Rijkswaterstaat
Ministry of Infrastructure and Water Management

Friction after Polishing

Experience with the test procedure in the Netherlands

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I'm Inge van Vilsteren, working at the Dutch Road Authority for our highway structure. My colleague Paul Kuijper did a lot of research on both the Friction after Polishing test and the Polish Stone Value-test. Since he is on holiday I will try to inform you about the experiences out of these tests.

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- What is your motivation to deal with the test method?
  What are the shortcomings of the system you use?
- What do you see as the potential of this test method?
- Which topics or questions would you like to discuss in the workshop?
- What experiences and evaluation backgrounds are available for FAP in your country?

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We all became a questionnaire in advance of this workshop [1]. I will use this as a guideline trough the different findings in our tests.

Motivation to deal with the test method and the shortcomings of the system we use

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First I would like to explain what would be the Dutch motivation to start using the FAP test.

In advance I should mention that merely all our test are done on PA. We did do some test on Dense Asphalt Concrete, but these are just few results, that no real good correlations can be taken out of this.

- PSV only suitable for tests on aggregate size 7,2 mm – 10 mm.
- FAP is suitable on asphalt mixtures with different aggregate sizes.

- PSV is not suitable to test aggregates mixture from different origin
- FAP is suitable for asphalt mixtures with PR

- Reproducibility PSV (EN 1097-8:2009) < Reproducibility PSV (EN 1097-8:2018)
- Reproducibility PSV (EN 1097-8:2018) ≈ Reproducibility FAP (EN 12697-40:2014)

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For our toplayer asphalt mixtures we use the PSV as a minimal requirement for the aggregates that are used.
A few questions have come up out of this test in relation to our asphalt mixtures;

Within this test as normative only the size 7,2 till 10 mm stones are used. Most of our toplayer mixtures now are PA16. But due to noise regulations it is to expected that in the near future more and more Two layered PA will be used. This toplayer has as main aggregate a size 8 or even an size 5.
The question rises if the PSV-test is representative for these type of mixtures.

For our binder and baselayers we nowadays have up to 60% recycling, sometimes even higher. For our toplayers a lot of contractors already have mixtures with 30% recycling. Due to environmental demands it is to be expected that these percentages will rise fast in the near future. Our requirements to virgin aggregates will just give us information for a portion of the aggregates in these new mixtures.
To retrieve a PSV-value of a mix of aggregates out of recycled materials and virgin materials, is not often done yet and will probably give a wide spread of results.

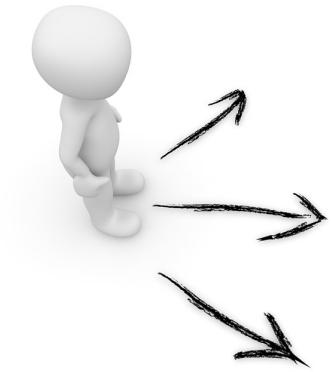
The reproducibility of the 2009 version of this norm (EN 1097-8:2009)
is less than it will be in the new 2018 version.
In the 2009 version reproducibility is 4,8. In the new 2018 version no reproducibility is mentioned. But if we look into our own round robin test results this reproducibility is about 9,7 [2].
As a road authority I now look into my requirements. We nowadays ask for a PSV of 58.
If I relate this requirement to the reproducibility than the old normative has a spread of 8,2% and the new one is about 16,7%.

I use these figures to compare them with the relative reproducibility in the FAP test.
In the norm of the FAP-test (EN 12697-40:2014) no reproducibility is mentioned. But if we look at the data we got out of our own round robin through 9 test facilities, we see that the reproducibility is 0,077. In relation to our requirement of 0,44 this gives around 18% of relative reproducibility. This reproducibility is based on test on two samples of PA.

On our findings we say that the reproducibility in the PSV test is as good as it is in de FAP test.

Extra: The Netherlands has commented on prEN 1097-8 (PSV-test). TG 11 did not agree to modify this value. The consequence of this decision is that the requirements laid down in the Netherlands with regard to the polished stone value must be increased by two points. In order to fit the test results of the control stone within the stated values for the control stone, the limits for the range of the control stone have been broadened. As a result the unjustified chances of approval and rejection will increase. It is also for this reason that Rijkswaterstaat is of the opinion that the FAP test is in conformity with EN-EN 12697-40:2014.

What do you see as the potential of this test method?



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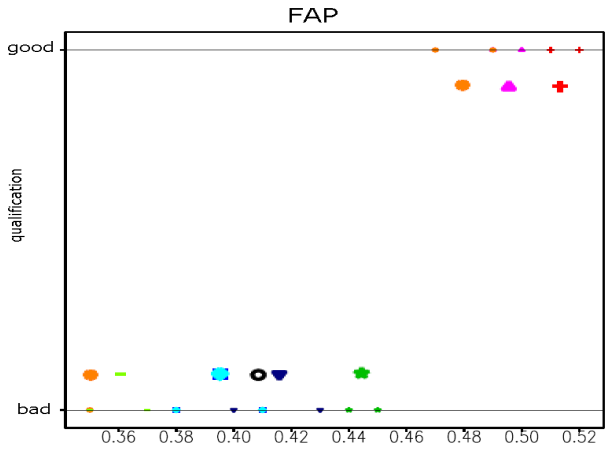
What is in our opinion the potential of the FAPtest?

Good prediction of the development of the skidding resistance in practice



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In our findings the FAP test can be used to distinguish 'good' mixtures from 'poor' mixtures if we judge them on skid resistance in FAP compared to the field performance [3].

In this figure we have results of test sections in the road. We selected a few road sections out of our skid resistance data. We selected road sections that had already a low skid resistance compared to the years laying in traffic and road sections that performed unexpectedly good under high amount of traffic for long time (450.000 passing vehicles; roughly equivalent of 20 years lifetime) (roughly 60000 passes a day). Cores were taken out of the shoulder; no polishing of the stones could have occurred. The age of the road sections was roughly the same. These cores are tested in the FAP. And now we see that a low value in the FAP corresponds with the poor performing road sections. The turning point in this case is on a FAP value of about 0,45 and 0,48.

The small dots in this plots are all individual measurements. The bigger points represent the average results.

This still is quite an small test; we started with 3 good and 3 poor roadsections. Due to an issue with one type of mineral, augit porphoryt, that resulted in extra poor test results in road sections, 4 extra poor sections were added in our graph.

Target value (FAP)	Probability of wrongful approval of poor mixtures (%)	Probability of wrongful rejection of good mixtures (%)
0.48	5	38
0,47	8	31
0.46	11	25
0.45	15	19
0.44	19	15
0.43	25	11
0.42	32	8

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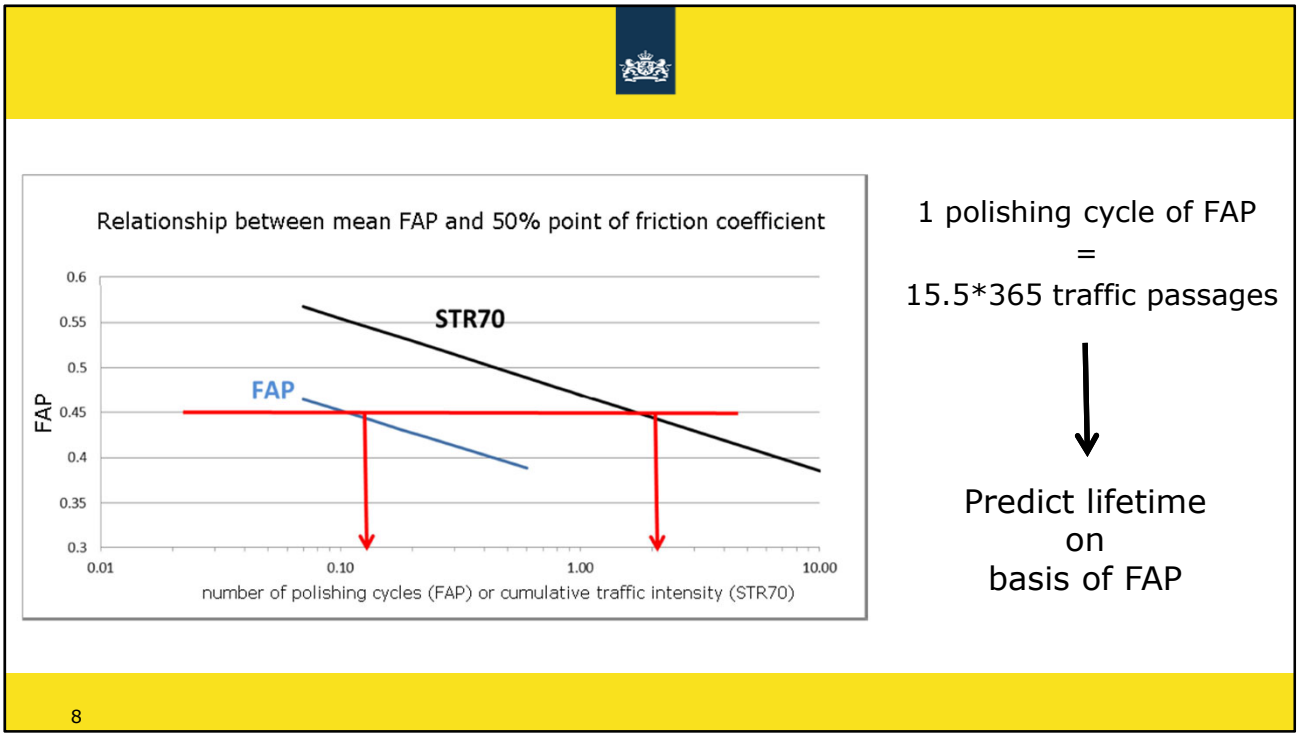
We did also look into the chance of wrongful approval or wrongful rejection.
In this sheet you can see our validation tests if we look into our own skid resistance of road sections versus the FAP-test results.
At the first data set we came up with a target value of 0,46 and an probability of respectively 20% and 18%. The results of the Round Robin test [4] and extra data were added to the dataset. The table in this sheet is based on this latest dataset [5].

Our internal working group decided that we as a road authority can take the slightly bigger risk than 19% of wrongful approval, against the better chance for the contractor for not getting a wrongful rejection.
We measure our road-network once every two years for safety; his means that we will be alarmed in time if such situation of a road section with a poor mixture occurs.
This is why we now decided to aim for FAP 0,44.

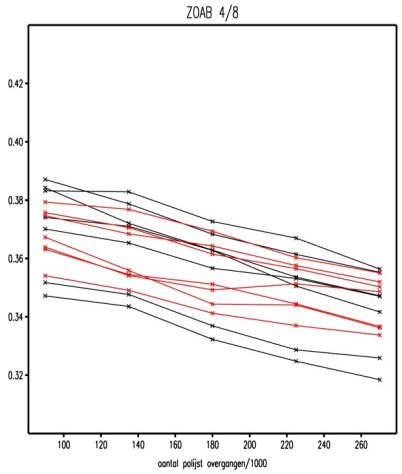
De in deze sheet gehanteerde onterechte goed- en afkeurkansen zijn gebaseerd op de resultaten van het validatieonderzoek en daarna opgedane ervaringen. Uit het validatieonderzoek kwam nog een waarde van 0,46 met onterechte goed- en afkeurkansen van 20% respectievelijk 18%. Door latere ervaringen mee te nemen is deze tabel ontstaan. De werkgroep stroefheid heeft indertijd besloten om als opdrachtgever een iets groter risico te willen dragen. Vandaar de richtwaarde 0,44.



There is a parallel in the decline of de skid-value in the FAPtest and the decline of the skid-resistence in the field [6].
In the future it might be possible to predict the lifetime of a toplayer mixture based on FAP-results.

In the sheet it is mentioned that, based on our findings, one polishing cycle with the FAP can be compared with 15,5*365 traffic passages in the field.

Extra: The polished stone value is carried out on granules with a fraction 10 mm -7.2 mm. With this result a prediction is made for the performance of an asphalt mixture in the road. There is an excellent relationship between the mineralogical composition of the mineral aggregate and the polished stone value of this mineral aggregate (see: Annex 5). The same appendix also shows that a reliable statement can be made through mineralogy and the polished stone value about the expectation of the maximum number of passages that a road section can stand before the standard for the skid resistance is exceeded.



Black lines: Cores out of the road (BK)

Red lines: Test specimens according EN 12697-33, method 5.3 (WSV)

Top layer	origin	FAP
PA 16	BK	0.331
PA 16	WSV	0.310
PA 8	BK	0,371
PA 8	WSV	0,368

Conclusion:
No significant difference between BK and WSV

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We did some test to compare te results of cores out of the road (black) of newly laid asphalt versus samples made in the lab by using the slab compactor (red) [7].
This is done on a fine PA mixture with 4 to 8 mm aggregate. And on a PA 16.
Starting at 90.000 cycles the test was prolonged till about 300.000 cycles.
The results given in the table are the average results out of 6 specimens for PA16 and out of 7 specimens for PA8.
Our conclusion from the total range of results is that there is no significant difference in the results we get from lab made specimens and cores out of the road.
However, additional research is still necessary.

Als voorbeeld staan in de grafiek de resultaten van de proeven op ZOAB 4/8 van kernen uit de weg (zwart) en kernen die met de WalsSektorVerdichter (rood) zijn gemaakt. In de tabellen staan de gemiddelde FAP waarden per deklaagtype (PA 16 of PA 8) en herkomst (BK of WSV). Bij PA 16 is het een gemiddelde over 6 proefstukken per herkomst en bij PA 8 over 7 proefstukken per herkomst. De conclusie is dat er geen significant verschil is aangetoond tussen de kernen uit de weg en de kernen die met de WalsSektorVerdichter zijn gemaakt.

Topics or questions to discuss

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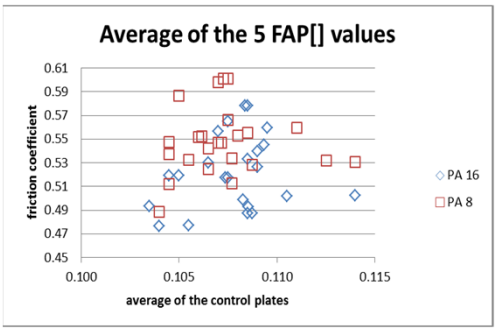
But still there are some questions to discuss



lab	avg. all FAP
7	0.4973
4	0.5165
3	0.5186
2	0.5234
1	0.5452
6	0.5472
9	0.5472
8	0.5488
5	0.5658

lab	avg. all control plates
7	0.1047
2	0.1048
8	0.1069
9	0.1075
6	0.1075
5	0.1076
3	0.1084
1	0.1094
4	0.1128

lab	corrected
7	0.3926
4	0.4038
3	0.4102
2	0.4187
1	0.4359
6	0.4397
9	0.4397
8	0.4419
5	0.4582

Conclusion: The effect of the control plate is negligible.

Point of consideration: These additional measurements introduce additional noise.

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On the left side you see a figure that is taken out of our round robin research at 9 test facilities [4].
The friction coefficient of the test specimens is set out against the results of the control plates within this test.
In the round robin the same specimens were prepared and tested.
If we look at the first table lab 7 had the lowest result for this mixture type and lab 5 got the highest FAPresult on this mix.
If this is caused by slight changes in the device than the control plates should have the same ranking. But that's not the case. The control plate of lab 7 still has less skid-resistance than the rest. But the runner up now is not lab 4 but it is lab 2. And the results of lab 4 are now the best of al the plates tested.
If we use these values to correct our original test result we see that the ranking is still exactly the same as it was before.

Our conclusion; the test plate in the current system has no sufficient effect.
The extra test with the glass plate introduce additional noise in the end results.

An alfabetical overview of the participants on the Round Robin test is given below:
Asphalta (Germany), BASt (Germany), Ecomaterials (France), TPA-Wien (Austria), TRL (England), TU-Aachen (Germany), TU-Braunschweig (Germany) TU-München (Germany) TU-Wien (Austria)

According to EN 12697-49:2014:
μref = known value of the Laboratory Skid Resistance of the control plate

There is no declared value for it in the norm.

Recommendation:

EN 12697-49 has to declare a value for μ_{ref}
EN 12697-49 has to declare a range for μ_{km}:

Absolute difference from $\mu_{km(before\ test)}$ - $\mu_{km(after\ test)}$ ≤ 0,004

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In the EN 12697-49 no value is given for μ_{ref}. Within the PSV-test there is a given value for the controlstone.

Our recommendation would be to provide an value for μ_{ref} to be used. On top of this it is our recommendation to add an maximum value for the range between $\mu_{km(before\ test)}$ en $\mu_{km(after\ test)}$. Based on our round robin test results on the glass plate this value should not exceed 0,0004.

Experiences for FAP in the Netherlands

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What experience do we have in the Netherlands with use of the FAP-test?

- Only research
- No FAP-test equipment available
- Still no regulation

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I showed a portion of our results in the Netherlands, but it all still is only research.

We do all our tests in Germany, mainly at Bast and Aken.

And we do not have regulations in The Netherlands for the FAP test jet, but we are really considering if we could use this test as one of our functional requirements on the (toplayer) asphalt mixes.

In Nederland hebben we tot op heden uitsluitend onderzoek verricht. Er is nog geen regelgeving op het gebied van de FAP-test.

Literature List

	Inner RWS	Outer RWS	
[1]	Workshop BASt	Workshop BASt	
[2]	Reproducibility PSV	Reproducibility PSV	
[3]	Validation FAP-test	Validation FAP-test	
[4]	Round Robin FAP-test	Round Robin FAP-test	
[5]	E-mail approval	E-mail approval	
[6]	Relatie FAP-praktijk	Relatie FAP-praktijk	
[7]	Relatie lab-praktijk	Relatie lab-praktijk	
	Inner/outer RWS	User name	Password
[8]	Presentaties workshop	BASt_intern3	DidI3Z!

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