i3C Phase 2

Chaire de recherche industrielle
du CRSNG sur l'interaction
charges lourdes-climat-chaussées

Development of an analysis tool to quantify the effect of superheavy load vehicles on pavements

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GRINCH
GROUPE DE RECHERCHE EN INGÉNIERIE DES CHAUSSÉES

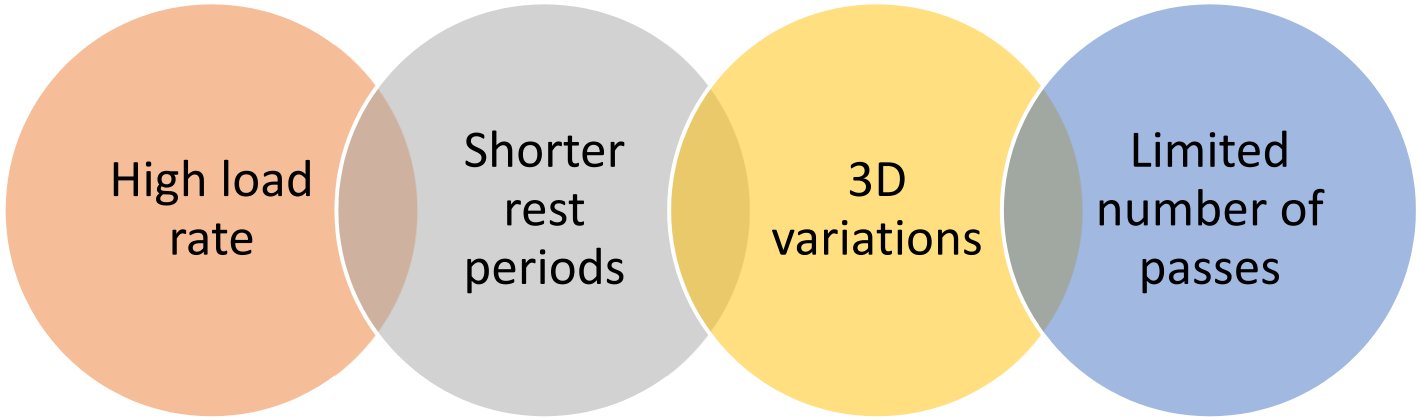
CRSNG NSERC

Presentation Outline

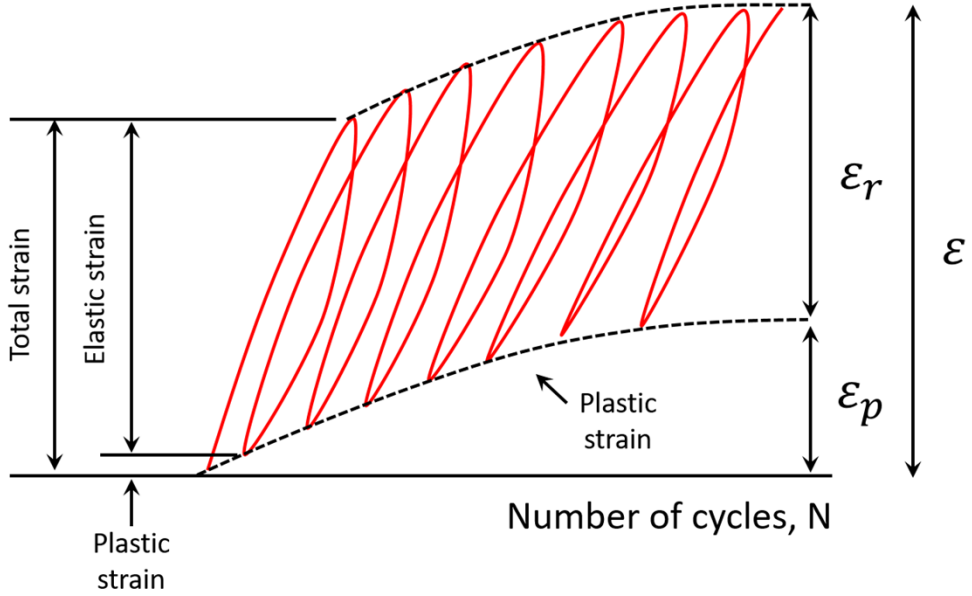
1. Introduction
   a. Research needs and goals
2. Criteria and software development
   a. Proposed analysis criteria
   b. Software organization
3. Application examples
4. Conclusions and future work

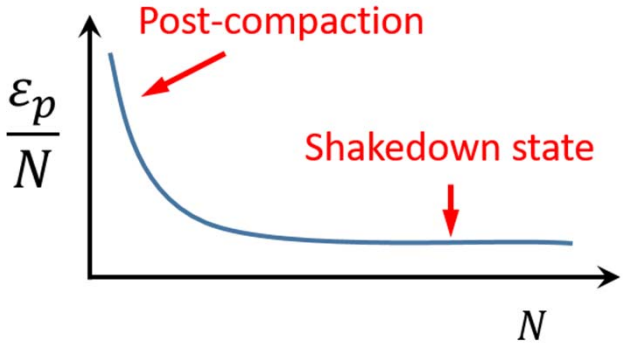

XTRA
H2O

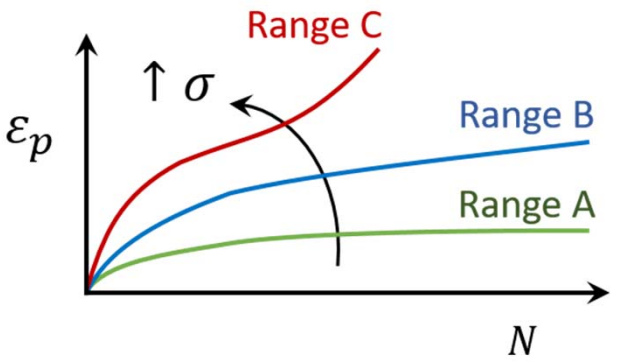

↑ 150kN per axle
Unconventional axle configuration
ABB


High load rate
Shorter rest periods
3D variations
Limited number of passes

Problem Statement:
Research needs and goals







Based on: Lekarp & Dawson, 1998; Dawson & Wellner, 1999; Werkmeister et al., 2001; Rahman & Erlingsson, 2015.

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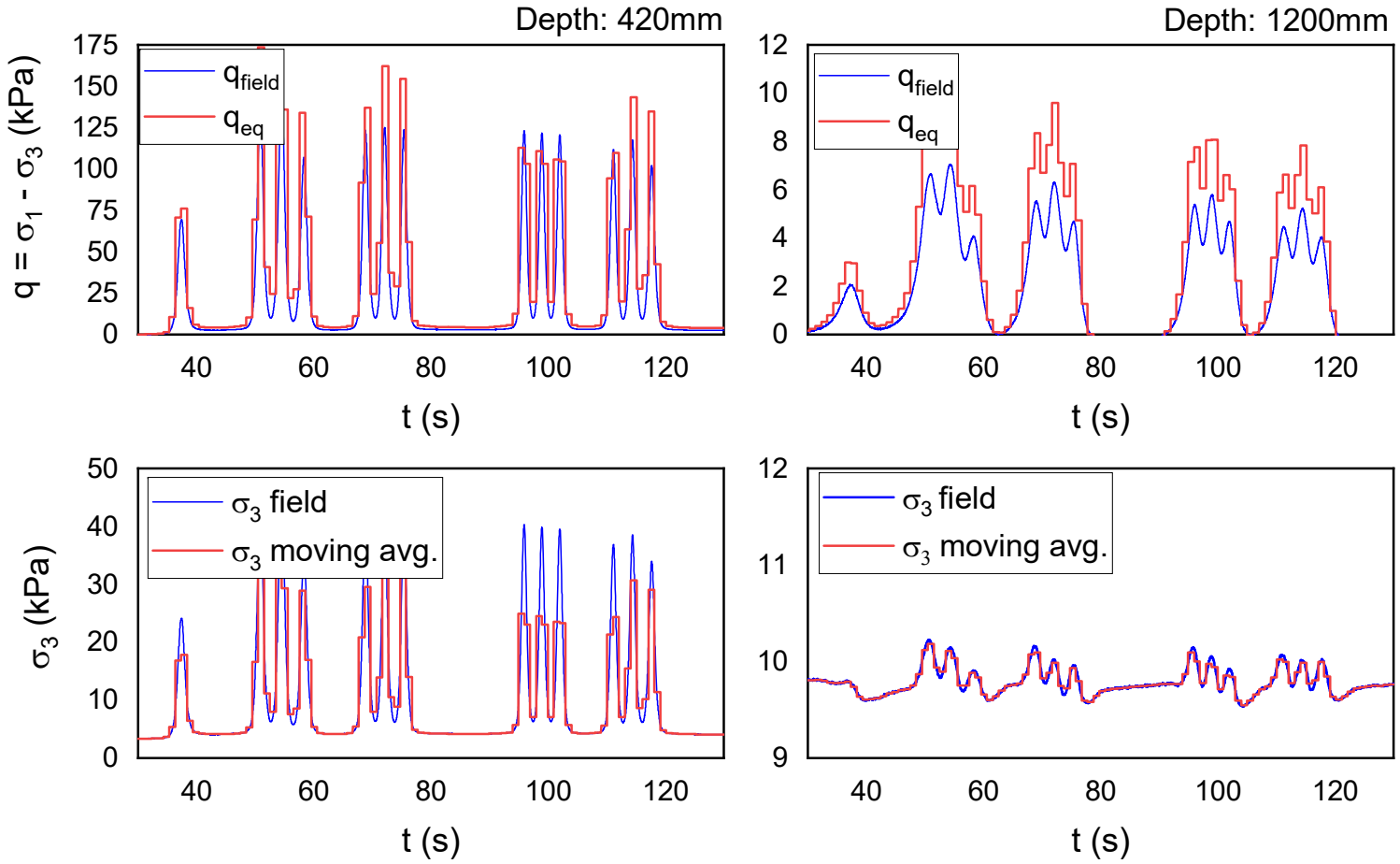
Research needs and goals



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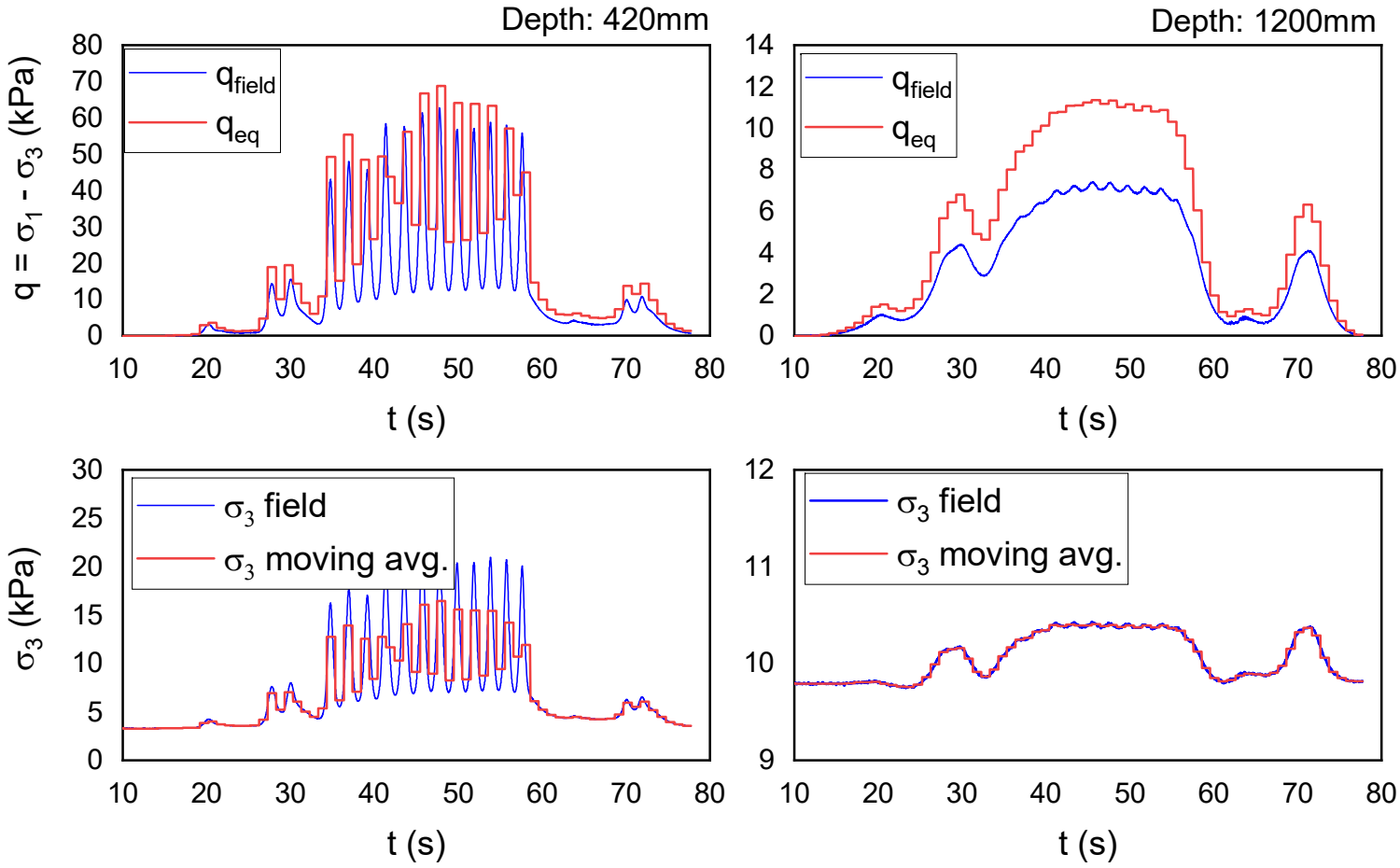
Research needs and goals



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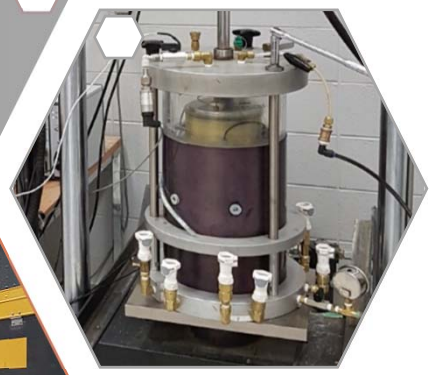
Criteria and software development:

Proposed analysis criteria

Transport of multi-axle SHL (2019, 2020)

Repeated load triaxial (RLT) testing (2017 - 2020)

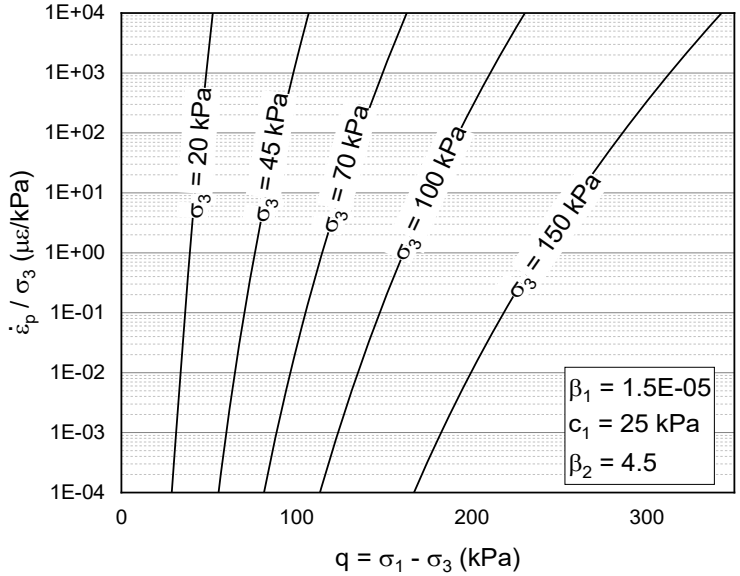


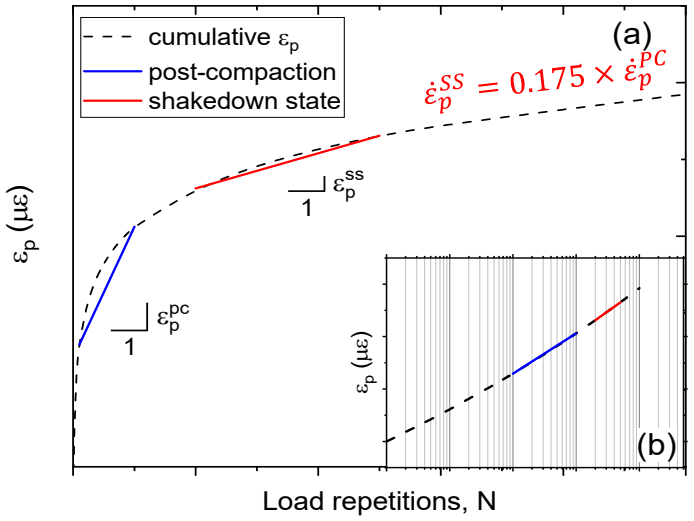
Accelerated pavement test (2018)

Incremental loading conditions (2017,2018)

Criteria and software development:

Proposed analysis criteria | Damage indicator





$$\frac{\dot{\varepsilon}_p}{\sigma_3} = \beta_1 N_c \left(\frac{|q_{eq} - c_1|}{\sigma_3} \right)^{\beta_2}$$

Where, $\dot{\varepsilon}_p$ is the plastic strain rate,

q_{eq} is the deviatoric stress lab/field equivalent, in kPa

σ_3 is the confinement stress in kPa.

β_1, β_2 and c_1 are shape parameters

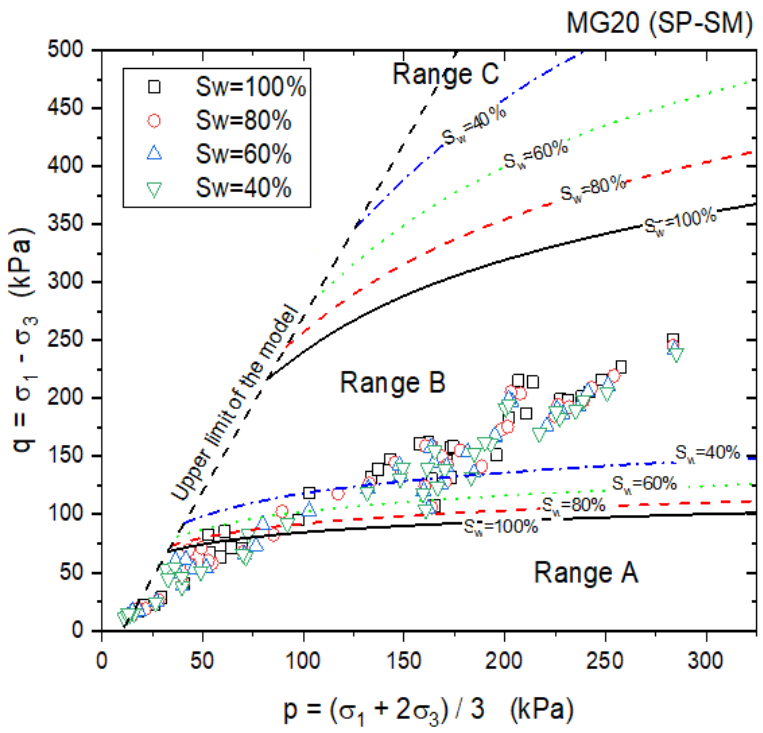
N_c is an adjustment factor to consider S_w and ρ_d

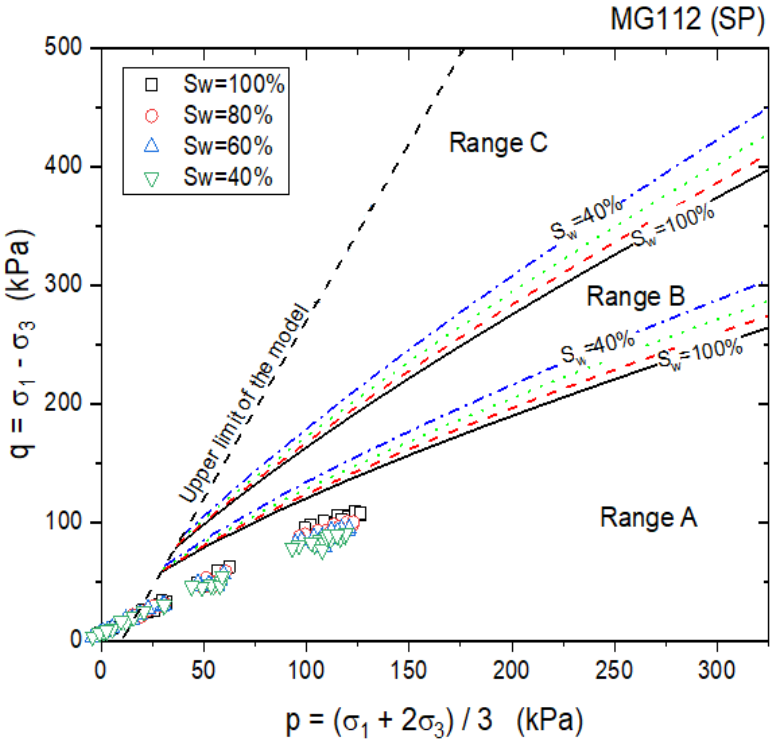
$$q_{eq} = q_{min} - \left(\frac{\pi \times (q_{avg} \times t - q_{min})}{2 \times \cos(\pi \times t)} \right)$$

$$N_c = \frac{\dot{\varepsilon}_p}{\dot{\varepsilon}_p^{ref}} = a_1 \times S_w \times \left(\frac{\rho_d}{\rho_w} \right) + a_2 \times S_w$$

Criteria and software development:

Proposed analysis criteria | Limit state





$$q_{lim} = \sigma_3 \left(\frac{\dot{\varepsilon}_p}{\beta_1 N_c \sigma_3} \right)^{1/\beta_2} + c_1$$

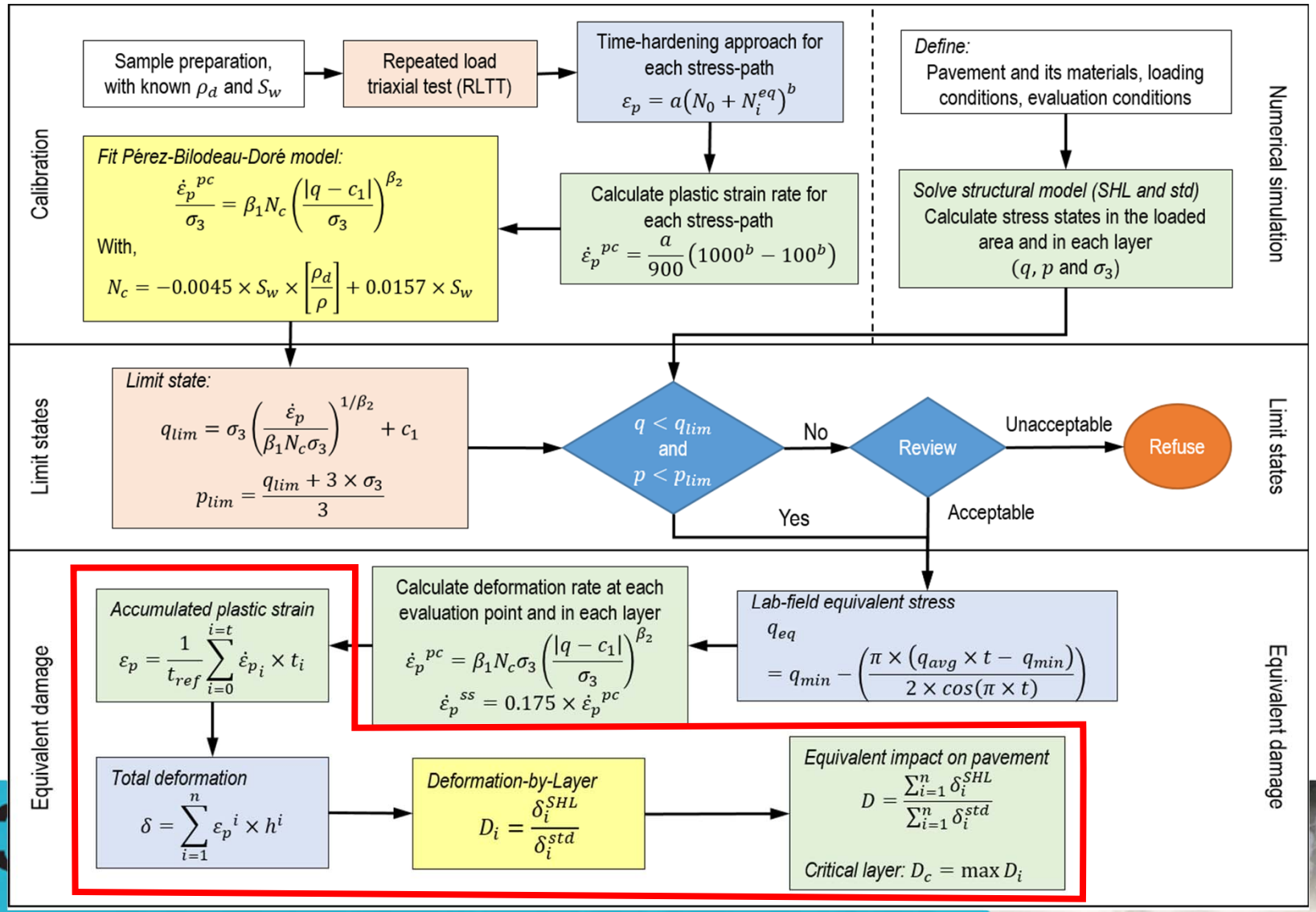
$$p_{lim} = \frac{q_{lim} + 3 \times \sigma_3}{3}$$

Limit	PD accumulation between 3000 and 5000 cycles	Deformation rate ($\dot{\varepsilon}_p$)
Range A – Range B	45 με	2.25 10^{-2} με /cycle
Range B – Range C	450 με	2.25 10^{-1} με /cycle

Source: CEN, 2003

Criteria and software development:

Proposed analysis criteria | Analysis criteria



Criteria and software development:
i3C-SHL software

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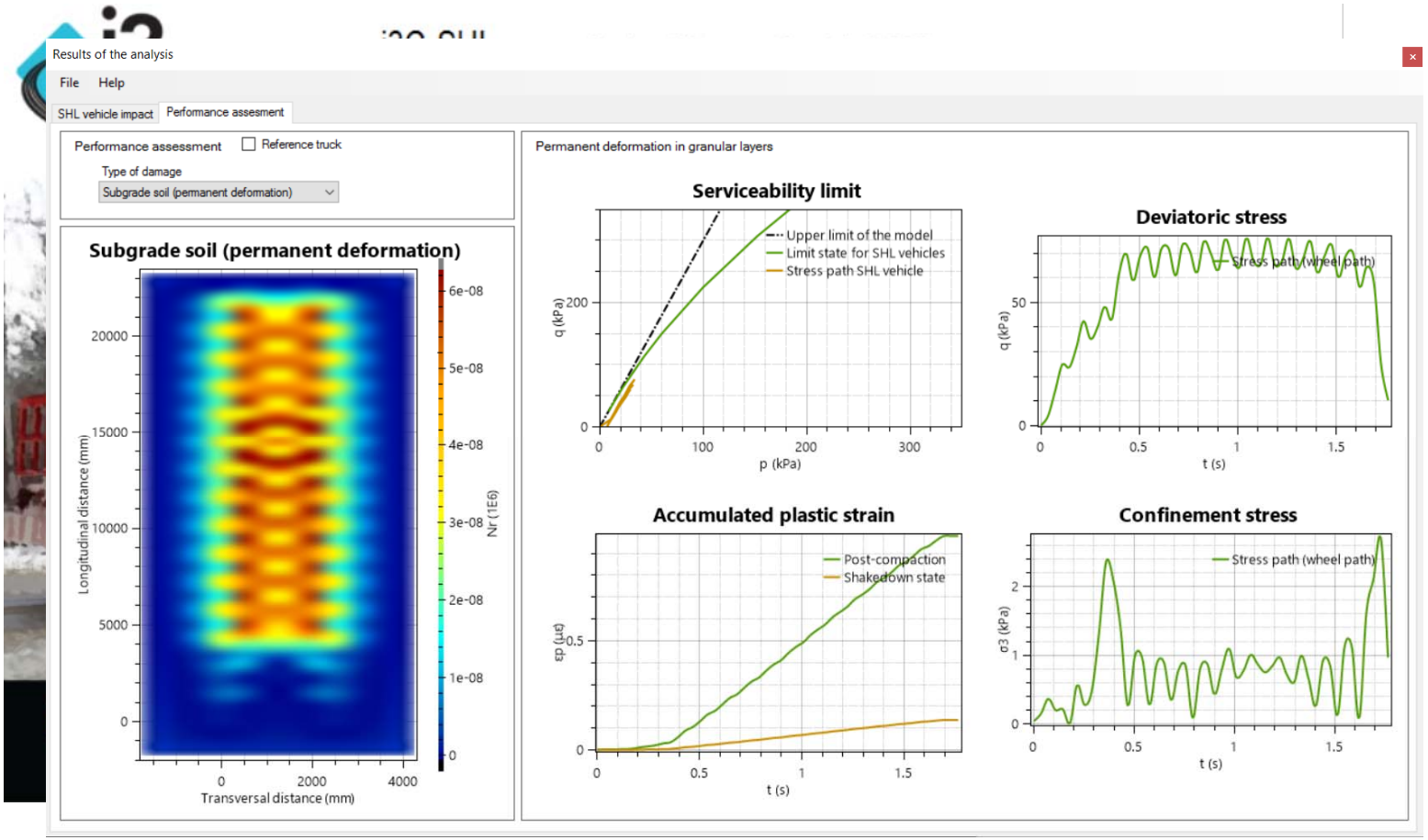
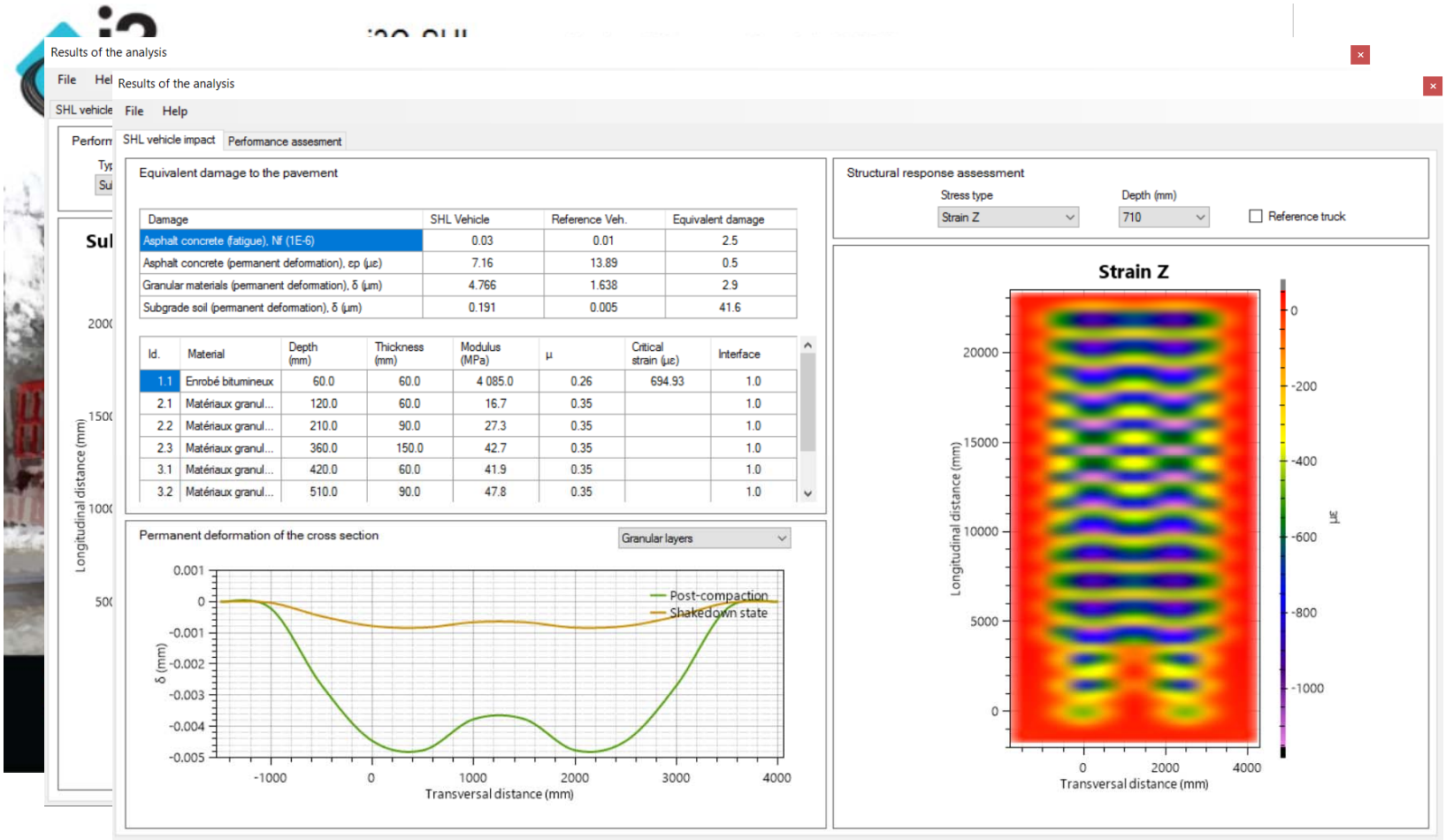


Criteria and software development:
i3C-SHL software



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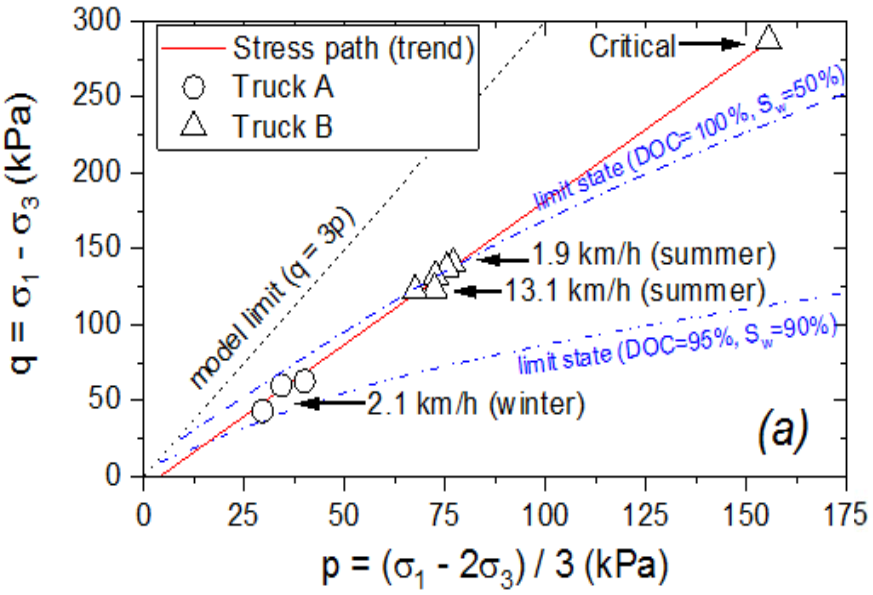
Application examples (field measurement) :
La route de la Baie-James (RBJ)

Case		1	2	3	4	5
Season		Winter	Summer			
Vehicle type		Truck A	Truck B			Critical
Number of passes		3	2	1	2	1
Speed. (km/h)	Mean	2.1	1.9	6.1	13.1	2.5
	Std.Dev	0.550	0.282	-	0.712	0.125

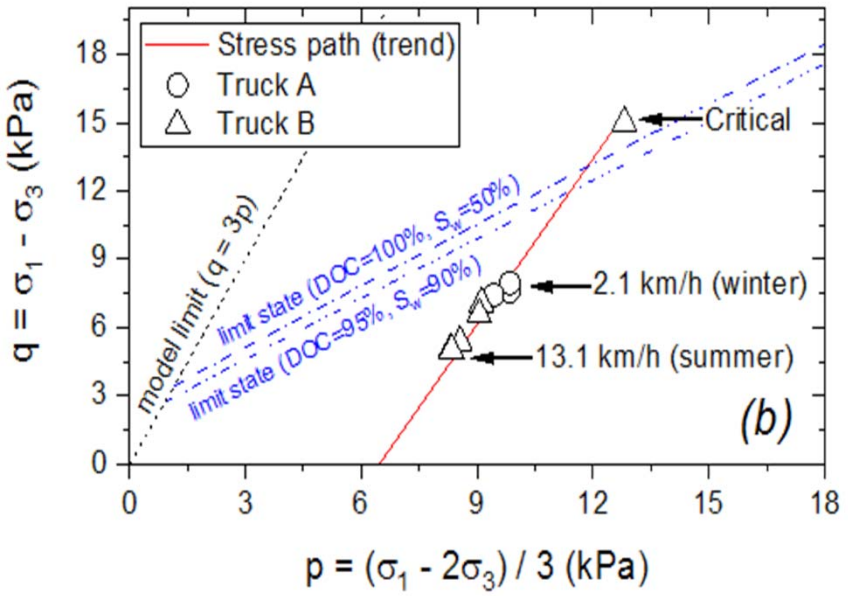
Application examples (field measurement) :

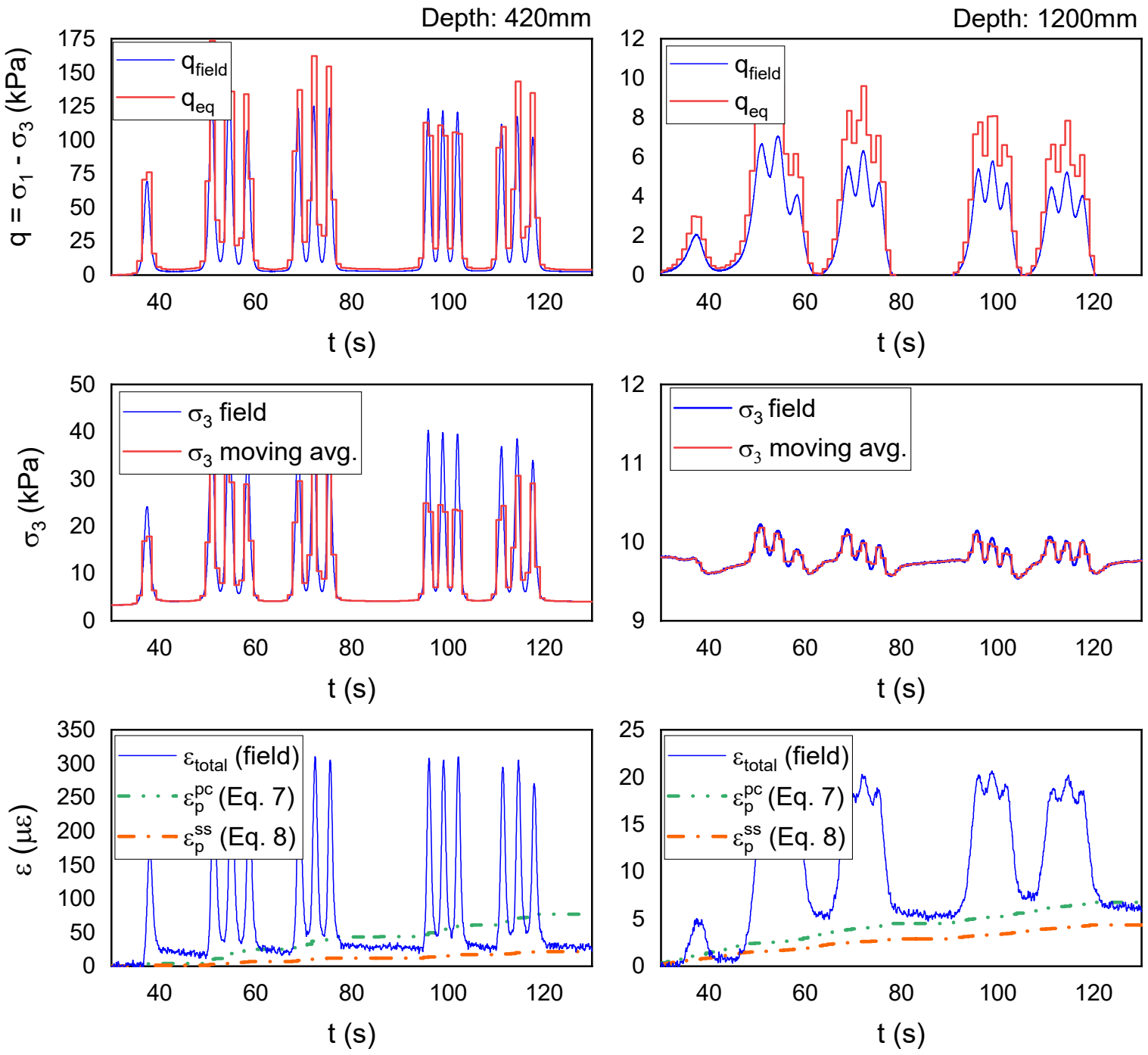
RBJ | Limit state and stress paths (field measurement)

MG20 (GW) at 420mm depth



MG112(SP) at 1320mm depth




Depth: 420mm
Depth: 1200mm
q = σ1 - σ3 (kPa)
qfield
qeq
t (s)
σ3 (kPa)
σ3 field
σ3 moving avg.
ε (με)
εtotal (field)
εpc (Eq. 7)
εss (Eq. 8)

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Conclusions and future work

- Special axle configurations = Particular mechanical response
- A limit state, based on the Shakedown theory, can be defined for the analysis of SHL
- The permanent deformation rate offers a rational tool for the analysis of the SHL effect

Conclusions and future work

- It is still necessary to define performance models for asphalt concrete layers for SHL conditions
- It is necessary to offer alternatives to the parameters of the permanent deformation rate model at level 2 (based on material properties) and level 3 (typical values).

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Thank You!
Merci!

- Questions? -

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Partenaires