



FORMATION
TECHNIQUE
ANNUELLE

GESTION DE
LA QUALITÉ ET
DÉVELOPPEMENT
DURABLE

Impact de l'ajout de GBR dans les enrobés

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Granulats bitumineux recyclés - GBR

- Reclaimed Asphalt Pavement – RAP
- Agrégats d'enrobés - AE



GBR



{ > 80 millions de tonnes utilisé en 2019¹
Tas accumulé en 2019 de 125 millions de tonnes¹



Tas accumulé de 4,3 millions de tonnes en 2018²



450 000 tonnes utilisés³

1 – NAPA, 2020

2 – Mneina et Smith, 2019

3 – BQ, 2010

GBR - USA

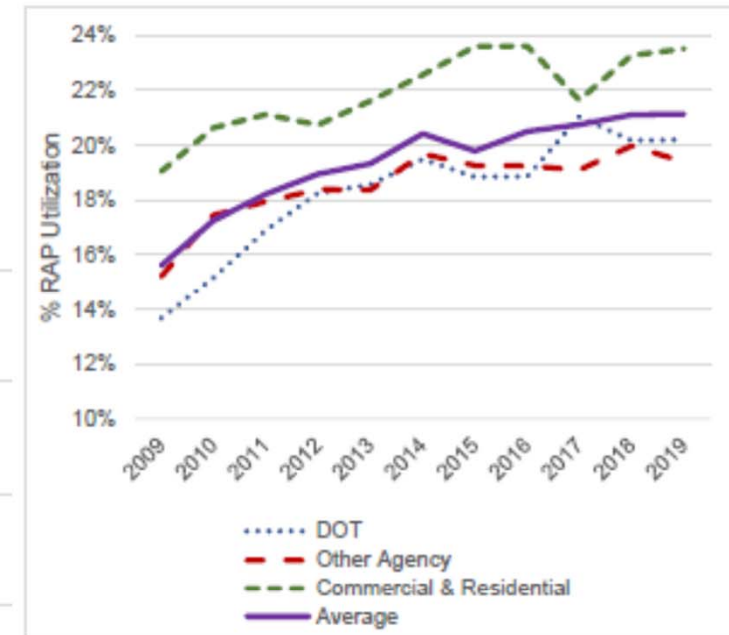
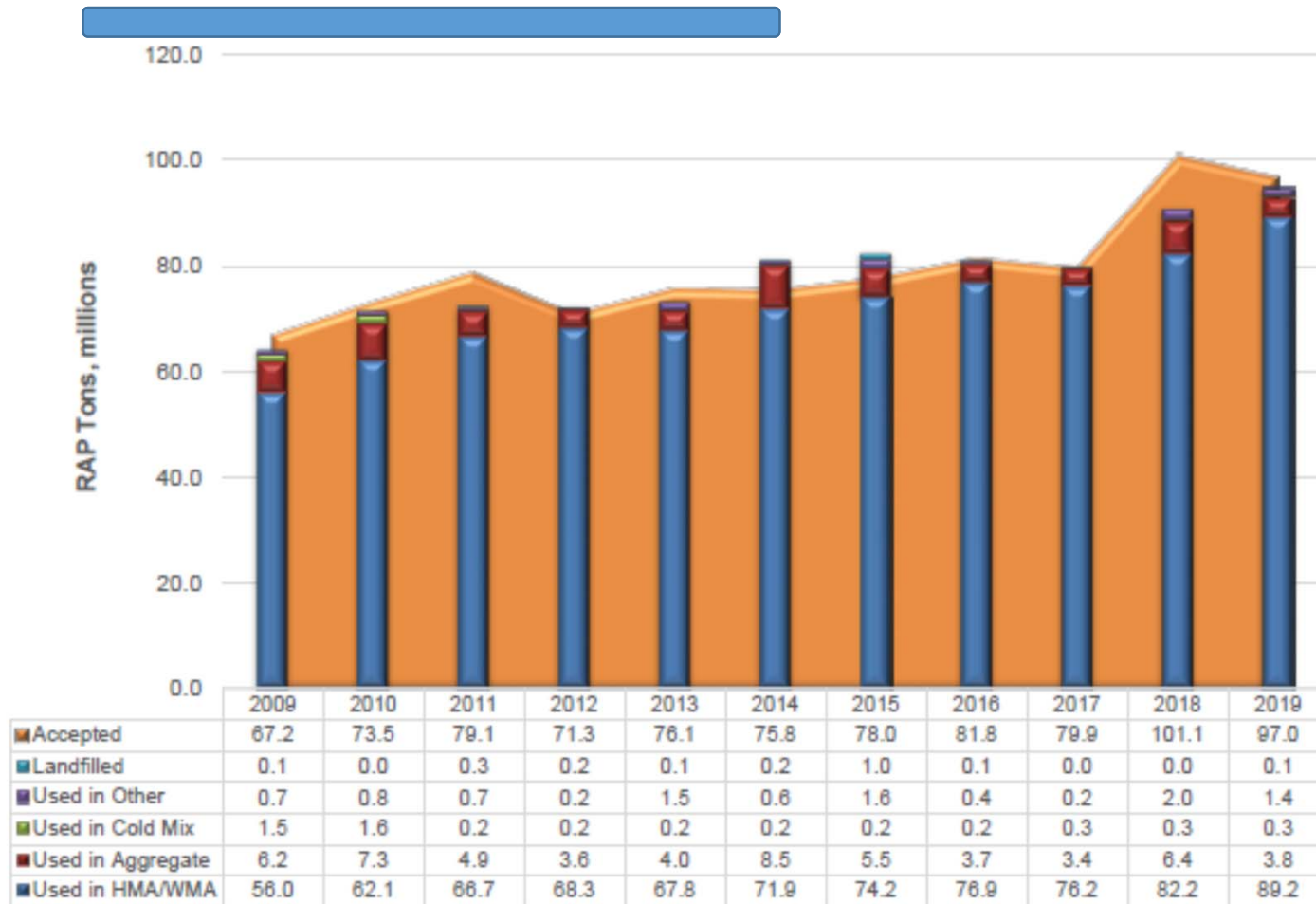
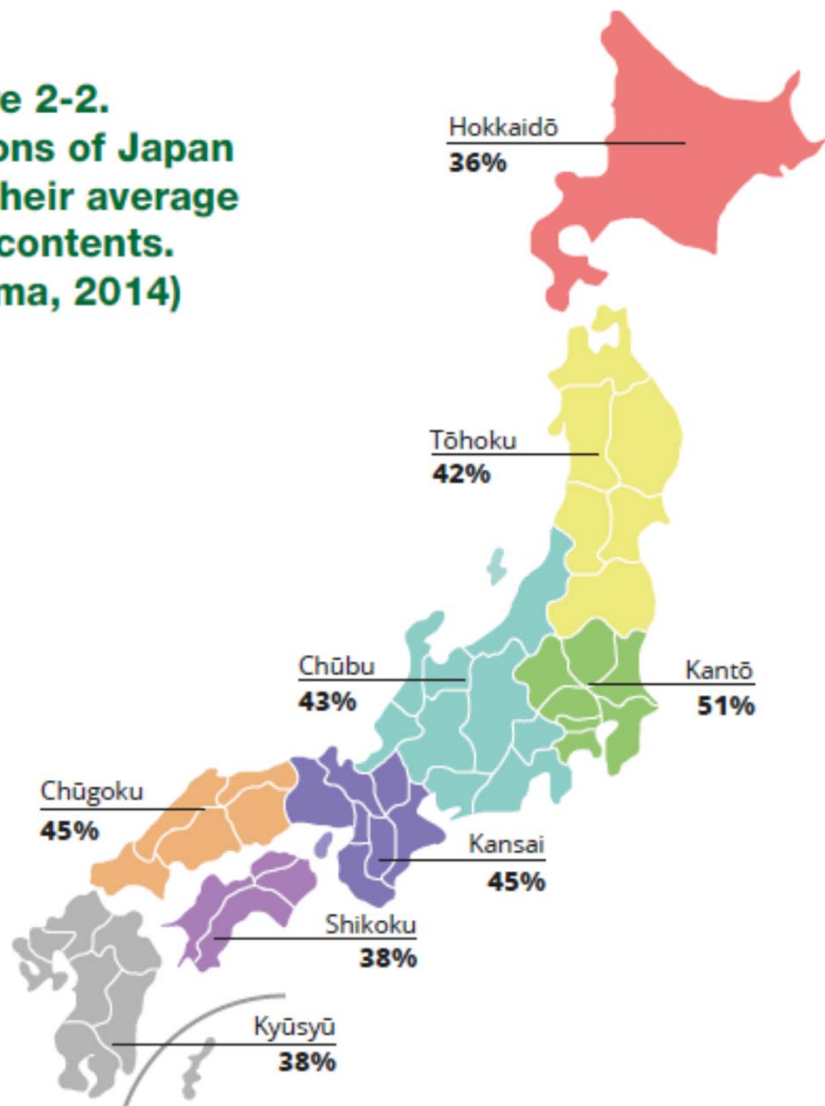
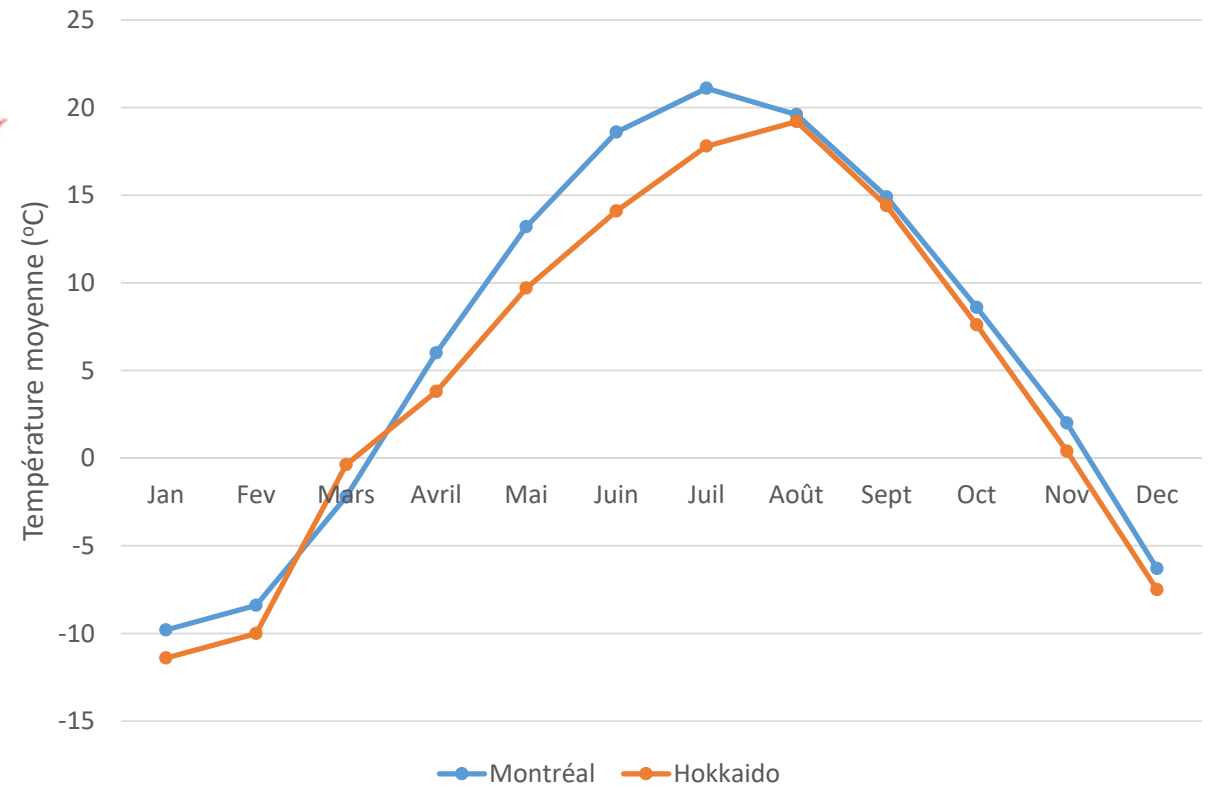
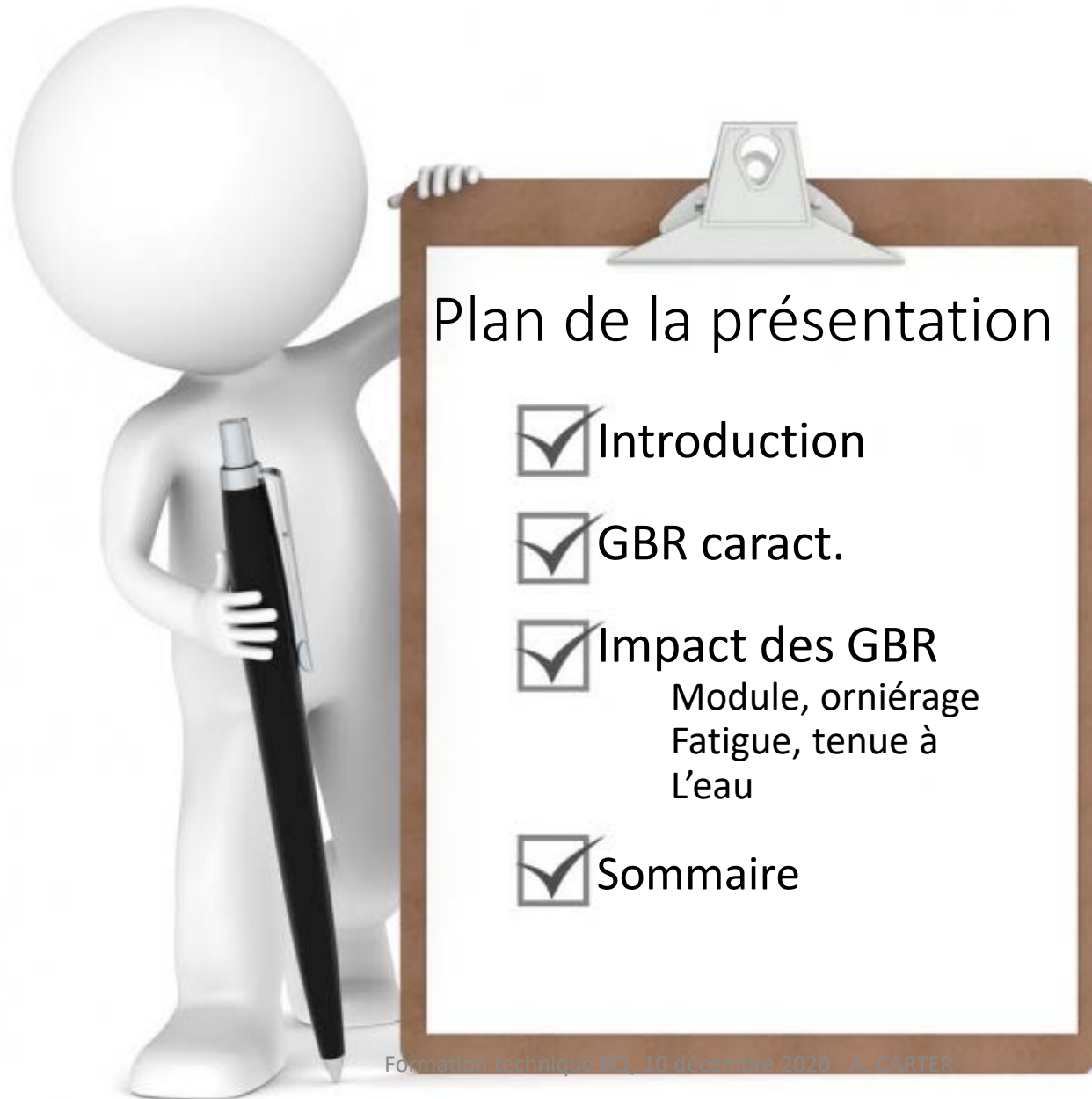


Figure 2-2.
Regions of Japan
and their average
RAP contents.
(Hirama, 2014)



NAPA, 2015



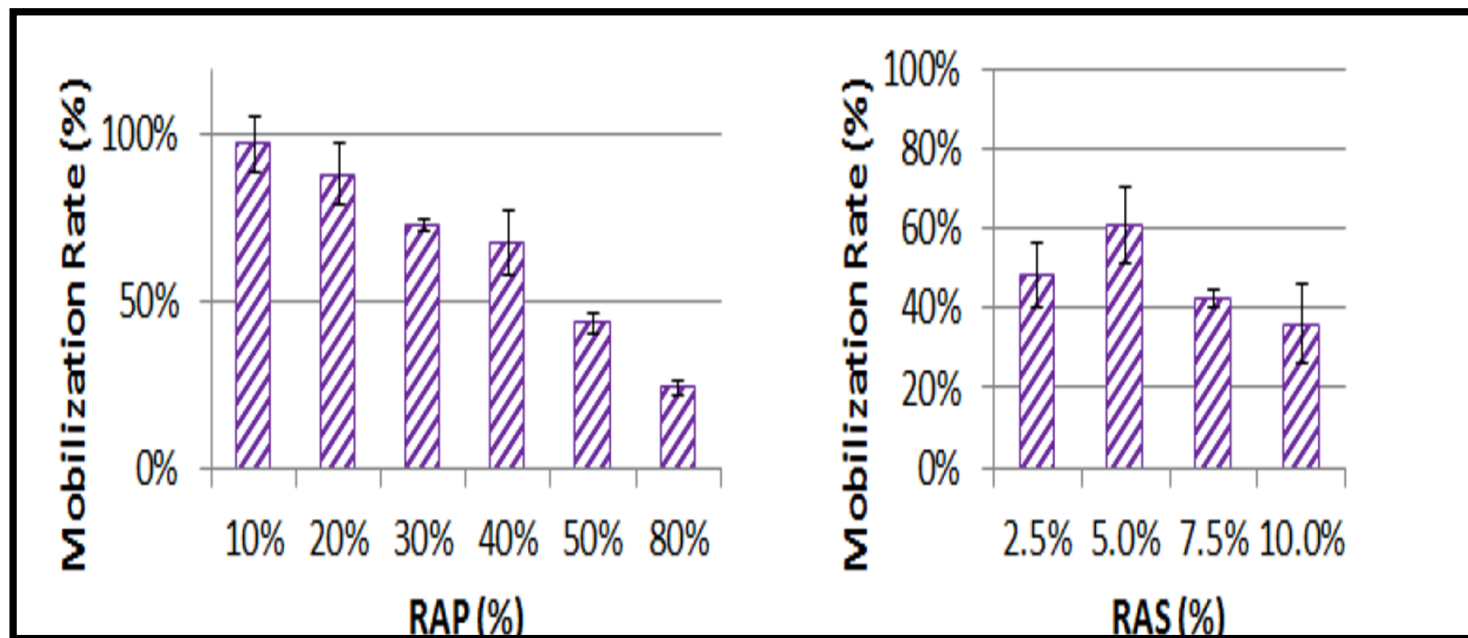


Caractérisation des GBR

- Teneur en bitume
 - Extraction avec solvant
 - Four à ignition
- Granulométrie
 - Courbe blanche
 - Courbe noire
- Mobilisation du bitume?
- Rigidité / grade du bitume?
- Présence de polymère?
- Enrobé déjà re-re-re-recyclé?



Mobilisation du bitume



(Zhao et al 2014)

Grade du bitume

			RAP-1 (0 / 12)	RAP-2 (0 / 12)	RAP-3 (0 / 12)	RAP-4 (0 / 12)	RAP-5 (0 / 12)	RAP-6 (0 / 12)	RAP-7 (0 / 20)	RAP-8 (0 / 20)
Elastic recovery (Rec _{3,2}), %			41.7	54.3	55	42.5	35.3	42.3	31.0	0.0
Non-recoverable crepp compliance (J _{nr 3,2}), kPa ⁻¹			0.2655	0.0891	0.0547	0.0505	0.4991	0.2505	0.4991	8.7280
Compliance delta (J _{nr diff}), %			19.6	16.5	38.1	9.1	68.4	14.4	65.5	68.4
Letter (MSCR)			E	Fail	Fail	Fail	Fail	E	Fail	Fail
Penetration , dmm			15	13	13	13	35	12	20	105
BBR results	m(60)	-12°C	0.345	0.309	0.329	0.290	0,290	0.315	0.411	Fail
	s(60)		123	220	144	330	330	154	61.3	Fail
	m(60)	-18°C	0.293	0.257	0.286	0.238	0,259	0.273	0.344	Fail
	s(60)		253	441	262	597	240	304	137	Fail
	T _{low} (°C)		-27.19	-22.99	-26.05	-20.86	-24.49	-24.16	-31.9	Fail
DSR	T _{high} (°C)		88.5	96.3	98.7	100.5	84.0	89.0	82.9	68.1
PG HT-LT			88-22	94-22	94-22	100-16	82-22	88-22	82-28	64-??
PG HTx-LT			64E-22	-	-	-	64E-22	-	-	-

Bitume des GBR

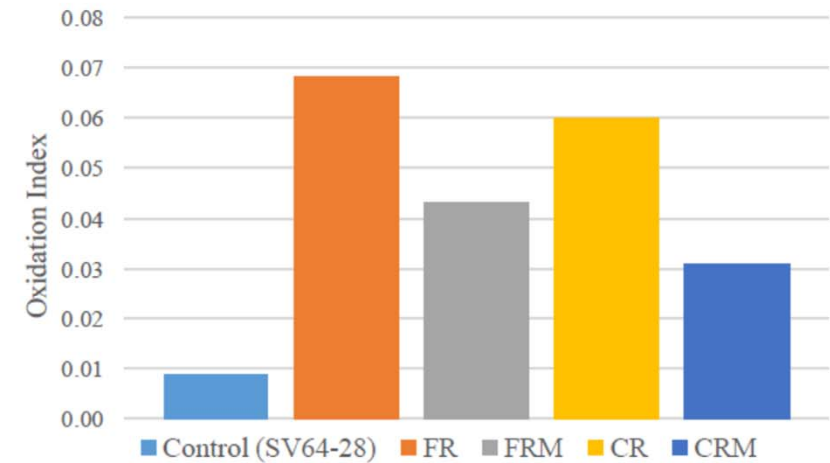
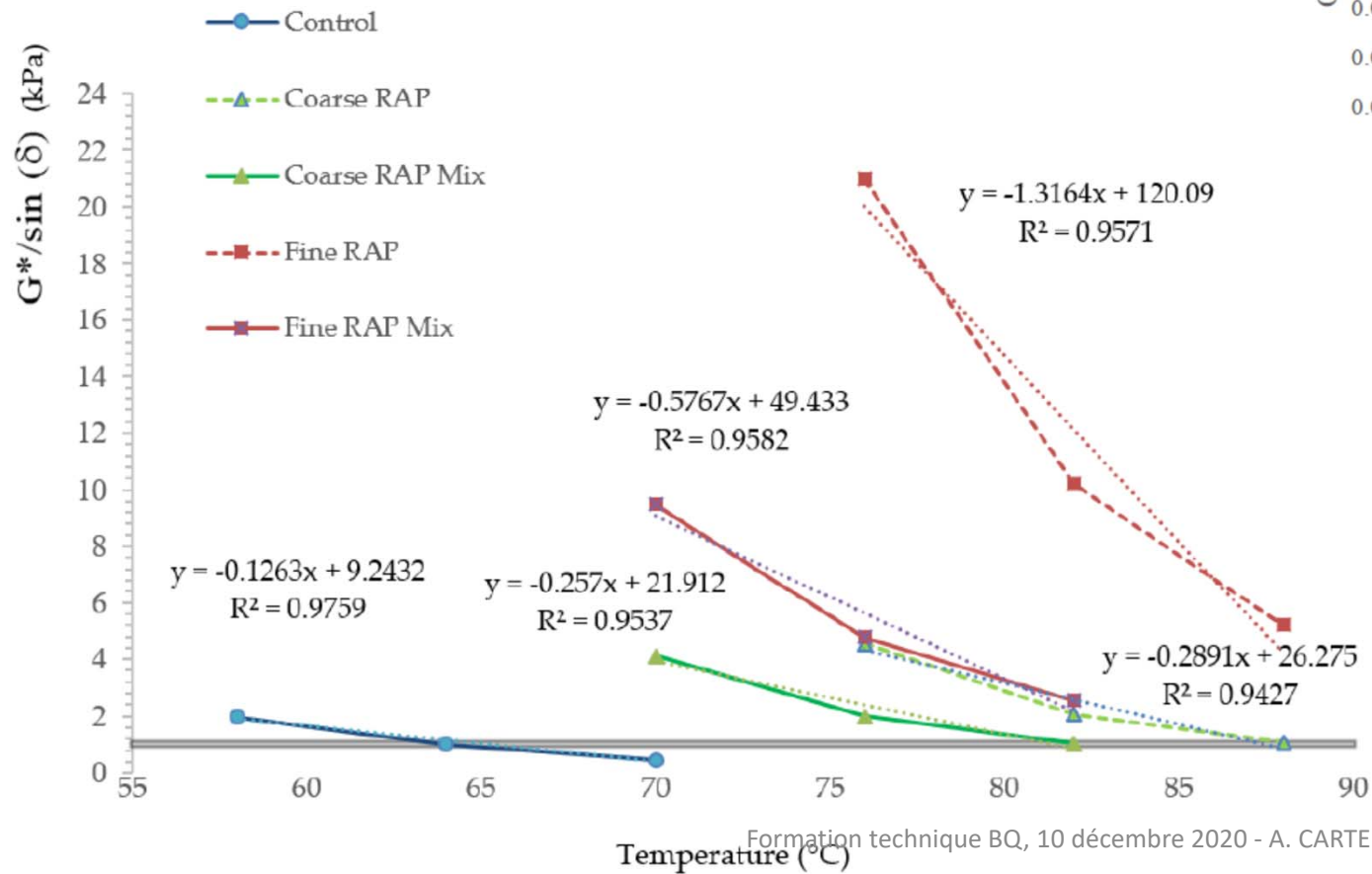
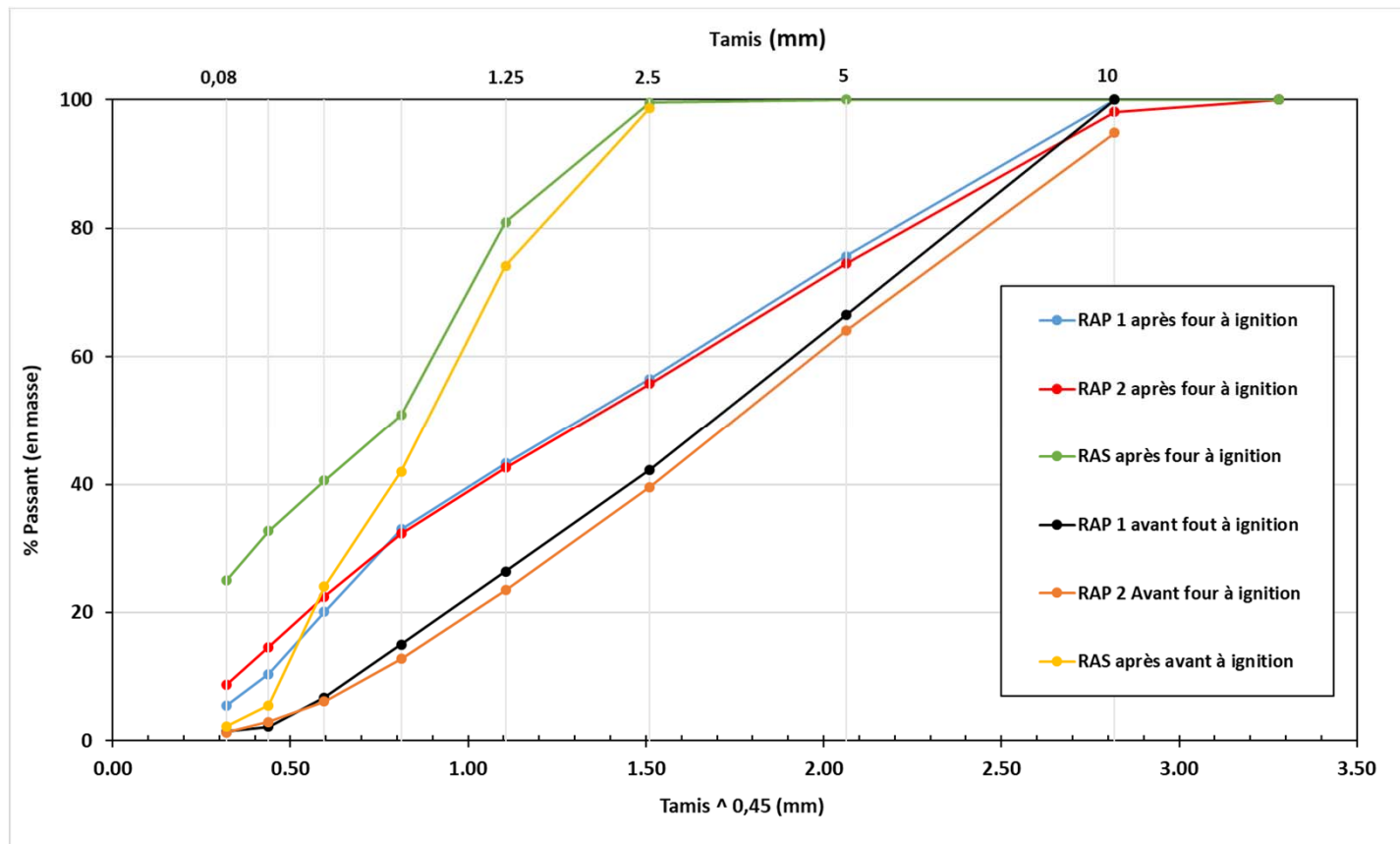


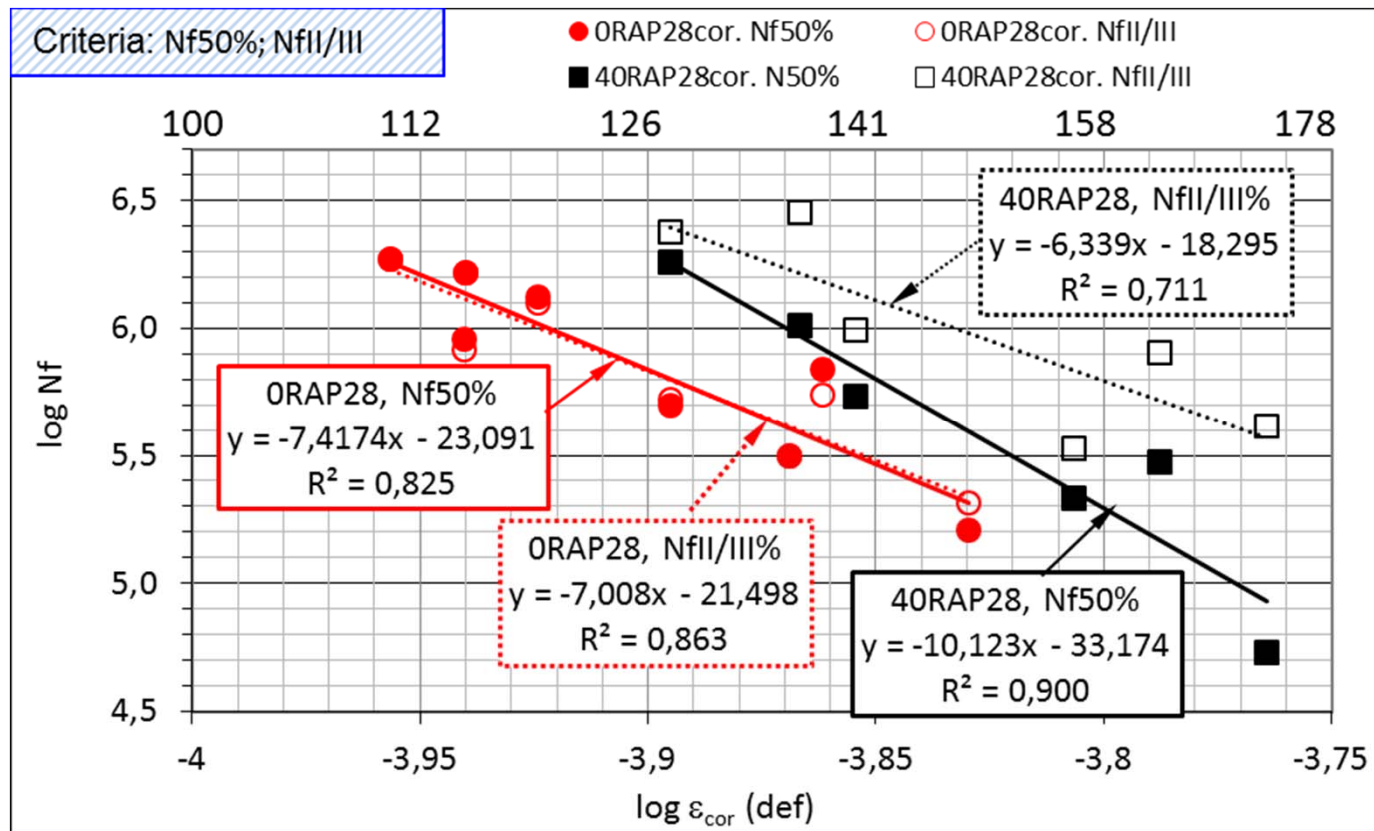
Figure 9. FTIR carbonyl oxidation indices.

Granulométrie

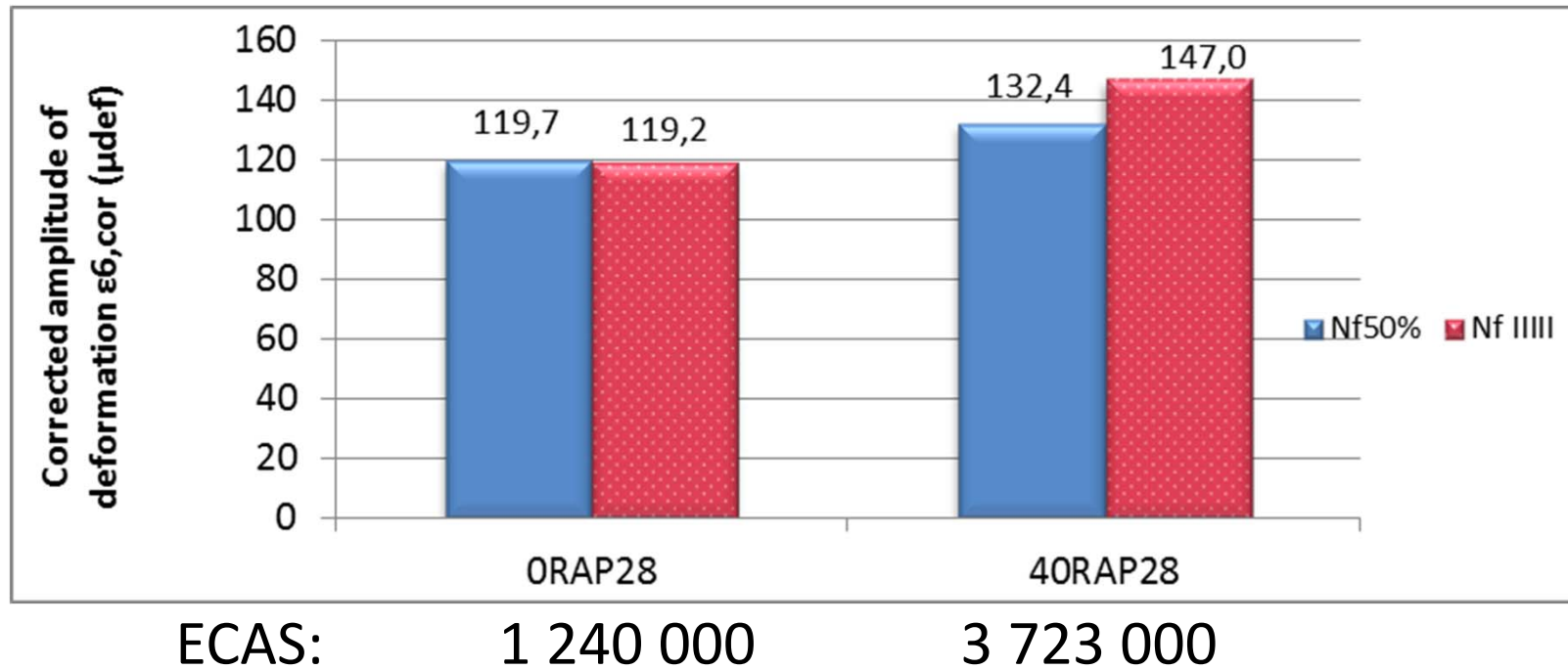


Formation technique BQ, 10 décembre 2020 - A. CARTER

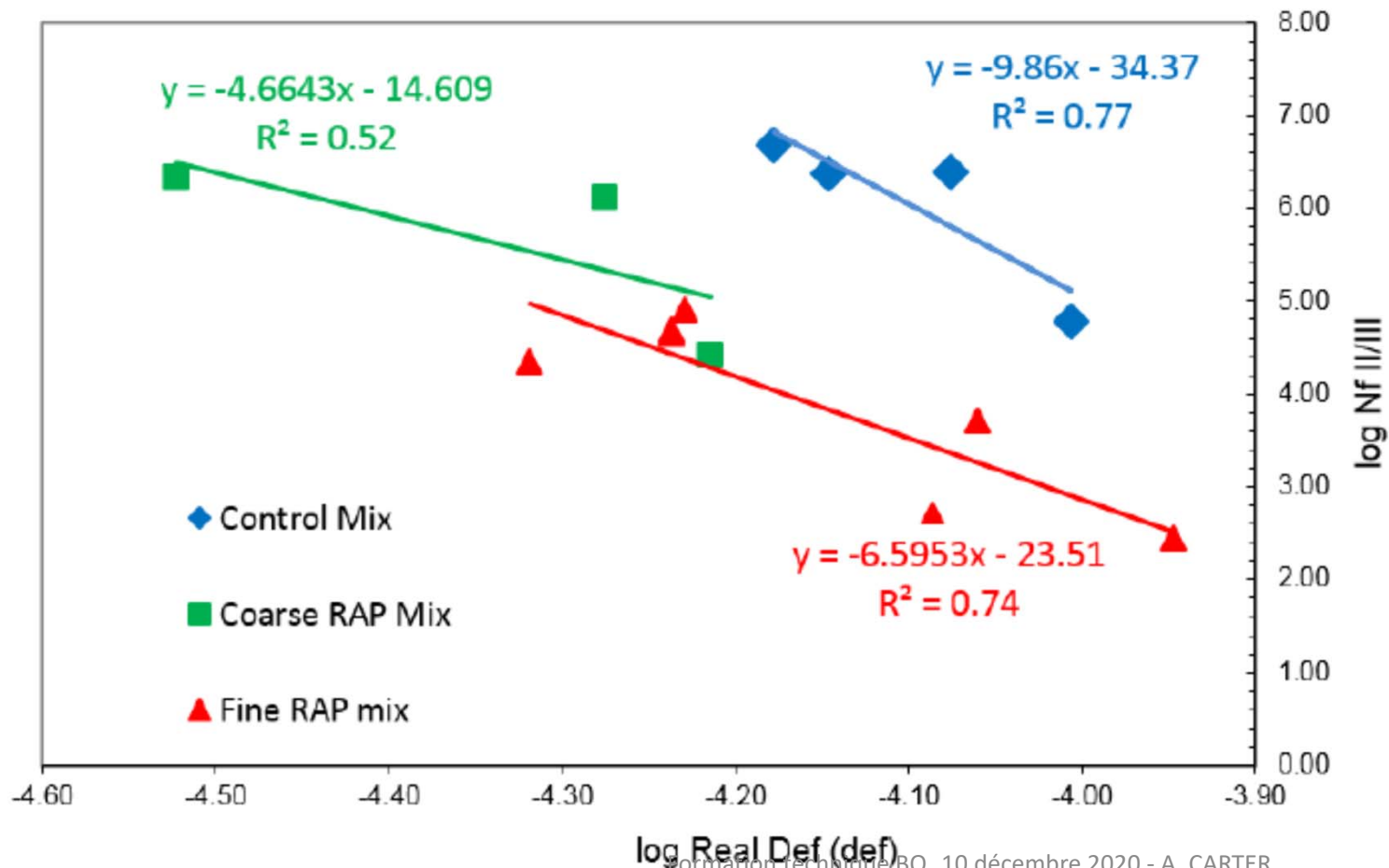
Résistance à la fatigue



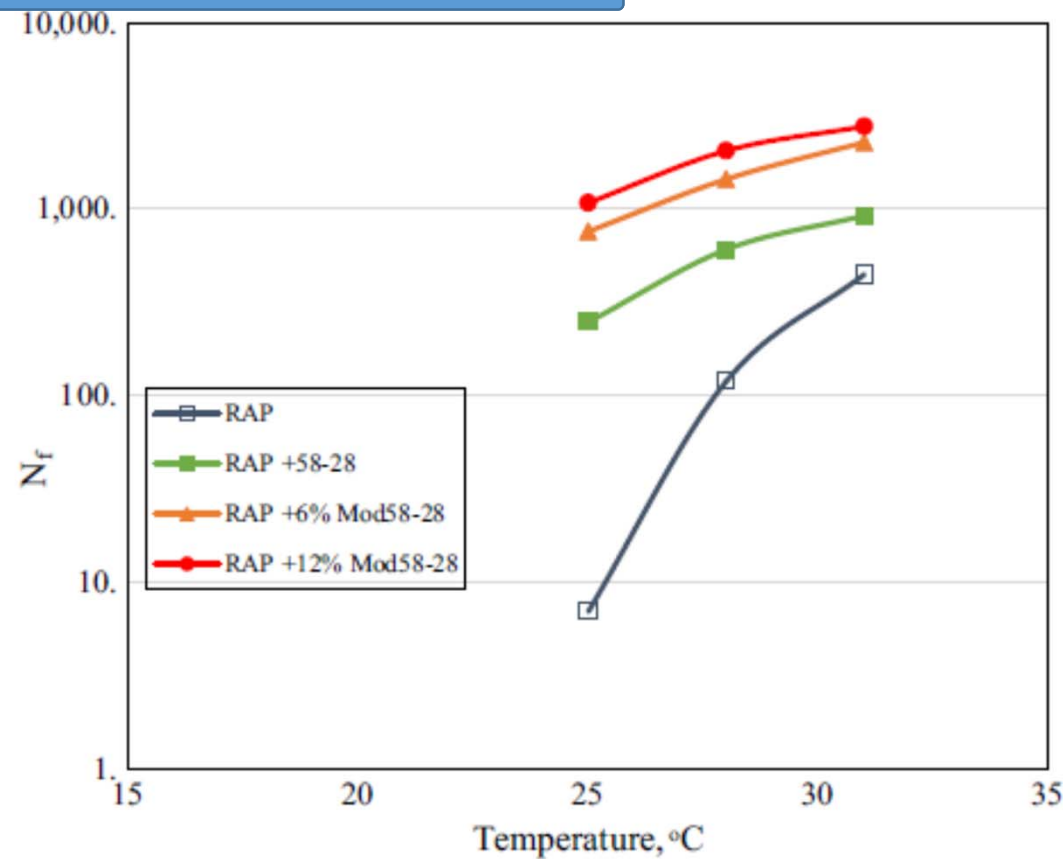
Résistance à la fatigue



Résistance à la fatigue



Résistance à la fatigue



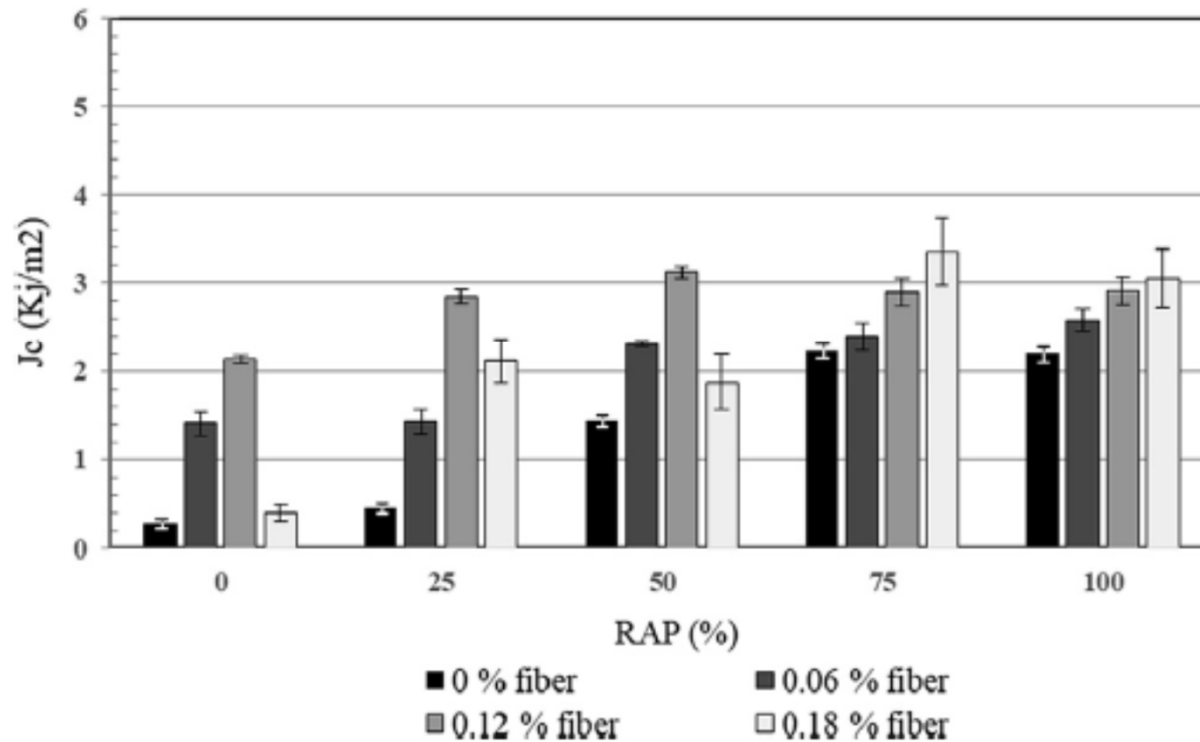
Elkashef et Williams, 2017

Fig. 8. Cycles to failure at a strain rate of 5%.

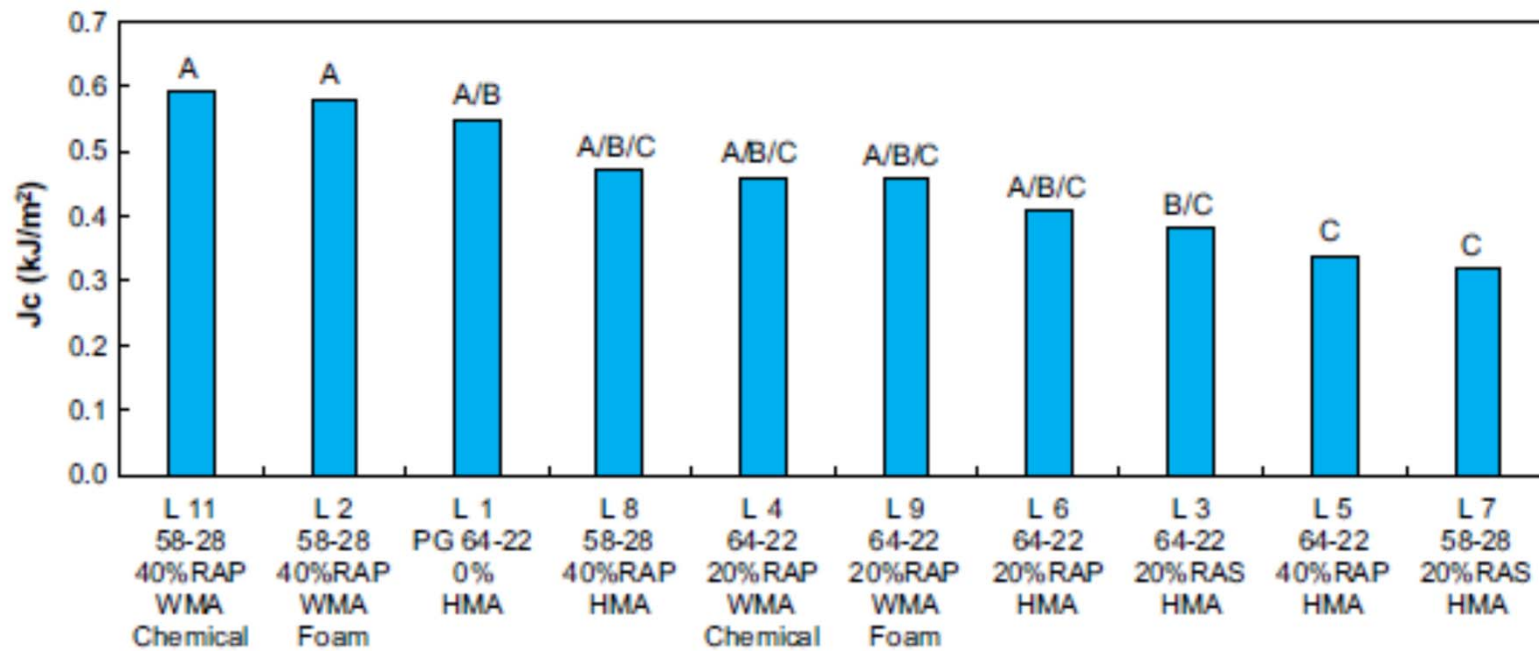
Formation technique BQ, 10 décembre 2020 - A. CARTER

Propagation des fissures

Jc at -15°C

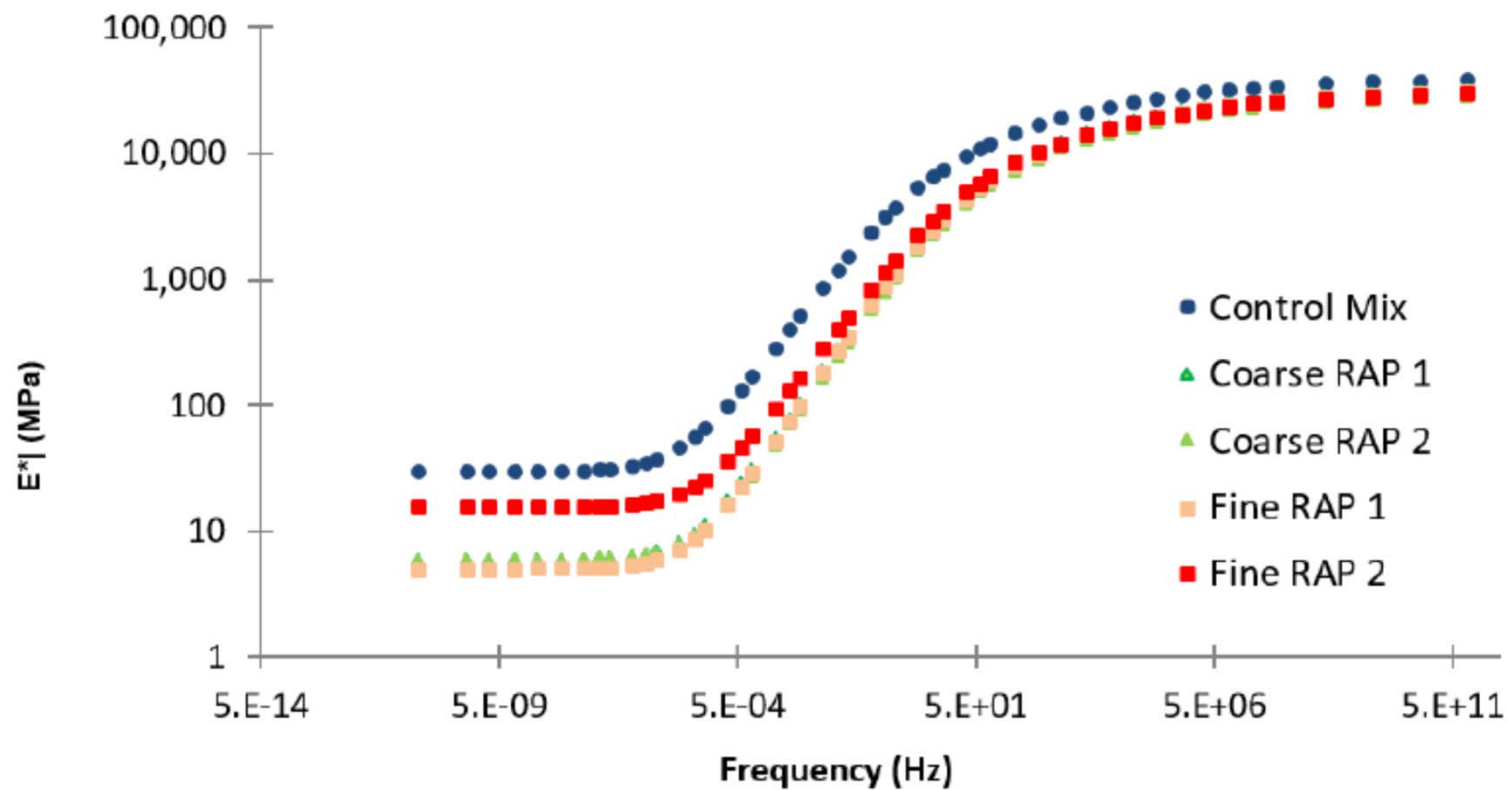


Propagation des fissures

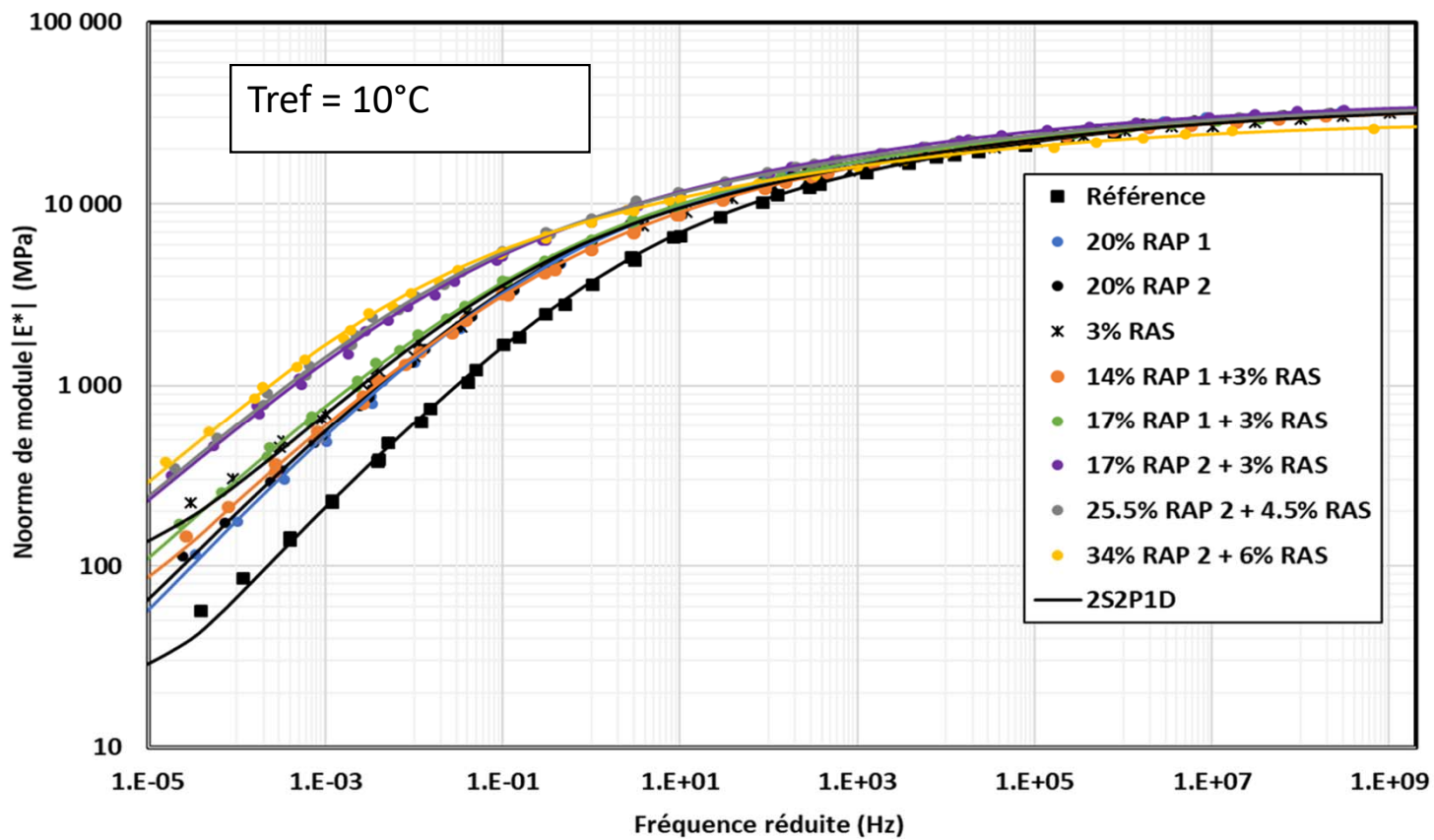


Cao et al., 2019

Module complexe

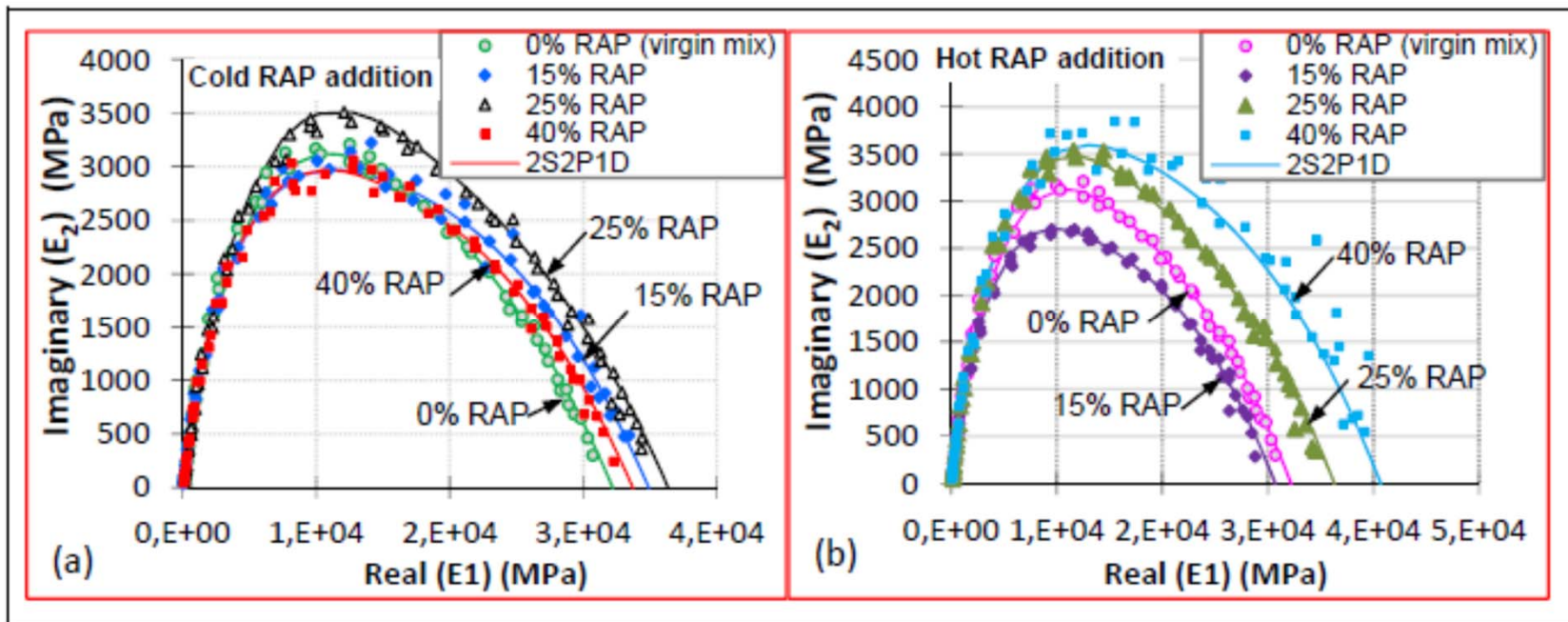


Module complexe

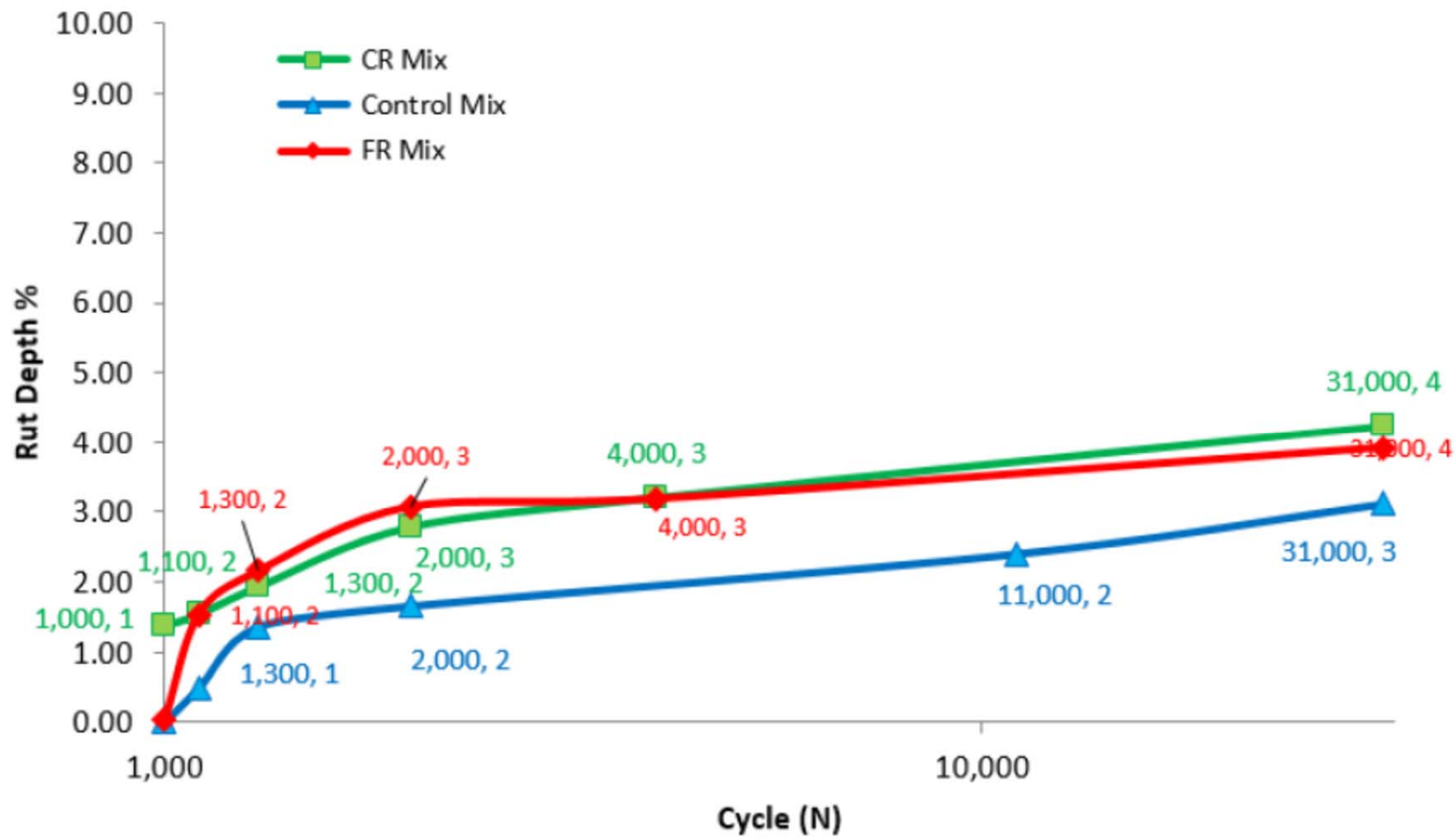


Formation technique BQ, 10 décembre 2020 - A. CARTER

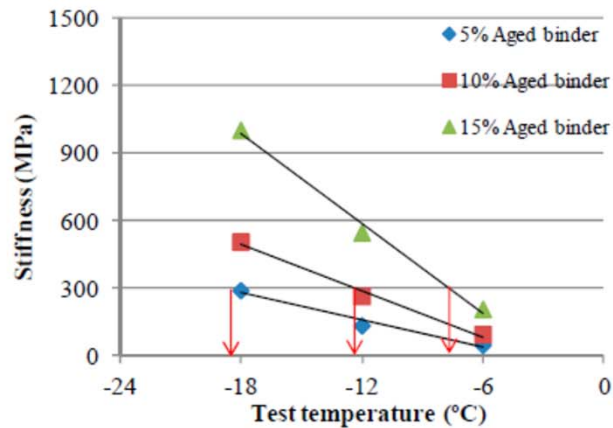
Module complexe



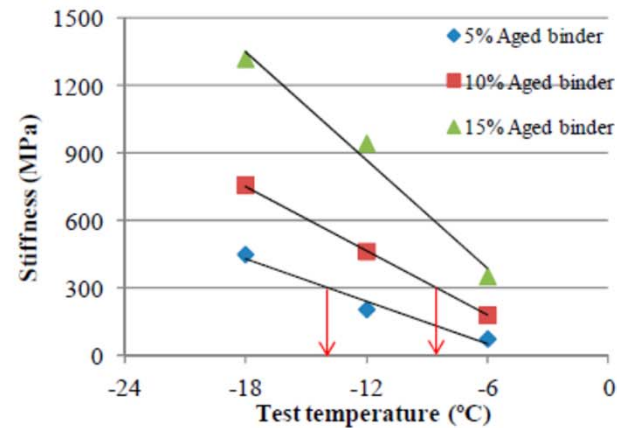
Résistance à l'orniérage



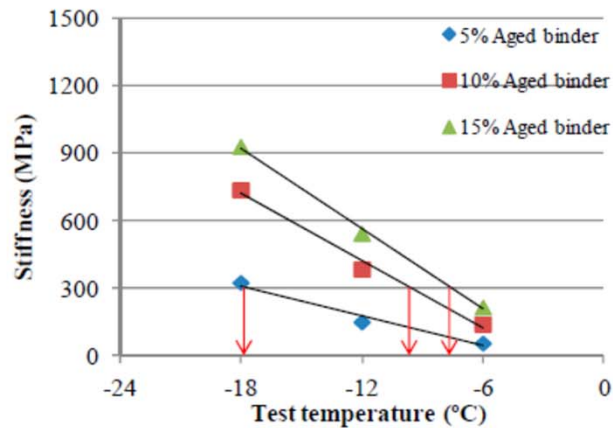
Résistance à fissuration thermique (BBR)



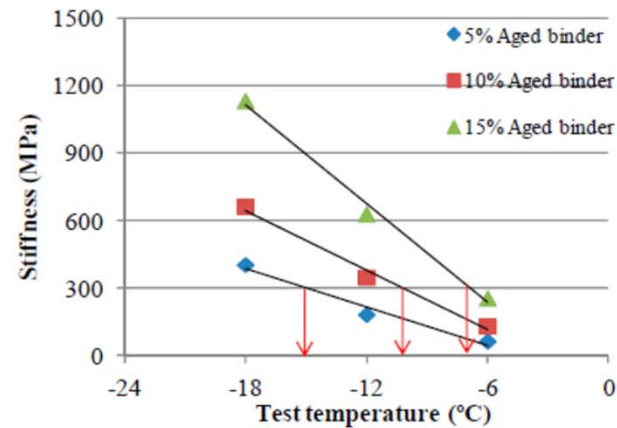
(c)



(d)

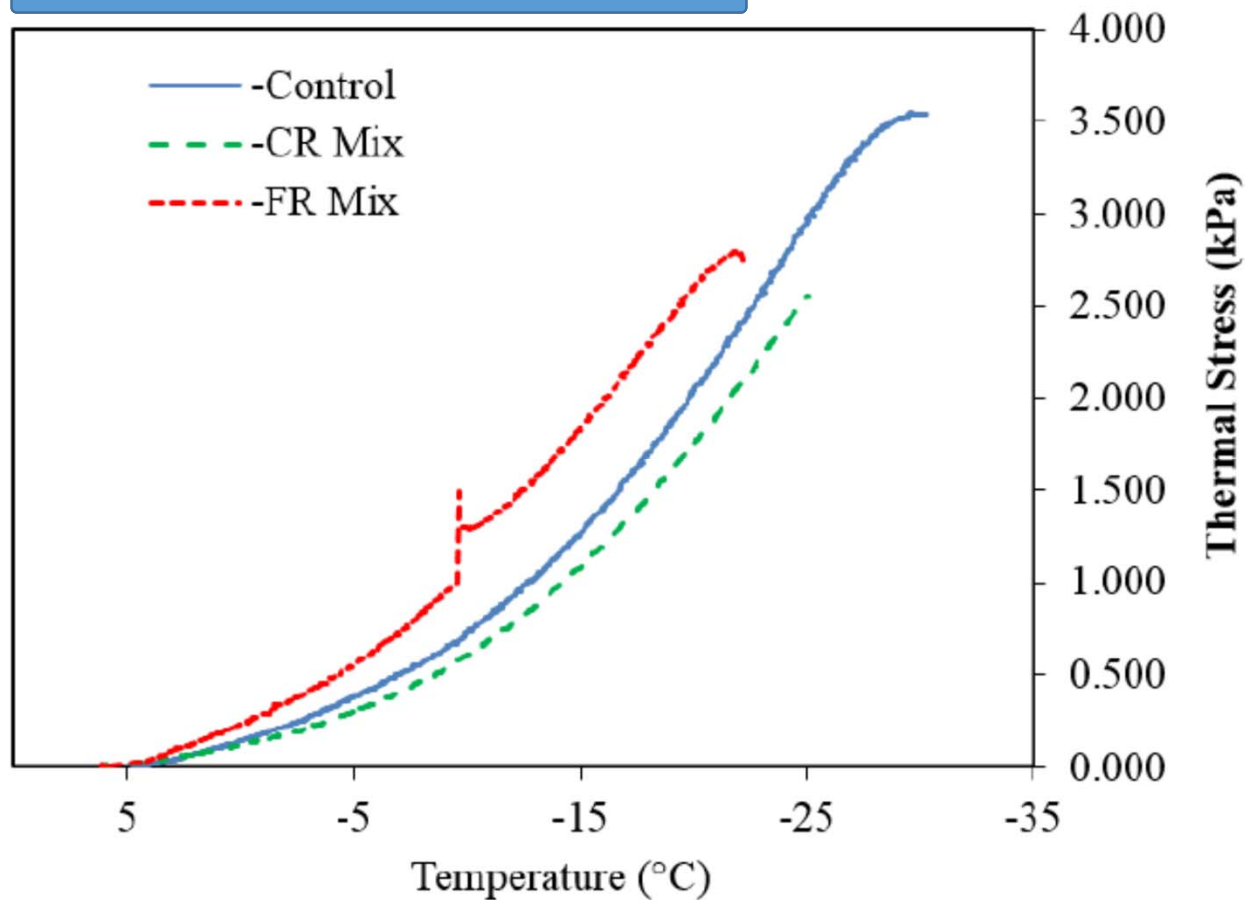


(e)



(f)

Résistance à la fissuration thermique



Sommaire

- Enrobés avec GBR performant très bien
 - Augmentation du module
 - Augmentation de la résistance à l'orniérage
 - Fatigue...ça dépend
 - Fissuration thermique
 - Peut être contrôlée

Questions

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Merci!

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