Behavior of partially saturated asphalt concrete pavement under freezing and accelerated pavement testing conditions

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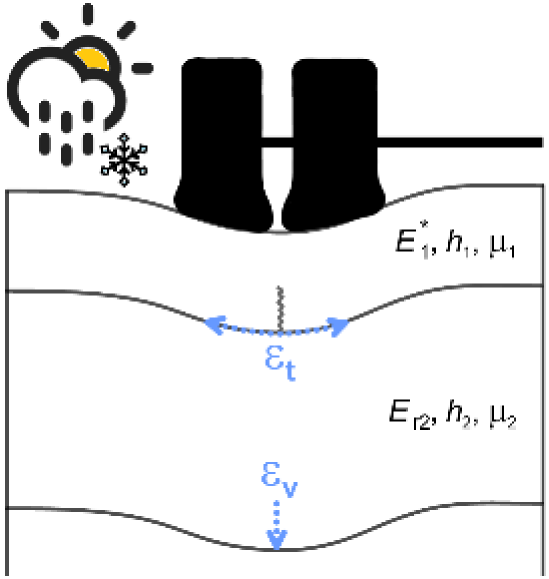
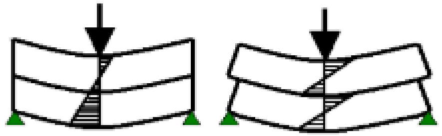
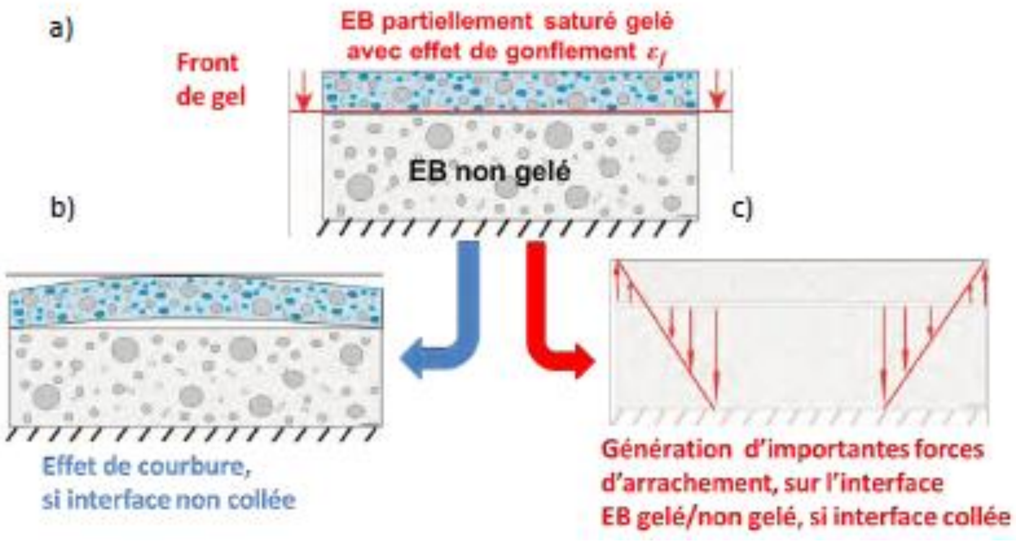


HMA bonding

- Importance of adequate HMA layers bonding for structural adequacy and monolithic response
    - HMA mix, aggregates, emulsion



- Inadequate bonding associated with lower load bearing capacity and increased damage
- Laboratory evidence of AC layers debonding when freezing of a water-rich surface layer
    - Strains : Elastic, thermal and frost heave
- Suspected to play an important role in delamination and potholes development
- Development of an experimental protocol to quantify this phenomenon in combination of traffic loads



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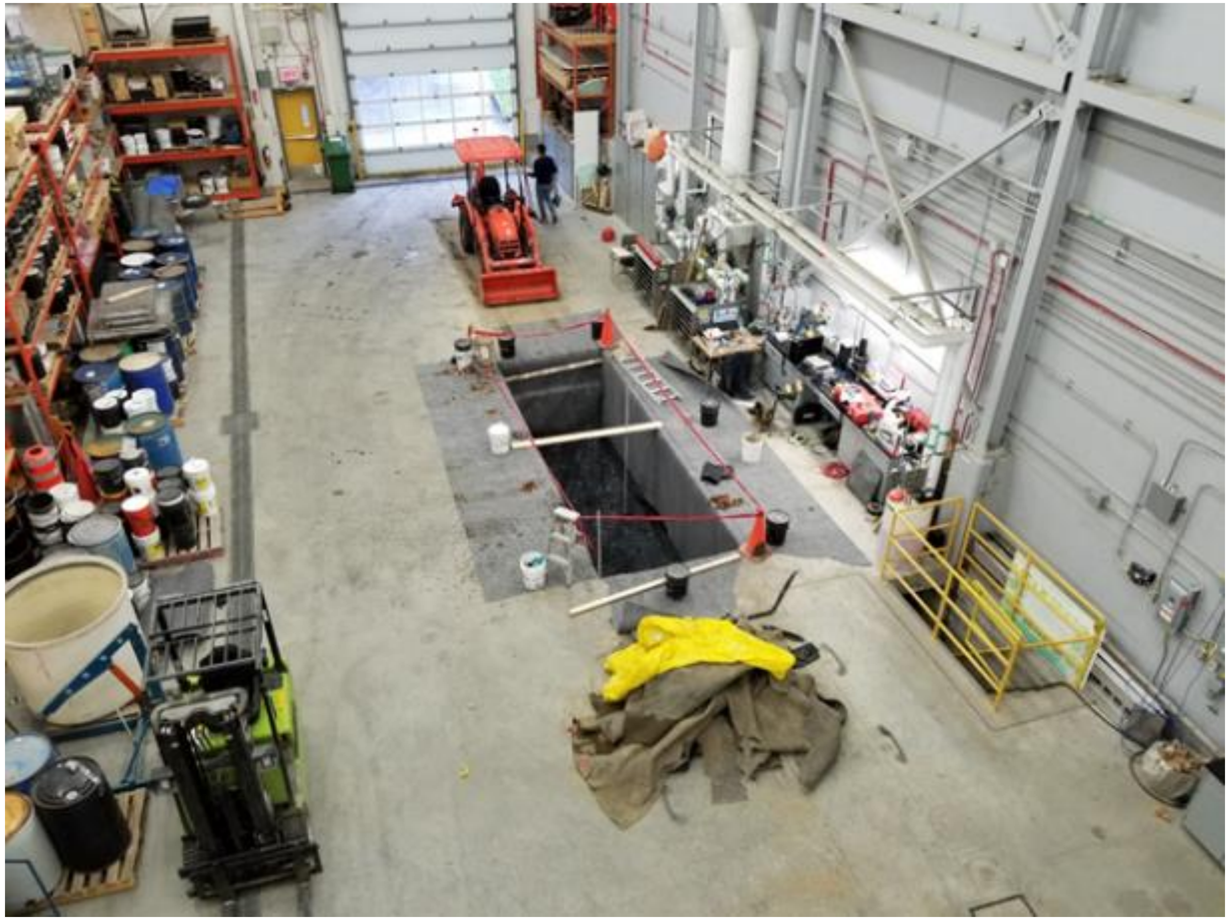

Test pit

- 2 x 6 x 2 m
- Temperature control (bottom)
- Water table control

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Construction

Examples of sensors :

Paving

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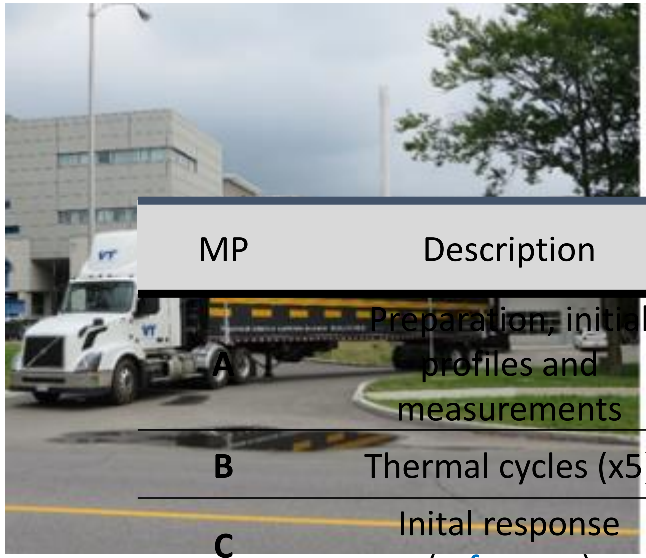
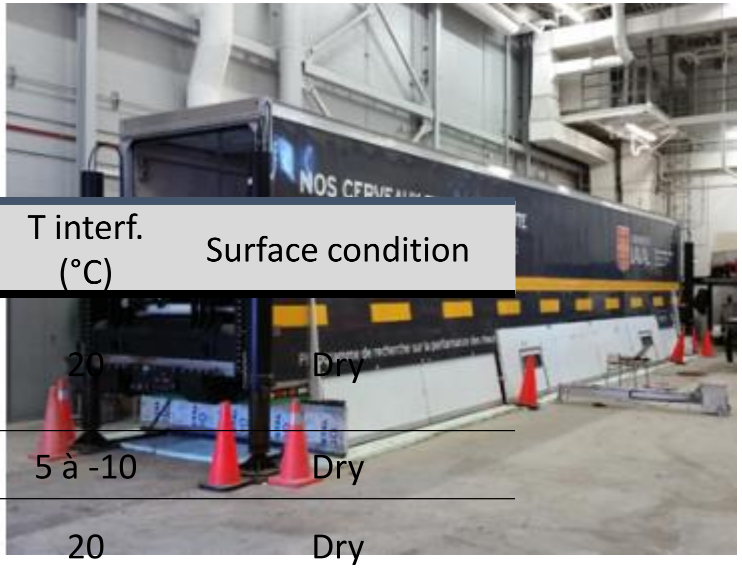
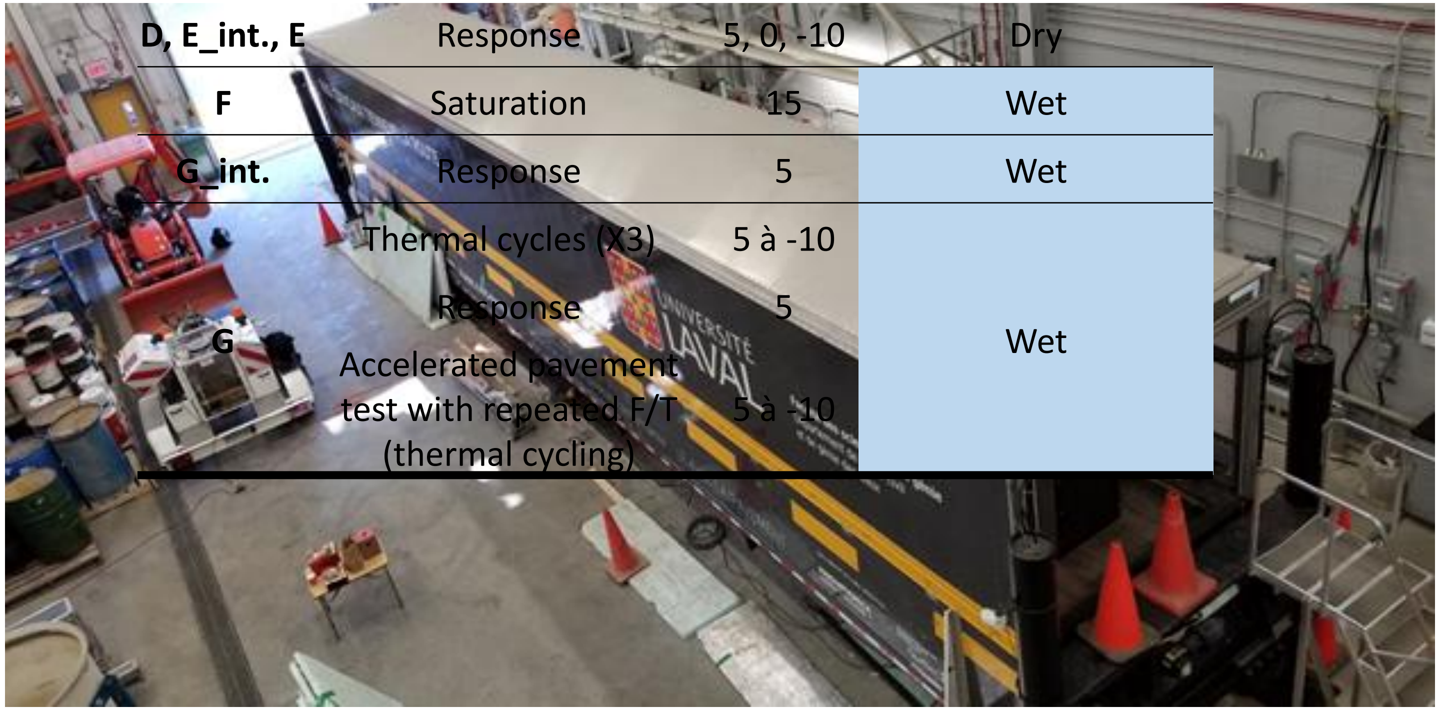
HVS

- Legal vehicle
- Lab. and in situ testing
- 20 K cycles / d
- 0 to 10 km/h
- 5 to 100 kN
- Wheel wandering
- 40+ to –20 °C



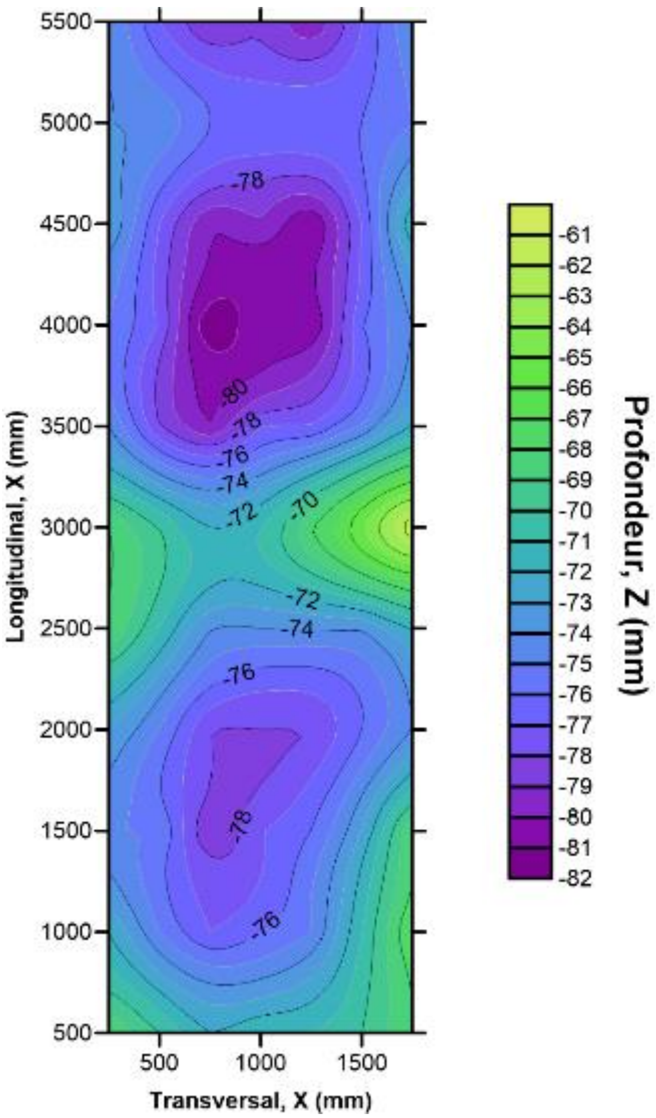




MP	Description	T interf. (°C)	Surface condition
A	Preparation, initial profiles and measurements	20	Dry
B	Thermal cycles (x5)	5 à -10	Dry
C	Inital response (reference)	20	Dry
D, E_int., E	Response	5, 0, -10	Dry
F	Saturation	15	Wet
G_int.	Response	5	Wet
G	Thermal cycles (X3)	5 à -10	Wet
	Response	5	
	Accelerated pavement test with repeated F/T (thermal cycling)	5 à -10	

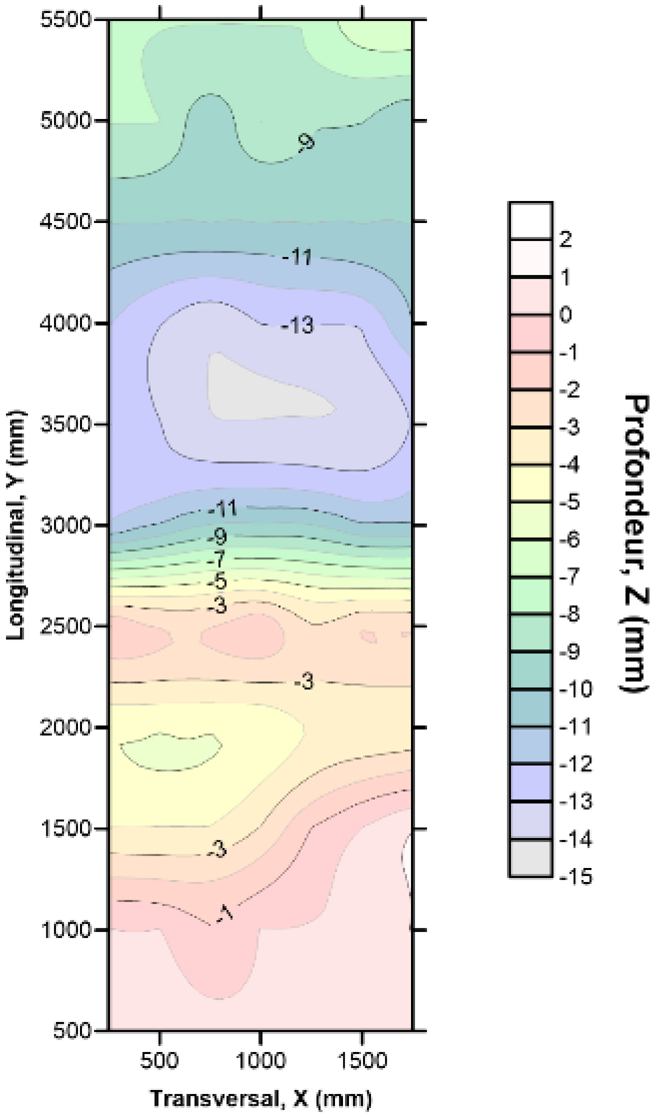
Layer	Thickness (mm)
HMA (surface)	68
HMA (base)	77
Unbound base	234
Unbound subbase	474
Silty sand	841
10-14 mm	300
Total thickness	1994

GB20



77 mm, SD=4

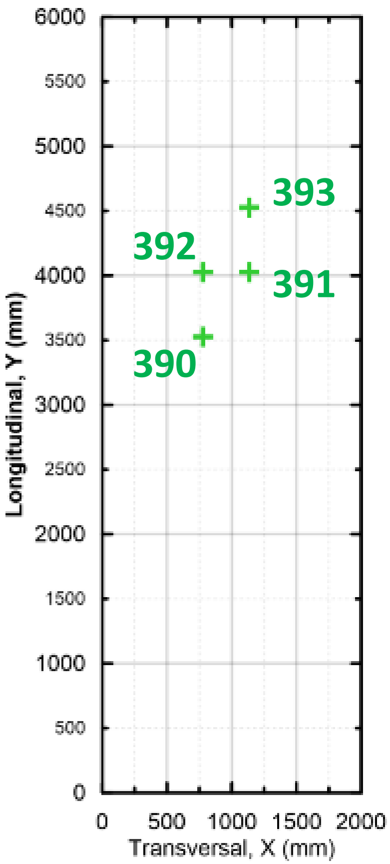
ESG10



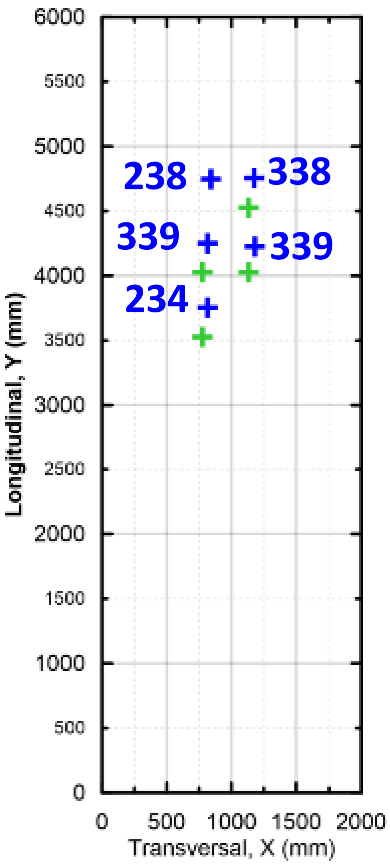
68 mm, SD=5

HMA sensors

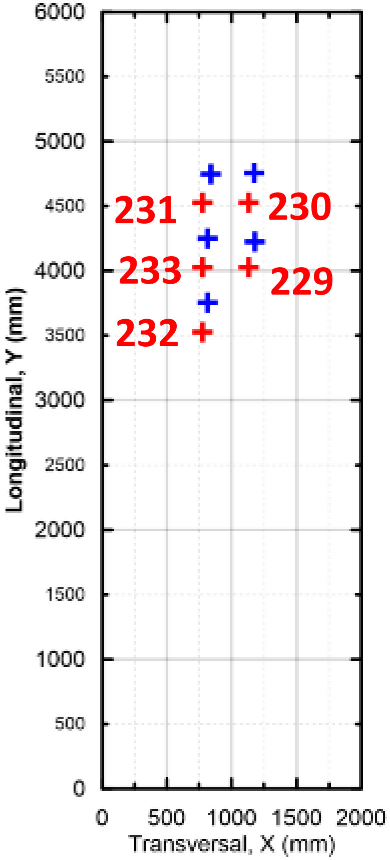
Bottom base layer



Top base layer



Bottom surface layer

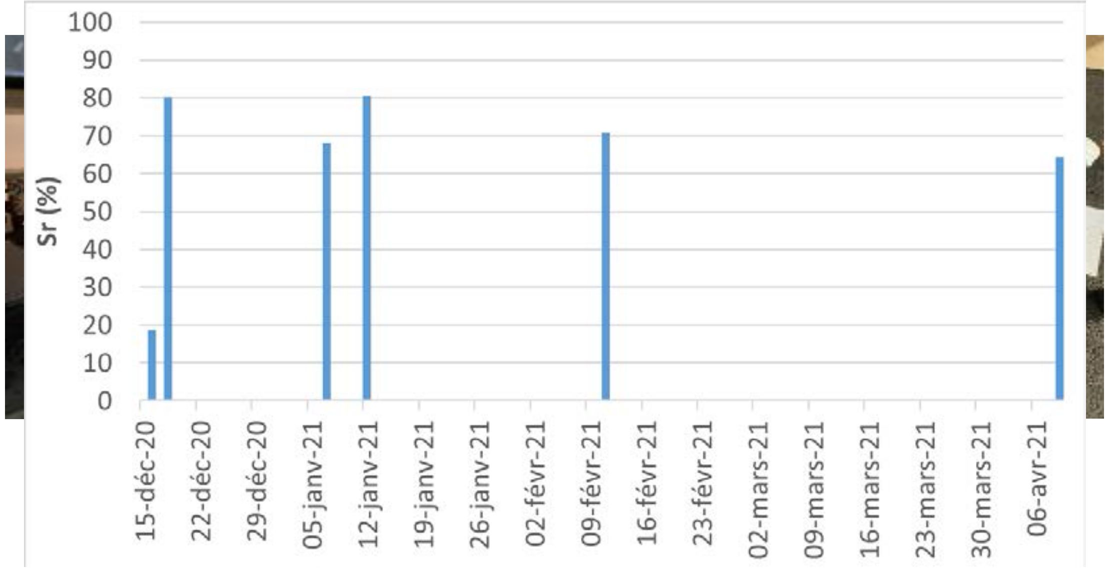


AC layers debonding under freeze-thaw cycles

- **Construction of a surface pit to increase the degree of saturation of the surface layer**

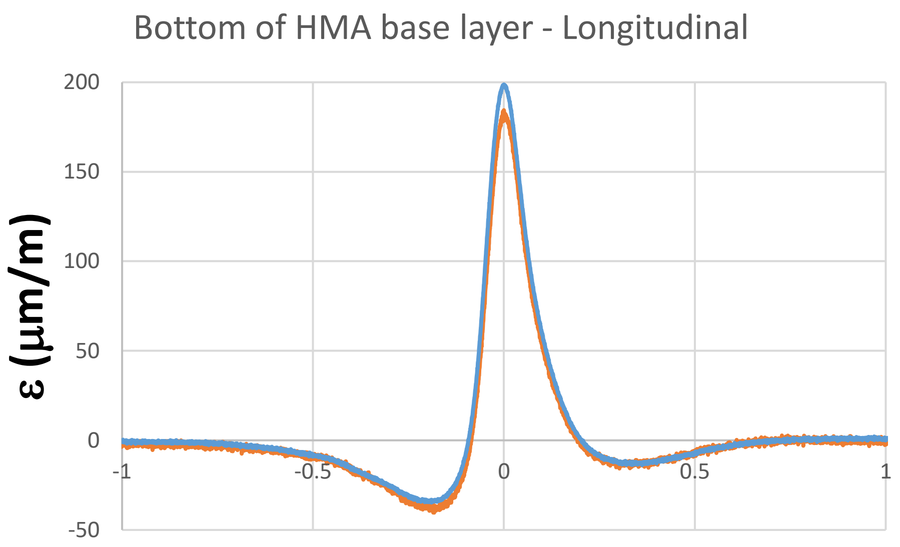
AC layers debonding under freeze-thaw cycles

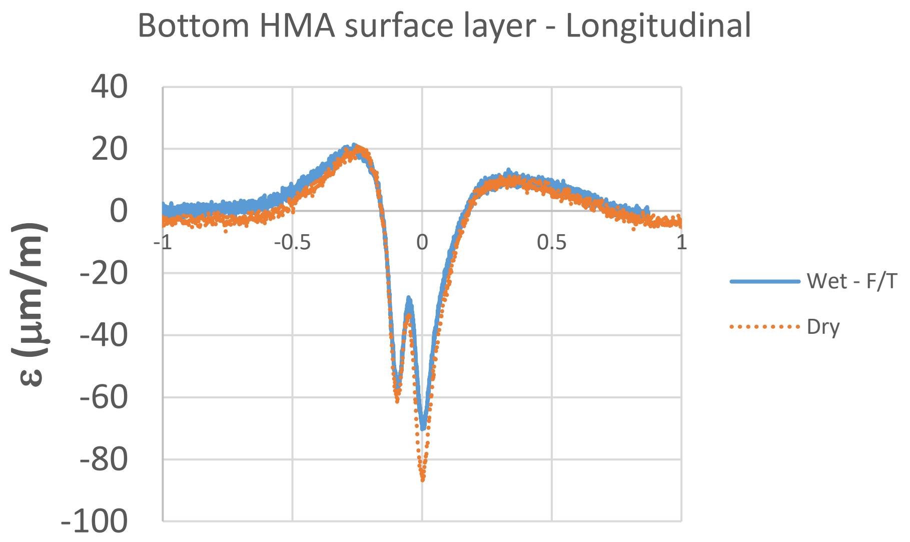
- Increasing the degree of saturation
- Estimated degree of saturation of the AC surface layer of 60 %



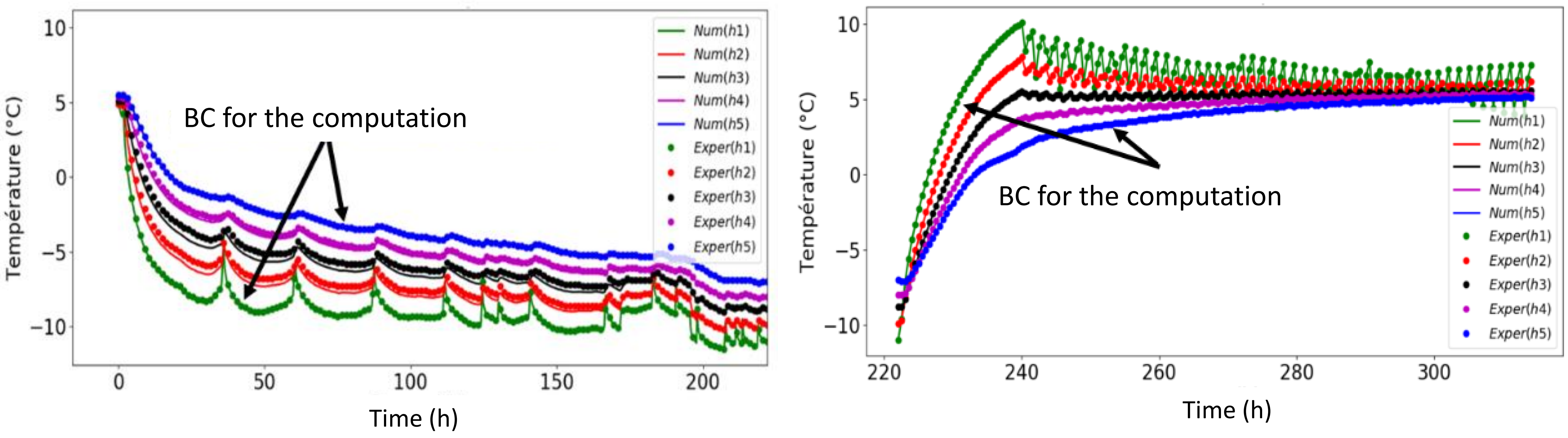
Mechanical response

- Ongoing analysis of mechanical strain signals

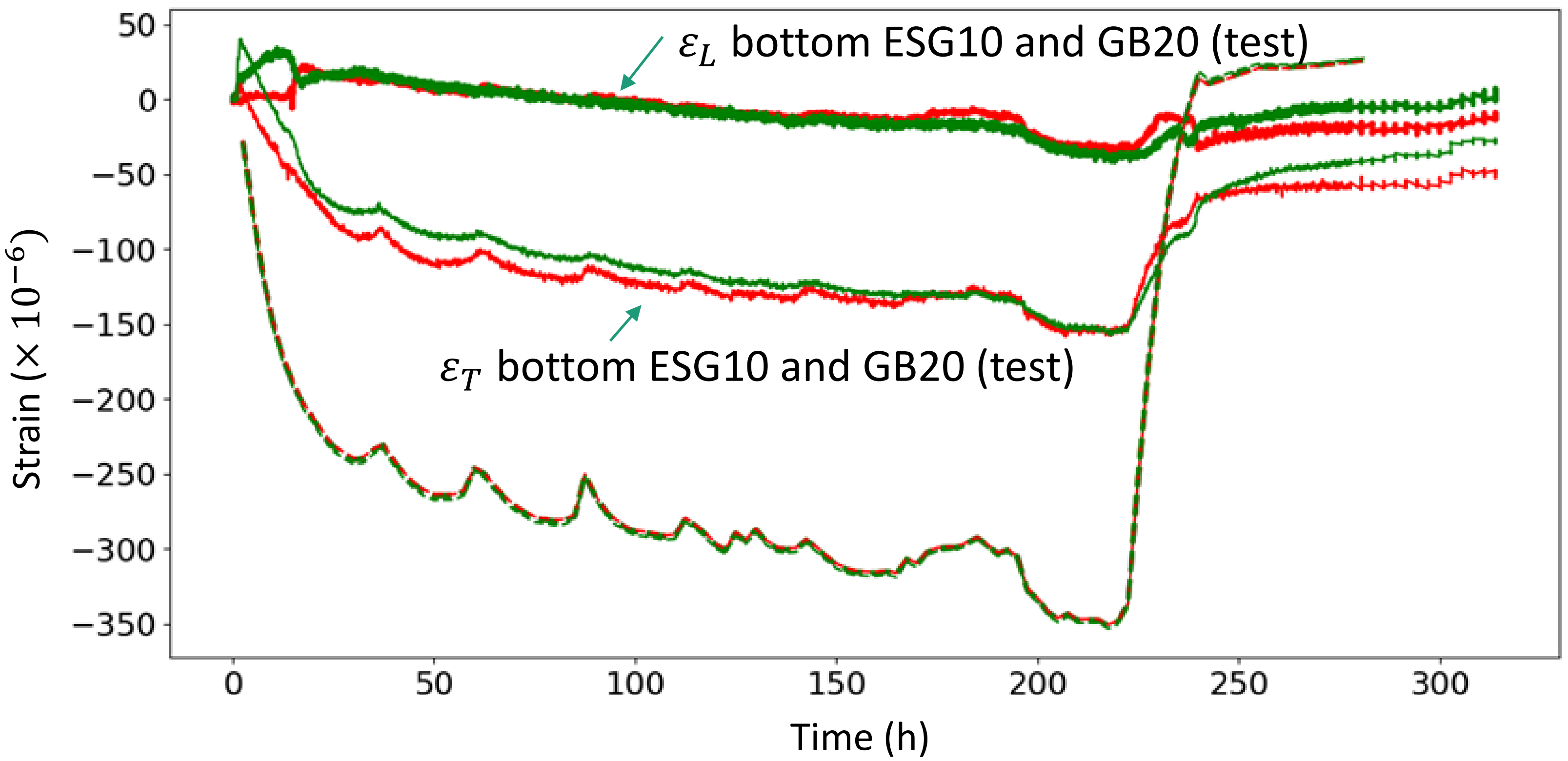




A typical temperature cycle applied to the structure (between +5°C and -10°C) and the resulting temperature gradient in the AC layers

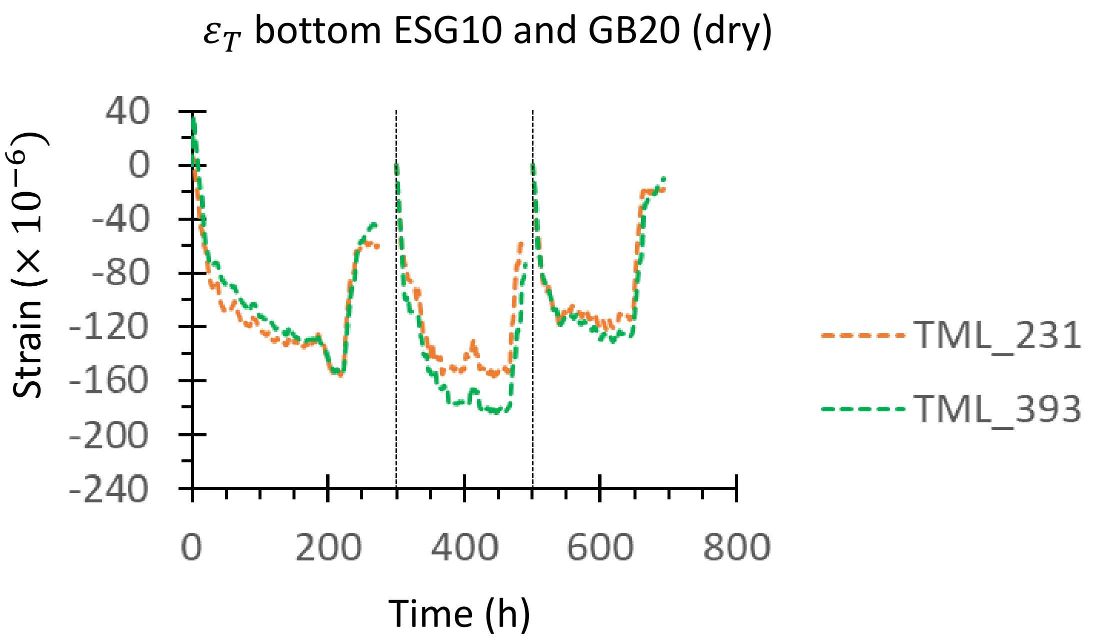


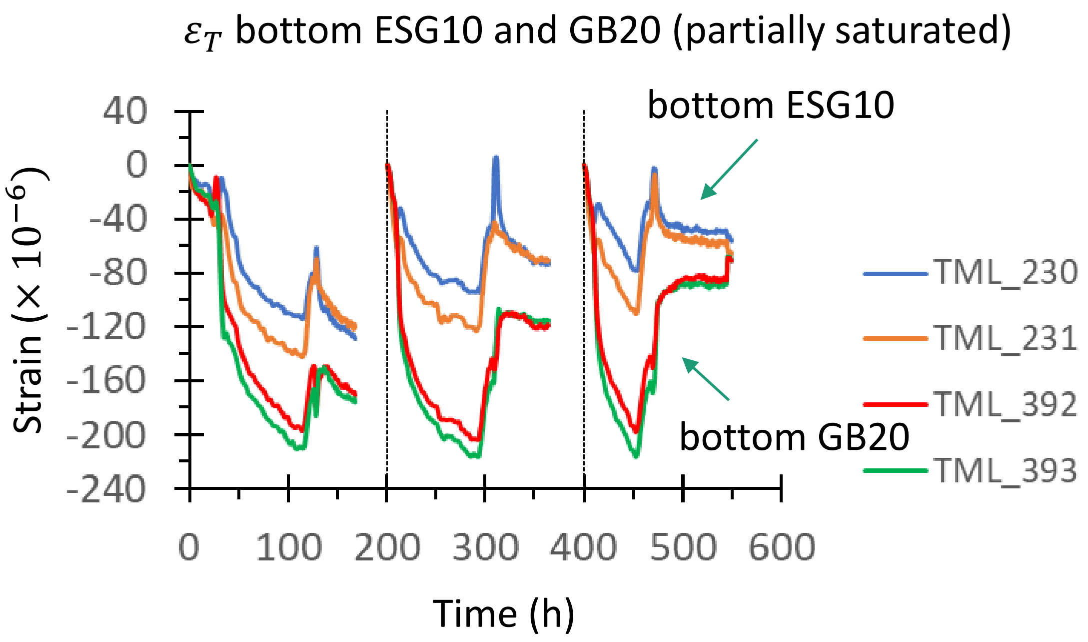
Evolution of strains at bottom of ESG10 and GB20 in directions L and T: gage measurements over a temperature cycle



- Measured strains globally in contraction (<0) in both directions
- Strains at bottom of ESG10 close to those at bottom of GB20 in directions L and T (no global bending of the bituminous layers despite the thermal gradient in the structure)
- ε_T higher than ε_L → reflects structural anisotropy attributed to friction at bottom of GB20 different in the L and T directions and arising for the "slow" thermal loading. This effect, largely pronounced in direction L, considerably limits deformation of the structure in this direction

Experimental facts: transversal strain at bottom of ESG10 and GB20



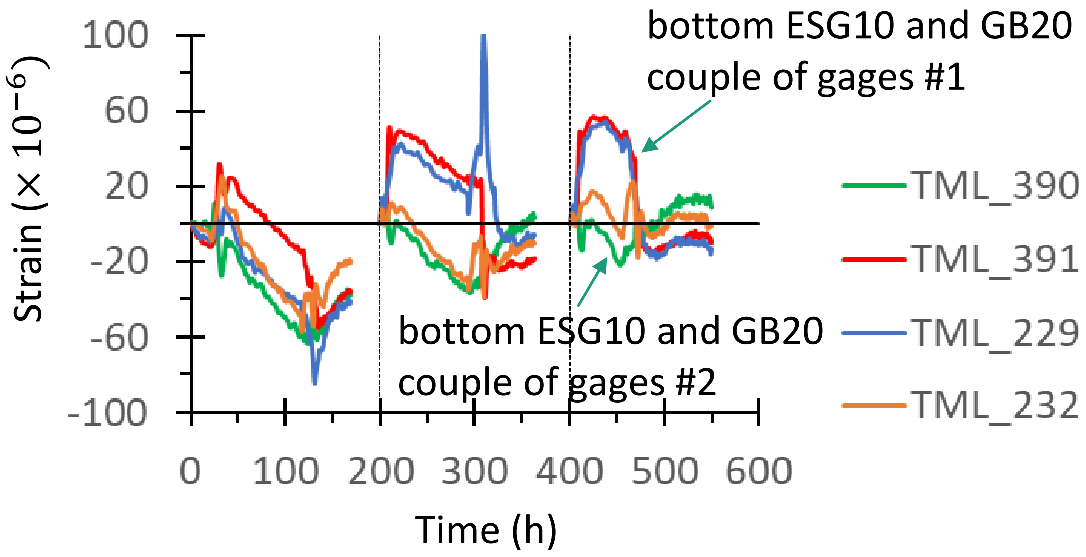


About the partially saturated structure (figure on right)

- Strains measured by different gages located at same depth in the AC layers quite similar
- Good repetition of the response along the 3 temperature cycles
- In contrast to the response under dry conditions (left): difference in the transversal strains measured at bottom of ESG10 and GB20 → diminishing the friction properties between the AC layers and introducing a swelling strain in the model

Experimental facts: longitudinal strain at bottom of ESG10 and GB20

ε_L bottom ESG10 and GB20 (partially saturated)

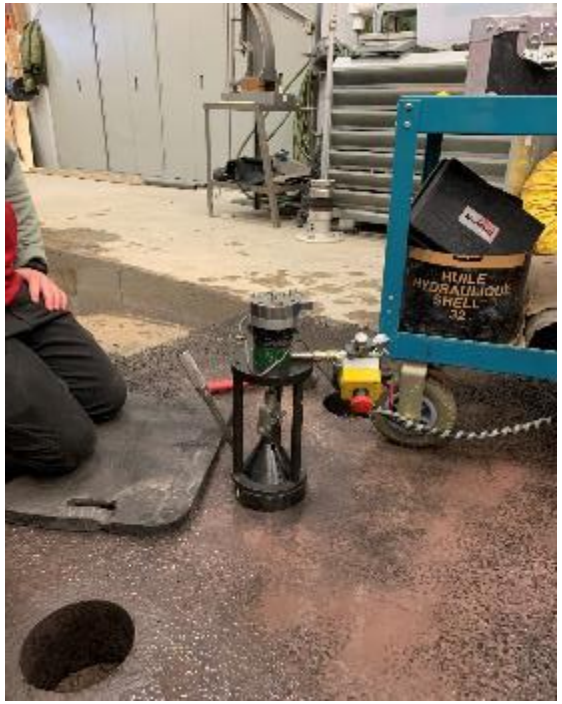


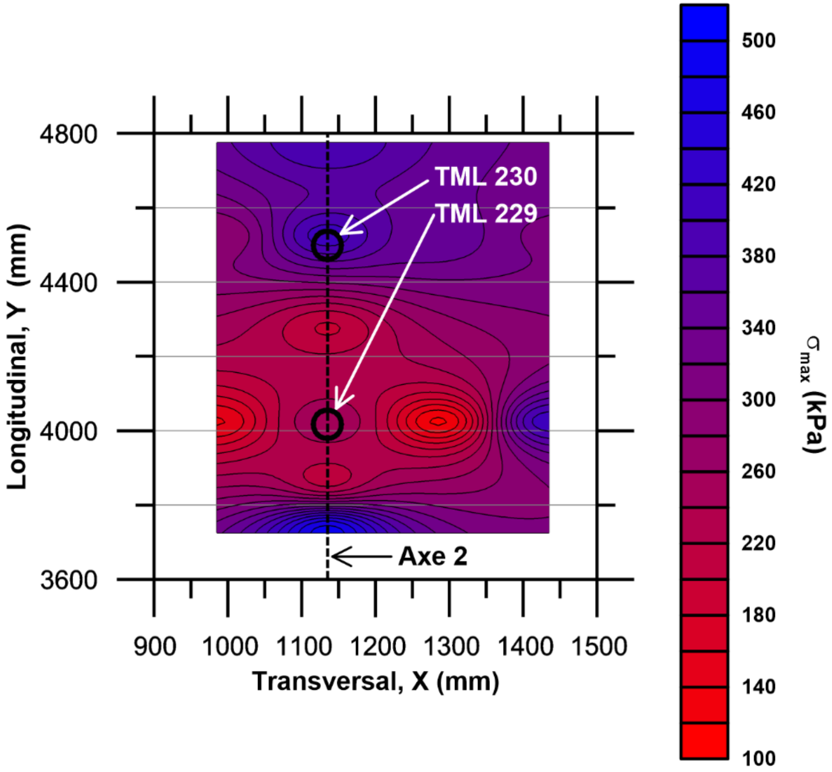
About the partially saturated structure

- Longitudinal strains smaller than transversal ones but of significant values
- For a given couple of gages, longitudinal strain measured at bottom of ESG10 and GB20 similar → keeping with “strong” friction conditions at bottom of GB20
- Strains measured by the 2 couples of gages evolves in the course of the temperature cycles
  - Values quite similar during cycle #1 but different at cycle #2 and #3
  - Could be explained by the development of vertical cracks in direction T close to couple of gages #1

Effect of F/T on the interface properties

- AMAC test



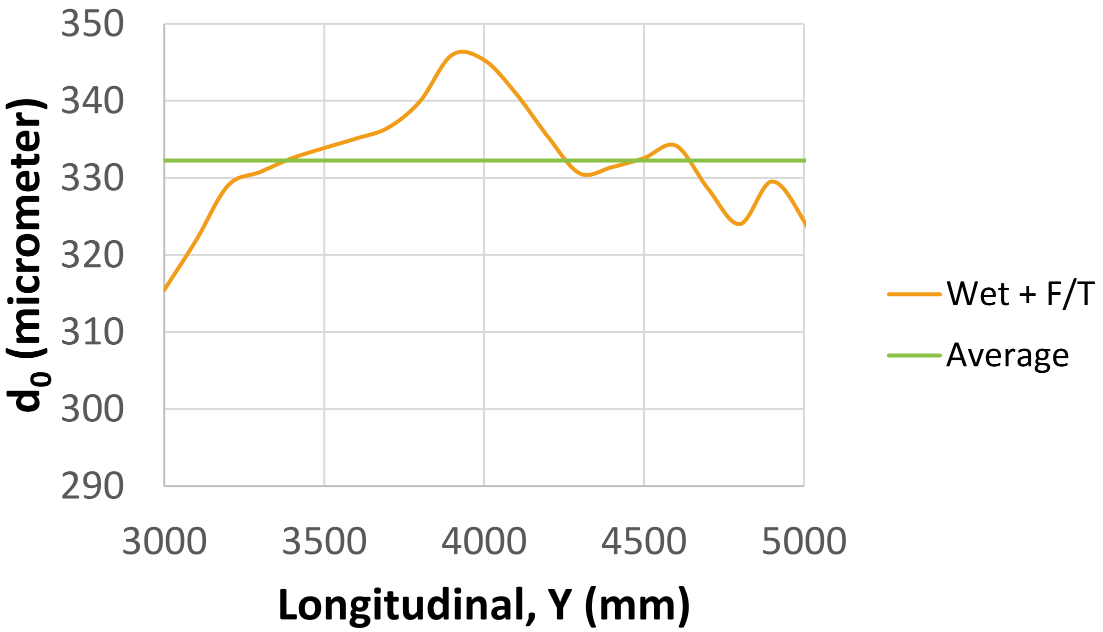


After construction
σ_{max} = 462 kPa
(perfect bond)

After wet + F/T
σ_{max} = 285 kPa
(moderate bond)

Effect of F/T on the interface properties

- Deflection



Concluding comments

- Seasonal freezing and thawing has a tremendous impact on pavement response and performance
- HVS is among the great tools to assess these impacts in controlled environments
- Studies at the material and system scale
- Not always easy to reproduce the most realistic and harshest conditions

Thank you !

Questions and comments ?

Research funding :

Ministry of Transportation of Quebec

DGITM (France)