

Effect of aging on cracking resistance

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Background

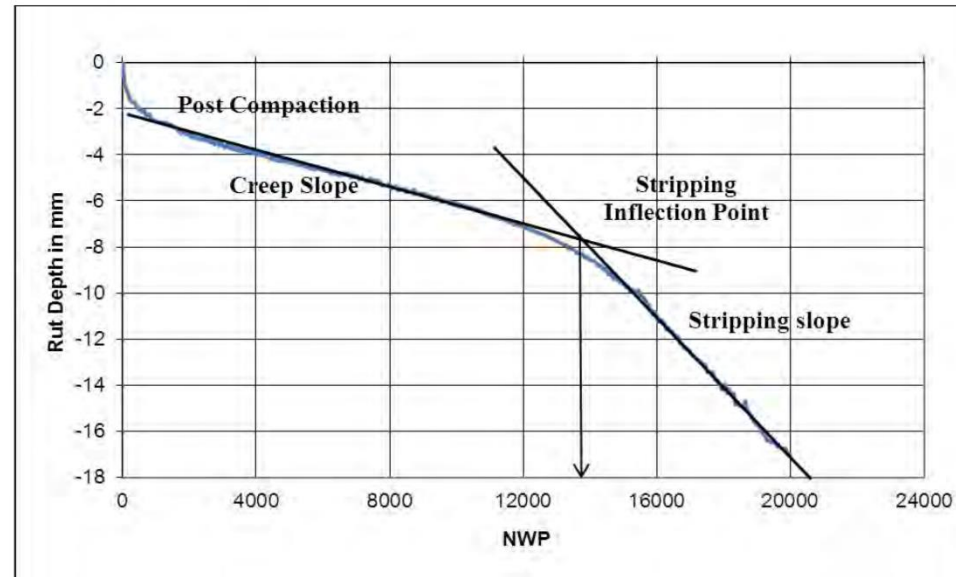
- The volumetric method of mix design has several shortcomings.
- Several states have moved towards BMD implementation.
- Oklahoma DOT has conducted several pilot projects using BMD approach.
- ODOT has set forth a plan to fully implement BMD within the next few years.
- Several research projects are underway to support ODOT efforts:
 - Aging study (PI: Dr. Elkashef)
 - Benchmarking study (PI: Dr. Deb Mishra)

What is Balanced Mix Design (BMD) ?

- Use performance-based testing to balance between cracking and rutting resistance.
- Of course, we still need to meet moisture resistance, durability, etc.

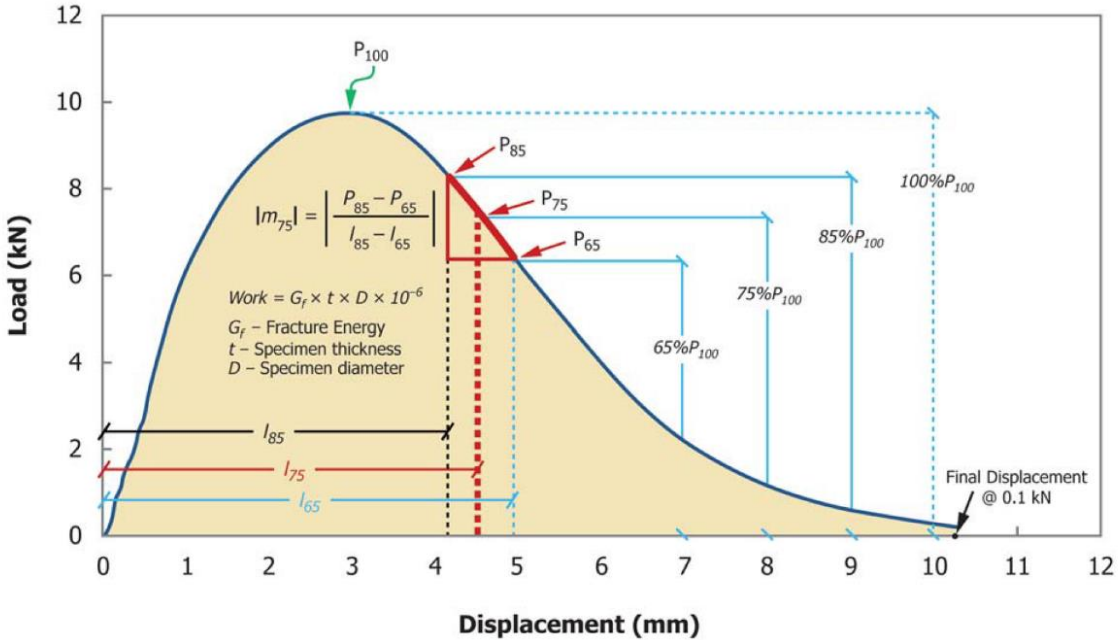


Performance-based testing (Rutting)



	PG64	PG70	PG76
Min. No. of Cycles to 12.5 mm, 122 F	10,000	15,000	20,000

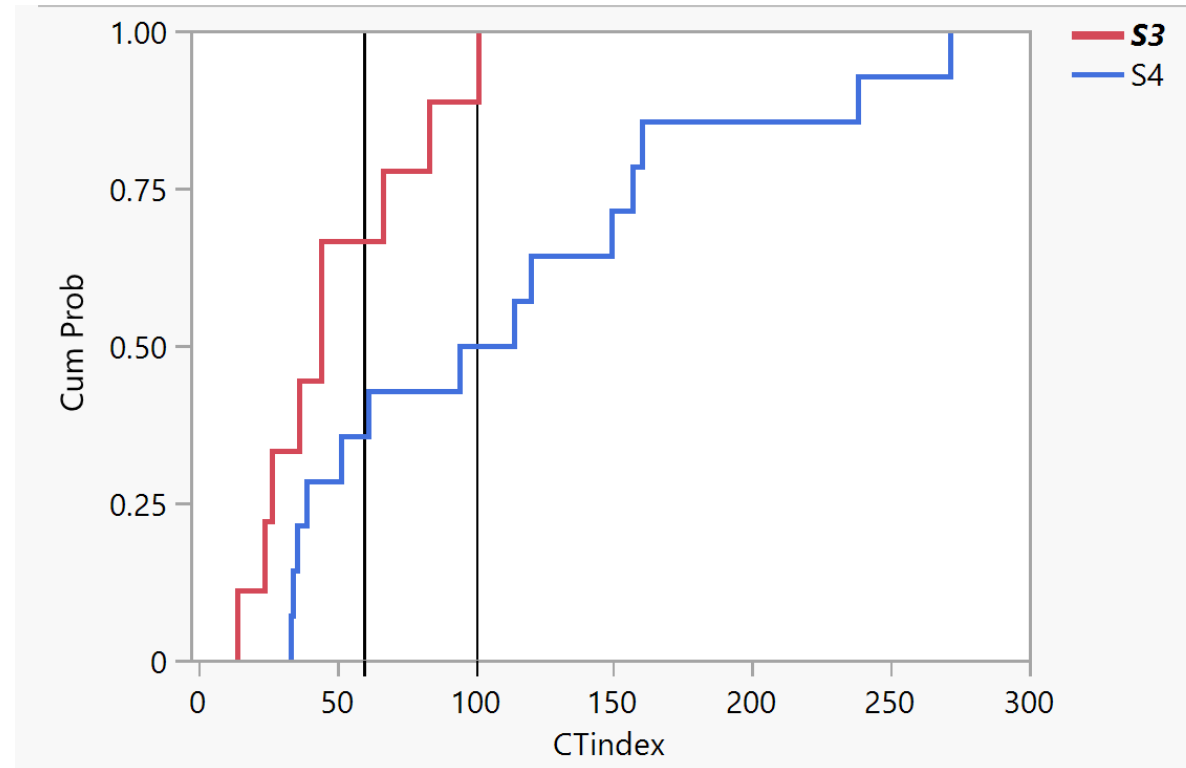
Performance-based testing (Cracking)



		PG64	PG70	PG76
Min. CT index	Surface	100	100	100
	Intermediate	60	60	60
	Base	60	60	60

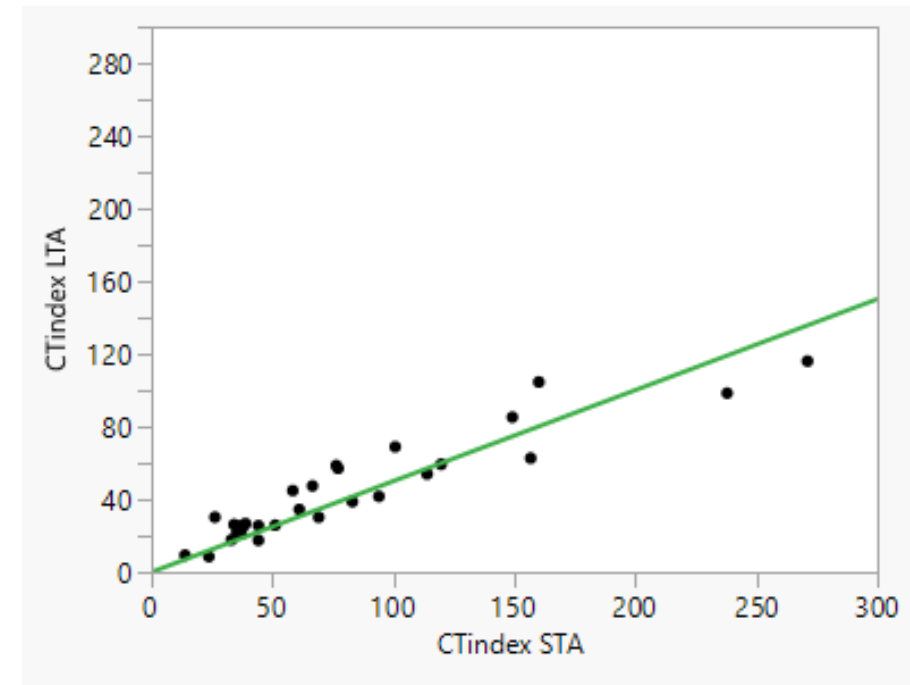
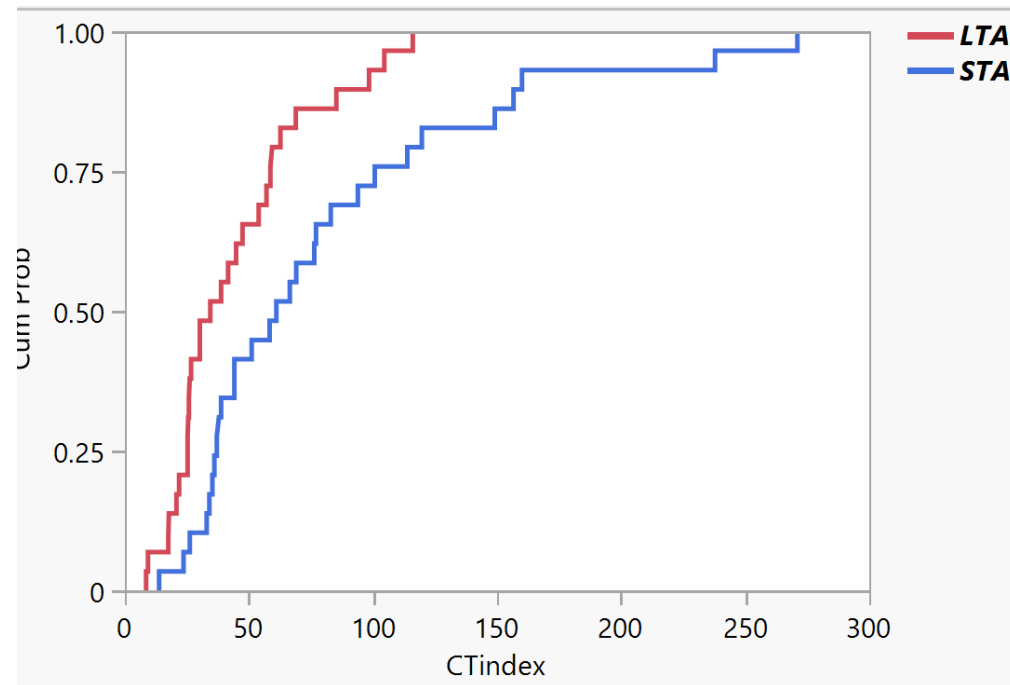
CTindex of plant-produced mixes

- 50% of S4 mixes are below CT_{index} of 100
- 70% of S3 mixes are below CT_{index} of 60

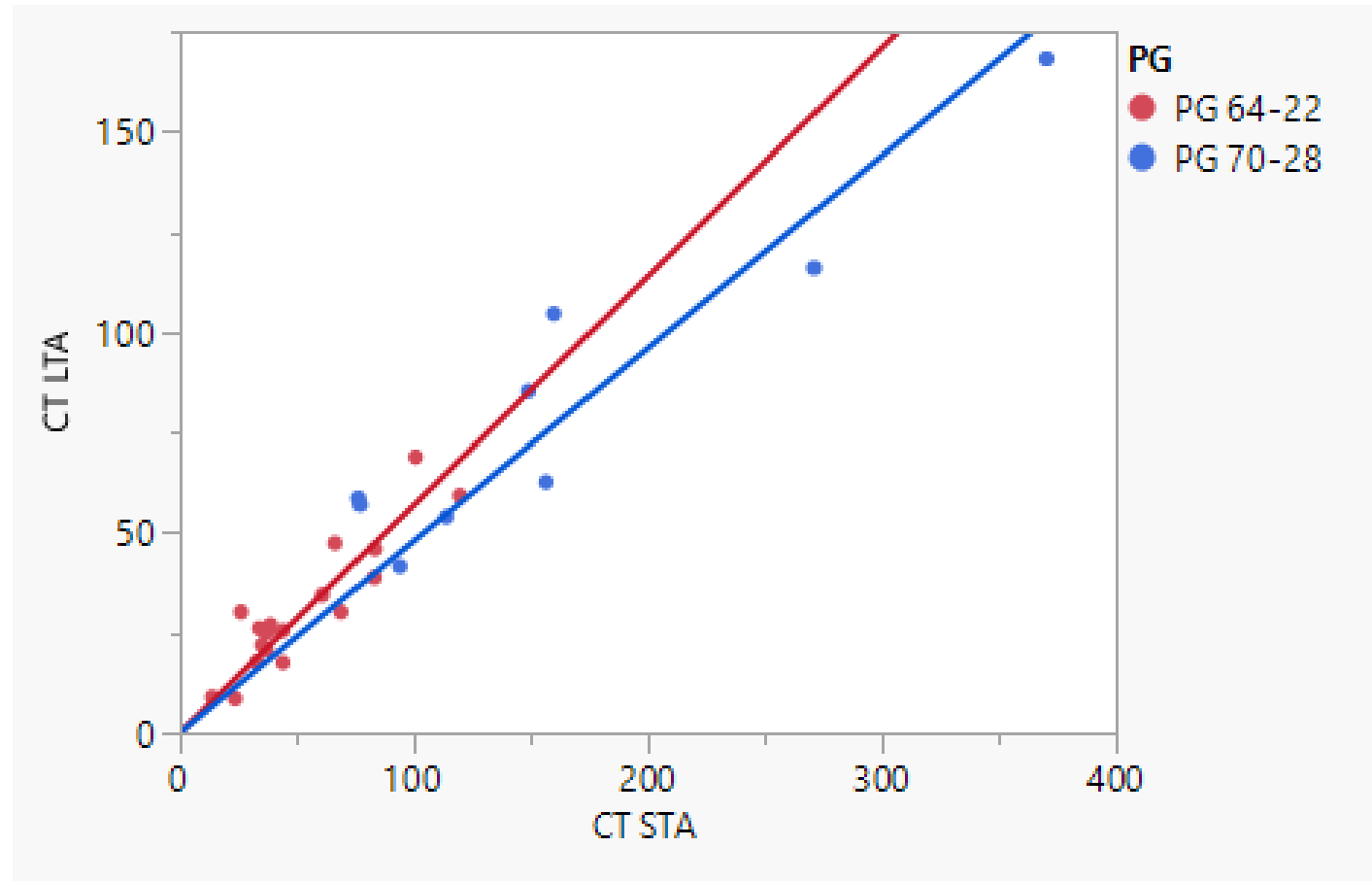


Effect of long-term aging on CTindex

- Long-term aging (8 hours at 135C) to simulate 3-5 years in-service
- CT_{index} decreased by about 50% with long-term aging.

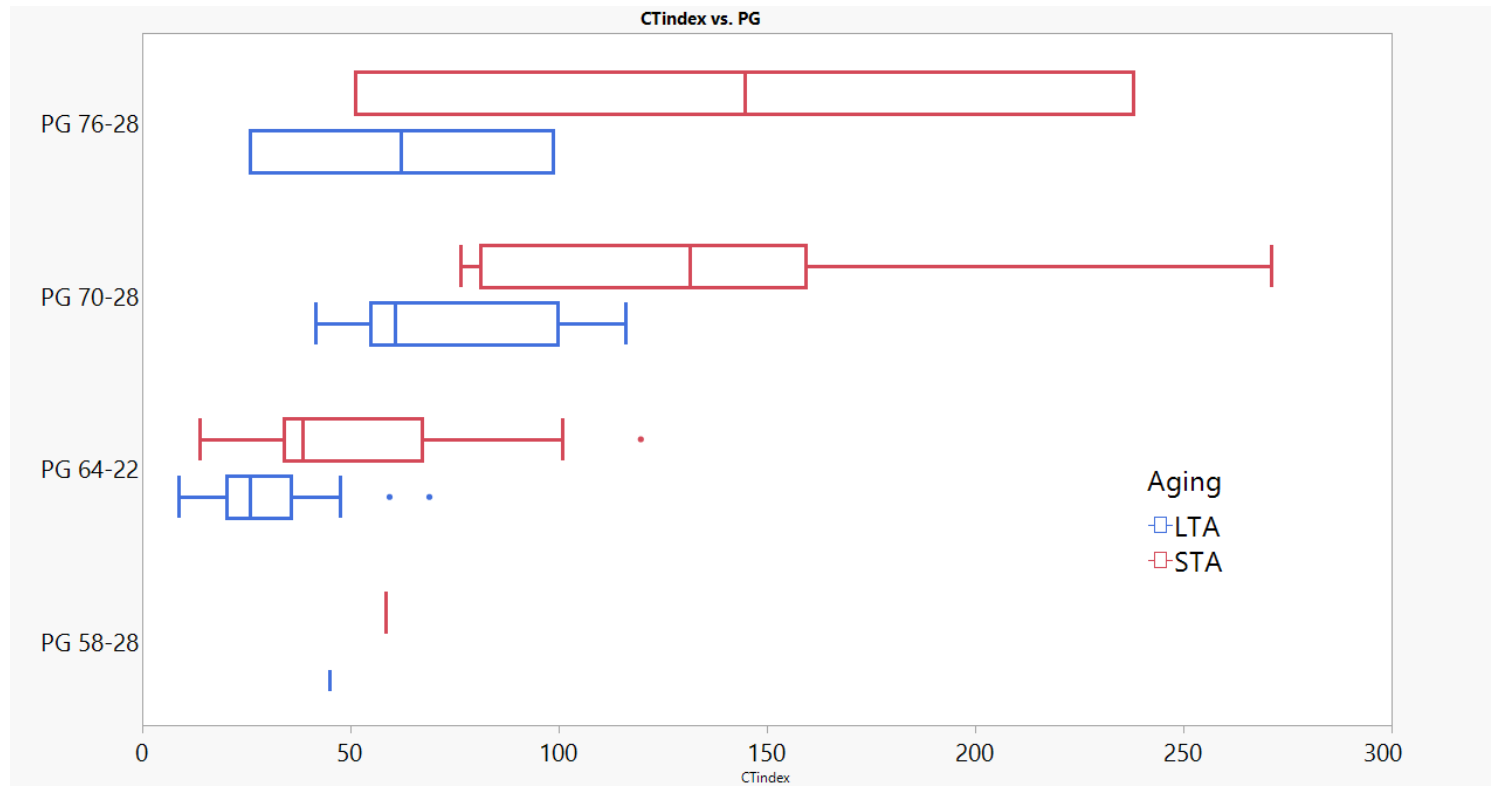


Effect of long-term aging on CTindex



Effect of polymer modification

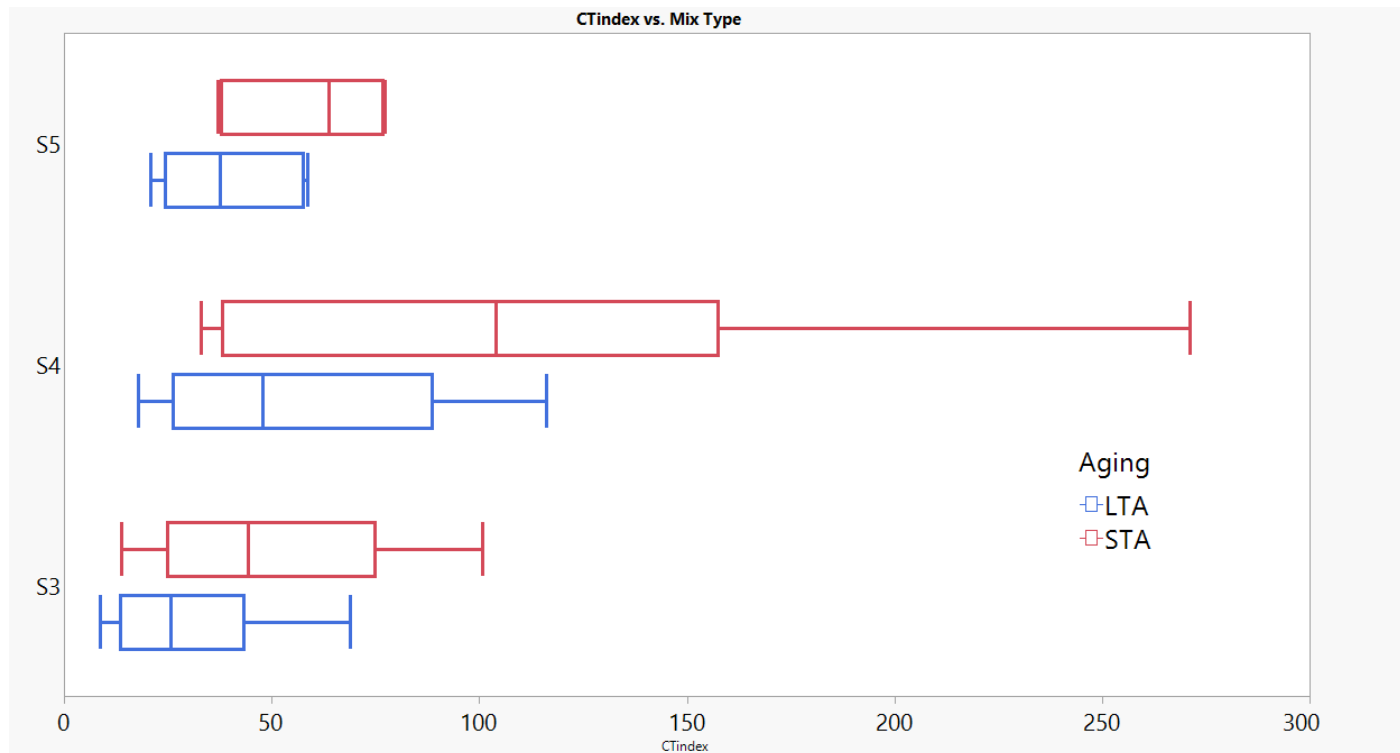
- Mixes with polymer modified binders generally had higher CTindex compared to neat binders.



Factor	Games-Howell
	Pairs
Binder Grade	64-22 vs 70-28

Effect of Mix Type

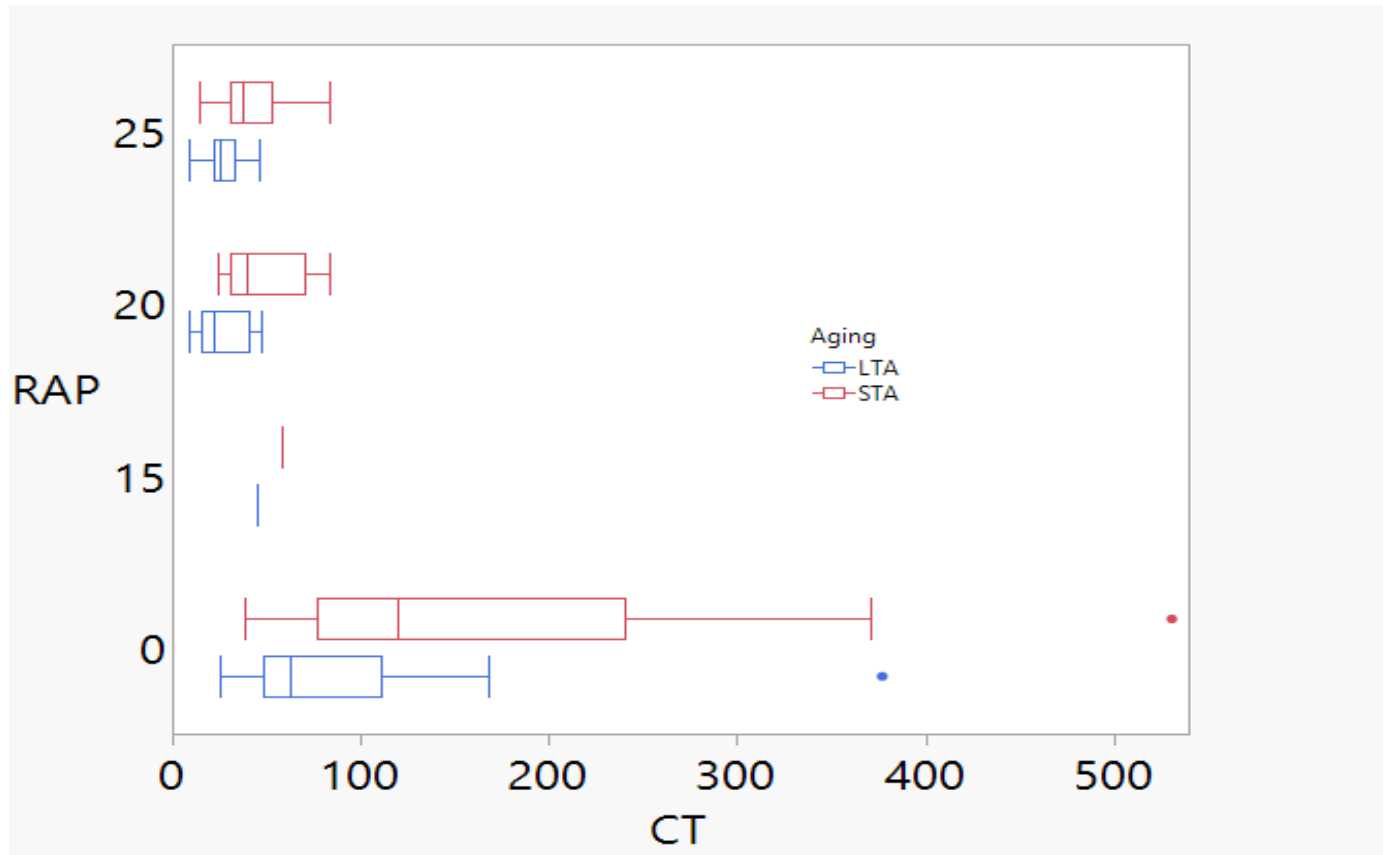
- S4 mixes appear to have higher average CT_{index} but a big overlap existed between mix types due to the wide range of mix variables.



Factor	Games-Howell
	Pairs
NMAS	S5 vs S3
	S4 vs S3

Effect of RAP

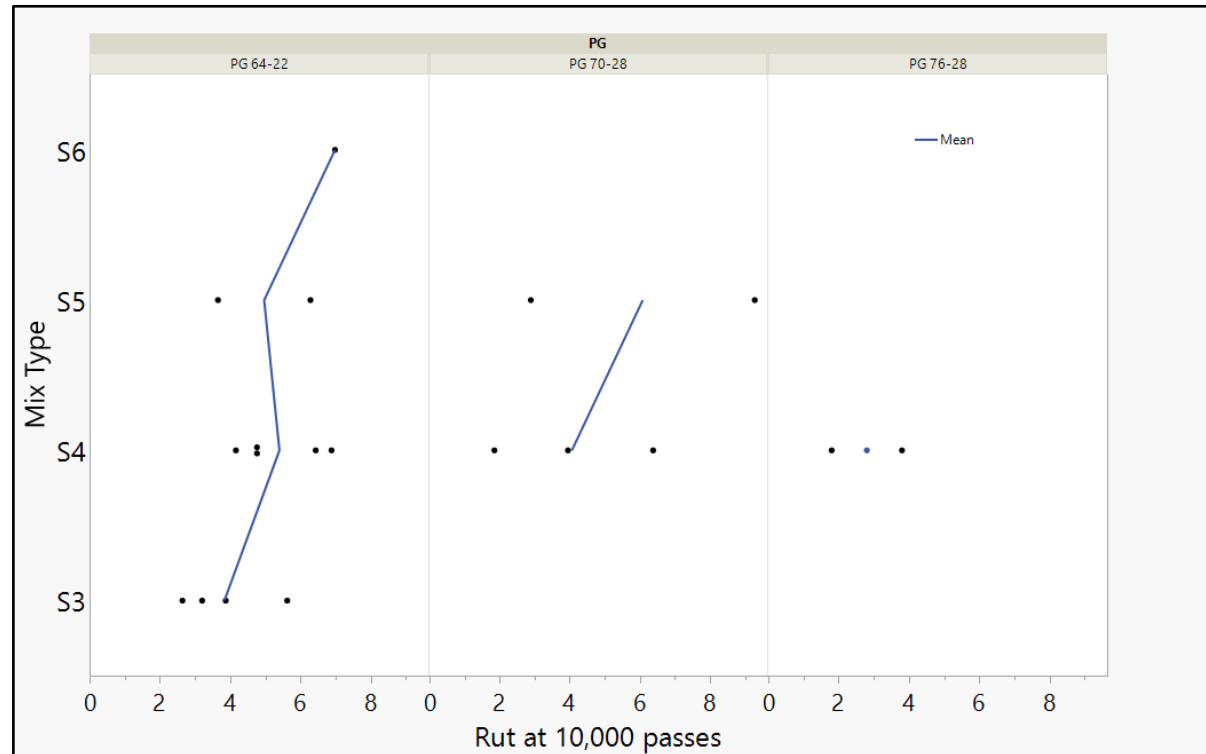
- Addition of RAP resulted in lower CTindex



Factor	Games-Howell
	Pairs
RAP Content	0 vs 20
	0 vs 25

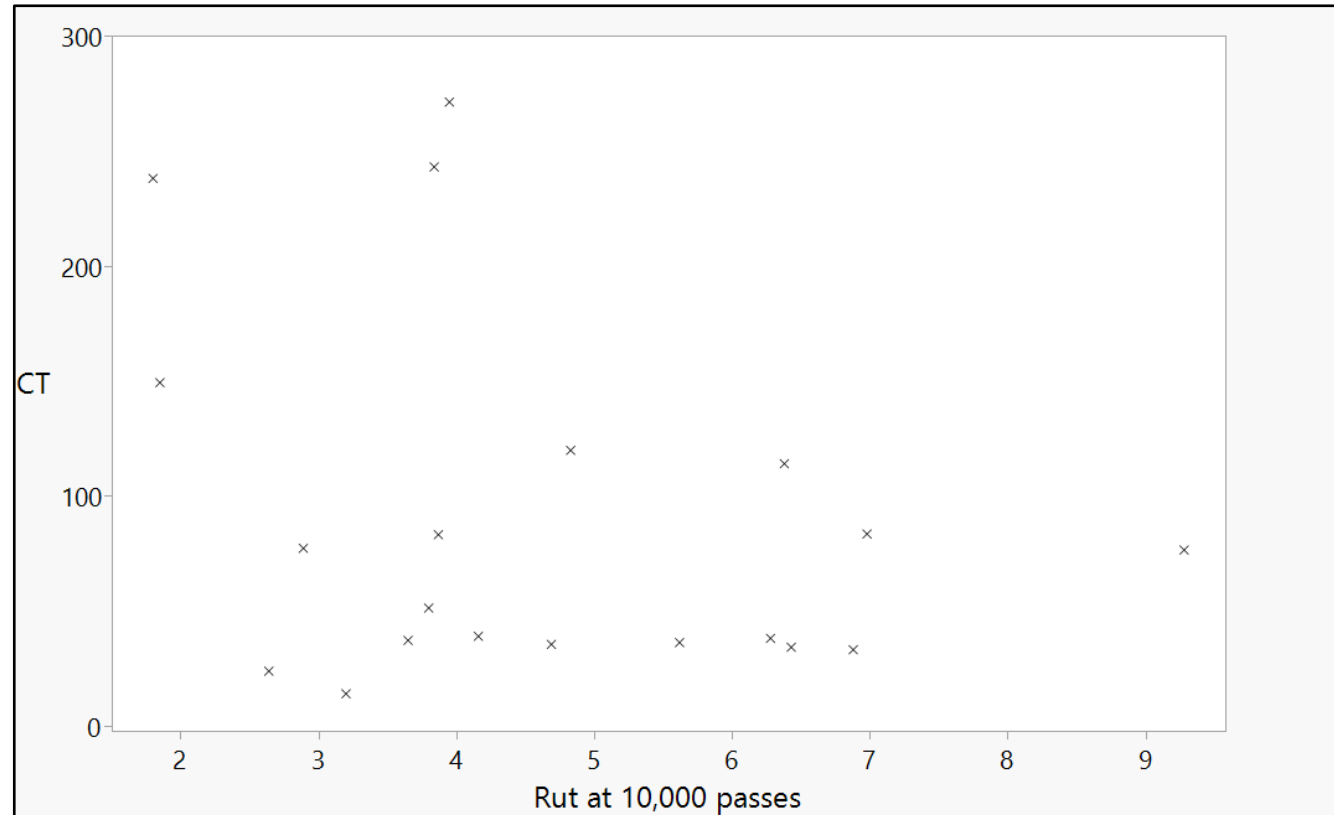
Rutting

- All mixes met ODOT rut criteria
- On average, finer mixes had higher rut depth



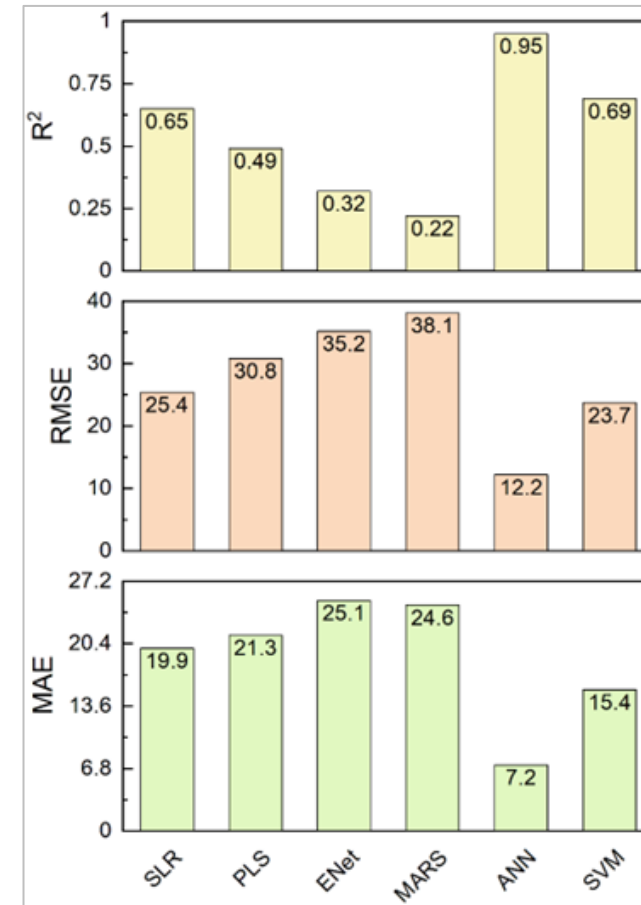
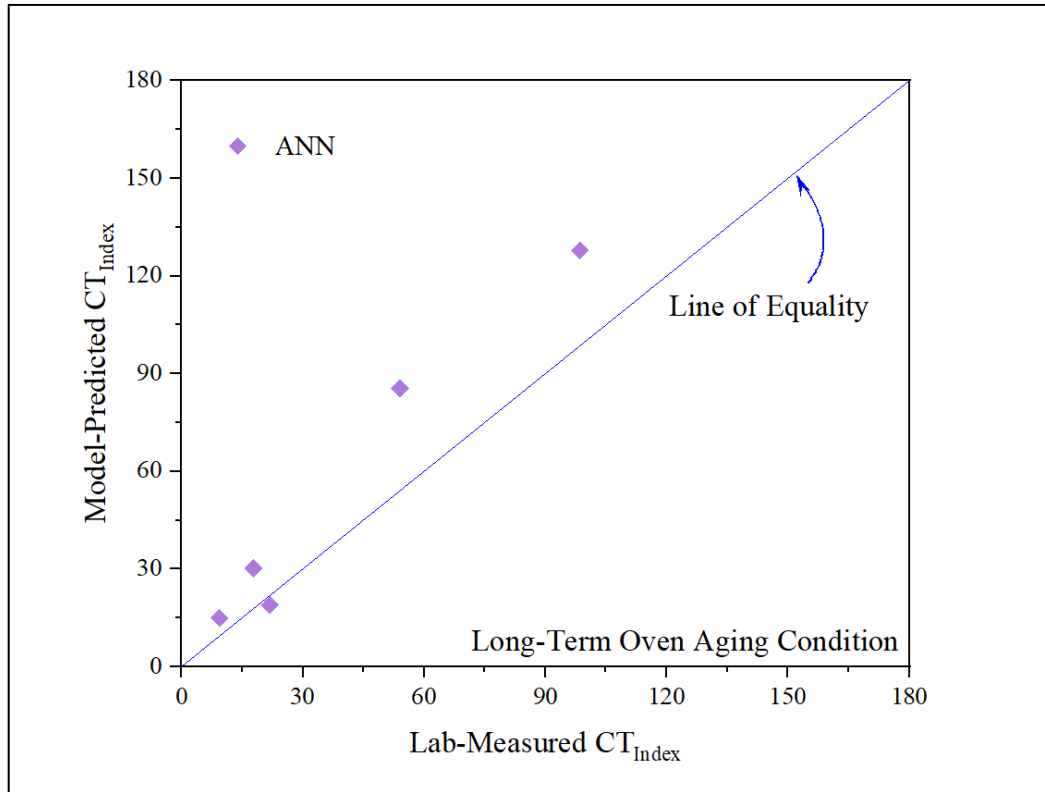
IDEAL-CT and HWT

- Mixes had a wide range of CT_{index} and rut depth



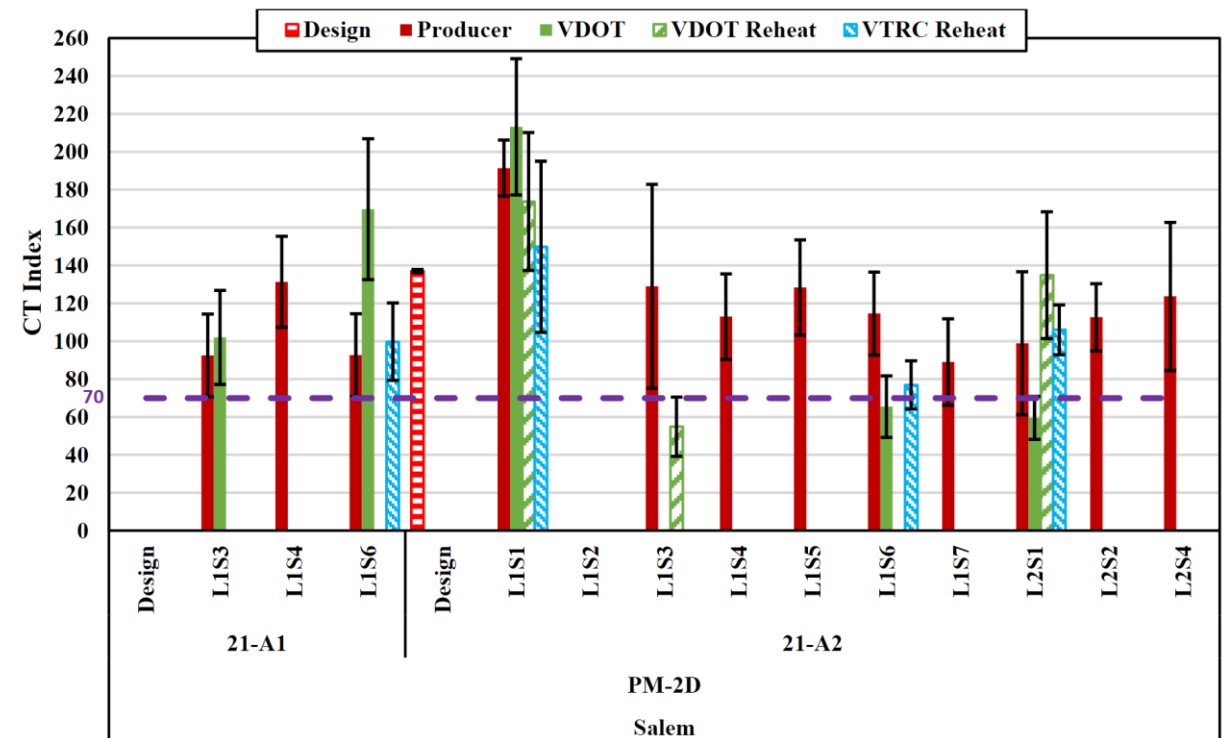
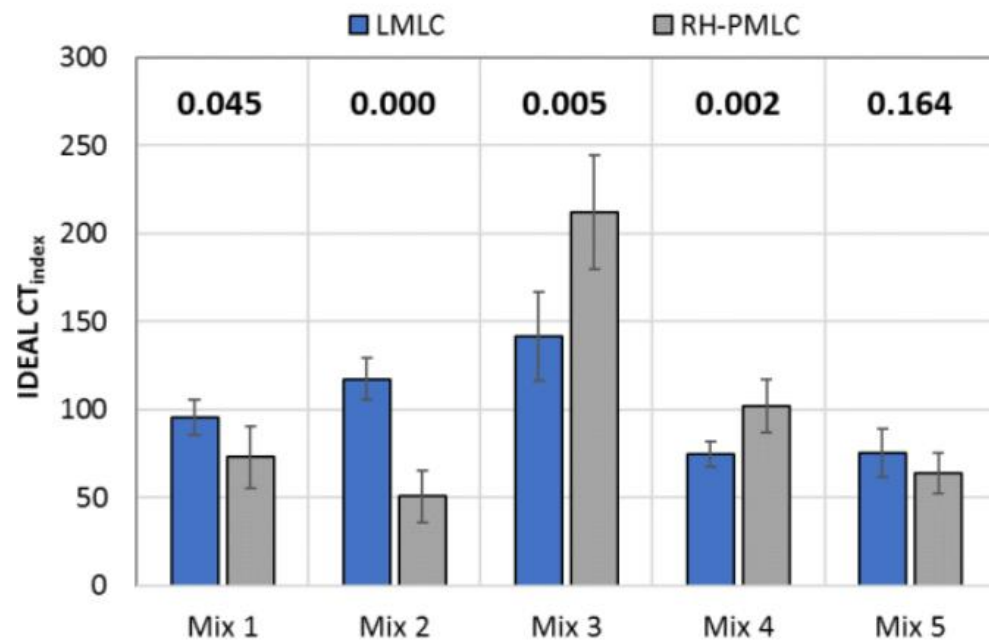
Developing predictive modeling

- Different statistical models were used to predict CT_{Index}



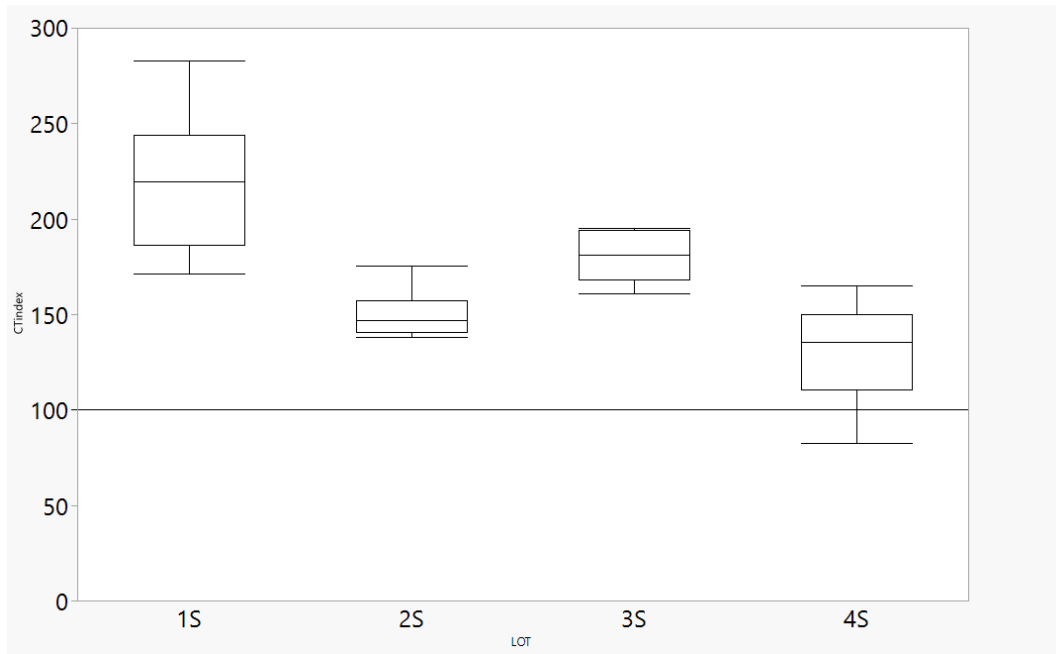
BMD and Acceptance

- Performance-tests are sensitive to binder aging.
- Design → Production → Reheating

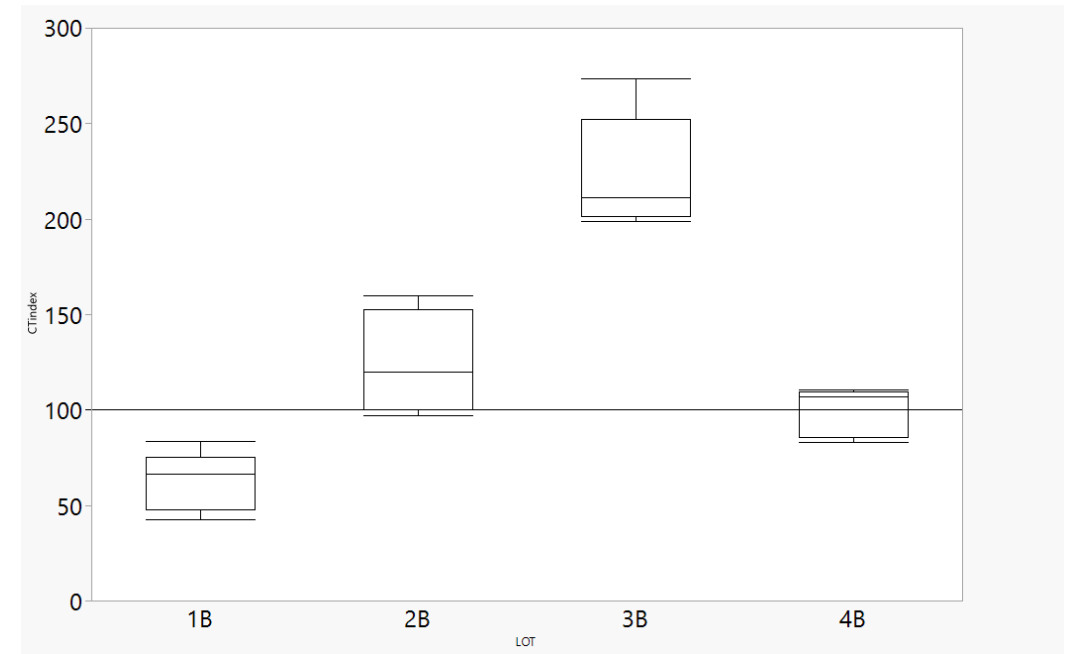


Production variability

- Control mix: S4 – 0% RAP – Polymer-modified binder
- BMD mix : S4 - with RAP – Neat binder



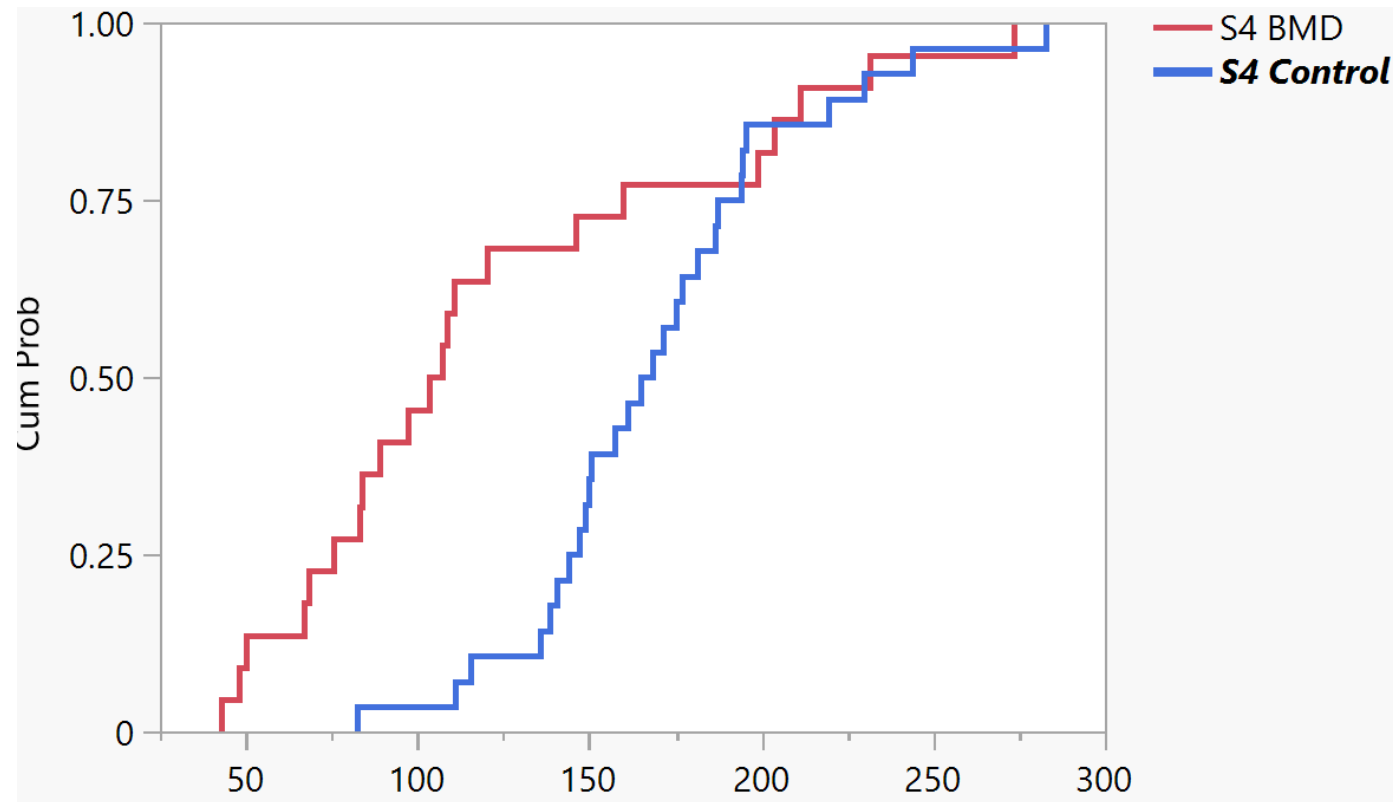
Control



BMD

Control vs BMD

- Both mixes met minimum CTindex requirements
- S4 Control had no RAP and a polymer-modified binder



Findings

- Long-term aging results in almost a 50% decrease in cracking resistance.
- Preliminary results show notable variability in cracking test results during production.
- Use of PG76 and PG70 binders in most cases result in an increase in CT_{index} compared to PG64 binder.
- Mixes with high RAP can be designed to meet BMD criteria. QC/QA is critical to ensure produced mixes have consistent performance.

Acknowledgment

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Thank you!
