort.

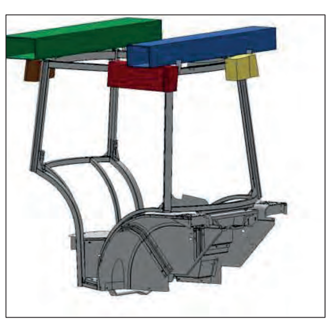
Finite Element (FE) model was developed with LS-DYNA:



- ROPS CAD geometry was accurately meshed with 2D shell elements since most of the components were tubular steel frames and thin metal sheets. Average mesh size of 7 mm was a good balance between accuracy and computational time. The total number of elements corresponded to 150000 shell elements.
- Welds were modeled as a deformable connections between parts. Sheet metal pieces were connected (welded) using shell elements.
- Silent block was modeled with beam elements. The radial and longitudinal stiffness were set up according to experimental results.



ENGIN SOFT



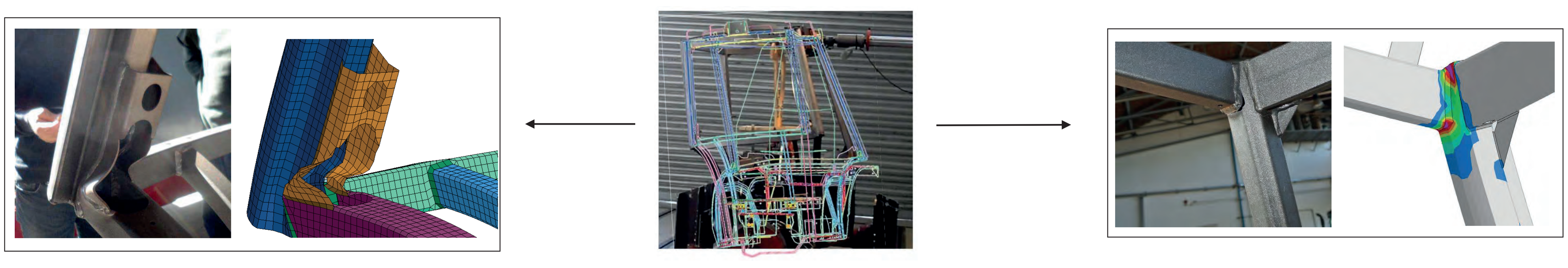
Experimental tests, a stiff beam operated by a hydraulic cylinder was used to apply the force to the cab in order to achieve a calculated energy (force vs deflection) or a crushing force value.

Numerical simulations, a loading device was modeled as a rigid component loading the ROPS structure; meanwhile a specific "surface to surface" contact was assigned between the loading device and the ROPS. The force was the result of a prescribed motion of the loading device.

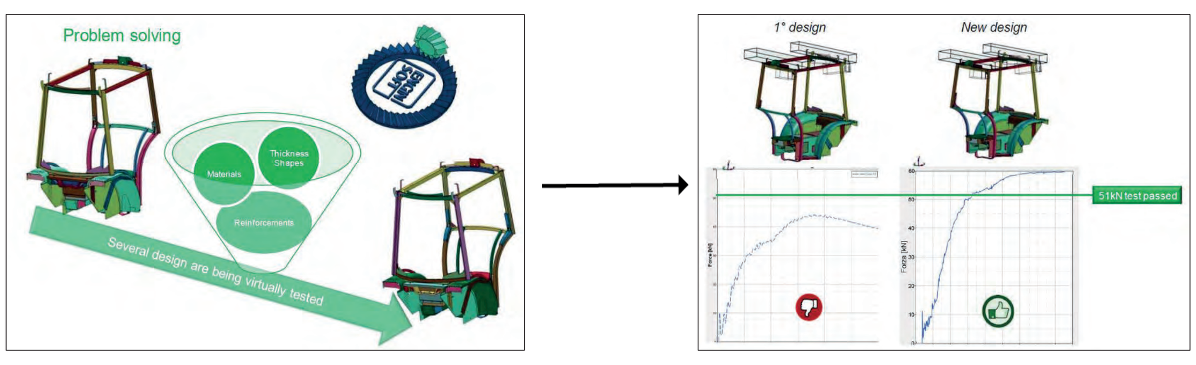
The experimental results of the failed ROPS test were compared to the numerical simulation data.

Results

1. Optimisation of the numerical model on the basis of the comparison experimental vs numerical



2. New ROPS cab with optimised performance in terms of strength behaviour and costs



3. ROPS experimental testing confirmed numerical findings in terms of loading response and stressed areas.

1° design

Sequence	TEST	VALUE	
1	Rear loading	E = 500+0.5·M= 1775 [J]	Passed
2	Rear crushing	F = 20·M= 51 [kN]	Passed
3	Front loading	E = 500+0.5·M= 1775 [J]	Passed
4	Side loading	E_{IS} = 1,75·M= 4462.5 [J]	Passed
5	Front crushing	F = 20·M= 51 [kN]	NOT Passed

New design

Sequence	TEST	VALUE	
1	Rear loading	E = 500+0.5·M= 1775 [J]	Passed
2	Rear crushing	F = 20·M= 51 [kN]	Passed
3	Front loading	E = 500+0.5·M= 1775 [J]	Passed
4	Side loading	E_{IS} = 1,75·M= 4462.5 [J]	Passed
5	Front crushing	F = 20·M= 51 [kN]	Passed

Conclusions

The use of a numerical simulation accompanied by a robust methodology could ensure a high reliability of the virtual prediction with respect to the normalized tests. The comparison between experimental and numerical data allowed to analyse and solve the critical points. The validation of the optimised model could lead to a better evaluation of ROPS performance, reducing the time and the cost of the normalised ROPS testing process.

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