Wykorzystanie wskaźnika CT-index do oceny odporności MMA na spękania

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Zakres prezentacji:

- Podejście amerykańskie (BMD)
- Test Ideal-CT
- Analiza wyników badań
- Wnioski

Dlaczego dotychczasowe metody projektowania MMA są niewystarczające?

With the current volumetric mix design system...

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Nowe podejście w USA
Balanced Asphalt Mixture Design

- *„asphalt mix design using performance tests on appropriately conditioned specimens that address multiple modes of distress taking into consideration mix aging, traffic, climate and location within the pavement structure”*

Koncepcja optymalizacji własności MMA

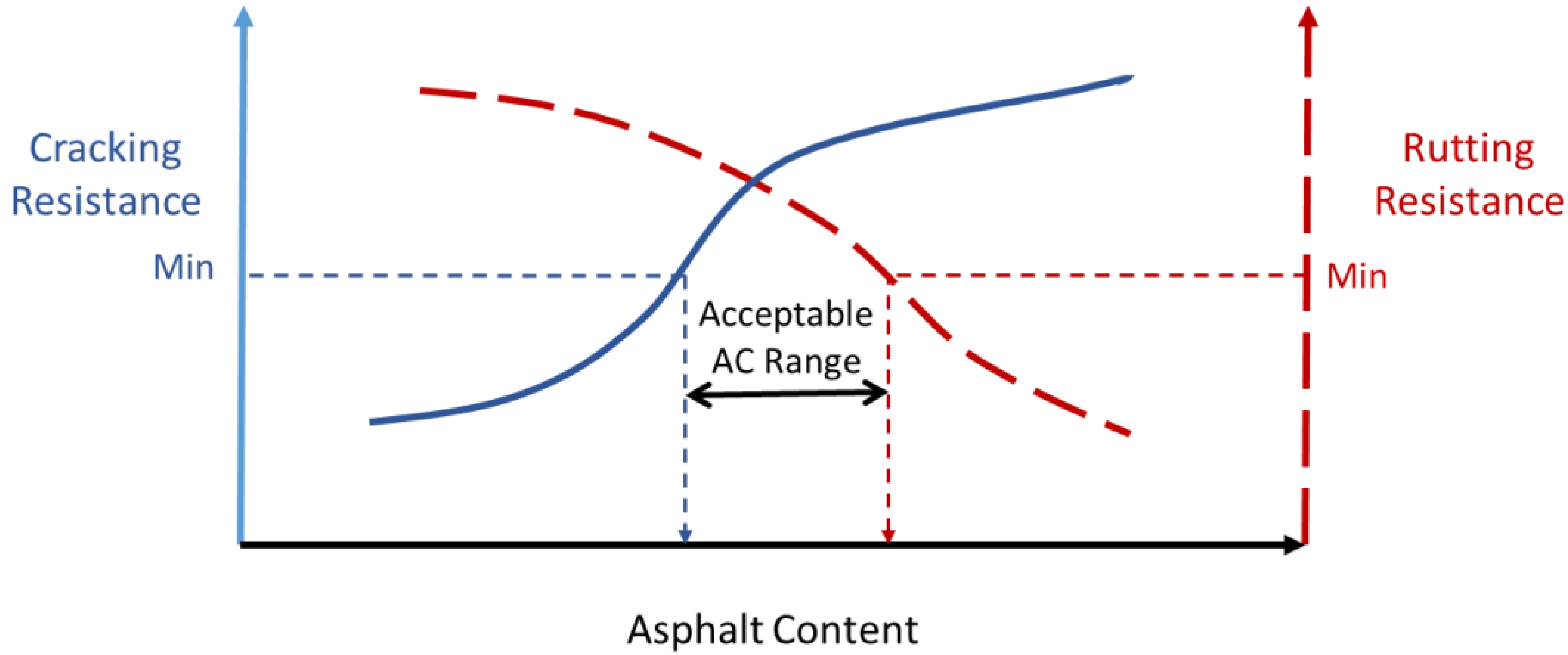
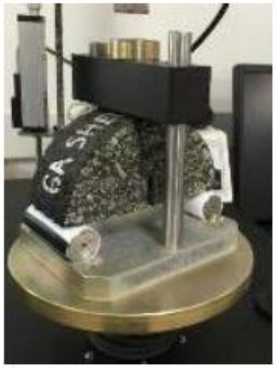


Figure 1.2. Concept of balanced mix design (Newcomb & Zhou, 2018)

Wybrane metody badania spękań (BMD) wg NCAT

Selected Top-Down Cracking Tests

SCB-LA



I-FIT

OT-TX

OT-NCAT

IDEAL-CT

AMPT Cyclic Fatigue

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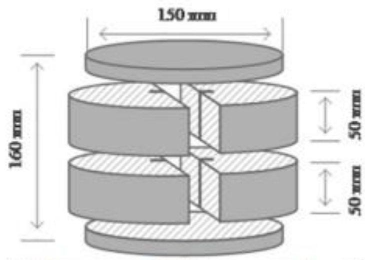
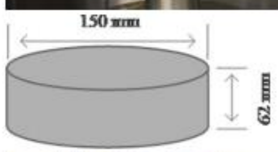
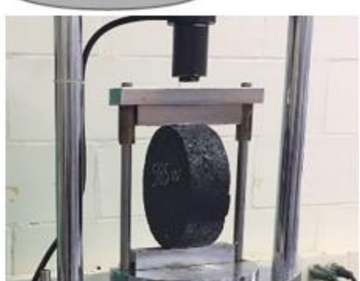
Porównanie metod badania odporności na spękania

Table 3
Thermal cracking tests[24].

Test standard		Cracking parameter	Test temperature	Number of specimens	Specimen preparation and test time	Equipment cost	Overall practicality QC
ASTM D7313 DCT		Fracture energy	PG low + 10℃	3	5 cuts and 2 holes/ specimen ; Total time:4–5 days	$50000	Poor
AASHTO TP 105 SCB-low temperature		Fracture energy	PG low + 10℃	3	5 cuts/2 specimens and 2 sensors; Total testing time:3–4 days	$100000	Poor
ASTM D8044 SCB-J_c		J_c-critical strain energy release rate	25℃	12	7 cuts/4 specimens; Total time:7–8 days(including 5 days at 85 ℃ aging)	< $10000	Poor
ASTM TP 124 SCB-FI		Flexibility index	25℃	6	5 cuts/2 specimen; Total testing time:2–3 days (including sample drying)	< $10000	Fair
IDT-University of Florida method		Energy ratio	10℃	3	2 cuts/specimen and 4 sensors; Total testing time:4–5 days	> $100000	Poor
Tex-248-F OT		Crack resistance index	25℃	3	4 cuts/specimen and gluing; Total testing time:3–4 days	$50000	Poor
AASHTO T 321 BBF		Number of cycles	20℃	3	6 cuts/specimen; total testing time:3–5 days	> $100000	Poor
ASTM D8225 IDEAL-CT		Crack tolerance index(CT_{index})	25℃	3	No cutting or gluing; Total testing time: 1 day	< $10000	Good
AASHTO TP 107 AMPT cyclic fatigue test		Fatigue damage parameters	Intermediate temperature	4(+3 for E* test)	1 coring and 2 cuts/specimen and gluing; Total testing time:4–5 days	$85000	Poor

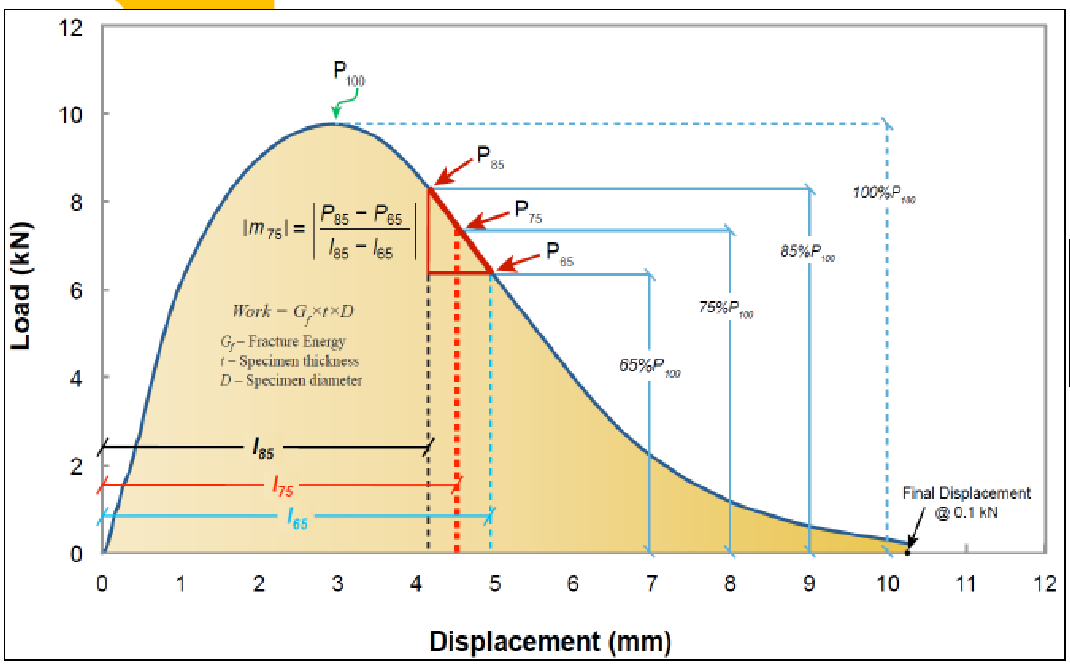
Porównanie testu SCB i IDEAL-CT

Table 1
Specimen preparation and testing set-up for SCB-IFIT and IDEAL-CT.

Testing Methods			Requirements and Limitations
SCB-IFIT	Specimen		• 3 cuts from gyratory specimen and 1 notch • A chop saw for cutting and a band saw or table saw for notching • Extra time to dry the specimen after cutting
	Set-up		• A specific bend test fixture • Testing machine with a closed loop, feedback-controlled servo hydraulic load frame • A program for fitting measured data and analyzing flexibility index
IDEAL-CT	Specimen		• No cutting or notching • Test gyratory specimen directly
	Set-up		• Share loading strips with IDT test • Marshall test equipment can be used • Less training for routine uses in DOTs and contractors' laboratories • Data analysis is easy to follow

Wyznaczanie parametru odporności na pękanie MMA (test IDEAL-CT wg NCAT)

IDEAL-CT Overview



(Zhou et al., 2017)

$$CT_{index} = \frac{t}{62} \times \frac{G_f}{|m_{75}|} \times \frac{l_{75}}{D} \times 10^6$$

$$Gf = \frac{W}{t \times D}$$

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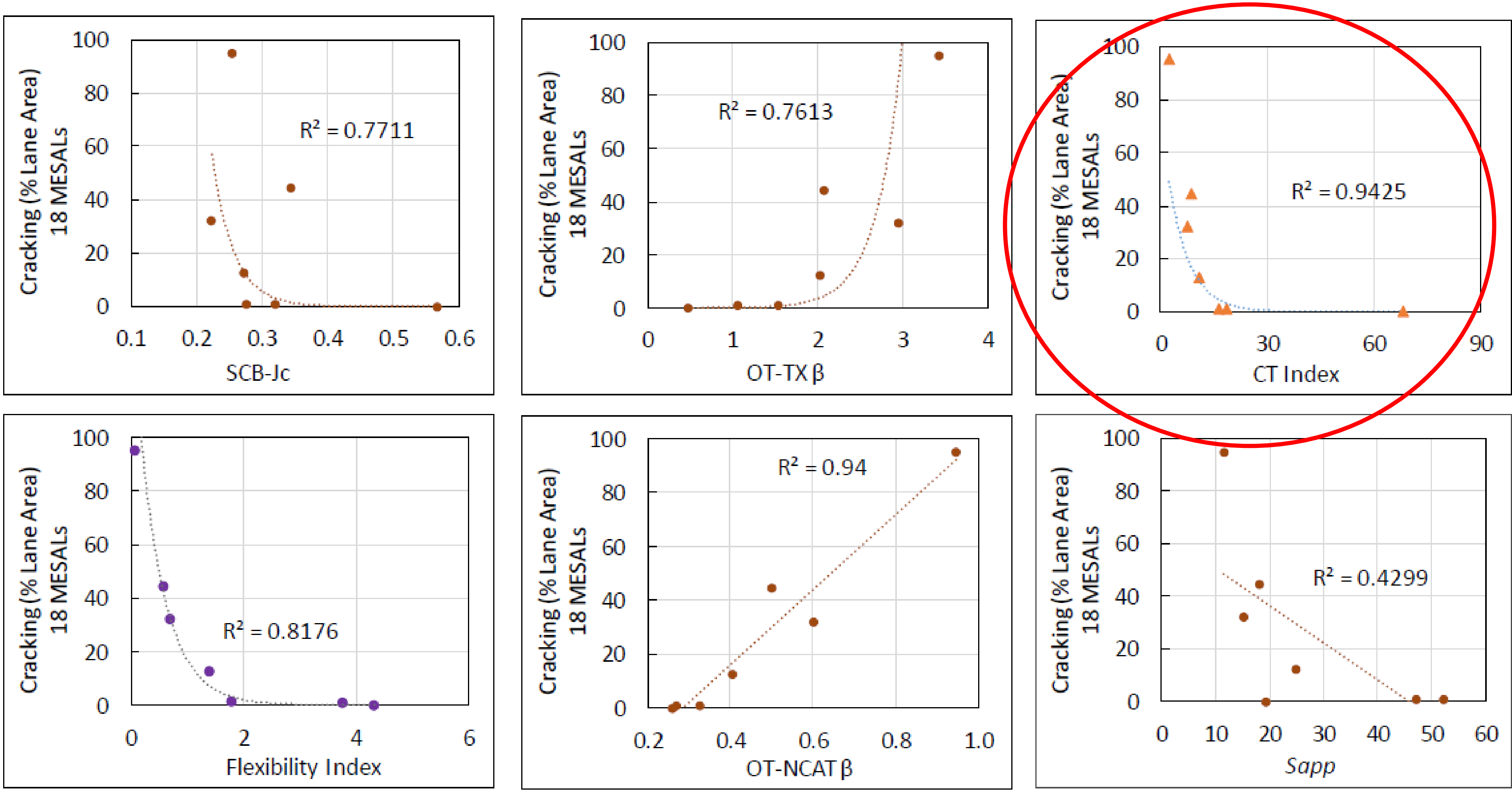
Korelacje laboratoryjnych metod badawczych z wynikami badań poligonowych wg NCAT

PMLC Critically Aged 8 hrs. @ 135°C

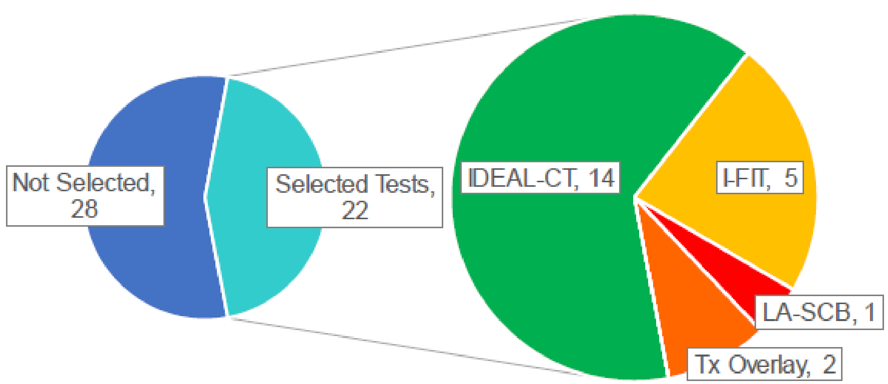


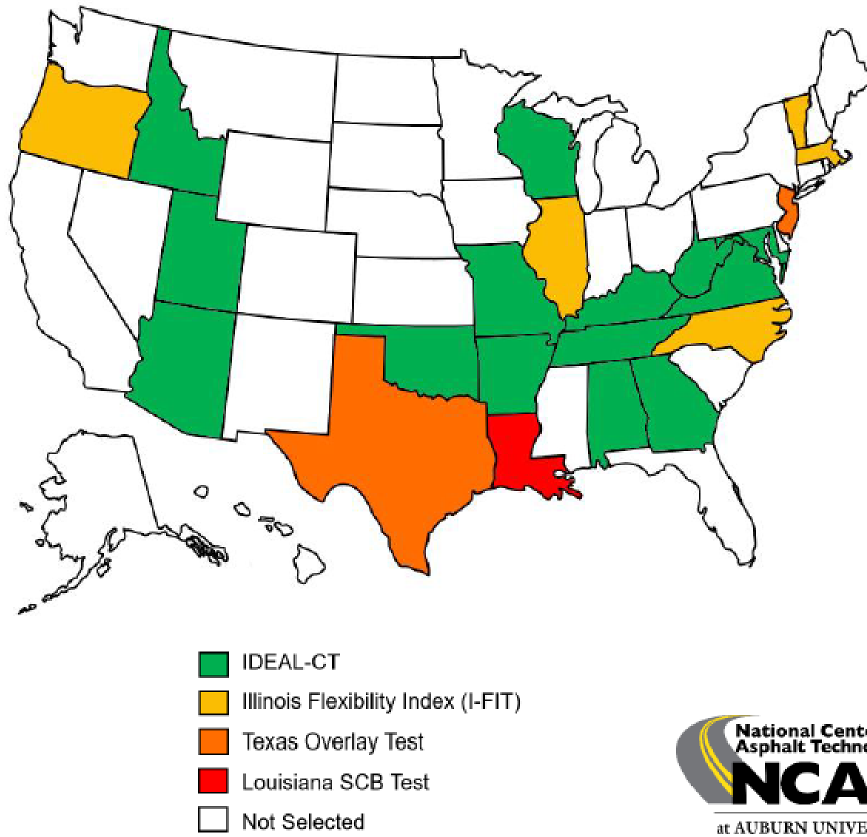
Wybrane metody badań spękań generowanych ruchem drogowym wg NCAT

Load Related Cracking Tests

Load Cracking Tests Selected

(# of states)





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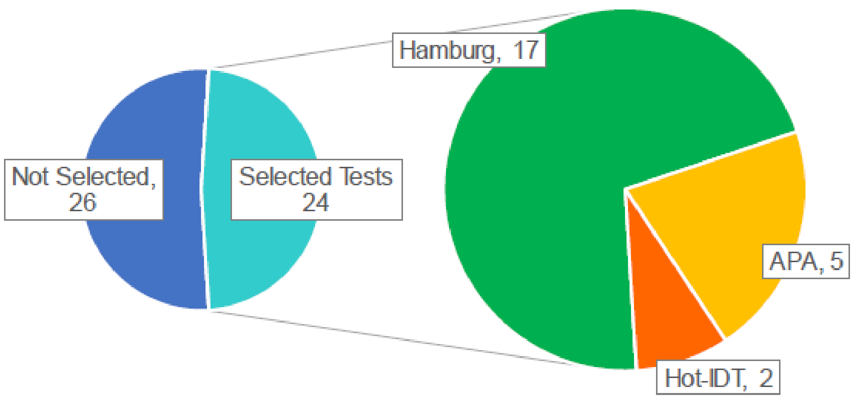
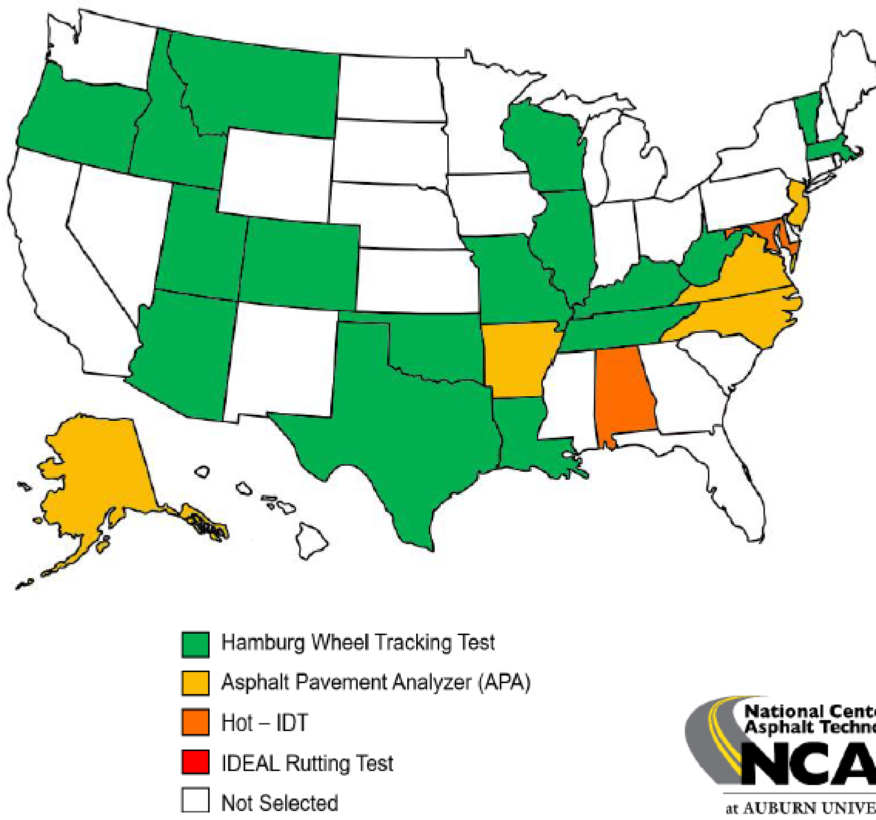
Wybrane metody badań odporności na koleinowanie wg NCAT

Rutting Tests

Rutting Tests Selected
(# of states)





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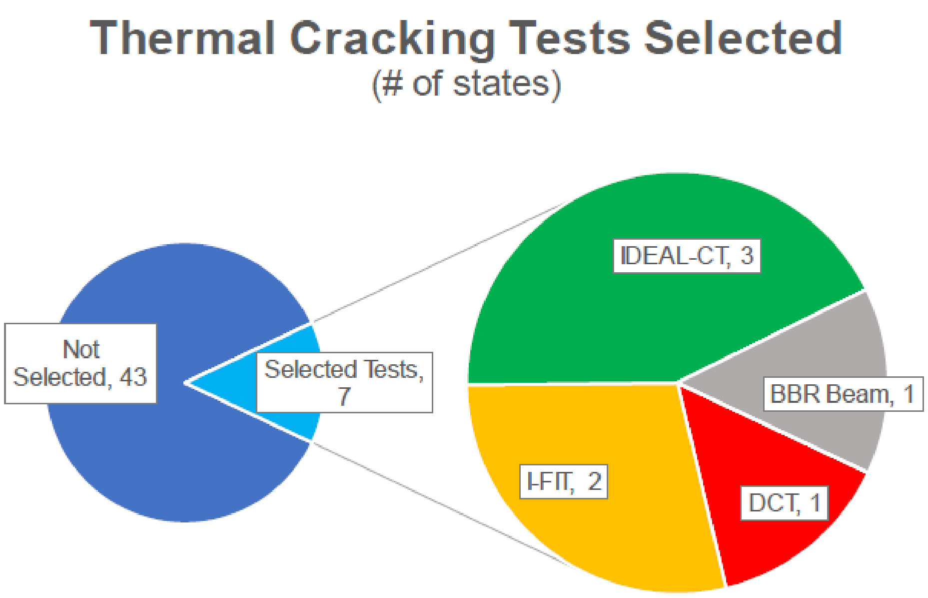
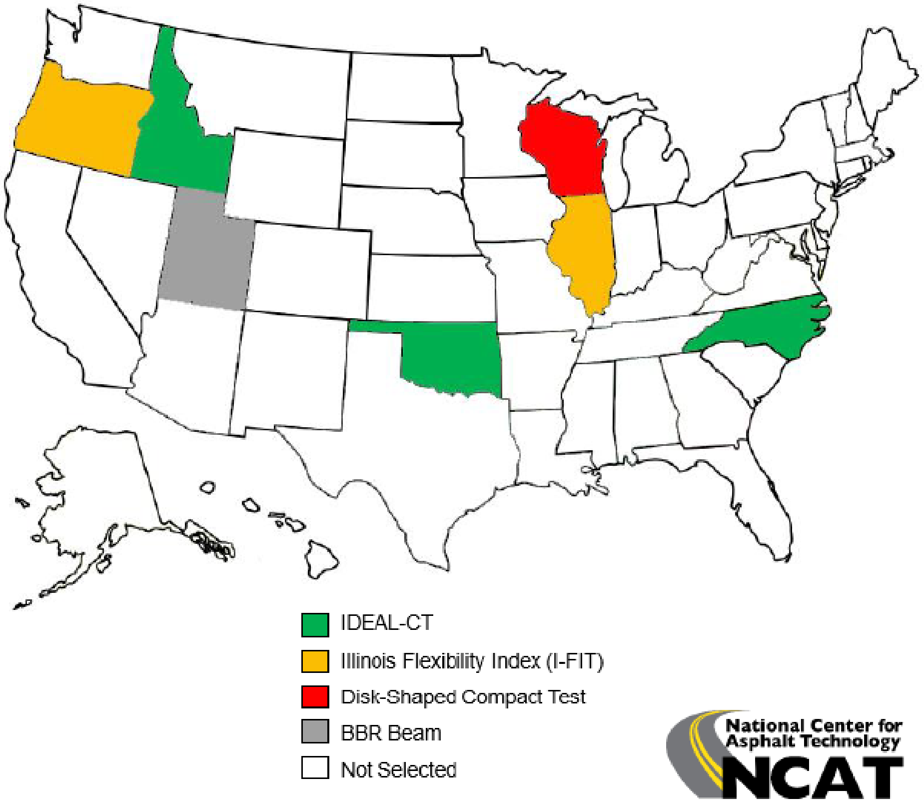
Wybrane metody badań spękań termicznych wg NCAT

Thermal Cracking Tests





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Kryteria odporności na spękanie CT-index dla stanu Ohio

Crack Resistance and Durability of Ohio DOT Asphalt Mixtures Using I-FIT & IDEAL-CT: Phase 2

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Project ID 109887

November 2021

Final Report

Table 4. Recommended Performance Criteria for the IDEAL-CT Test

Mix Type	Minimum CT_{index}
Item 442 (Superpave) 12.5 mm (Surface)	80
Item 442 (Superpave) 19 mm (Intermediate)	60
Item 441 (Marshall) Type 1 Surface Mixes	80
Item 441 (Marshall) Type 1 Intermediate Mixes	80
Item 441 (Marshall) Type 2 Intermediate Mixes	60
Item 302 (Marshall) Mixes	60

Wymagania CT Index dla stanu Georgia

TABLE 5 – IDEAL-CT PERFORMANCE TESTING AND ACCEPTANCE CRITERIA		
Design Roadway Classification	**Asphaltic Concrete Mix Type**	**Mix Design and Quality Acceptance Minimum CT Index**
State Routes (Non-controlled access) <10,000 ADT	4.75 mm and All Superpave Mix Types	≥ 50
State Routes (Non-controlled access) ≥10,000 ADT	All Superpave Mix Types	≥ 70
Interstates and Controlled Access State Routes	All Superpave Mix Types	≥ 100
Interstates and Controlled Access State Routes	All SMA Mix Types	≥ 150

Kryteria płatności w oparciu o CT Index dla stanu Missouri

Table 6. MoDOT Performance Test Criteria for Production Acceptance

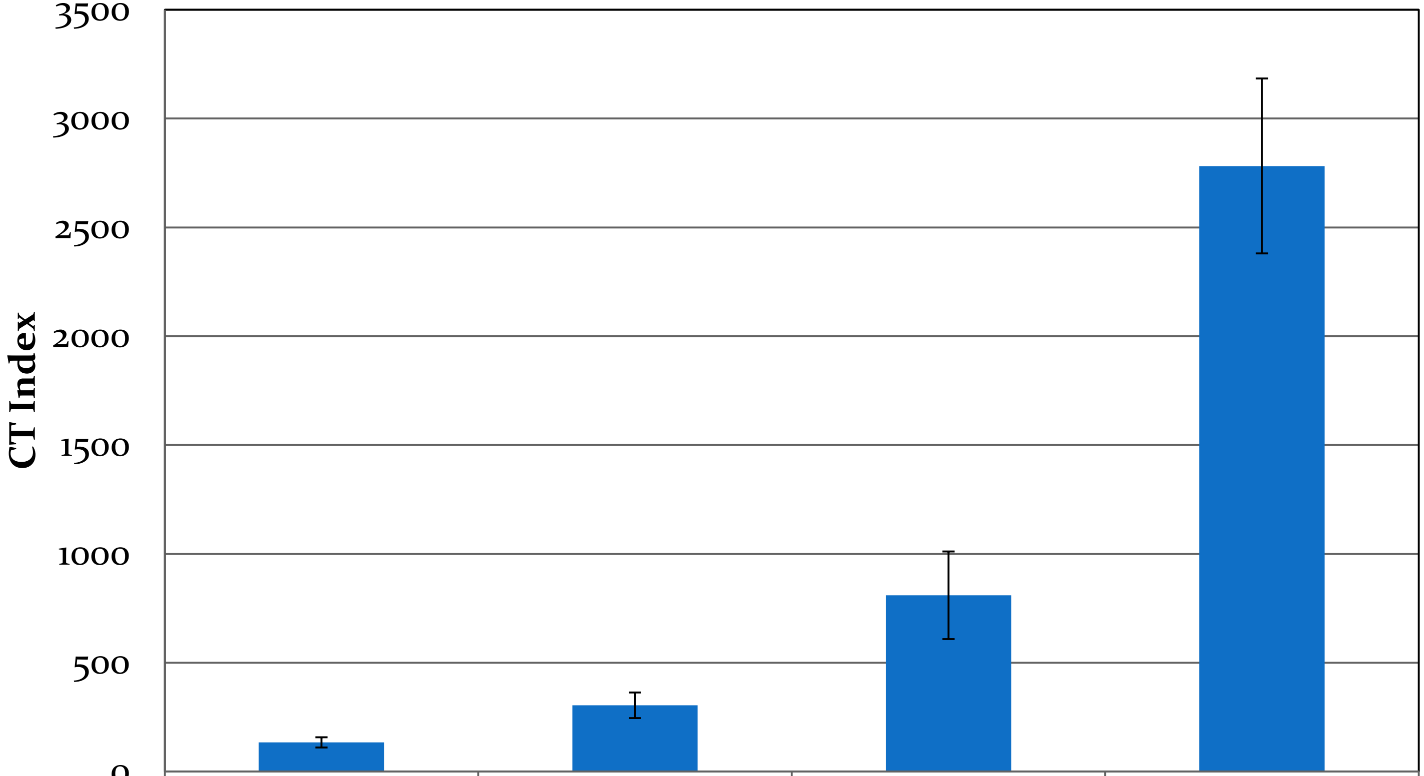
Mix Type	I-FIT *FI* Criteria	IDEAL CT_{index} Criteria	Percent of Contract Price
Superpave (NMAS < 19.0 mm)	< 2.0	< 32	98%
	2.0 to 3.9	32 to 60	100%
	4.0 to 7.9	60 to 97	102%
	> 8.0	> 97	103%
SMA	< 6.0	< 80	98%
	6.0 to 11.0	80 to 159	100%
	12.0 to 15.0	160 to 180	102%
	> 15.0	> 180	103%

Przegląd kryteriów dla CT-index

Table A.8. Minimum Threshold Value Used or Proposed in Different Studies for CT_{index}.

Reference	Threshold Value	Comments
Bennert et al. (2018)	245	Table 4 (High-performance thin overlay)
	245	Table 4 (Bituminous-rich inter course)
	180	Table 4 (High RAP – surface course)
	140	Table 4 (High RAP – inter/base course)
Newcomb and Zhou (2018)	80	Table 3.3
Diefenderfer and Bowers (2019)	80	Table 5
Buttlar et al. (2020)	150	Table 6-2 (High criticality surface lift)
	100	Table 6-2 (Medium criticality surface lift)
	55	Table 6-2 (Low criticality surface lift)
	100	Table 6-2 (High criticality non-surface lift)
	70	Table 6-2 (Medium criticality non-surface lift)
	35	Table 6-2 (Low criticality non-surface lift)
Zhou et al. (2020)	55	Table 3 (TxDOT dense graded mixes)
	90	Table 3 (Superpave mixes)
	135	Table 3 (Stone matrix asphalt)
	180	Table 3 (Thin overlay mix)
	400	Table 3 (Crack attenuating mix)
Alkuime et al. (2021)	80	Table 5
Diefenderfer et al. (2021)	70	Page 46

Wskaźnik CT dla mieszanek do warstwy ścieralnej



	AC 50/70	AC PMB 45/80-65	SMA 45/80-65	HUFC 45/80-80
Serie1	134	304	810	2782

Wpływ czasu starzenia na właściwości MMA

NCHRP 20-44(16): Implementation of the Ideal Cracking Test for Asphalt Mix Design and QC/QA

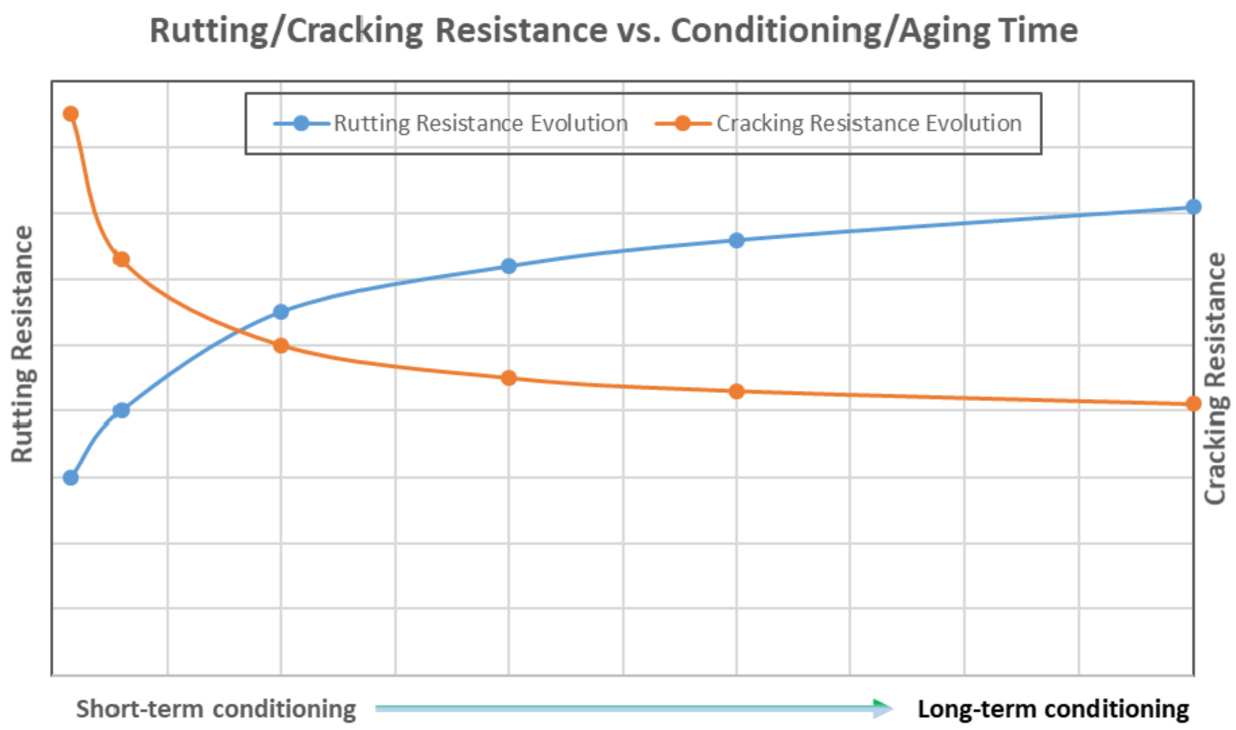
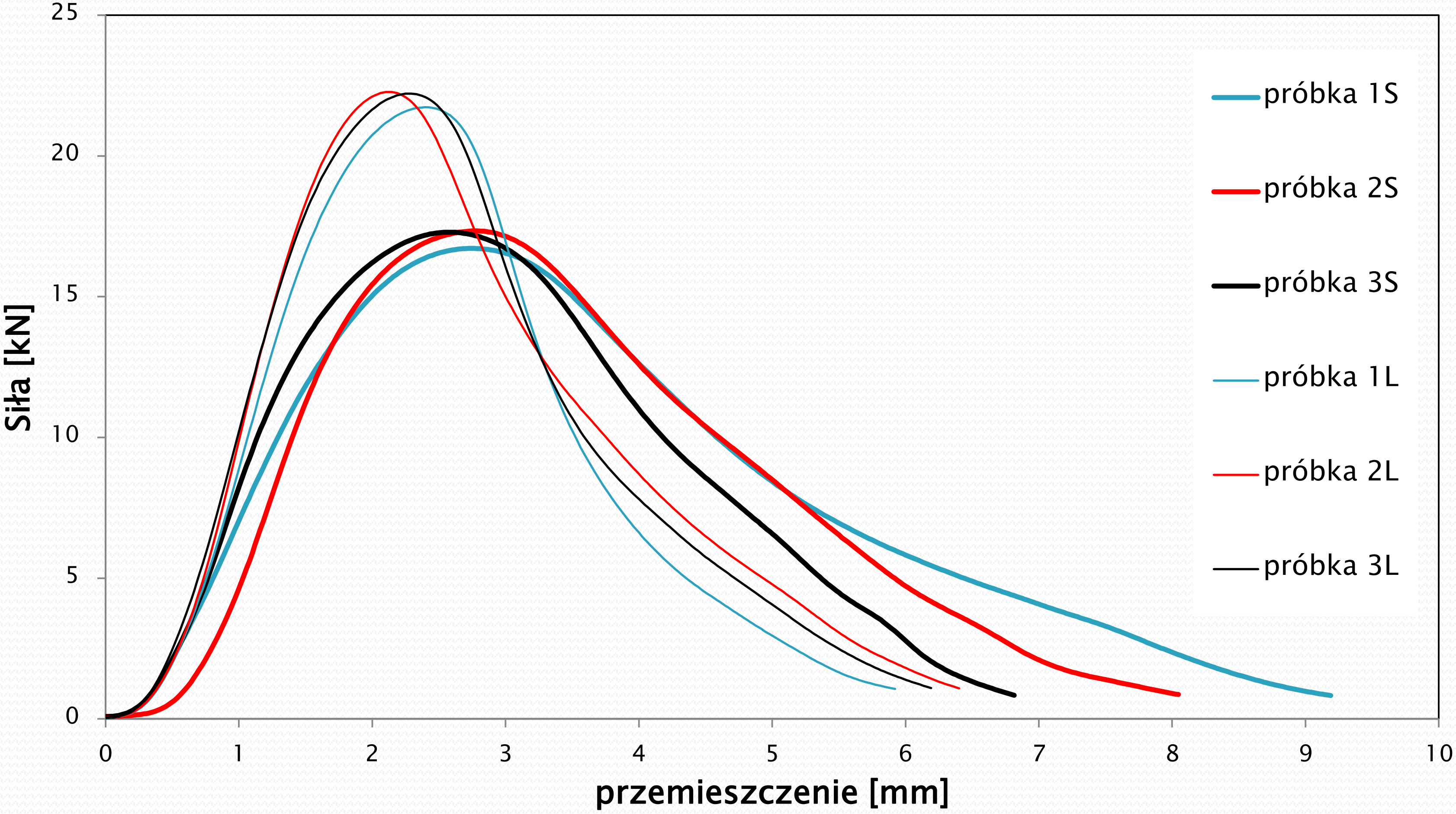
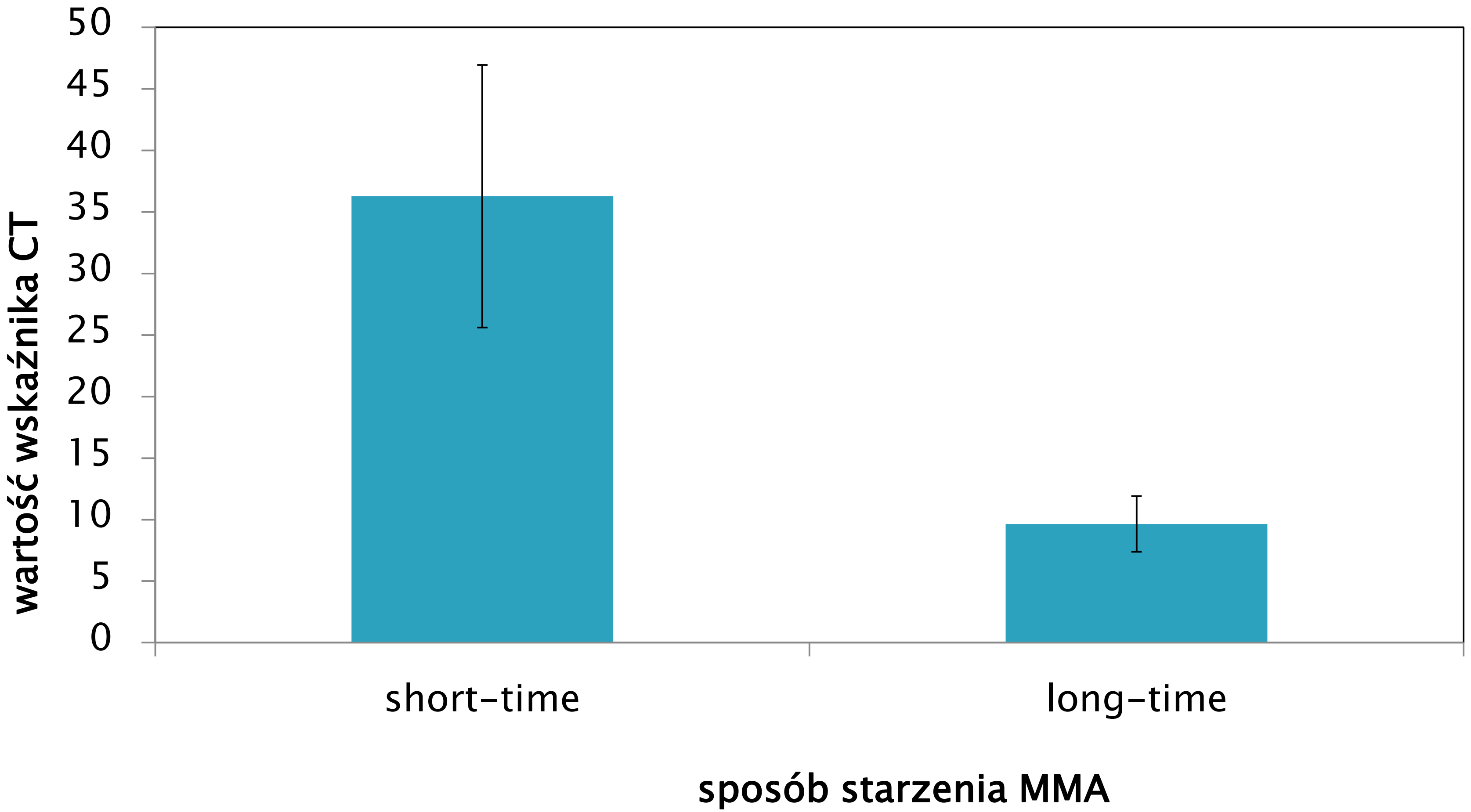


Figure 4. Rutting and Cracking Resistance Evolution vs. Conditioning/Aging Time.

Wykresy siła – przemieszczenie z badania IDEAL-CT



Wskaźnik CT dla mieszanki AC 16 W 35/50



Wnioski

- Potrzebne są nowe badania dla mieszanek z dodatkiem materiałów z recyklingu, zwłaszcza w zakresie wpływu starzenia na odporność na spękanie (w różnych warunkach obciążeń).
- Bardzo obiecujące wydaje się wprowadzenie testu Ideal CT, który jest tani, prosty i powtarzalny, a wg badań amerykańskich uzyskuje dobrą korelację z wynikami badań polowych.
- W przypadku wyboru metody badań odporności MMA na spękania pozostaje ustalenie poziomu wymagań w zależności od funkcji warstwy, warunków obciążenia ruchem, warunków klimatycznych, grubości nawierzchni, itp.