The expansion transverse to the wheel load on the bottom of the asphalt layer was reduced by 25-45 % (depending on the asphalt mix) as a result of the carbon fibre grid "S&P Carbophalt G".

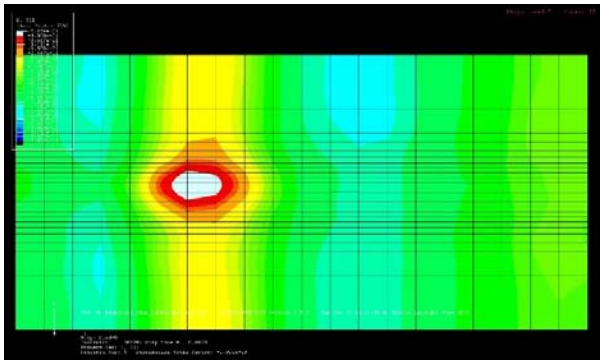

Image 5: without carbon fibre reinforcement

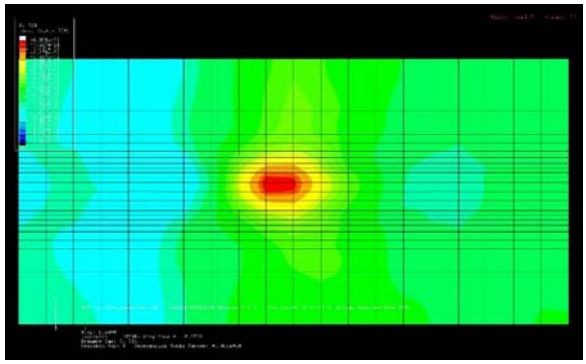

Image 6: with carbon fibre reinforcement

Image 5 and 6 show the compressive stress in front of and behind the wheel load, when being rolled over, as well as the tensile forces under the wheel load. In the carbon-fibre pavement specimen the forces are fed into the grid and absorbed by it. The asphalt layer thus experiences reduced stress.

8. Design concept for C-fibre reinforced asphalt pavements

The design software BISAR 3.0 gives a possible design concept for carbon-fibre reinforced asphalt pavement layers. In a first stage, a binder course measuring 12 cm in thickness and a wearing course of 4 cm in thickness were placed on an existing old base. The expansion is determined using the software under standard load conditions.

Asphalt layer	Thickness (cm)	Elasticity modulus (MPa)	Layer designation	Load number	Vertical load (kN)	Vertical stress (MPa)
1	4 cm	3000	New wearing course	1	20	0.577
2	12 cm	4000	New binder course	2	20	0.577
3	Old, existing base	1500	Existing base			

Expansion beneath wearing course (µ):	**XX = 58.3**
(Result of BISAR 3.0 software)	**YY = 33.9**
	ZZ = 59.3

Table 11: Design with BISAR 3.0 "without S&P Carbophalt grid"

In a second stage the carbon fibre grid was placed underneath the wearing course. Thanks to the carbon fibre grid the stiffness (modulus of elasticity) of the 4-cm thick upper layer as well as the 4-cm thick bottom layer is increased by approx. 30 %.

Asphalt layer	Thickness (cm)	Elasticity modulus (MPa)	Layer designation	Load Number	Vertical load (kN)	Vertical stress (MPa)
1	4 cm	4000 (+ 25 – 30 %)	New wearing course (+ 30 % stiffness)	1	20	0.577
2	4 cm	5000 (+ 25 – 30 %)	New binder layer (+ 30 % stiffness)	2	20	0.577
2 a	8 cm	4000 (no influence)	New binder layer (no influence of the asphalt reinforcement	2	20	0.577
3	Old, existing sub-base	1500	Existing sub-base			

Expansion beneath wearing course (μ):	**XX = 47.4 (- 19 %)**
(Software BISAR 3.0 result)	**YY = 28.1 (- 17 %)**
	ZZ = 39.5 (- 34%)

Table 12: Dimensioning with BISAR 3.0 "with S&P Carbophalt grid""

The results determined using the BISAR 3.0 software show a reduction in expansion of 19% to 34%. The results verify the tests carried out by EMPA. A simple dimensioning of carbon-fibre reinforced asphalt pavement layers is thus possible using the BISAR 3.0 software. The influence of the C-fibre reinforcement is reproduced as an increase in stiffness of the asphalt layer lying above and beneath the C-fibre reinforcement.

9. Deflection measurements on C-fibre reinforced asphalt pavement layers

In autumn 2003, the load-bearing capacity of the Andermatt-Hospental main road in Switzerland was tested before and after installation of a 4-cm thick new asphalt overlay reinforced with S&P Carbophalt. Measurements were conducted with a Lacroix deflectograph at a rear axle load of 10 t.

Image 7/8: Lacroix measurement vehicle and beam in the measurement position