VENTRACO CHEMIE B.V.

RheoFalt®

c2c Sustainable Production of Asphalt

RheoFalt HP-AM is a vegetable resin additive used for the 100% recycling of asphalt without any further need of new materials.
We can now limit the use of new materials, and as a result this means a considerable reduction of the carbon dioxide emission.

RheoFalt HP-AM is used to rejuvenate the asphalt without any loss of the original properties.

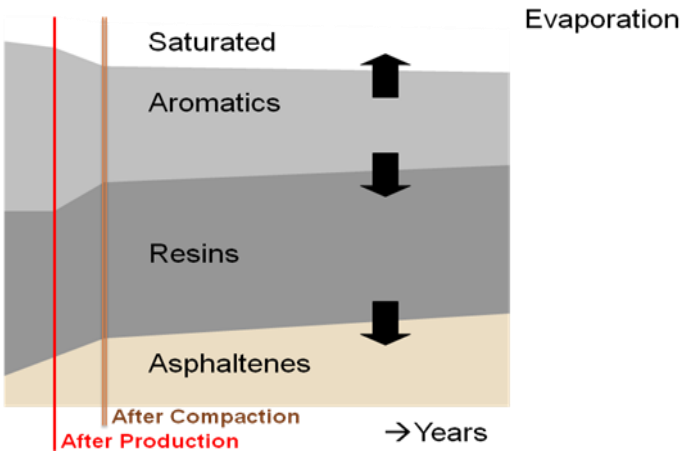
RheoFalt® HP-AM

SUSTAINABLE PRODUCTION OF ASPHALT

1. Introduction:

The aging of hot rolled asphalt is mainly caused by deterioration of the bitumen ("glue") of the asphalt mix. Because of this aging the asphalt will show cracks. These cracks are responsible for the failing of the total construction. The same phenomenon causes the loss of minerals on the surface. When the asphalt is renewed the old aged asphalt is often not used for the same application. When the asphalt is recycled only a small percentage is used in hot rolled asphalt application or the asphalt granulate is used for the foundation of new asphalt. Both methods only use a limited amount of the raw material potential, present in the old asphalt granulate (down-cycling). For many years extended research has been done, in order to be able the reuse a higher percentage of the aged asphalt. Up till now this was not possible because the asphalt had to behave in the same manner as new asphalt based on virgin materials and should not be more expensive than new hot rolled asphalt.

2. Bitumen:

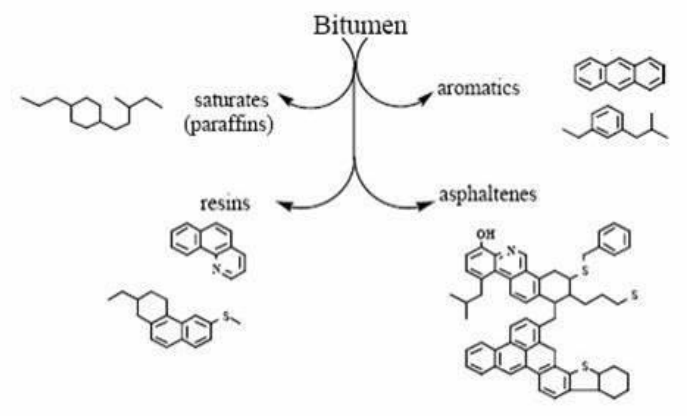


Aged bitumen will lose the flexibility because the lighter components, such as the aromatics and the light paraffines evaporate or breakdown due to chemical degradation. The unsaturated components gradually react to products similar to the asphaltenes. These asphaltenes show more elastic properties than viscous properties. The aged bitumen get more and more brittle and the asphalt fails.

In the past oils were used to make the bitumen more viscous and soft, the problem however is that these oils work as a plasticizer which has a negative influence on the stability of the asphalt and will decrease the adhesion on the minerals.

3. Development of the RheoFalt HP-AM:

New developments started when we were asked to develop an additive which would make it possible to fully recycle asphalt in combination with a bitumen donor. In prior research certain types of *chemicals can be used* to renew the bitumen. Especially the resins showed some promising results.



4. Research on Bitumen:

In order to be able to renew the aged bitumen, we compared an aged reclaimed bitumen with a 45-60 penetration bitumen. The rheological tests showed a bitumen which is much too brittle and has more cold crack properties than virgin bitumen. In our quest for the revival of the bitumen a couple conditions were very important:

The rejuvenating additive should:

- Chemically be similar to the components lost in aged bitumen
- Readily available
- Economical feasible
- Environmental safe (both for nature and for personnel)
- Low addition rates
- Easy to implement in any asphalt mixing plant
- Durable (C2C)

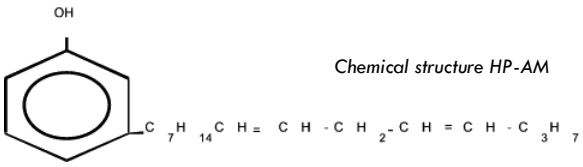
In the past a lot of materials have been tested to rejuvenate this aged bitumen but with limited effect. The most used products are mineral - and vegetable oils next to the addition of softer bitumen. Both products have big disadvantages; oil works as a plasticizer and will weaken the asphalt stability considerably, it also decreases the adhesion on the minerals. Soft bitumen will have a positive effect on aged bitumen but the addition rate is high and an extra bitumen tank is needed to store the hot bitumen.

A quick scan of the possible suitable raw materials gave the following results:

- Oil (low stability; low adhesion)
- Free Fatty Acids (works as a plasticizer; same problems as oil)
- Soft bitumen (high addition rates; extra bitumen storage)
- Waxes (expensive)
- Resins (chemical & natural) (mostly expensive; sticky if handled as solids)
- Flux additives (works for short period of time; often VOC)
- Fatty Acids derivatives (reactive; storage stability)
- Polymers (EVA & SBS) (expensive; difficult to incorporate; poor workability)
- Amides (expensive; handling)

Apparently the resins looked like the best solution because they had a similar chemical structure as the aromatics and the resins present in virgin bitumen. One of the resins which has been on the market for

decades is a natural resin with a high temperature stability. This specific resin was tested in bitumen and showed a very good compatibility with hot bitumen.



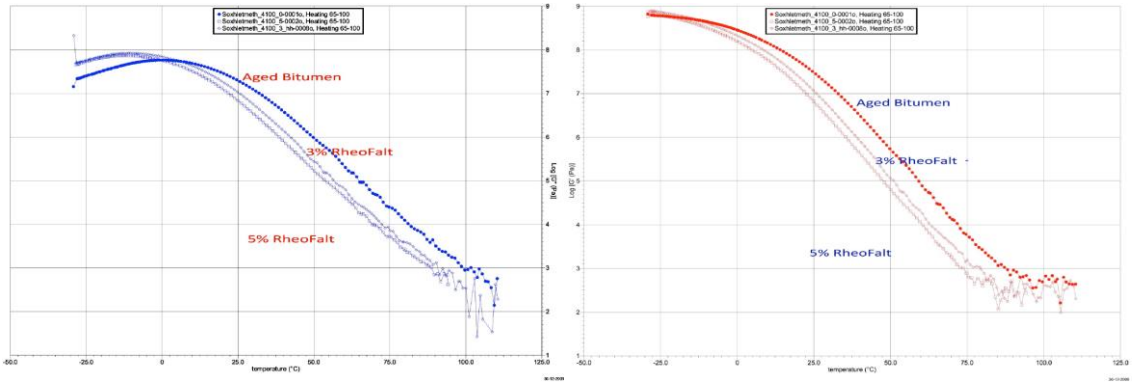
Chemical structure HP-AM

5. Rheological test:

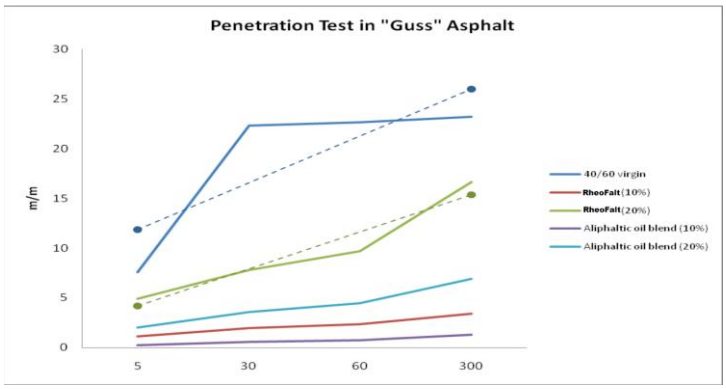
In our research we tested several resins and resin blends both natural and petrochemical. In these tests a positive effect on the aged bitumen was observed. In the rheological test we only looked at the range of resins which we thought most suitable to renew the bitumen. The solution was to be found in the liquid or soft resins at room temperature.

The resin HP-AM shows a significant increase of viscous properties in the aged bitumen.

In the rheological test a low addition rate already showed a significant result in improvement of the visco-elastic properties.



6. First tests on asphalt



The most feasible resins were tested in an asphalt mix to see if the behavior was detectable in an asphalt mix. For this experiment a “Guss Asphalt” was used because this high binder containing asphalt gives a good indication of the bitumen properties.

7. Dynamic testing on asphalt

After the first indicative test the selected resin (RheoFalt HP-AM) was extensively dynamically tested in more than 200 asphalt samples. These tests showed a positive effect on aged bitumen in After the first indicative tests the selected resin (RheoFalt HP-AM) was extensively dynamically tested in more than 200 asphalt samples. These tests showed a positive effect on aged bitumen in several asphalt mixes.

STAB 0/16 - 0/22 Referance (50% RAP with virgin bitumen)

Fatique Curve in (N) = $A_0+A_1*\ln(\varepsilon)$		Fatique Curve $N=k_1 \cdot \varepsilon^{k2}$		Features	
$q=A_0$:	**36,928**	$\log_{10} k_1$:	**16,038**	Number of Tests:	
$p=A_1$:	**-4,883**	k_2:	**-4,883**	for elogation - characteristics:	1.(
R^2:	0,879			mean E_{ini} [MPa]:	
$s_{x/y}$:	0,86			elogation - characteristics [µm/m]:	

STAB 95% Recycling with 5% RheoFalt (no virgin bitumen)

Fatique Curve in (N) = $A_0+A_1*\ln(\varepsilon)$		Fatique Curve $N=k_1 \cdot \varepsilon^{k2}$		Features	
$q=A_0$:	**38,408**	$\log_{10} k_1$:	**16,68**	Number of Tests:	
$p=A_1$:	**-5,326**	k_2:	**-5,326**	for elogation - characteristics:	1.(
R^2:	0,842			mean E_{ini} [MPa]:	
$s_{x/y}$:	0,706			elogation - characteristics [µm/m]:	

STAB with bit. Donor & 15% RheoFalt (no virgin bitumen)

Fatique Curve in (N) = $A_0+A_1*\ln(\varepsilon)$		Fatique Curve $N=k_1 \cdot \varepsilon^{k2}$		Features	
$q=A_0$:	**46,864**	$\log_{10} k_1$:	**20,353**	Number of Tests:	
$p=A_1$:	**-6,594**	k_2:	**-6,594**	for elogation - characteristics:	1.(

During these tests partially recycled asphalt and fully recycled asphalt (100%) were tried. For fully recycled asphalt two variations were used:

a. STAB (base course) only based on RAP with no new bitumen
b. STAB with partially reclaimed asphalt and new aggregates in combination with roofing bitumen. Old roofing bitumen were used as a bitumen donor. Because this bitumen is a PmB *(polymer modified binder)* with oxidized bitumen, extra HP-AM was used in the trials. By using roofing bitumen as a donor no virgin bitumen are needed for the production of asphalt.

The results indicated that by using, 5% RheoFalt HP-AM on the bitumen level of the aged bitumen and 15% RheoFalt HP-AM on the bitumen level of the roofing granulate, asphalt which meets the high standard of the CE type testing according to the NEN-EN 12697 can be produced.

STAB 95% Recycling with 5% RheoFalt (no virgin bitumen)

Mean Results		T[°C]	***20,0***
f [Hz]	ε [µm/m]	E* [MPa]	phase - angle [°]
0,1	47,9	6.866	25,9
0,2	47,4	8.178	23,0
0,5	47,5	10.003	19,5
1,0	46,8	11.418	17,2
2,0	46,3	12.842	15,2
5,0	45,7	14.693	13,0
8,0	45,5	15.647	***12,0***
10,0	45,4	16.080	11,6
20,0	45,1	17.287	10,3
30,0	45,8	18.306	9,8
0,1	47,8	6.816	26,1

8. Dosing equipment

The dosing of the liquid resin is done via a special dosing pump. The total installation has especially been developed for this application and can “turn-key” be installed. The RheoFalt HP-AM is supplied in Flexi-Tanks of 20MT.

9. C2C

RheoFalt HP-AM is based on a natural vegetable resin which is a heavy fraction of a distillation process. The raw resin fraction is a by-product of and for that reason not competitive with food production. At the moment only as small percentage is economically used and the rest is burned or discarded. By using this resin CO_2 is bonded inside the asphalt.

When asphalt is recycled energy is saved because no, or fewer, new materials have to be used. Because of this the savings can even be bigger than the total energy needed to produce virgin asphalt (Novem Utrecht 2004). Because the resin used to recycle asphalt is not reactive nor volatile, the modified bitumen / asphalt is easily recyclable after the life span of the renewed asphalt.

Both the origin of the RheoFalt HP-AM and the ability to recycle up to 100% without using new bitumen or bitumen donors, is the ultimate cradle to cradle application as described in the Hanover principles first formulated by William McDonough and Michael Braungart, (Expo 2000 Hanover). “ Waste is Food”.

10. Conclusion

The results in the tests showed that 100% recycling of asphalt is feasible even if a bitumen donor is used. By recycling the reclaimed asphalt a big energy saving is realized as reported in the report of Novem, Utrecht 2004. The saving can be even bigger than the total energy consumption of new asphalt. This natural resin from renewable source is a true cradle to cradle application and is described in four patents.