Numerical modelling key results

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The following document presents a collection of the key results obtained during the finite element analysis of two different impact scenarios involving horse riders. All analysis was carried out using LSTC's 'Fast HYBRID III 50th Percentile' model. The results presented here will display the effective stress on two separate elements of the HYBRID III model's "rib cage": one central and the other located off-centre. The first impact scenario aims to replicate the impact between the rider and a fixed wooden corner fence, and the second aims to replicate the impact between horse and rider as a result of a rotational fall. Both impact scenarios will take place at velocities of both 5 m/s and 9 m/s. This approximately corresponds to the minimum and maximum required showjumping speeds across each class.

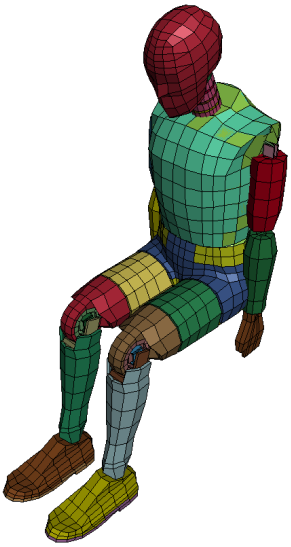

Fig. 1. LSTC's 'Fast HYBRID III 50th Percentile' model.

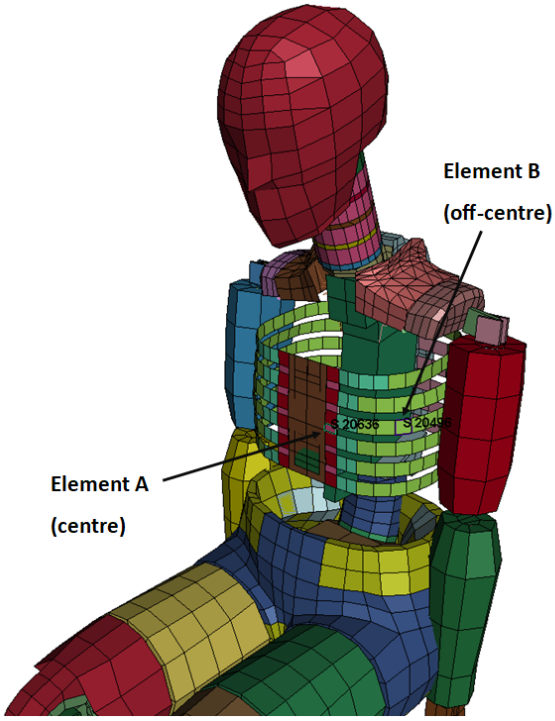

Fig. 2. LSTC's 'Fast HYBRID III 50th Percentile' model annotated to highlight rib cage elements A and B for which the effective stress will be measured and presented.

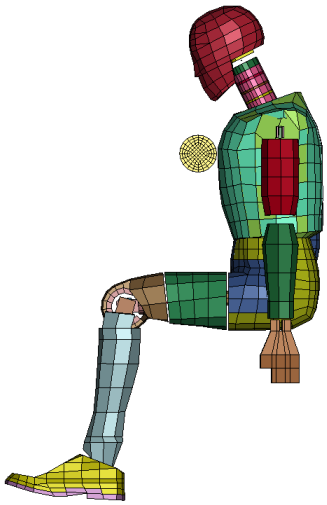

Fig. 3. Impact scenario 1, involving collision between HYBRID III and fixed wooden fence post.

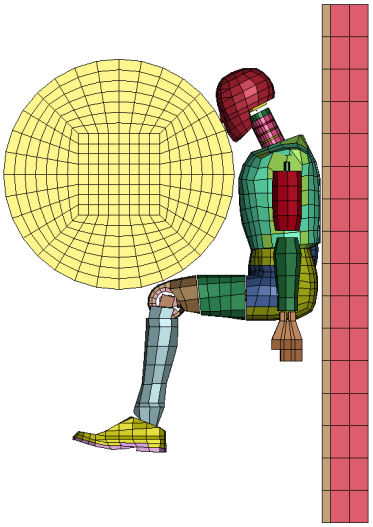

Fig. 5. Impact scenario 2, involving collision between HYBRID III and horse. Model also includes two layers of ground, one soft and one hard, as an approximate model of hard ground topped with a layer of loose sand.

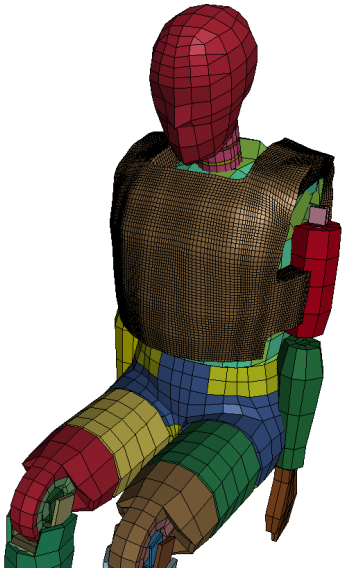

Fig. 4. LSTC's 'Fast HYBRID III 50th Percentile' model with protection provided by 3 layer foam protector with fabric cover.

Fig. 6. LSTC's 'Fast HYBRID III 50th Percentile' model with protection provided by air vest protector, inflated using a 50cc carbon dioxide cartridge.

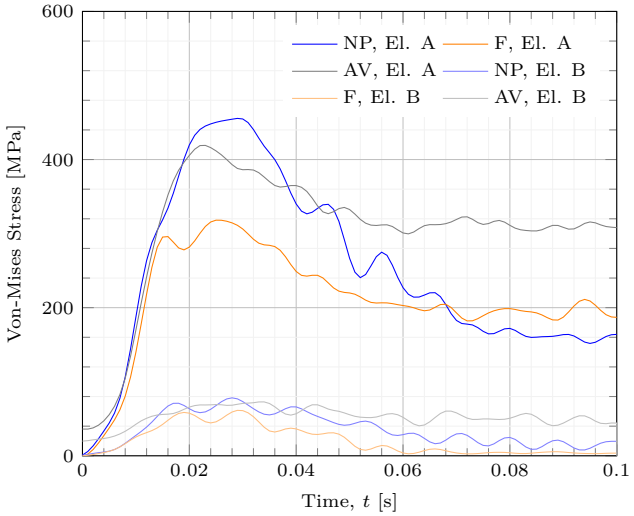

Fig. 7. Effective stress on HYBRID III elements A and B during impact with wooden fence post at 5 m/s. Note on legend: NP denotes no protection, F denotes foam protector, AV denotes air vest protector.

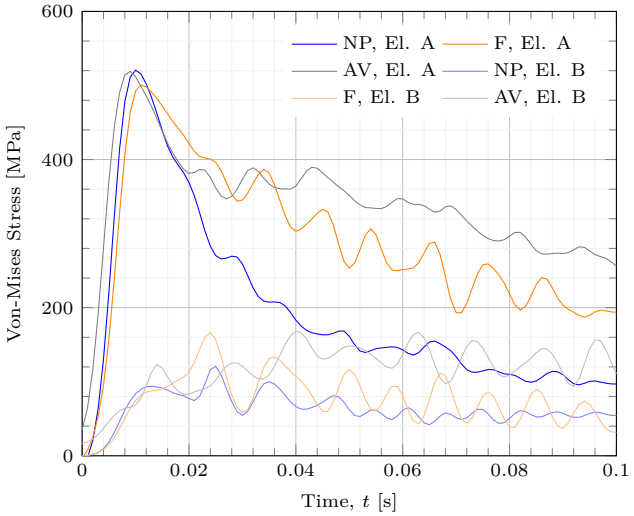

Fig. 8. Effective stress on HYBRID III elements A and B during impact with wooden fence post at 9 m/s. Note on legend: NP denotes no protection, F denotes foam protector, AV denotes air vest protector.

Table 1. Maximum effective stress and total stress-time on rib cage elements A and B for 5 m/s fence post impact.

Protection type	Element	Maximum stress [MPa]	Reduction from no protection [%]	Total Stress-time [MPa.s]	Reduction from no protection [%]
No protection	A	456	-	25.15	-
Foam	A	318	30.2%	21.19	15.7%
Air vest (50cc cartridge)	A	419	8.0%	30.64	-21.8%
No protection	B	78	-	3.60	-
Foam	B	61	21.6%	2.04	43.4%
Air vest (50cc cartridge)	B	73	7.0%	5.32	-47.8%

Table 2. Maximum effective stress and total stress-time on rib cage elements A and B for 9 m/s fence post impact.

Protection type	Element	Maximum stress [MPa]	Reduction from no protection [%]	Total Stress-time [MPa.s]	Reduction from no protection [%]
No protection	A	521	-	19.71	-
Foam	A	501	3.8%	28.90	-46.7%
Air vest (50cc cartridge)	A	519	0.3%	34.16	-73.4%
No protection	B	121	-	6.32	-
Foam	B	167	-37.9%	7.69	-21.7%
Air vest (50cc cartridge)	B	168	-39.1%	11.70	-85.0%

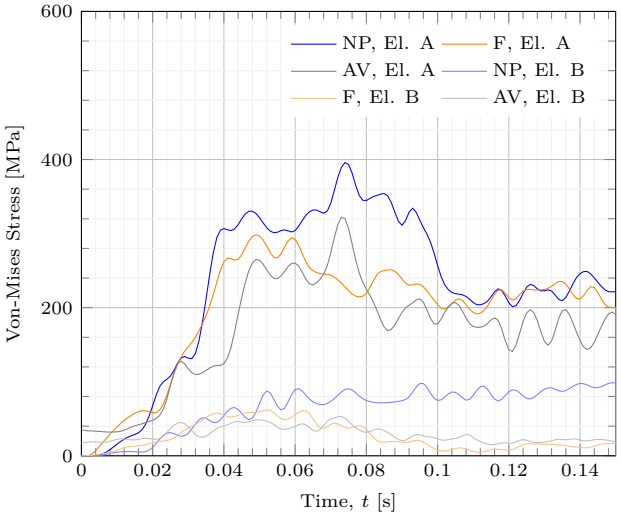

Fig. 9. Effective stress on HYBRID III elements A and B during impact with horse at 5 m/s. Note on legend: NP denotes no protection, F denotes foam protector, AV denotes air vest protector.

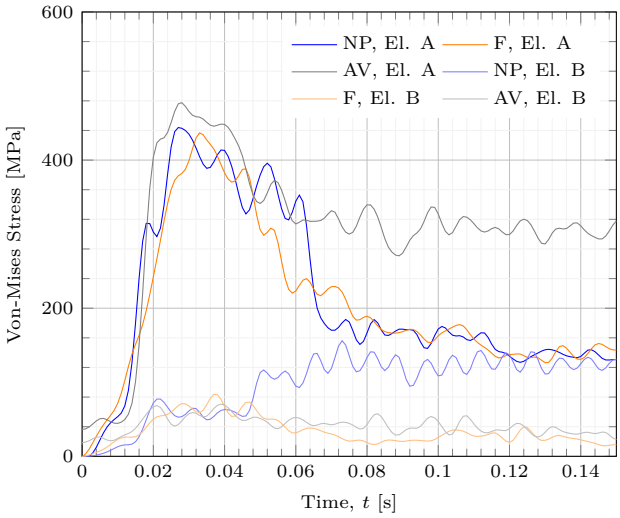

Fig. 10. Effective stress on HYBRID III elements A and B during impact with horse at 9 m/s. Note on legend: NP denotes no protection, F denotes foam protector, AV denotes air vest protector.

Table 3. Maximum effective stress and total stress-time on rib cage elements A and B for 5 m/s horse impact.

Protection type	Element	Maximum stress [MPa]	Reduction from no protection [%]	Total Stress-time [MPa.s]	Reduction from no protection [%]
No protection	A	396	-	34.42	-
Foam	A	298	24.7%	29.47	14.4%
Air vest (50cc cartridge)	A	322	18.6%	25.32	26.4%
No protection	B	99	-	9.66	-
Foam	B	62	37.0%	3.86	60.0%
Air vest (50cc cartridge)	B	53	46.2%	4.38	54.7%

Table 4. Maximum effective stress and total stress-time on rib cage elements A and B for 9 m/s horse impact.

Protection type	Element	Maximum stress [MPa]	Reduction from no protection [%]	Total Stress-time [MPa.s]	Reduction from no protection [%]
No protection	A	444	-	32.00	-
Foam	A	437	1.6%	30.81	3.7%
Air vest (50cc cartridge)	A	478	-7.6%	46.33	-44.8%
No protection	B	156	-	14.52	-
Foam	B	84	46.4%	5.09	64.9%
Air vest (50cc cartridge)	B	71	54.8%	6.29	56.7%

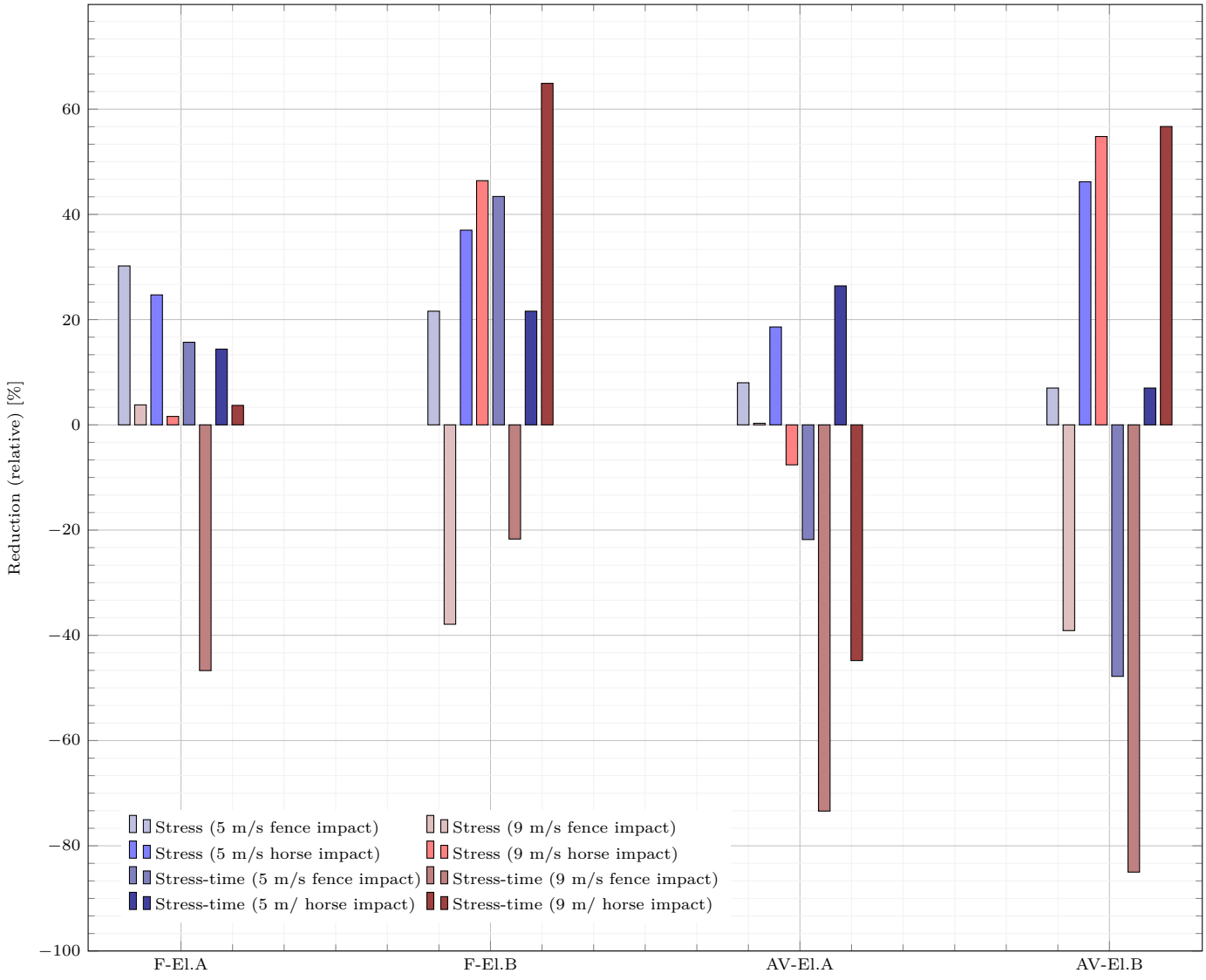

Fig. 11. Relative decrease in stress (von Mises) and total stress-time on rib cage elements A and B. Percentages calculated relative to the no protection models (NP-) for fence and horse impacts, at velocities of 5 and 9 m/s. Note on axis labels: F denotes foam protector, AV denotes air vest protector, ELA denotes rib cage element A and ELB denotes rib cage element B.