Asphalt Mix Design for High Tire Pressure & Gyratory Compactor

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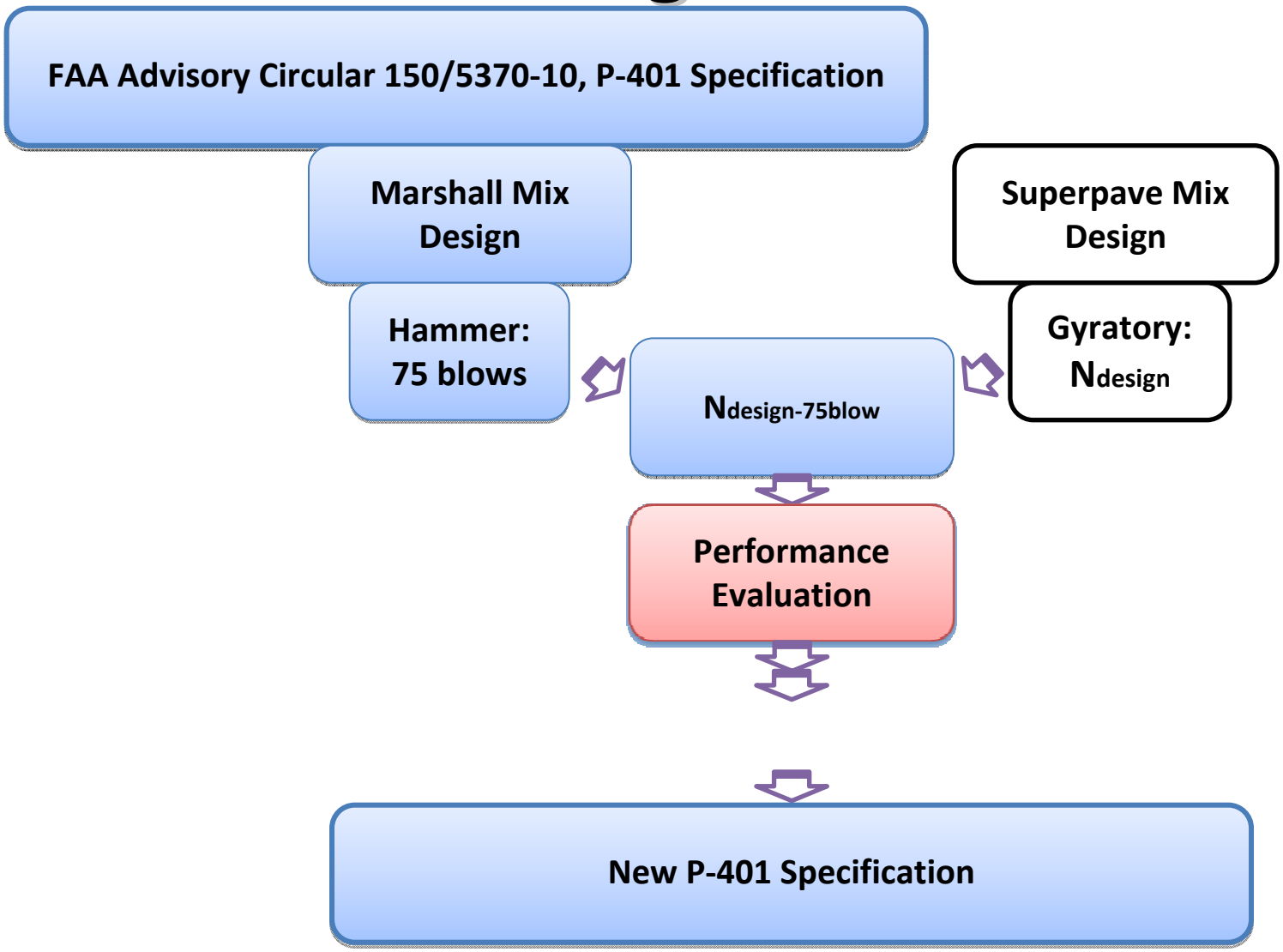
Backgrounds



Performance Evaluation

- Performance tests were conducted for **gyratory compaction and high tire pressure test projects**.
- A compaction level of **70 gyrations** provides similar volumetrics on average to that produced with **75 blows** of Marshall compaction hammer.
- HMA specimens were fabricated based on two compaction conditions.
  - 75-blow Marshall impact compaction.
  - 70 gyrations (similar volumetrics to 75-blow Marshall compaction).

Materials

- Gyration Study

Airport Code	Aggregate Type	Binder Grade
JFK	Granite gneiss	PG 64-22
JFK	Dolomite	PG 82-22m
		PG 64-22
ACY	Basalt	PG 64-22
LEX	Limestone	PG 70-22
ELM	Crushed Gravel	PG 64-28
NAPTF	Argillite	PG 64-22
CHO	Diabase	PG 64-22
NTU	Granite	PG 70-22

- High Tire Pressure (HTP)

Airport Code	Aggregate Type	Binder Grade
JFK	Granite gneiss	PG 64-22
		PG 70-22
		PG 76-22
		PG 64-28 + TLA
		PG 82-22
LEX	Limestone	PG 64-22
		PG 70-22
		PG 76-22
		PG 64-28 TLA
		PG 82-22
NAPTF	Argillite	PG 64-22
		PG 70-22
		PG 76-22
		PG 64-28 TLA
		PG 82-22

Performance Test

- Gyration Study

Purpose	Test Type
Rut Resistance	Flow Number
	APA
Fatigue Cracking	Uniaxial Fatigue Testing

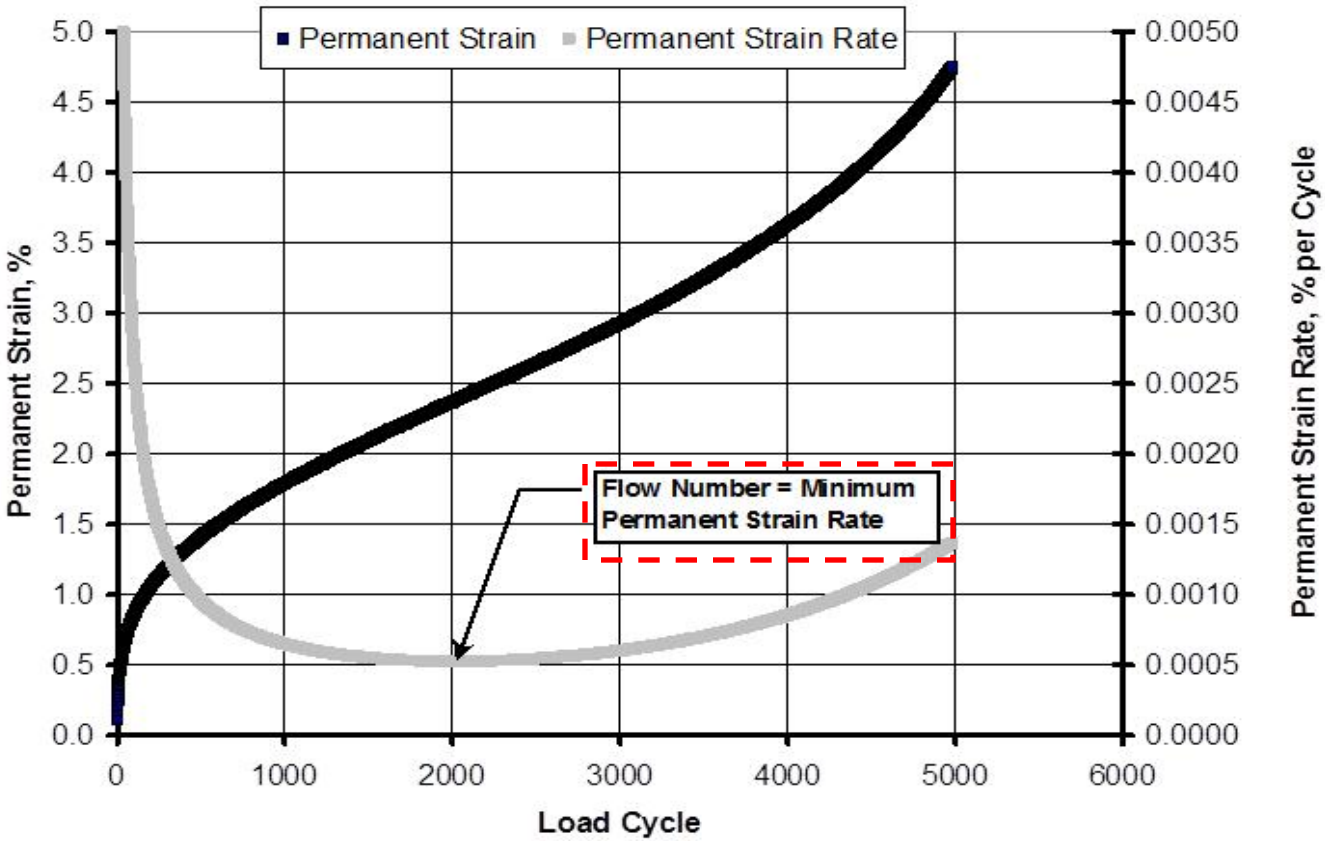
- High Tire Pressure (HTP)

Purpose	Test Type
Rut Resistance	Flow Number
	APA
	IDT
Fatigue Cracking	Fatigue Beam Testing (ongoing)

Flow Number

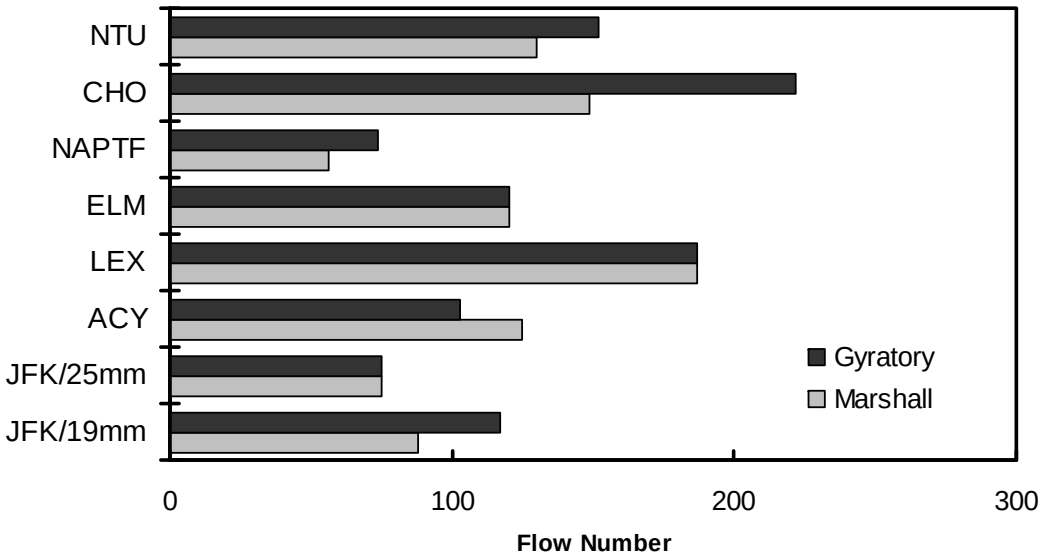
- Used JFK, ACY, LEX, ELM, NAPTF, CHO, and NTU(JFK and NAPTF are repeated for HTP) mixes at SGC 70-gyration and 75-blow Marshall compaction.
- Repeated deviatoric compressive 600 kPa (90 psi) stress (+ 1240 kPa (180 psi) and 1450 kPa (210 psi) for HTP).
- Tested at 50°C (+ 20, 35, and 65°C for HTP).
- Monitored permanent deformation and plotted with loading cycle.

Flow Number


Permanent Strain
Permanent Strain Rate
Flow Number = Minimum Permanent Strain Rate
Permanent Strain, %
Permanent Strain Rate, % per Cycle
Load Cycle
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0.0050
0.0045
0.0040
0.0035
0.0030
0.0025
0.0020
0.0015
0.0010
0.0005
0.0000
0
1000
2000
3000
4000
5000
6000

Flow Number

- Flow number test results show no significant differences between 70-gyration and 75-blow Marshall compaction.



Flow Number

- Gyration Study

Airport Code	Binder Grade	Flow Number	Compaction
JFK	PG 64-22	88	Mar
	PG 64-22	69	Mar
	PG 64-22	120	SGC
JFK	PG 82-22m	1,700	Mar
	PG 64-22	75	SGC
ACY	PG 64-22	120	Mar
	PG 64-22	100	SGC
LEX	PG 70-22	**190**	Mar
LEX	PG 70-22	190	SGC
ELM	PG 64-28	120	Mar
ELM	PG 64-28	120	SGC
NAPTF	PG 64-22	56	Mar
	PG 64-22	74	SGC
CHO	PG 64-22	150	Mar
	PG 64-22	220	SGC
NTU	PG 70-22	130	Mar
	PG 70-22	150	SGC

- High Tire Pressure (HTP): LEX

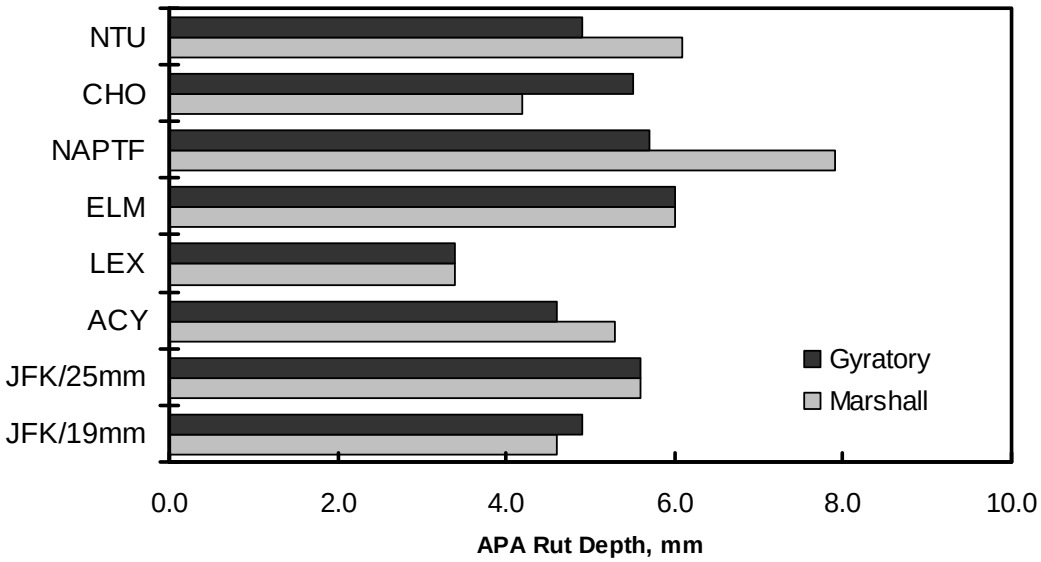
Temp., C	Stress, kPa	Flow Number for Binder Grade:				
		PG 64-22	PG 70-22	PG 76-22	PG 82-22	PG 70-22/ TLA
20	600	> 10000	> 10000	> 10000	> 10000	> 10000
	1240	6800	> 10000	> 10000	> 10000	> 10000
	1450	5070	> 10000	> 10000	> 10000	> 10000
35	600	1300	3360	7860	> 10000	> 10000
	1240	248	556	1390	3330	2640
	1450	116	256	600	1930	1160
50	600	112	**230**	541	2260	1090
	1240	14	34	63	208	134
	1450	9	14	29	103	71
65	600	13	28	59	232	141
	1240	1	4	6	12	13
	1450	1	2	4	7	6

Asphalt Pavement Analyzer

- Used JFK, ACY, LEX, ELM, NAPTF, CHO, and NTU(JFK, LEX, and NAPTF are repeated for HTP) mixes at SGC 70-gyration and 75-blow Marshall compaction.
- Applied 1,750 kPa (254 psi) hose pressure (+ 1,500 kPa (218 psi) hose pressure for HTP).
- Tested at 50°C (+ 35 and 65°C for HTP).
- Monitored rut depth at 8,000 cycles.

Asphalt Pavement Analyzer (APA)

- APA test results show no significant differences between 70-gyration and 75-blow Marshall compaction.



Asphalt Pavement Analyzer (APA)

- Gyration Study

Airport Code	Binder Grade	APA Rutting (mm)	Compaction
JFK	PG 64-22	4.6	Mar
	PG 64-22	6.1	Mar
	PG 64-22	4.9	SGC
JFK	PG 82-22m	1.2	Mar
	PG 64-22	5.6	SGC
ACY	PG 64-22	5.3	Mar
	PG 64-22	4.6	SGC
LEX	PG 70-22	3.4	Mar
LEX	PG 70-22	3.4	SGC
ELM	PG 64-28	6.0	Mar
ELM	PG 64-28	6.0	SGC
NAPTF	PG 64-22	7.9	Mar
	PG 64-22	5.7	SGC
CHO	PG 64-22	4.2	Mar
	PG 64-22	5.5	SGC
NTU	PG 70-22	6.1	Mar
	PG 70-22	4.9	SGC

- High Tire Pressure (HTP): LEX

Temp., C	Hose Pressure, kPa	APA Rut Depth (mm) at 8,000 Cycles for Binder Grade:				
		PG 64-22	PG 70-22	PG 76-22	PG 82-22	PG 70-22/ TLA
35	1,500	3.95	3.45	2.63	2.82	3.18
	1,750	4.49	3.44	2.80	2.42	3.43
50	1,500	11.86*	5.22	4.01	3.24	4.09
	1,750	14.00*	**5.08**	5.14	4.49	4.23
65	1,500	18.53*	9.21	7.01	4.55	5.49
	1,750	19.63*	16.33*	8.32	5.46	5.93

Indirect Tensile Strength Test

- Used LEX and NAPTF (only for HTP) mixes at SGC 70-gyration and 75-blow Marshall compaction.
- Tested at 40 and 55°C.
- Showed significant effect of temperature.
- Showed significantly greater strength of the NAPTF than the strength of the Lexington mixtures.

Indirect Tensile Strength Test

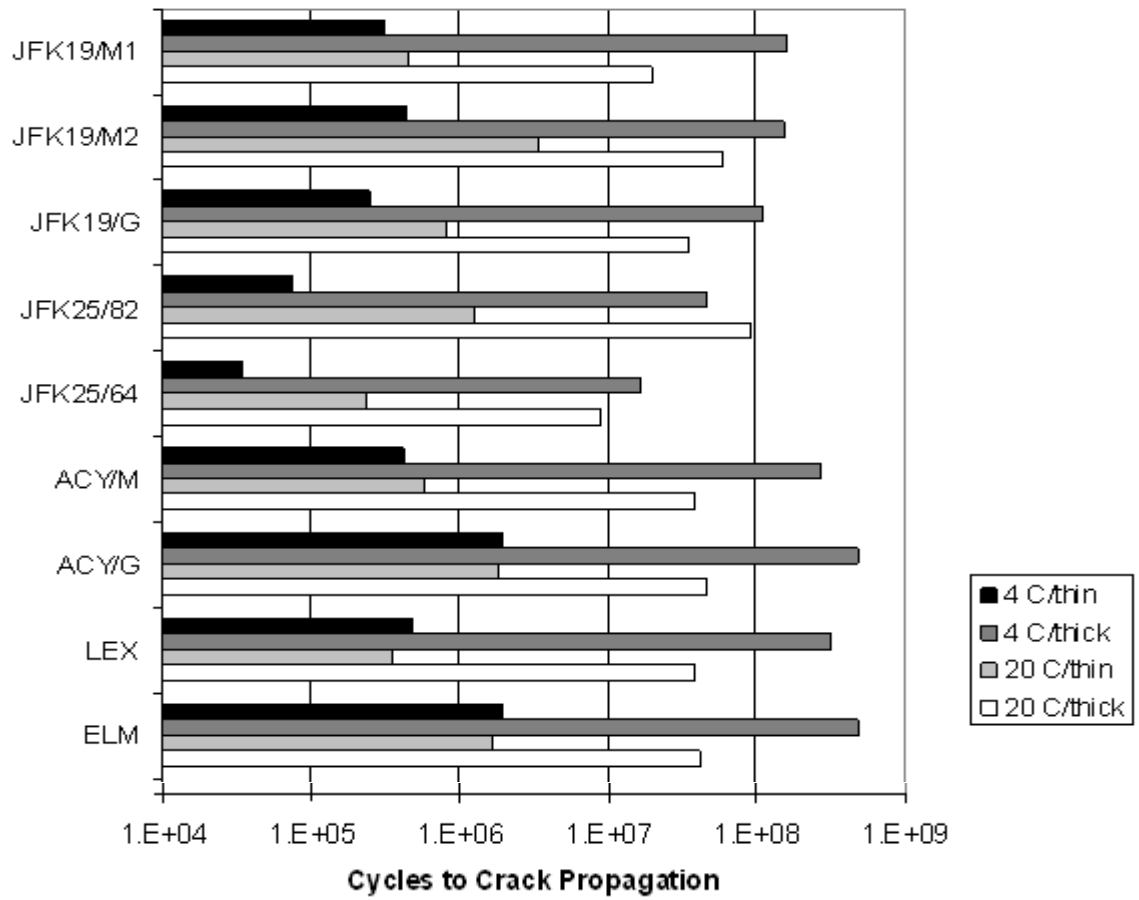
Mix:		Lexington	NAPTF
Laboratory:		AAT	SoilTek
Binder Grade	Temp. °C	IDT Strength, kPa	
PG 64-22	40	287	506
	55	127	249
PG 70-22	40	402	693
	55	163	279
PG 76-22	40	500	824
	55	214	365
PG 82-22	40	587	908
	55	276	397
PG 70-22 (TLA)	40	619	804
	55	271	432

Fatigue Test

- Used JFK, ACY, LEX, ELM, NAPTF, CHO, and NTU for uniaxial fatigue test using mixes at SGC 70-gyration and 75-blow Marshall compaction.
- Used JFK and NAPTF for fatigue beam test (ongoing).
- Tested at 4 and 20°C.

Estimated Cycles to Crack Propagation

- Fatigue test results show no significant differences between 70-gyration and 75-blow Marshall compaction.



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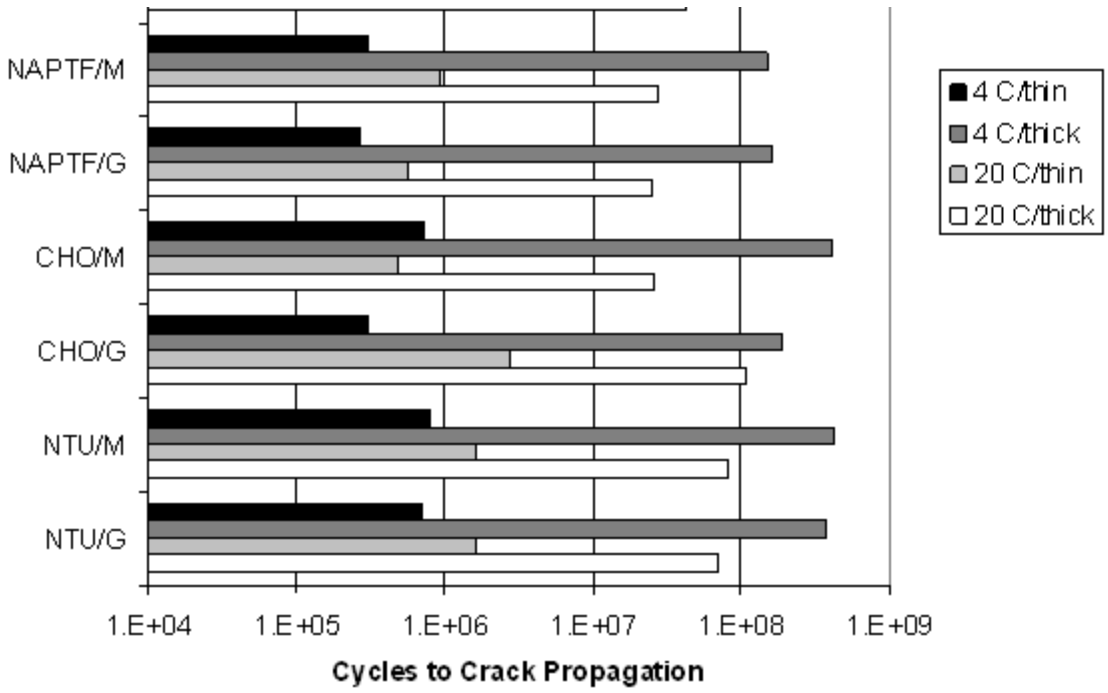
- Fatigue test results show no significant differences between 70-gyration and 75-blow Marshall compaction.



Conclusions

- Performance test results showed similar rut resistance and fatigue resistance between N_{design}=70 SGC and 75-blow Marshall compaction design.
- Test conditions are extended for further investigations of the results under 75-blow Marshall compaction design.

Thank you

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