Applus+ IDIADA

Material modelling services

Ondřej Marada

Simulia Days 2025

PUBLIC

WHO WE ARE & WHAT WE DO

IDIADA is an engineering partner to the automotive industry providing complete solutions for product development projects worldwide

OUR ASSETS

3.419 PROFESSIONALS
18,5% WOMEN
57 NATIONALITIES

FIRST CLASS STATE-OF-THE-ART
TESTING FACILITIES

24 COUNTRIES
60 LOCAL OFFICES

CONSTANT
INNOVATION
IN NEW SERVICES AND TECHNOLOGIES

COMPLETE SOLUTIONS FOR AUTOMOTIVE ENGINEERING

- PROJECT MANAGEMENT
- KNOW-HOW IN ALL VEHICLE FUNCTIONALITIES
- ENGINEERING, TESTING & HOMOLOGATION

References
Material cards

- IDIADA clients for material cards of steels, aluminum, thermoplastics, carbon fiber, rubbers

- Toyota
- Audi
- Lamborghini
- Skoda
- Nissan
- Stellantis
- Volvo
- TOGG
- DE TOMASO

OEMs

- Rehau
- SMP automotive
- Magna exteriors
- THK
- Simoldes
- SIRO

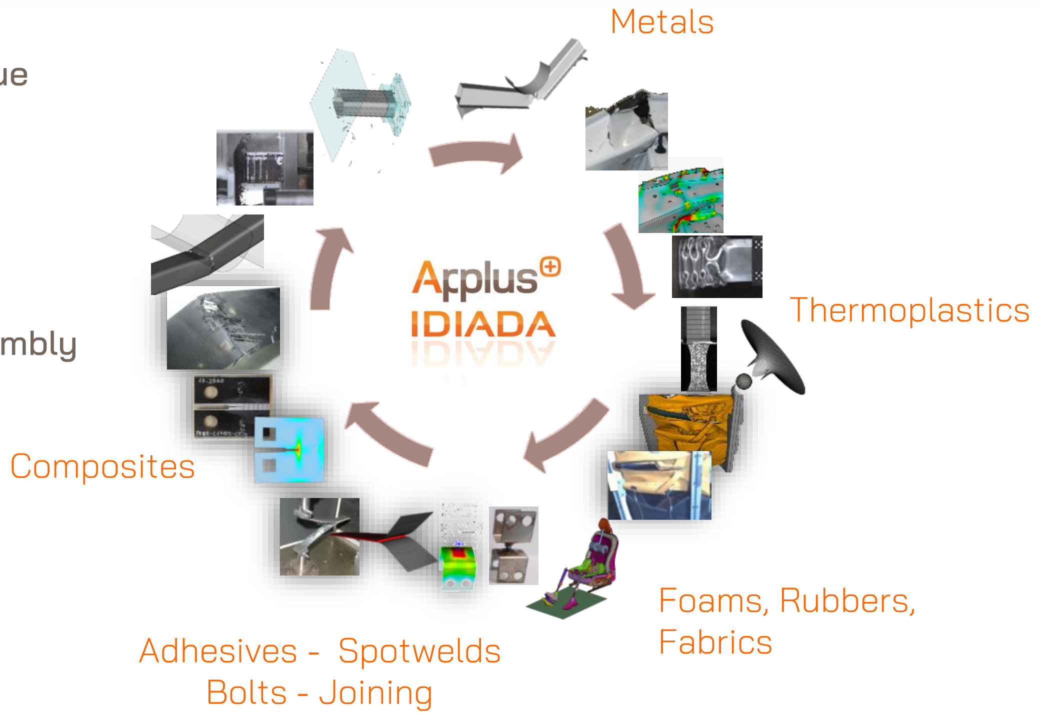
T1 suppliers

- ARRIVAL
- ZOOX
- FARADAY FUTURE
- EBRO

Startups

Material team

- Continuously evolving domain across scopes
  - **Crash, Stiffness & Strength, NVH, Fatigue**
- Specific requirements and methods for each material group and scope
- Dynamic building blog approach
  - **Coupon > component testing > subassembly**
- International team (ESP, CZ)
- Building one common & modular & solver independent platform for materials

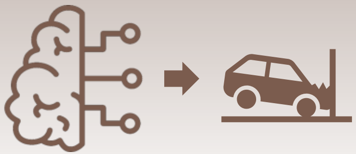


MULTI-MATERIAL LIGHTWEIGHT BODY SOLUTIONS

MATERIAL CARD PORTFOLIO

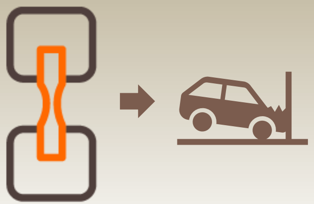
Four material cards levels for accurate evaluation of part designs at each stage of vehicle development

Estimated Material Card



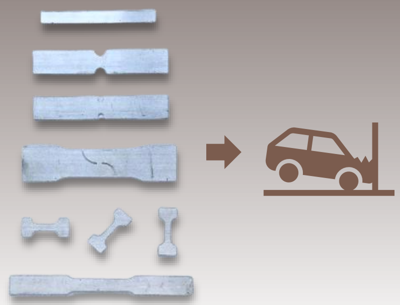
Definition & concept phase

Basic Material Card



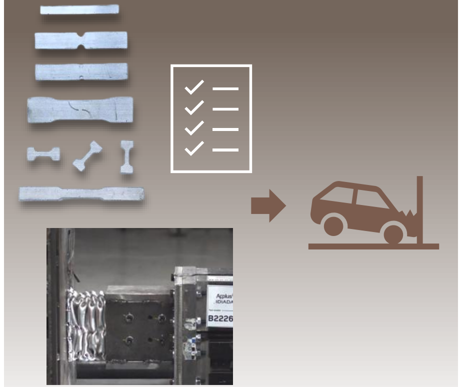
Pre-development phase

Advanced Material Card



Series development phase

Ultimate Material Card



Pre-series & series production phase

Initial Bill of Materials (BoM)

- From Applus+ Material Portal tests database
- IDIADA Material Card enrichment from know-how

- From reduced number of coupon test data
- IDIADA Material Card enrichment from know-how

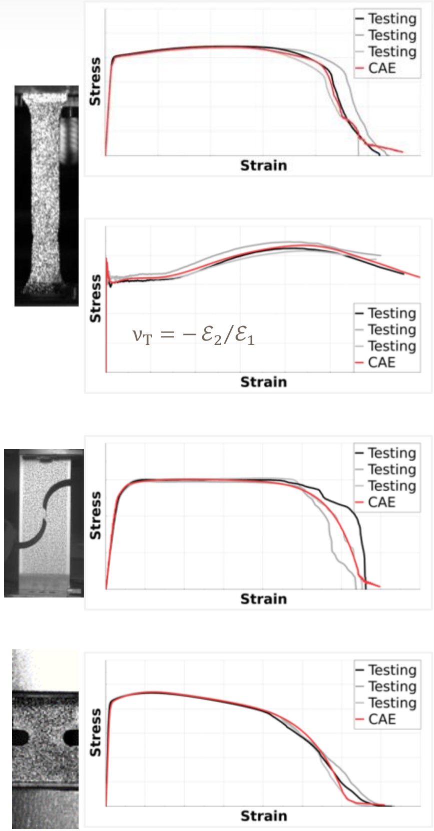
Test & Verification

- From coupon test data
- High-accuracy material card

- From coupon & component test data (prototype testing)
- Validated component accuracy (material & FEA guidelines)

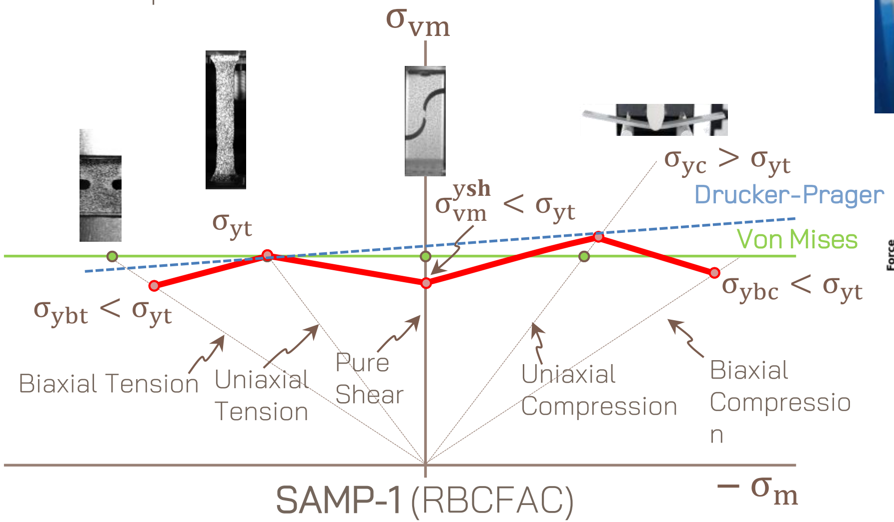
ALUMINIUM & STEEL ALLOYS

What is the advanced Material model

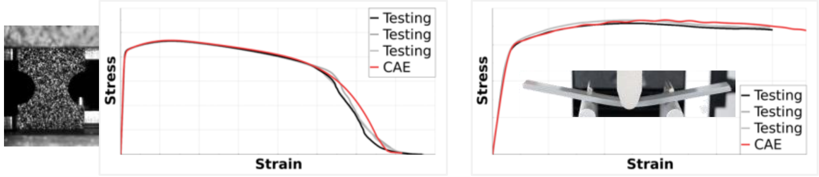


Experimental inputs:

- Complete Coupon test matrix
- Dynamic Axial crush & Quasi-static 3-point bending Component tests



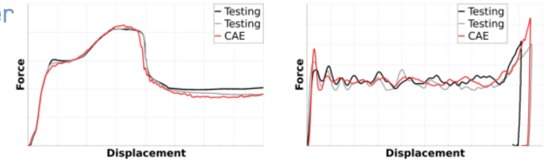
SAMP-1 (RBCFAC)

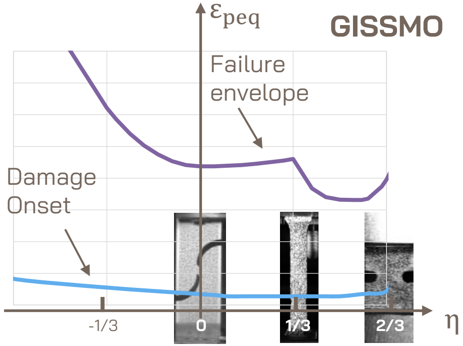


Quasi static 3-point bending

Axial crush

Courtesy of Faraday Future

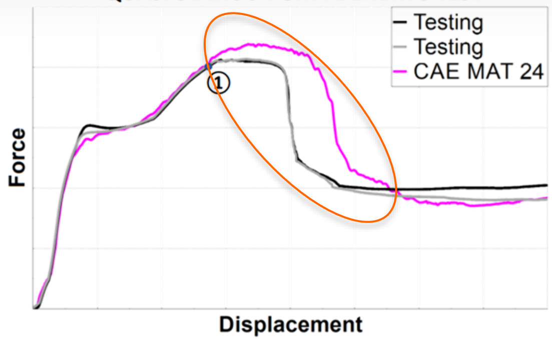


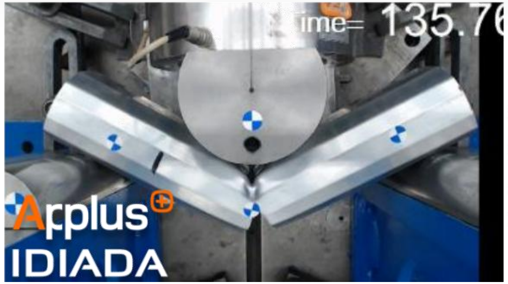


ALUMINIUM & STEEL ALLOYS

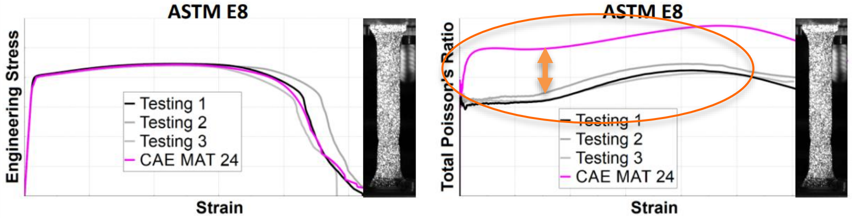
INSUFFICIENT PREDICTION OF MISES PLASTICITY MODEL

QUASI-STATIC 3-POINT BENDING TEST



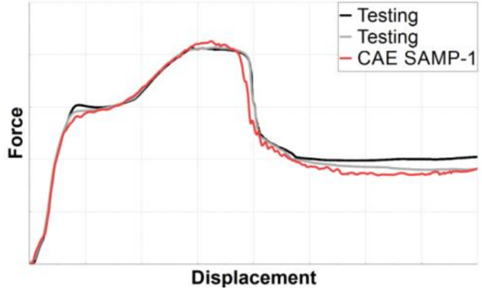


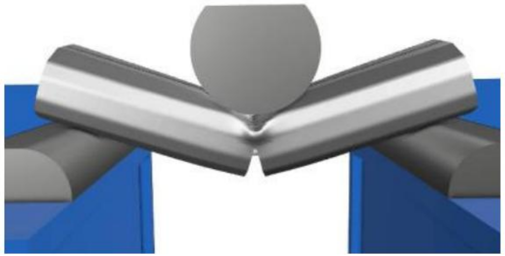
Lateral contraction in a tensile test



ASTM E8 coupon test. CAE correlation for MAT 24. Courtesy of Faraday Future

QUASI-STATIC 3-POINT BENDING TEST

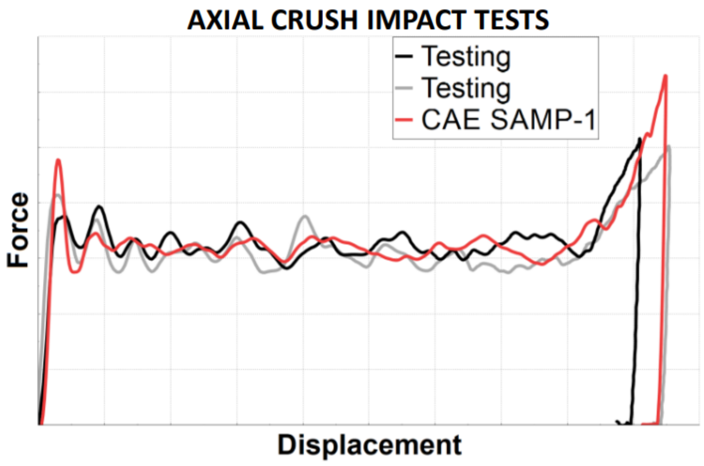


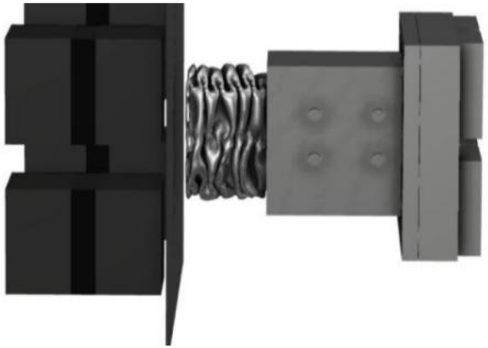


[1] Domínguez, Alejandro & Cruz, Pablo & Martorell, Lluis & García, Adrián & Martin-Santos, Eduardo & Hall, Andrew & Kelly, Patrick & Syed, Ilyasuddin & Idiada, Applus & Future, Faraday. (2023). **Advanced Plasticity & Fracture for Structural Car Body Metals in Crashworthiness CAE analysis: SAMP-1 plus GISSMO.**

ALUMINIUM & STEEL ALLOYS

What is the advanced Material model





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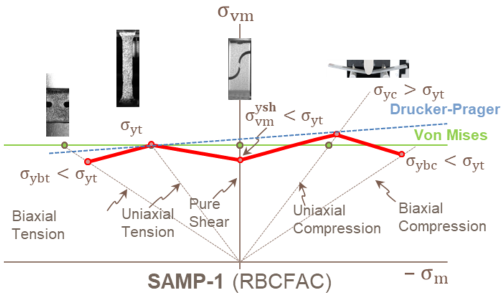
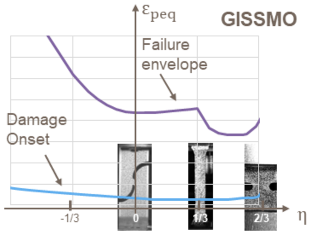
- Explicit world

LS-DYNA

Radioss™

PAM-CRASH





TIER 1

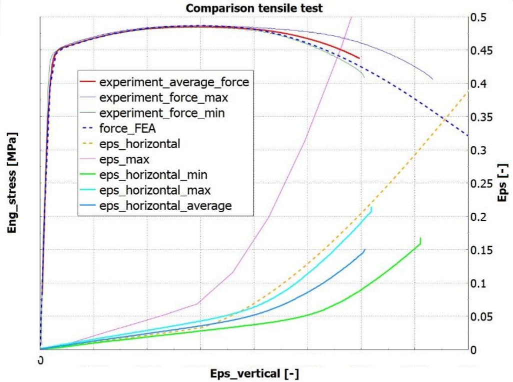
- Implicit + Explicit world

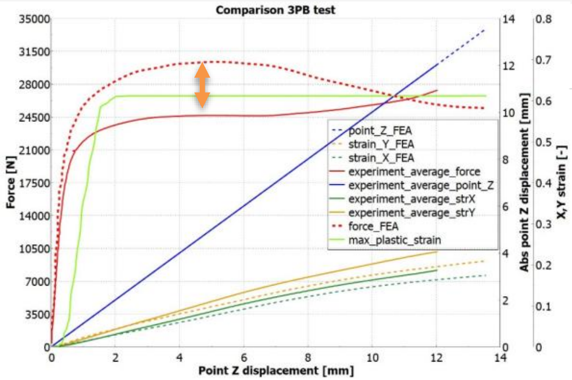
ABAQUS

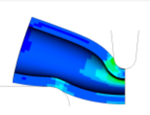
- Elasticity
- Plasticity
- Pressure-dependent yeild surface
- Non-quadratic yeild surface
- Variable Poisson's ratio in the plastic regime
- Damage Failure (stress state dependent)
- Damage onset (stress-state-dependent)
- Rate dependent behavior

ALUMINIUM & STEEL ALLOYS

BENDING PROBLEM







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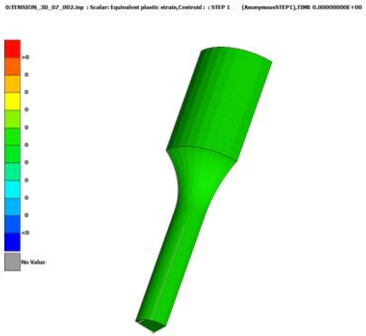
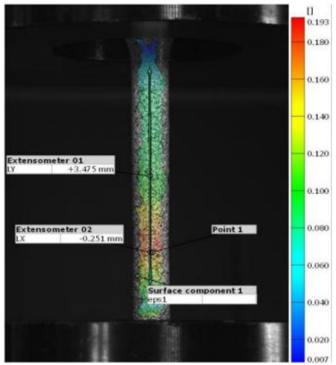
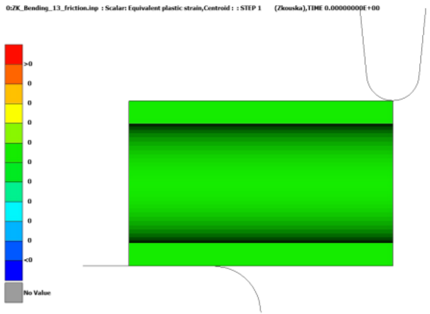
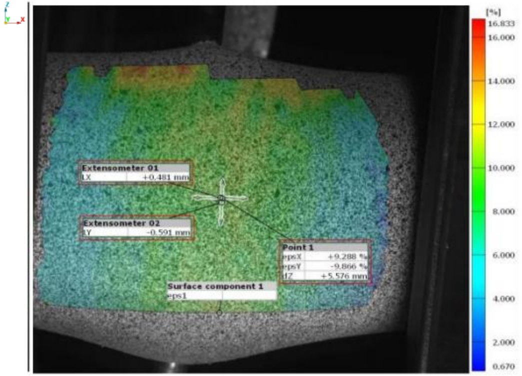
```
*PLASTIC, HARDENING=ISOTROPIC
```









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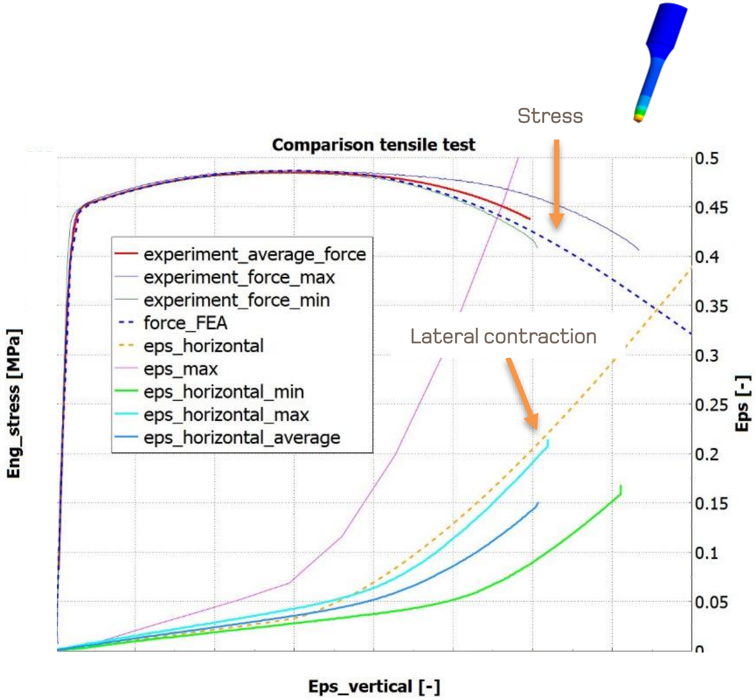
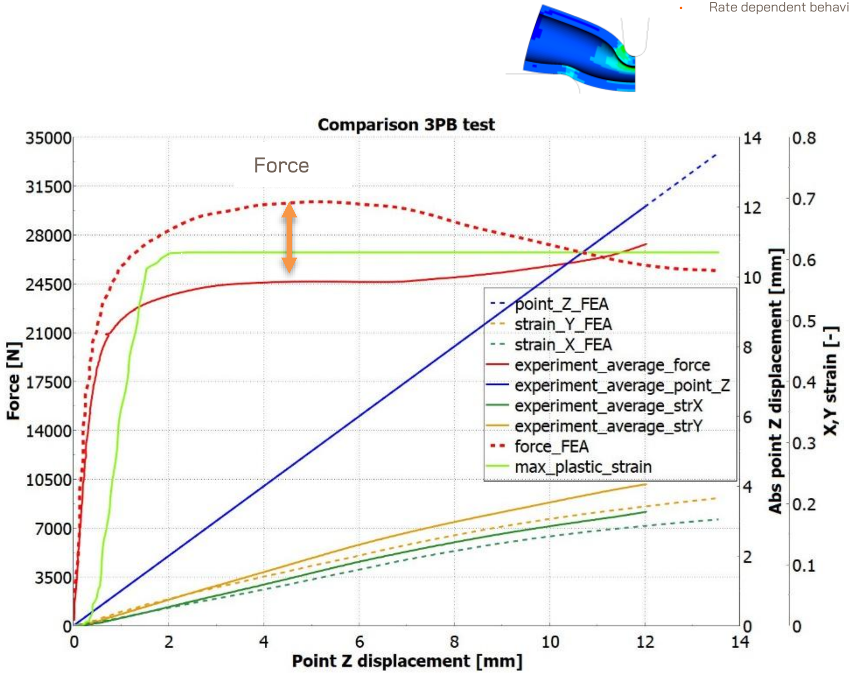
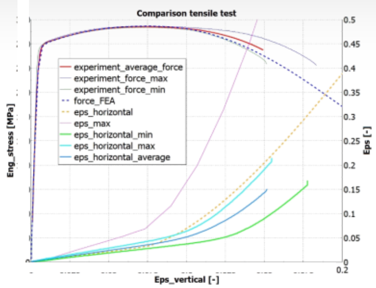
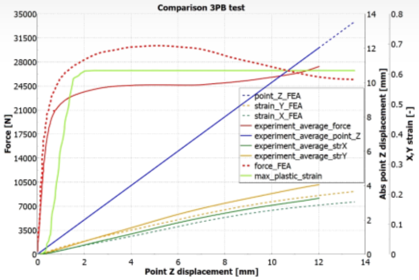


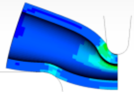


ALUMINIUM & STEEL ALLOYS

TRESCA-LIKE YEILD







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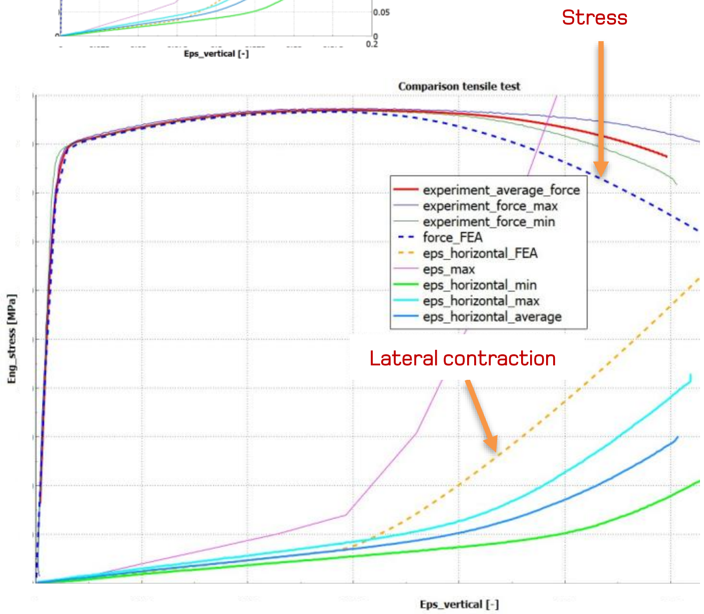
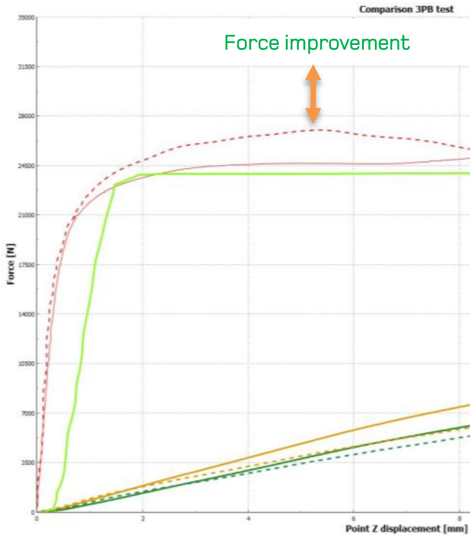
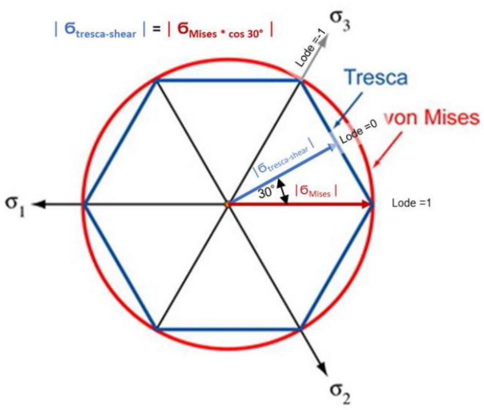





```
*PLASTIC, HARDENING=ISOTROPIC
*POTENTIAL,TYPE=TRESCA
```

(Hosford)



Tresca Yeild

- Elasticity
- Plasticity
- Pressure-dependent yeild surface
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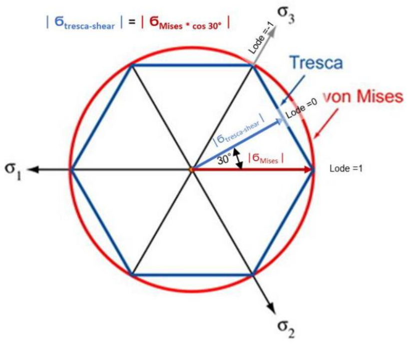
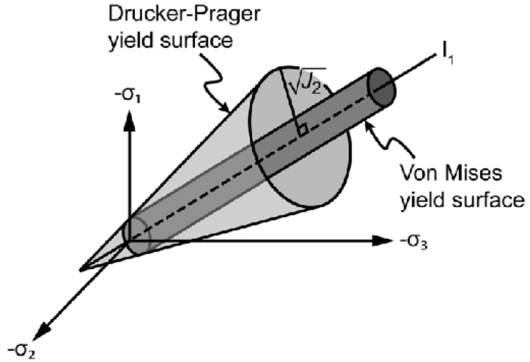
User defined field, type=specified

- Can model yeild surface based on e.g. LODE,TRIAX, PRESS
- Works with Standard & Explicit
- Works with shell
- Good performance

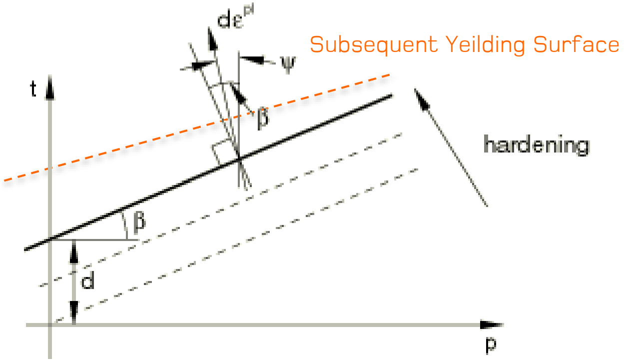
- Convergence is not guaranteed, especially in the case of Abaqus/Standard, and may lead to unstable solutions.

```
*DRUCKER PRAGER, SHEAR CRITERION=linear, DEPENDENCIES=2
**Friction Ang., 1=MISES Yeild Surf.,Dilation Ang., temp, LODE, PRESS
*DRUCKER PRAGER HARDENING, TYPE=COMPRESSION, DEPENDENCIES=2
**TENENSILE_STRESS, STRAIN      ,TEMP,  LODE    , PRESS
*User defined field,type=specified
 1, LODE
 2, PRESS
```



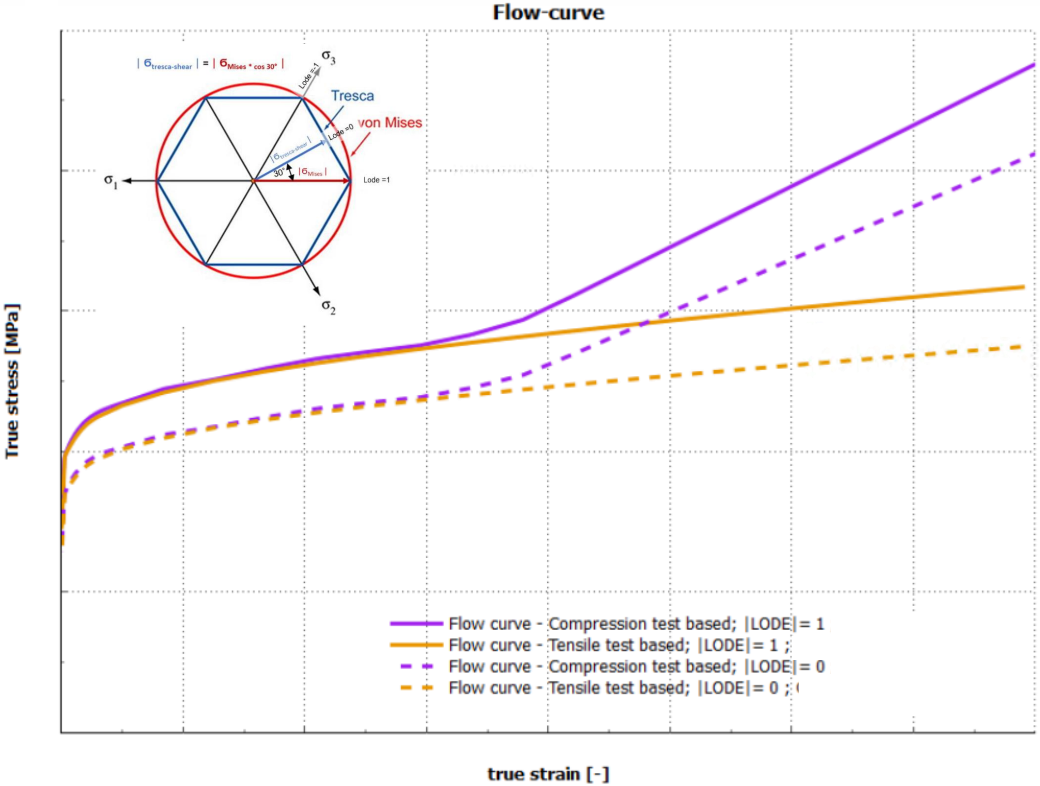


Dilation Angle $\psi \neq 0$ -> **non-associative flow rule**
"Poisson's ratio" in the plastic regime



ALUMINIUM & STEEL ALLOYS

Tresca Yeild



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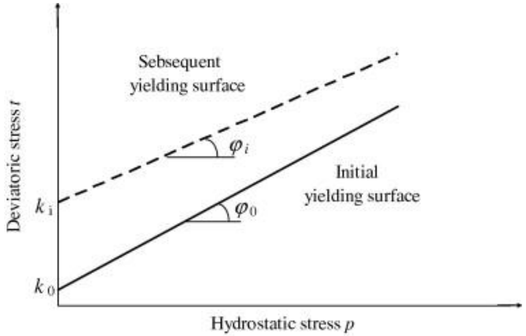
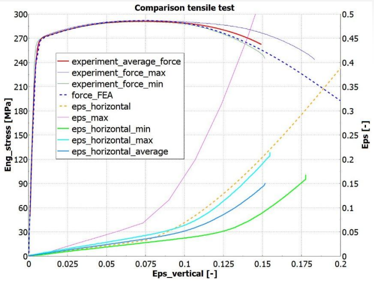
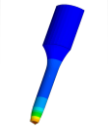
Dilation Angle ψ ≠ 0 -> **non-associative flow rule**
"Poisson's ratio" in the plastic regime

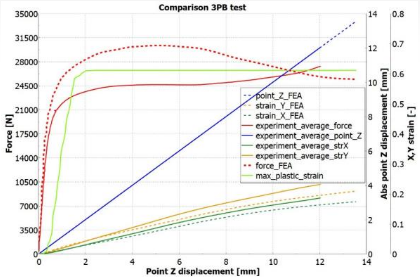


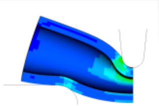
ALUMINIUM & STEEL ALLOYS

TRESCA YEILD









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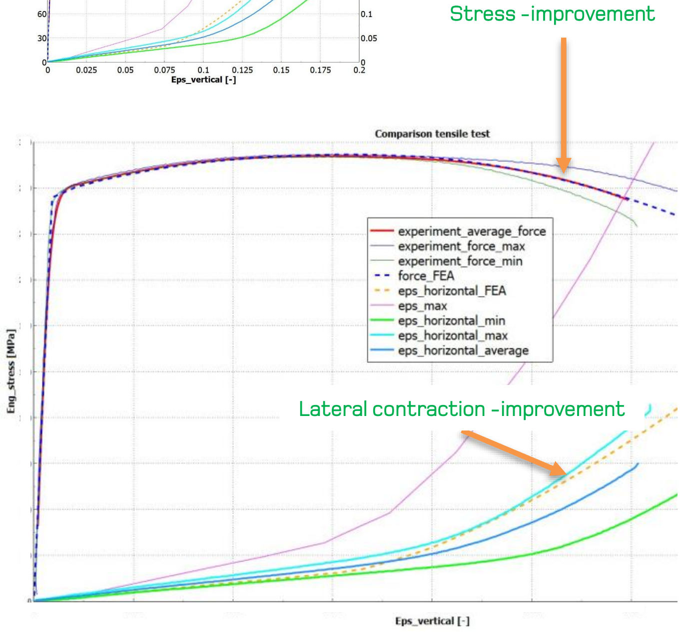
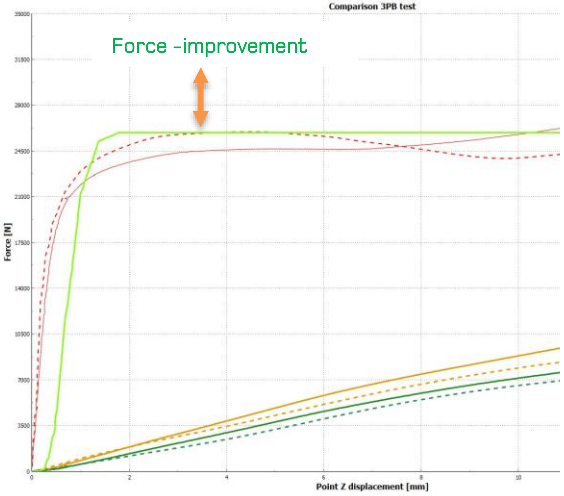
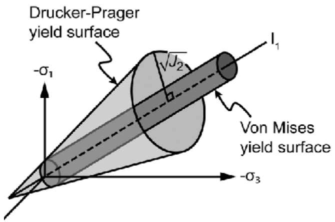
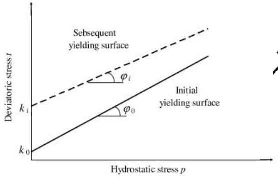
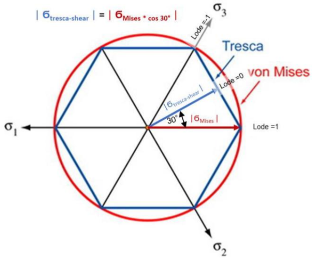


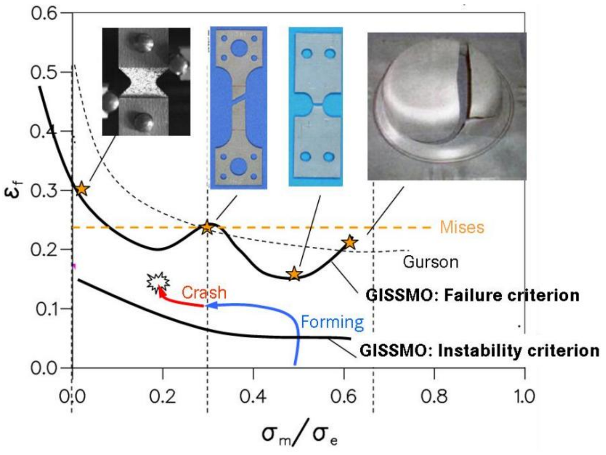






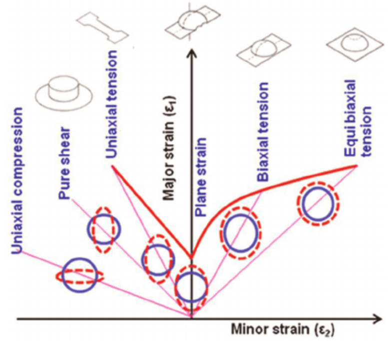


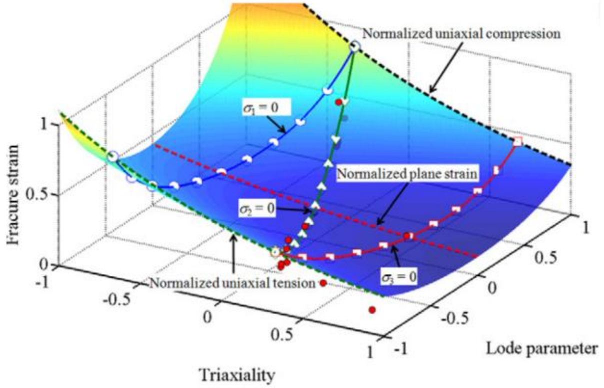
GISSMO approach



ABAQUS

- Hosford-Coulomb damage final failure
- FLD (Shell only)



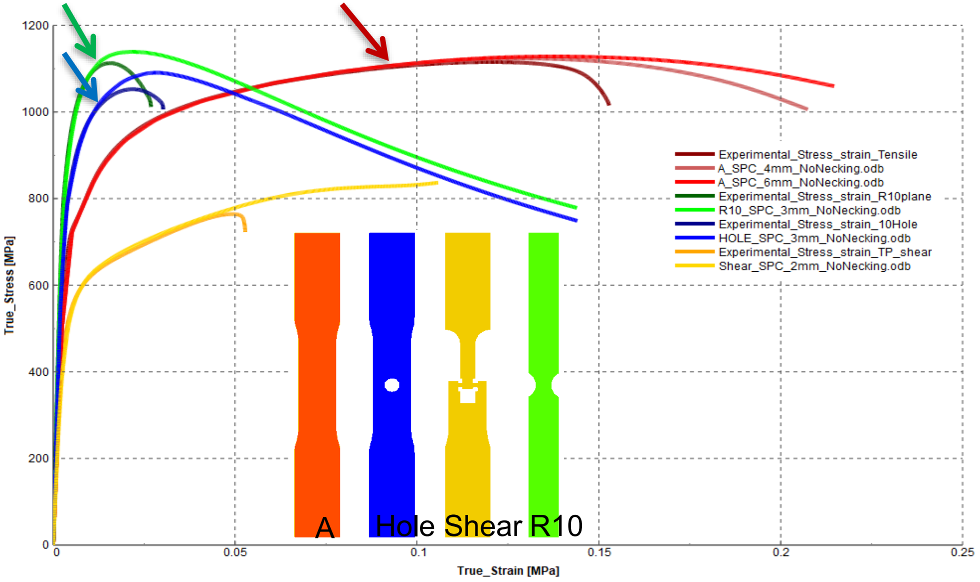


ALUMINIUM & STEEL ALLOYS

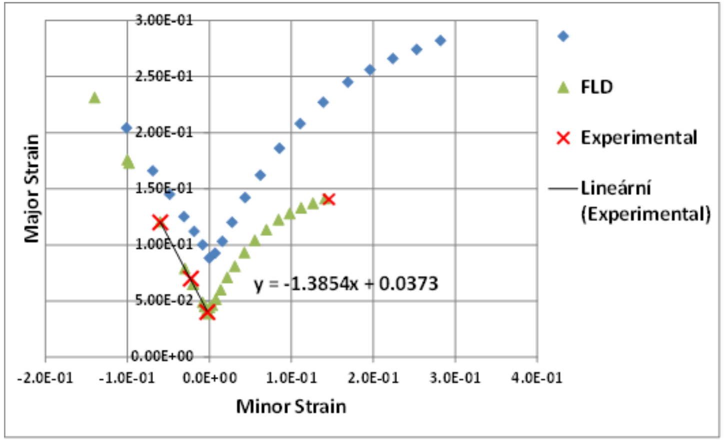
INSTABILITY CRITERION

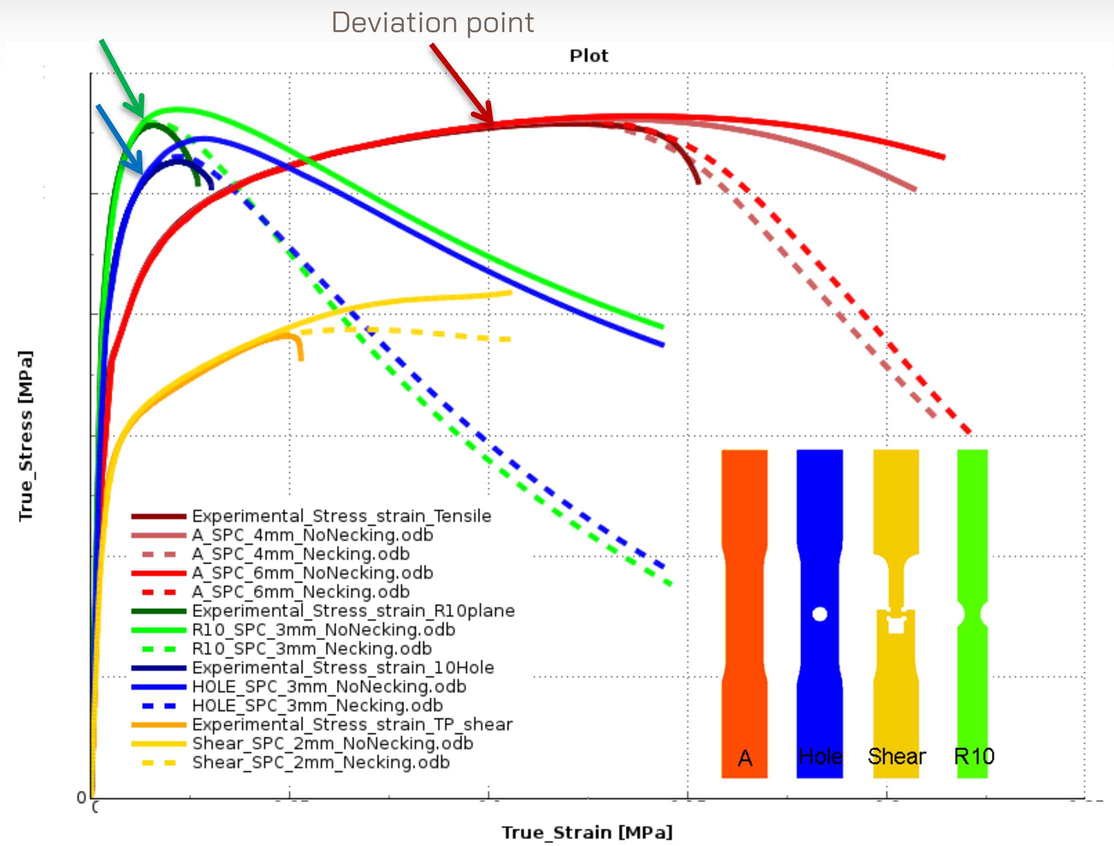
- Elastic + Plastic model vs experiment

Deviation point



ABQ_INSTABILITY_FLD				
	ε_{minor}	ε_{major}	alfa	PEEQ
A	-6.00E-02	1.20E-01	-5.00E-01	0.12
Hole	-2.26E-02	7.00E-02	-3.23E-01	0.07
R10	-2.55E-03	4.00E-02	-6.38E-02	0.04

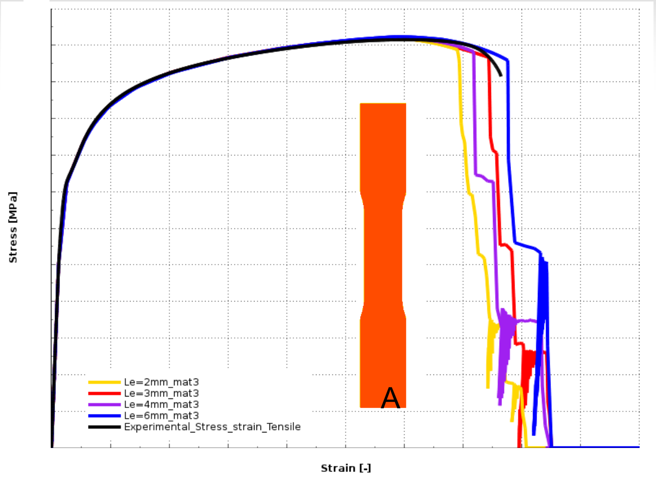




*DAMAGE INITIATION, CRITERION=MSLDFLD, DEFINITION=MSFLD
*DAMAGE EVOLUTION
**"Soft definition of damage evolution"

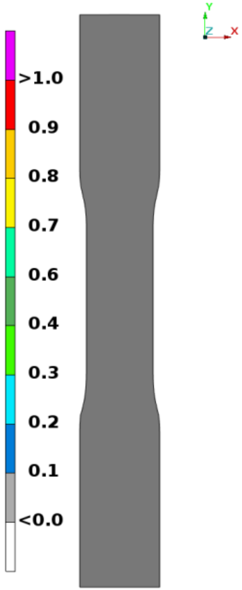
ALUMINIUM & STEEL ALLOYS

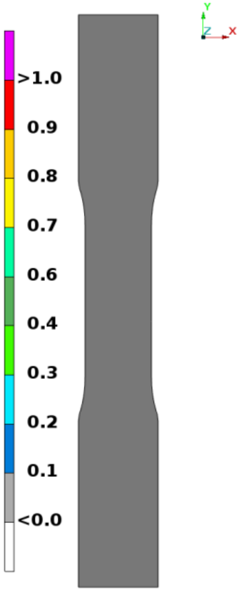
2 CRITERIA DUCTILE FAILURE APPROACH



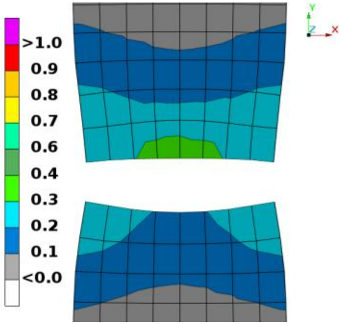
*DAMAGE INITIATION, CRITERION=MSLDFLD, DEFINITION=MSFLD
*DAMAGE EVOLUTION
**"Soft definition of damage evolution"

*DAMAGE INITIATION, CRITERION=HC
*DAMAGE EVOLUTION
**"hard cut"

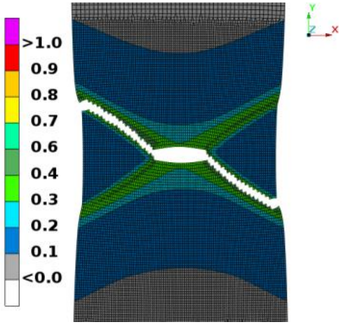




3mm MESH



0.25mm MESH

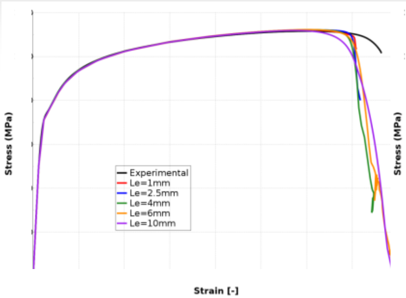


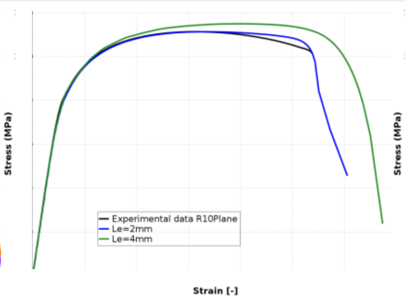
Test specimen

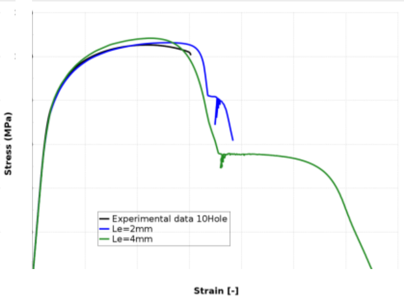
ALUMINIUM & STEEL ALLOYS

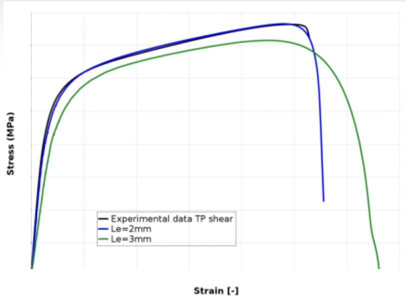
INSTABILITY CRITERION

LS-DYNA

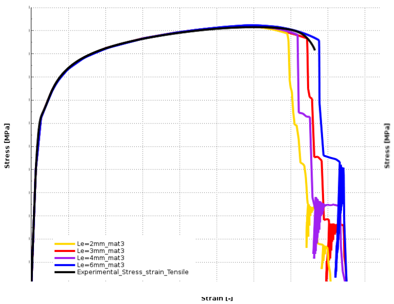


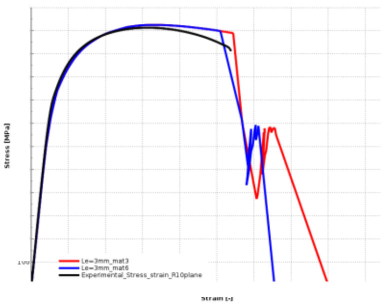


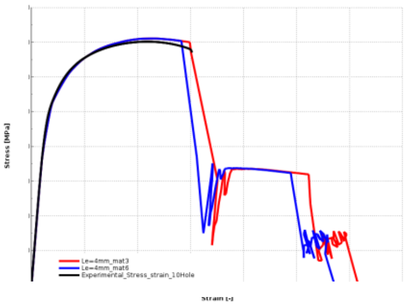


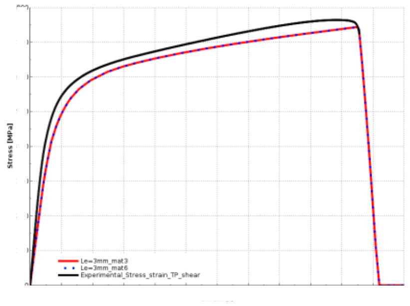


ABAQUS





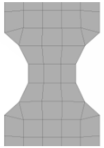




JSI5

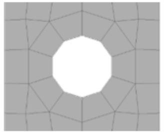
R10 Plane

3.4mm mesh*



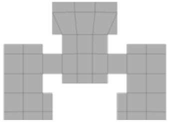
10 Hole

4mm mesh*



TP shear

3mm mesh



Conclusion

- Advanced material models improve model fidelity

- ABAQUS modular phylosophy allows an eqivalent modeling performance
- This works for both ABAQUS Standard & Explicit

- We make sure that our models describe reality in a wide spectrum of cases.

- Calibration, validation, and transferring of material models between solvers is both time-consuming and financially demanding. – Software tools, scripts, metodology are needed.

- IDIADA team is ready to help you in this field

THANK YOU

FOR YOUR KIND ATTENTION

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