i3C Phase 2

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

The i3C research chair

Past, Present and Future

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GRINCH
GROUPE DE RECHERCHE EN INGÉNIERIE DES CHAUSSÉES

CRSNG NSERC

The NSERC i3C industrial research chair

Phase 1 - 2008-2013

Chaire de recherche industrielle du CRSNG sur l'interaction Charges lourdes/Climat/Chaussées

Phase 2 - 2015-2020

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

Research activities started in 2008

Context

- Paramount importance of transportation infrastructures in Canada
- Rapid evolution of design methods and technologies
- Climate changes
- Degrading overall condition of road networks and infrastructure renewal deficit

The first industrial chair specialized in pavement engineering

i3C research Chair in numbers

	Phase 1	Phase 2
Partners	17	14
Funding	2.5 M	1.6 M
In-kind	110 K	132 K
Projects	15	10
Publications	115 (26 journal papers, 22 peer-reviewed conferences)	
Students	88 (6 PhD, 21 MSc)	
Research team	4 researchers, 3 technicians	

Research Program and Themes

Phase 1

- 1- Soils and pavement materials
- 2- Pavement design and performance
- 3- Surface characteristics and effectiveness of transportation industry

Phase 2

- 1- Pavement design and performance
- 2- Analysis of heavy loads on pavement
- 3- Pavement damage in cold regions

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Products

1. Improvement of knowledge and development of practical engineering tools
2. Training of highly qualified engineers
3. Research expertise
4. Scientific publications
5. Database
6. National and international cooperations




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Example of products – Low-Volume roads

- Unpaved road design tool

I3C - Conception mécaniste-empirique des chaussées non revêtues

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

Mode d'emploi

Données à entrer

Données calculées

Caractéristiques de la fondation		
Hauteur de fondation prévue	500	mm
Module Réversible fondation	100	Mpa

Caractéristiques du sol d'infrastructure		
Classification du sol	ML	
Module réversible d'été	70	MPa

Critère de conception		
Orniérage structural admissible	25	mm

Dommage moyen		
uf	7.09E-06	

Module effectif du sol d'infrastructure		
MR	75.55	MPa

Déformation au sommet du sol d'infrastructure		
εv	1.16E-03	

Nombre de cycles admissible		
N	139862	ÉCAS

Stabilité des pentes latérales		
Distance charge-accotement	35	cm
Hauteur de fondation	500	mm
Pente latérale P	1.5	P:1
Facteur de sécurité	1.51	

F.S>1.5 le risque de rupture des pentes est négligeable

Variation saisonnière des modules réversibles du sol d'infrastructure

Saison	Durée saison (mois)	Facteur saisonnier	MR sol infra (MPa)	dommage uf
Automne	1	1.16	81.2	6.53E-06
Hiver	1	8.92	500	8.32E-07
Début du dégel	1	8.92	500	8.32E-07
Fin du dégel	3.5	0.81	56.7	9.82E-06
Été	5.5	1	70	7.73E-06
Total	12			

Structure de chaussée

Fondation granulaire

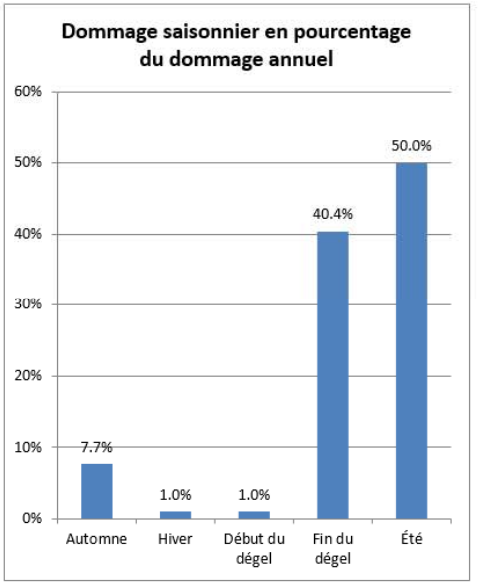
épaisseur 500 mm

module 100 Mpa

Sol d'infrastructure

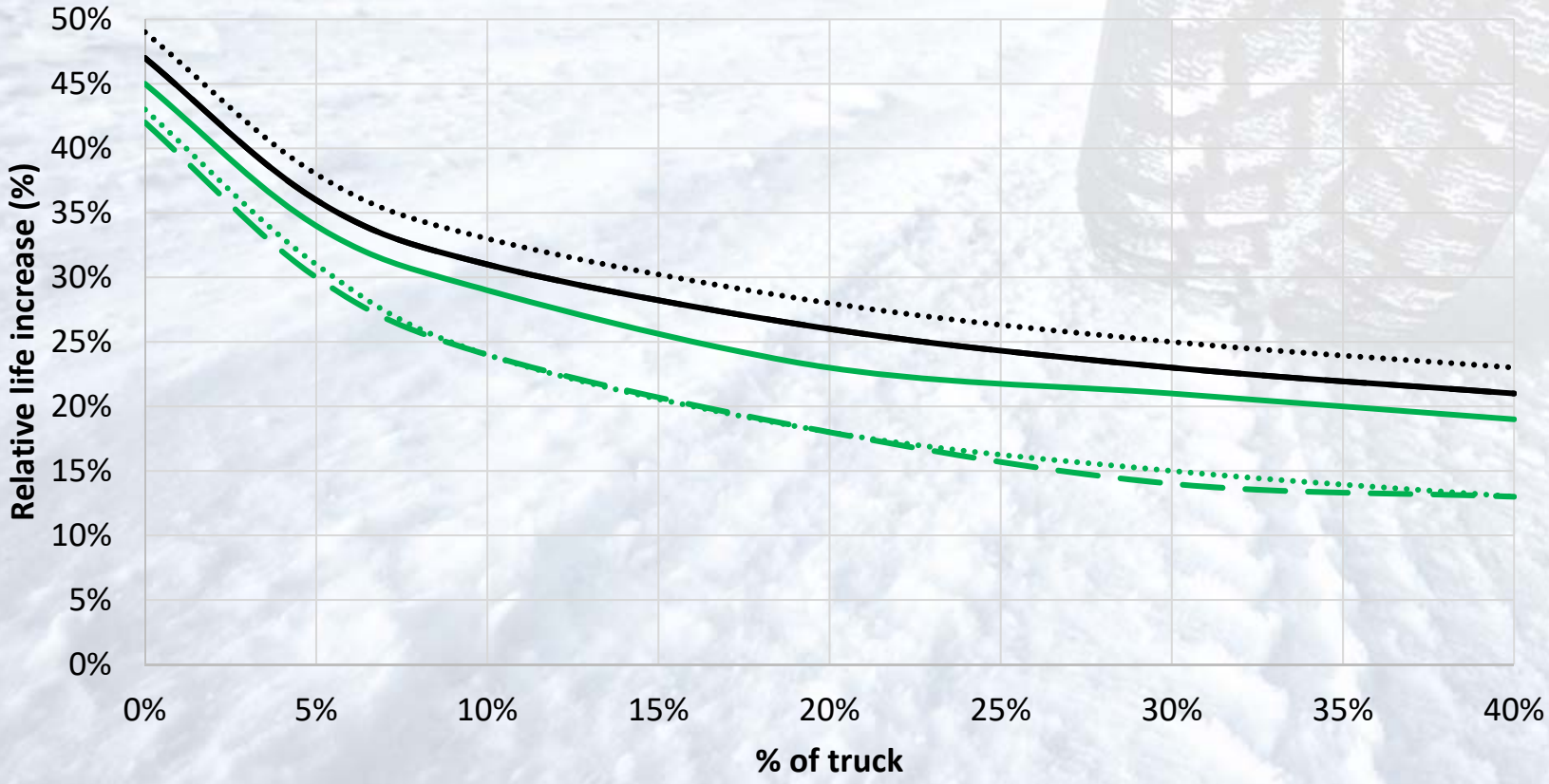
classification ML

module 70 Mpa



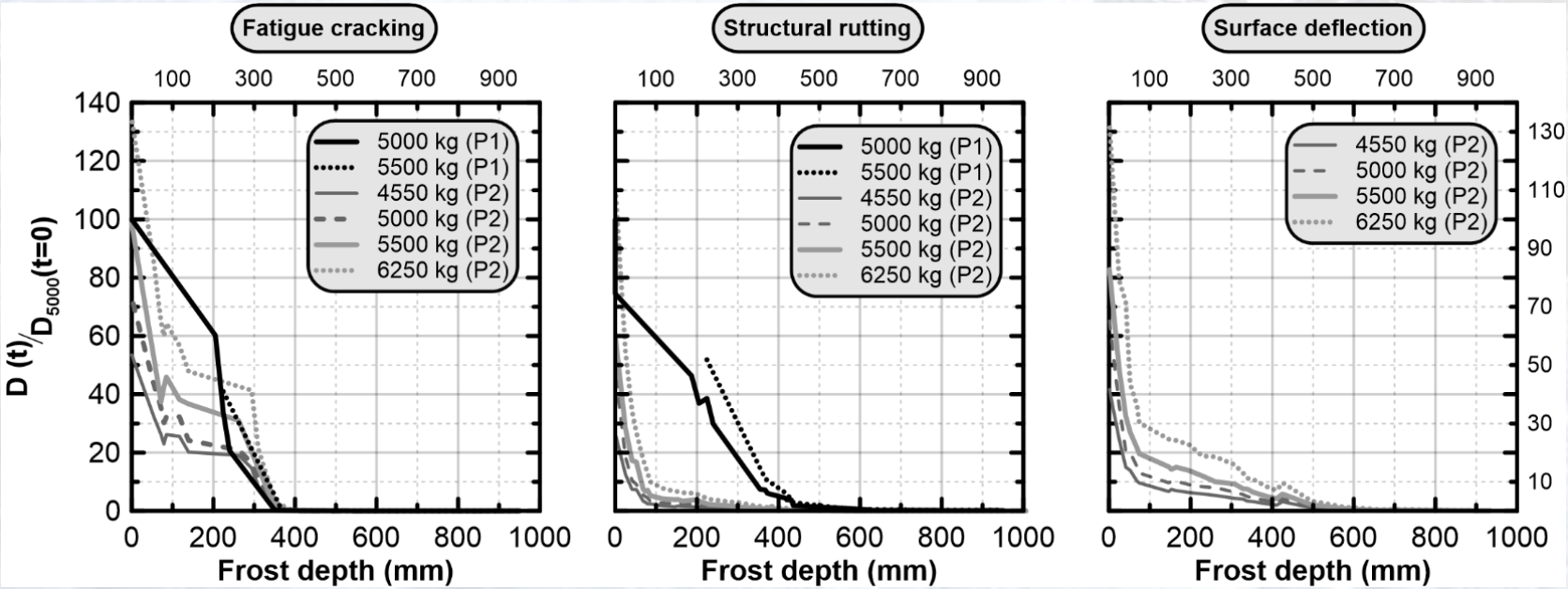
Example of products – Low-Volume roads

- Effect of surface treatment for low-volume roads



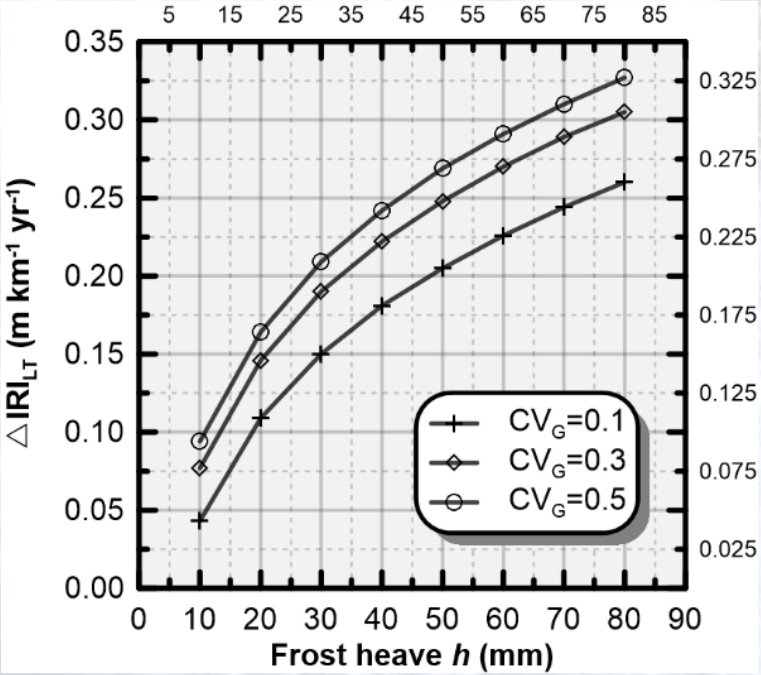
Example of products – Heavy loads

- Pavement strengthening in winter



Example of products - Climate

- Roughness damage function that considers frost heave and soil variability

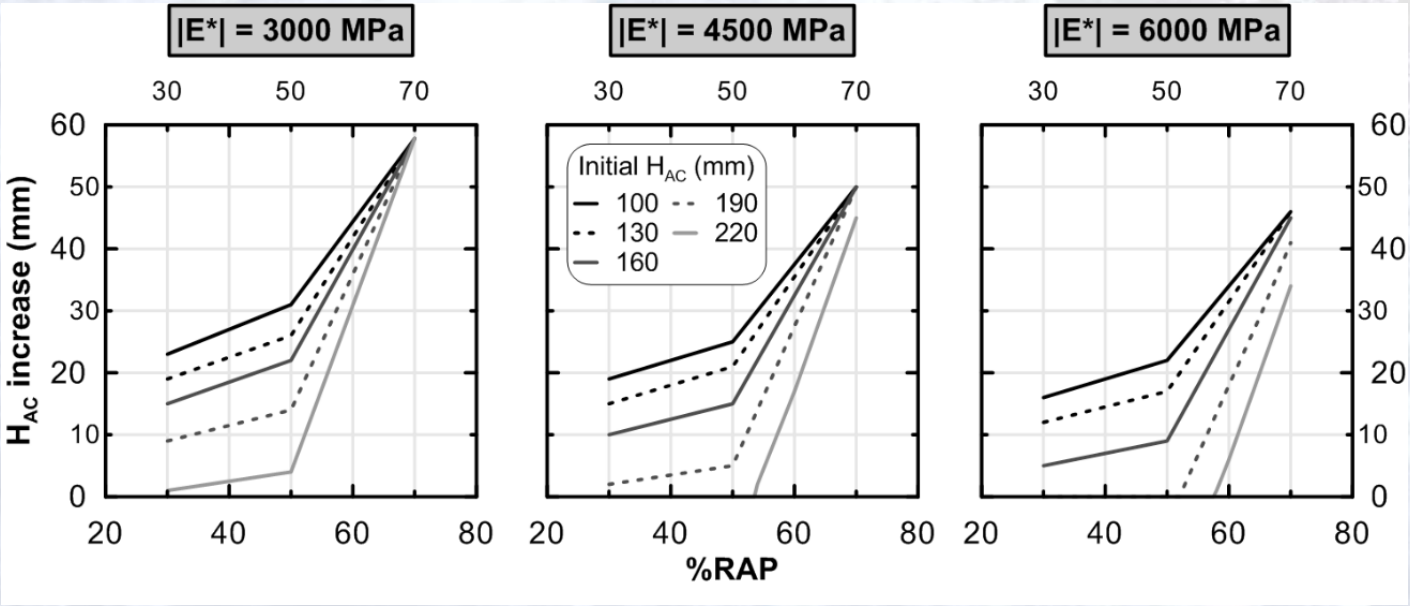


Example of products - Materials

- Design charts for permanent deformation mitigation

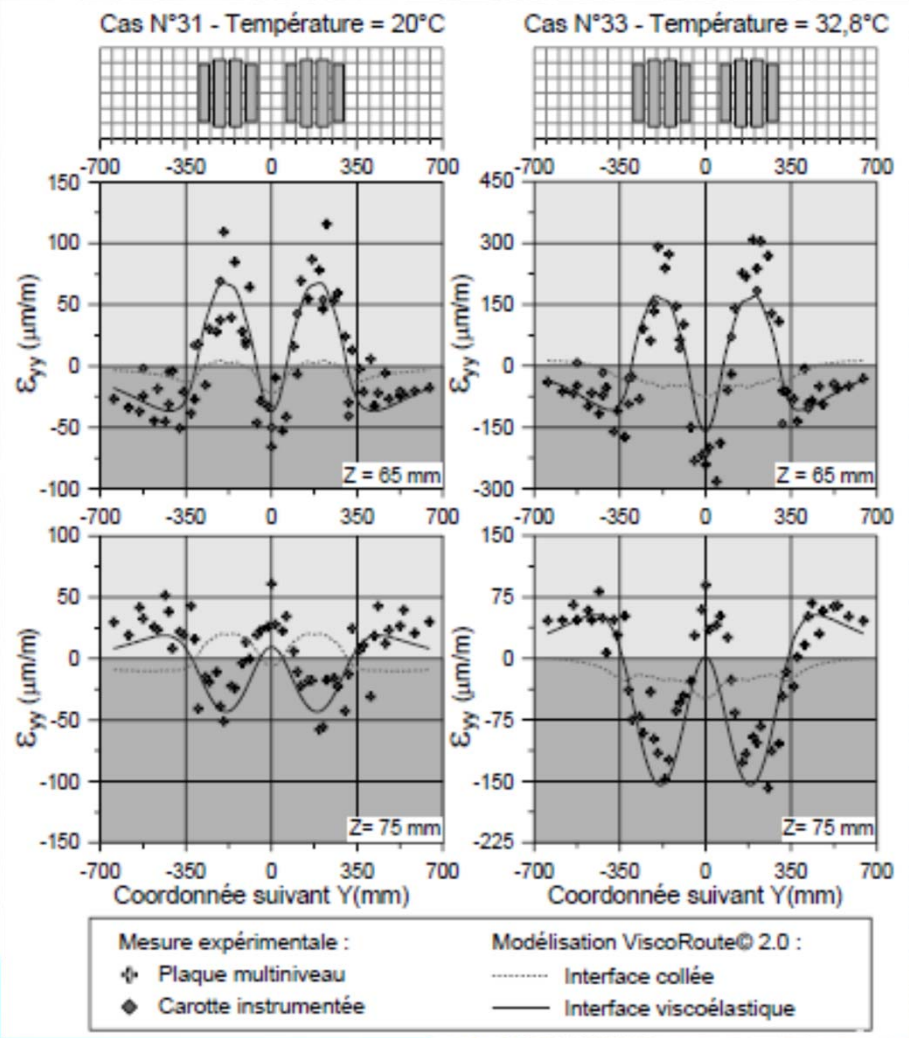
$$B = (2.4 \times 10^{-5}\sigma_d - 0.001)(\text{RAP} + 56.62) + 0.051 \quad \text{for RAP} \leq 50\%$$

$$B = (4.3 \times 10^{-5}\sigma_d - 0.0002)(\text{RAP} + 5.41) - 0.056 \quad \text{for RAP} \geq 50\%$$

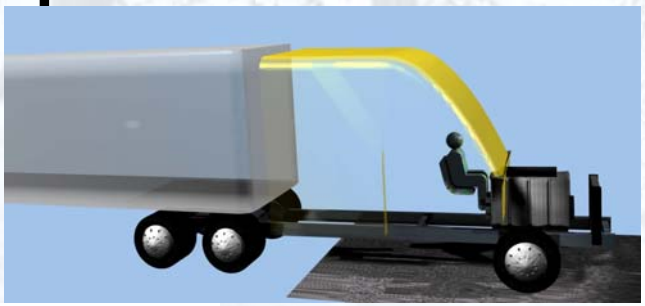


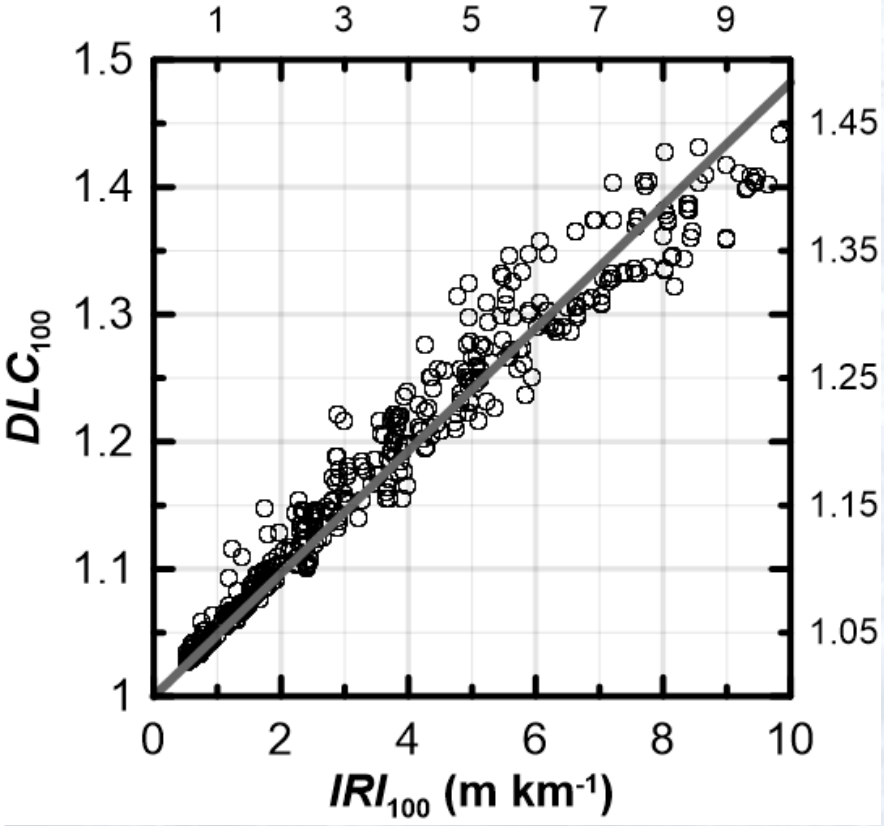
Example of products - Materials

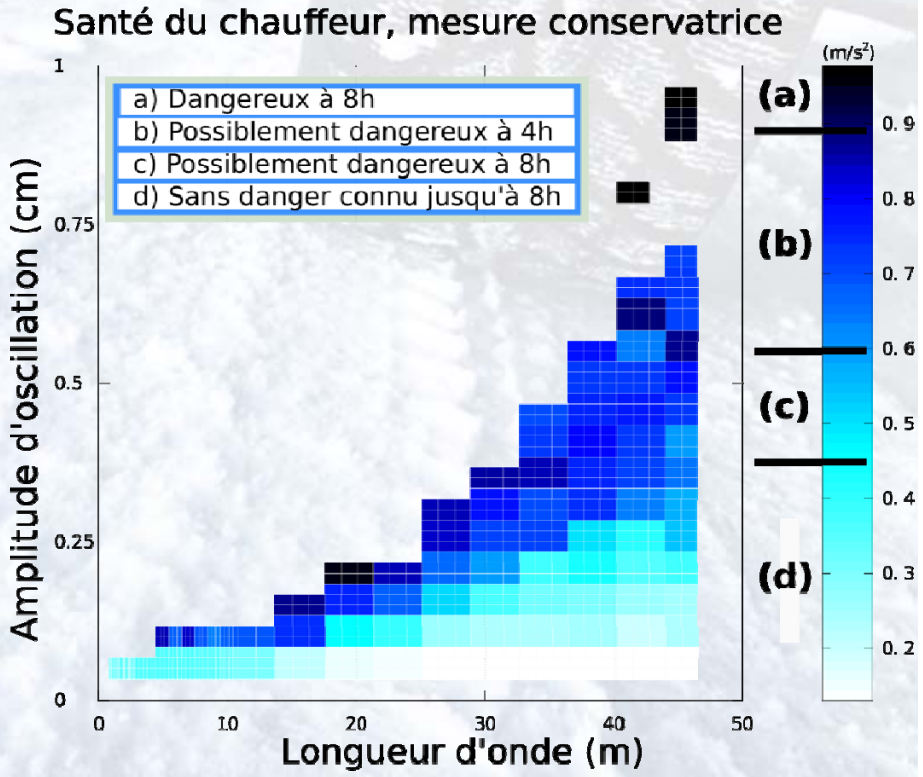
- New model for considering bonding between AC layers and its effect on pavement response



Example of products – Truck model







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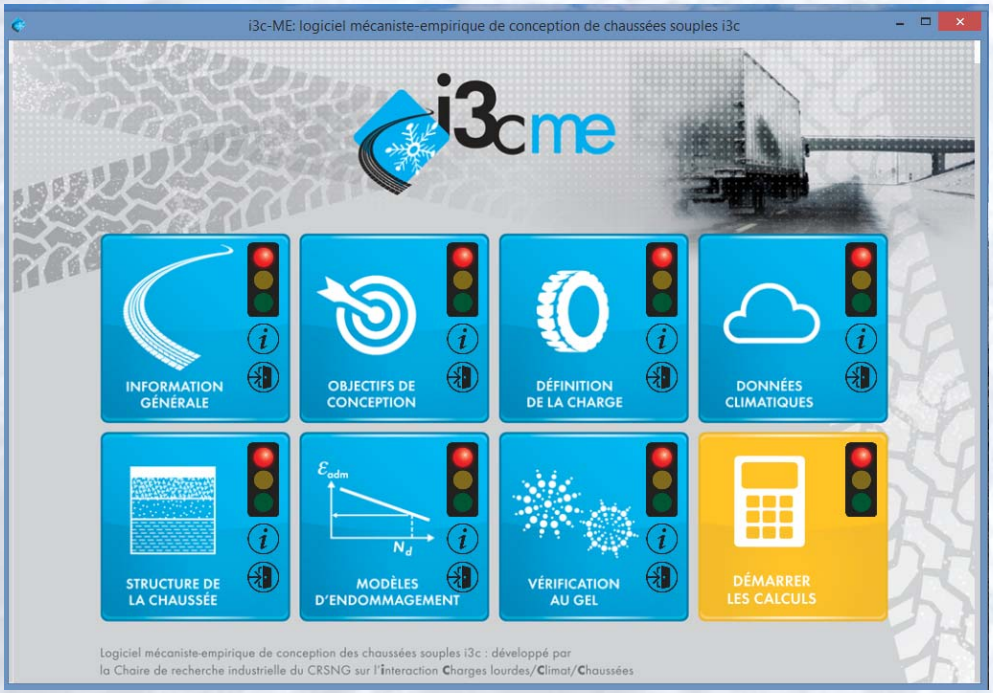
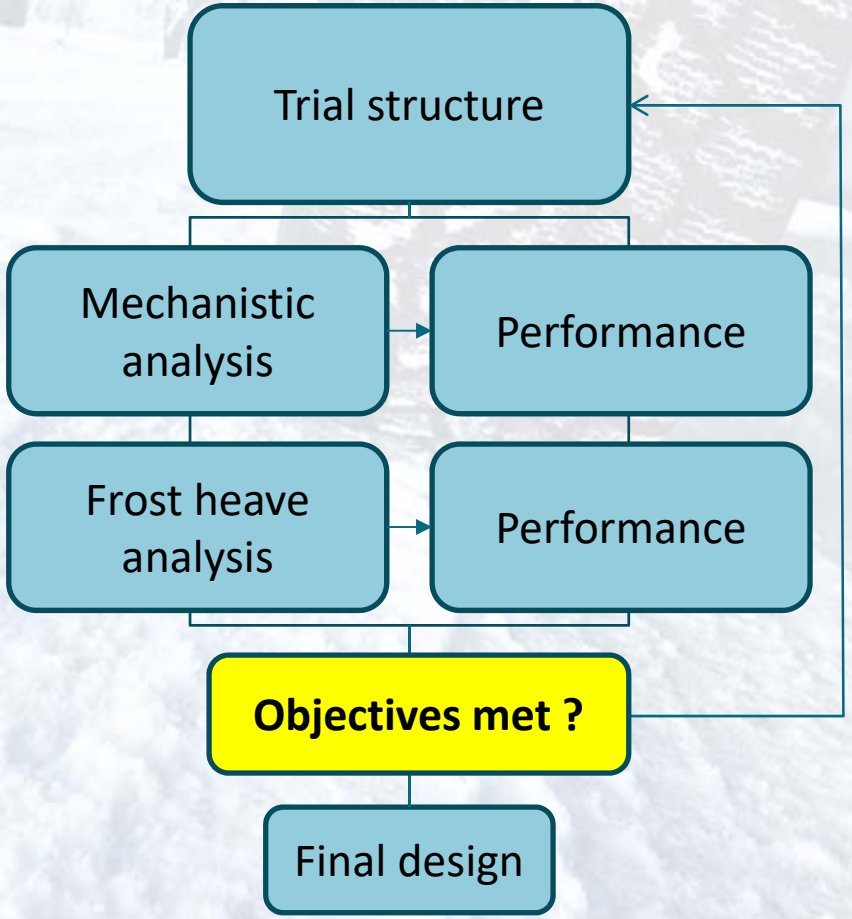
Software i3C-me: T^2 platform

i3C-me : Mechanistic-empirical flexible pavement design software

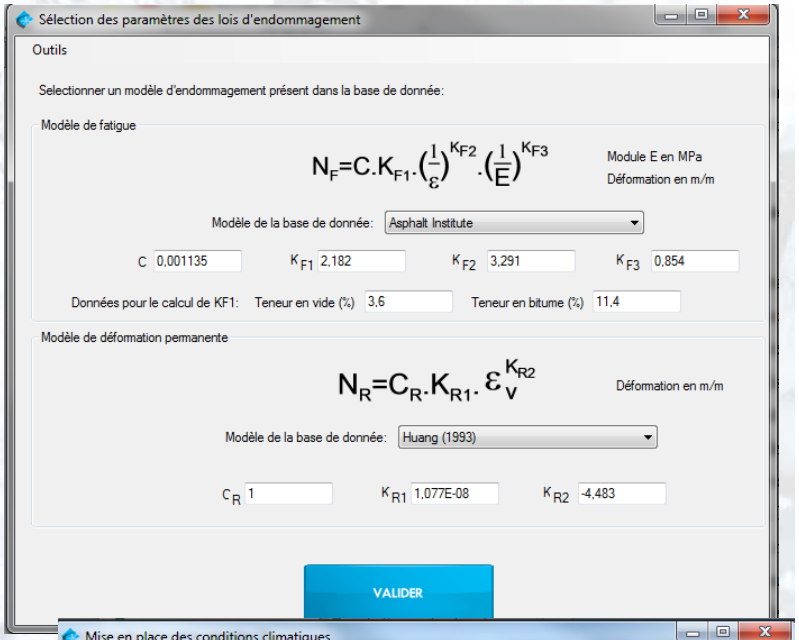
Freeware (https://i3c.gci.ulaval.ca/i3c-me/)

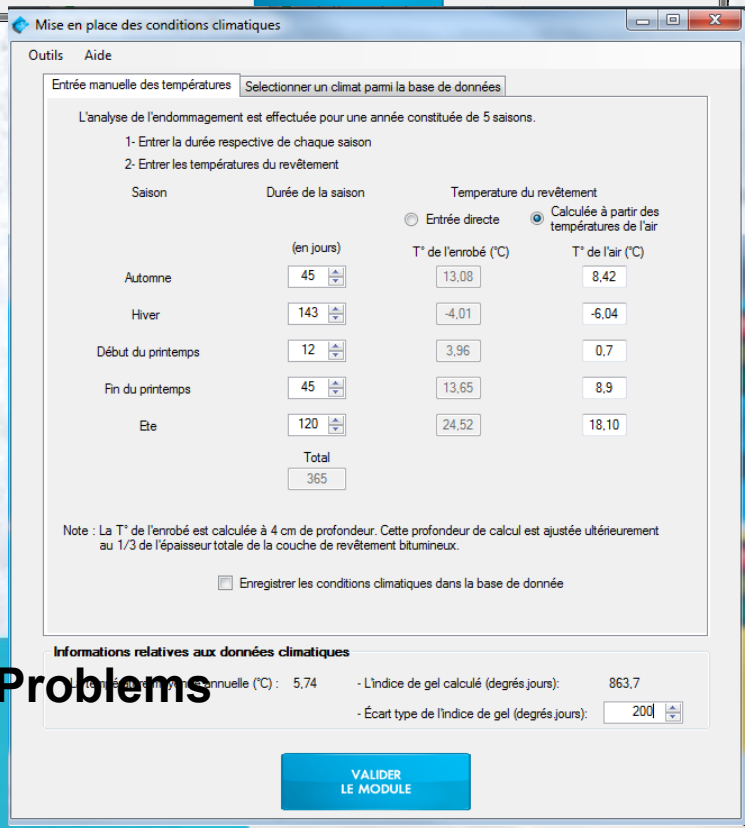




i3C-me

- It is a ME flexible pavement design software (structural and frost protection)
- Fully editable databases (materials, vehicles, climate, …)
- Includes research from UL and MTQ (and others …)
- Seasonal damage analysis
- « Hybrid » software between Chaussée2 (MTQ) and MnPave
- Detailed user's manual

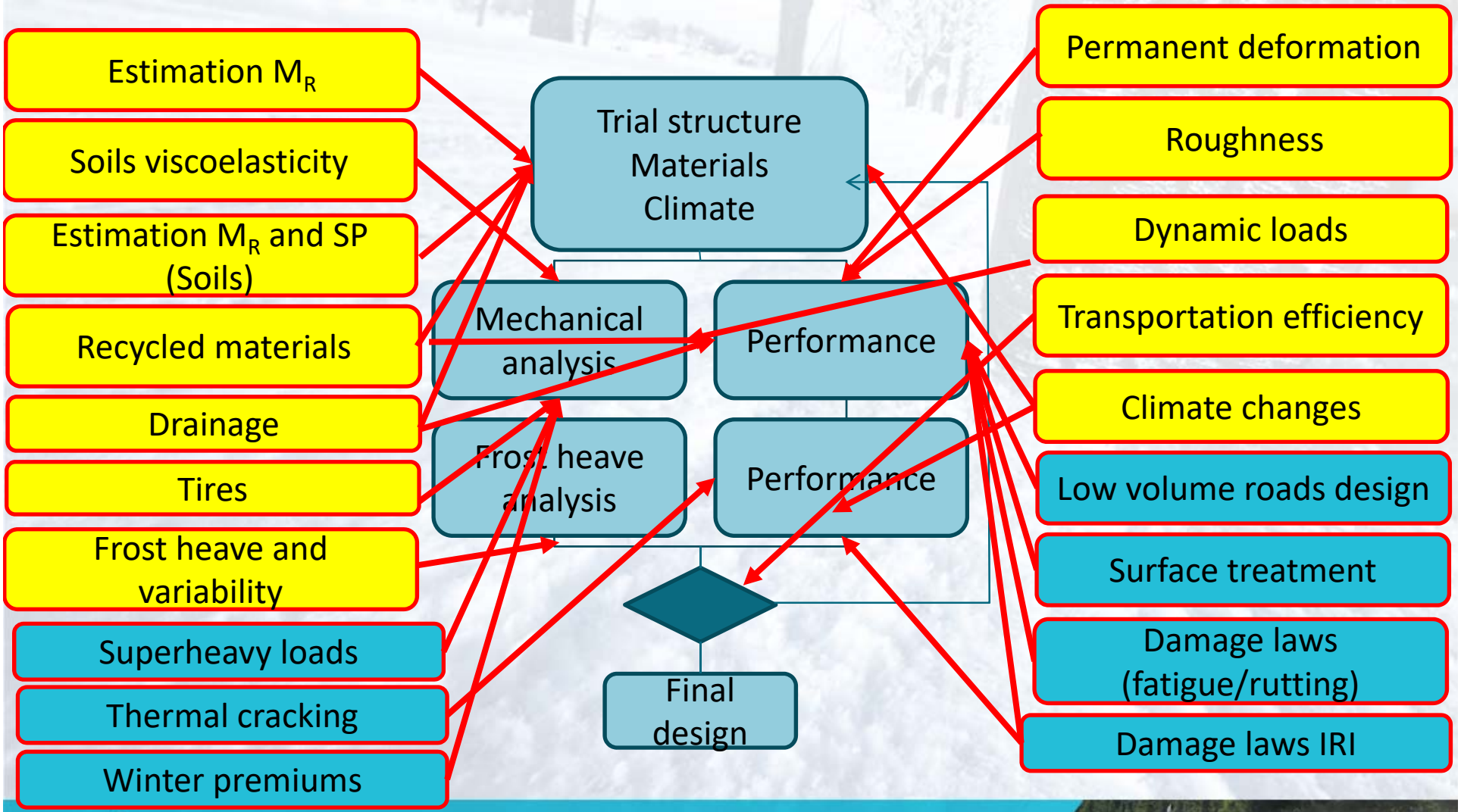




Questions / Contact / Comments / Problems

i3C-me@gci.ulaval.ca

Integration of research results in i3C-me



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Some topics studied in phase II

- Theme 1 - Analysis of profile data (diagnostic/decision tool) **(completed)**
- Theme 1 - ME low-volume roads design **(completed)**
- Theme 1 – Damage functions for fatigue cracking and structural rutting **(ongoing)**
- Theme 1 – Surface treatment and low-volume roads performance **(ongoing)**
- Theme 1 - Interpretation of the LWD data **(ongoing)**
- Theme 1 - Improvement of FDR (materials and construction quality) **(ongoing)**
- Theme 2 - Pavement strenghtening in winter **(completed)**
- Theme 2 – Superheavy loads transportation **(ongoing)**
- Theme 3 - Thermal cracking: Mechanisms and solutions **(ongoing)**
- Theme 3 – Effect of frost heave on pavement service life **(completed)**

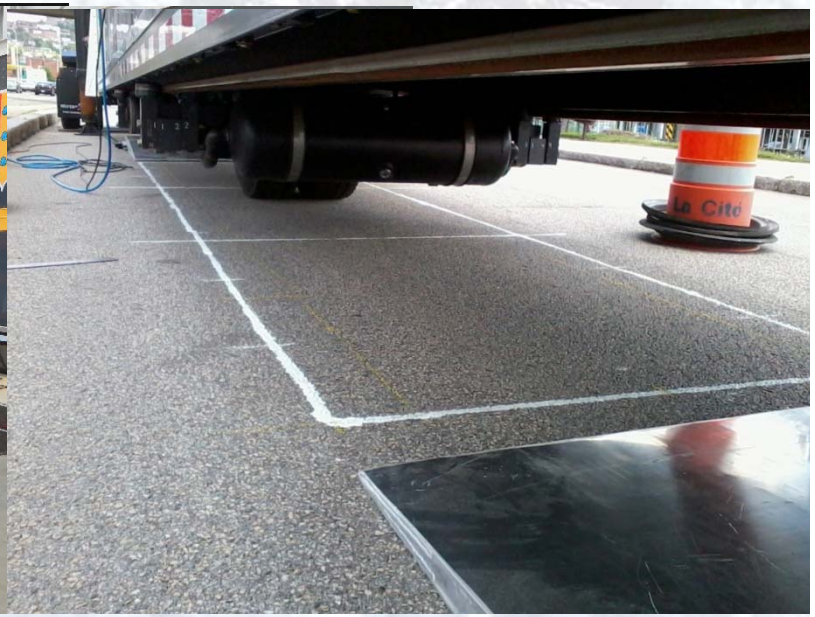
Each topic should find its way in i3C-me !

Program relies on a unique research facility and equipment

- Existing equipment

Increased research capacity with full scale heavy vehicle simulator and indoor test pit

- $18M grant from CFI



i3C Phase 2

Recent examples of R&D success

FPInnovations

FPInnovations collaborative research leads to a Winter Weight Premium extension of 8 days in Alberta

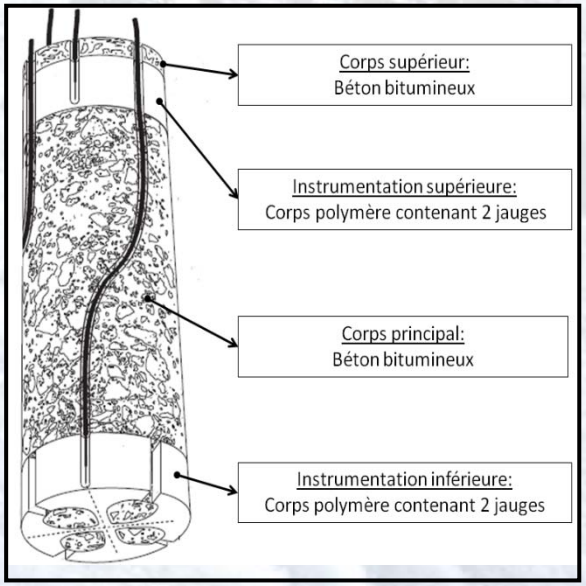
This change will also result in more than $2.0 million in savings for the forest sector annually alone. Other benefits include an estimated reduction in pavement maintenance costs of $1.4 million annually and the operation of fewer trucks on the road for the same total volume (safer, reduced greenhouse gases). It will also benefit to other industries hauling heavy loads.

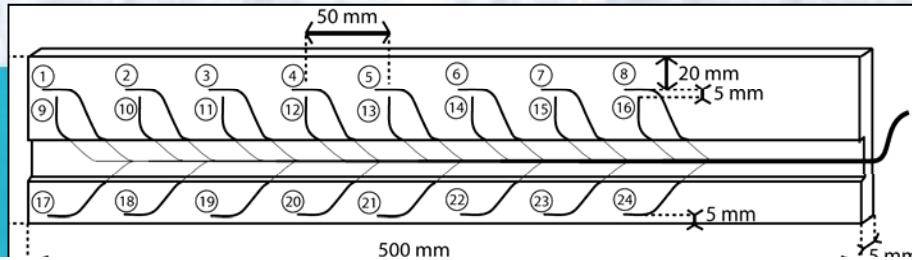
This win-win policy change is a result of several years of research and more importantly, collaboration between FPInnovations, Alberta Transportation, and Academia. “The key ingredients here were the identification of a true industry need and collaboration between all parties towards a science-based outcome with tangible benefits to our members and the forest sector”, notes FPInnovations’ Executive Vice-President Trevor Stuthridge.

FPInnovations teamed up with Laval University’s industrial NSERC Chair on the interaction between Climate, Pavements and Loads (I3C Chair), led by Professor Guy Doré. In their state-of-the-art, full-scale loading simulator, Doré’s team built a replicate of a typical Alberta pavement and applied a series of wheel loads. The fully instrumented pavement was entirely frozen and pavement responses were collected at different frost depths. The results corroborated and reinforced the preliminary findings from the advanced modelling conducted by FPInnovations.

Recent examples of R&D success

A State-of-the-art pavement instrumentation developed with OpSens is now part of their product catalog (with continuously increasing demand !)





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Examples of spin-offs resulting from i3C Chair activities

- Development of a methodology to test granular materials for permanent deformation behaviour (MTQ)
- Effect of climate change on pavements (Ouranos)
- Pavement response during thawing (MTQ)
- Pavement response under aircraft loading (FAA)
- Use of foam glass in pavement engineering (Coop R&D)
- Effect of heavy vehicles loading on dam crest and core (HQ)
- And many more …

Conclusion i3C

- Positive results from first phase
- Most of the products included in a new ME flexible pavement design software (free web download)
- Phase 2 ongoing
- Training of highly qualified personnel for present and future engineering challenges


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Département de génie civil
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FORCHEMEX
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