Reinforcement of Bituminous Wearing Course with Geotextiles on Road 588 in Soderhamn

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ABSTRACT: Geotextiles as reinforcement in bituminous overlays to delay reflective cracking is a method used since long especially in the USA. The method has been used in a lot of different projects, but there are big difficulties in finding out whether the method is cost effective or not. The major problem is to measure the effect of a geotextile built in between two asphalt layers. In this project we have tried to measure the effect in the laboratory by including geotextiles in test bodies 1x2 m in size. The test bodies were tested in a test bench at Swedish Road and Traffic Research Institute. The test bodies were pulled apart and the tensile strength and elongation at break was measured. The same type of geotextile reinforcements were also constructed on a test site on road 588. The road was yearly inspected and the cracks arisen were monitored. Every year the bearing capacity was measured by a Falling Weight Deflectometer (FWD). A few times the roadsurfaces' evenness was measured by a rolling laser equipment called Primal measurer.

1. INTRODUCTION

During the latest years lack of financial resources has caused the maintenance of paved roads to fall behind. Therefore it is urgent for the Swedish National Road Administration (SNRA) to find new and more cost effective maintenance methods. As a part of this struggle a research project was started in 1985 by the Swedish contractor Nordic Construction Company (NCC), with economic support from Swedish Contractors Research Fund (SBUF), SNRA and 4 geotextile suppliers. The main purpose of the project was to evaluate the the maintenance metod "Reinforcement of a wearing course by laying a geotextile between existing and new wearing course" in the laboratory and in the field.

2. TEST SITE

2.1 Geografical position

Road 588 in Söderhamn is situated in the middle of Sweden. The test site is 850 m long and 7 m broad.

2.1 Climate

In the area there are normally warm summers and cold winters. The mean amount of frost is about 500 negative daygrades °C. The normal frost depth is 1,7-1,8 m in frostsensitive soil.

2.3 Traffic

The average day traffic is about 2 680 in total. Heavy vehicles are about 20 %. The speed limit is 70 km/h and most of the private cars have studded tires during the winter season.

2.3 The road design

The structure of the road is rather weak which can be seen in fig 1.

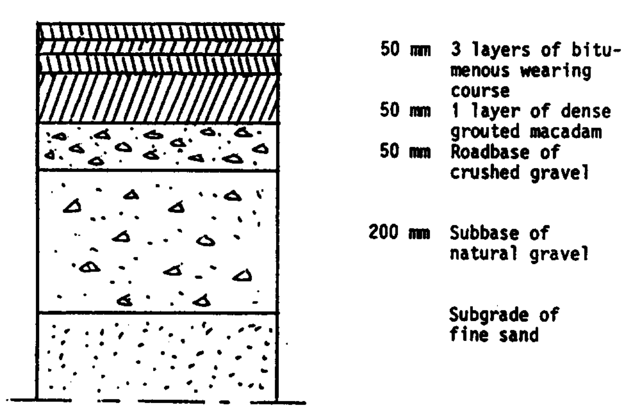


Fig 1. Road structure

2.4 The road condition

At the time for the test in 1987 the test road showed extensive alligator cracking (fig 2), a few transverse cracks and potholes had emerged in some places. Ther were also deep ruts emerging from low bearing capacity, aged pavement and high traffic volume in proportion to the road design.

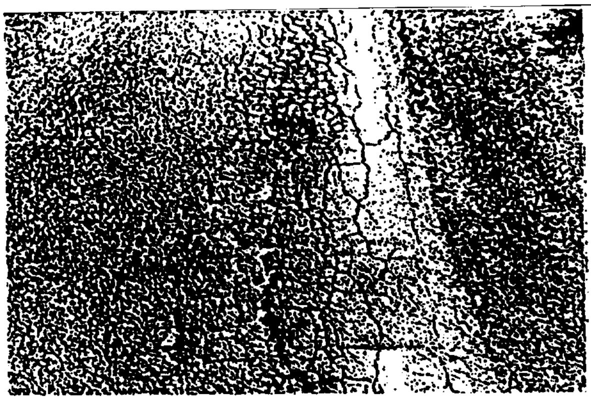
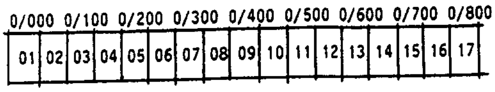


Fig 2. Alligator cracks in the test road

2.5 Preparatory work

The bearing capacity was tested with a Falling Weight Deflectometer, and it was found that the test road had low bearing capacity. The first half was in somewhat worse condition than the second half.
The test road was divided into seventeen testareas. Every second area was a reference area starting with the first area and ending with the last area. The four different geotextiles then were distributed by random sampling for each one to occur once on the first half and once on the second half of the test road.
The test areas are then located according to fig 3.



01. Reference
02. Fabric of polyester
03. Reference
04. Geonet of polypropylene
05. Reference
06. Geonet of polyester
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10. Geonet of polypropylene
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14. Fabric of polyester
15. Reference
16. Fabric of polypropylene
17. Reference

Fig 3. Testroad divided into test areas

2.6 The rehabilitation methods

A tack coating and a levelling course in average 35 kg/m^2 was laid all over the test road to get an even and dense surface for the wearing course.
After installation of the reinforcing materials a spread of 15 kg/m^2 asphalt concrete MABT12 was laid out and compacted and after that the wearing course of 80 kg/m^2 asphalt concrete MABT16 was laid out on the whole test road and compacted with a six tons vibratory roller.
There were four different geotextiles to be tested:

1. Fabric of polyester, 210 g/m^2, needlepunched. Tension at break 10 kN/m with 60-80 % elongation.

The levelling course was tack coated with three layers of bitumen emulsion, together about 1,1 kg/m^2, the fabric was rolled out and another tack coating of 0,4 kg/m^2 was sprayed on the fabric.

2. Fabric of polypropylene, 140 g/m^2, needlepunched. Tension at break 8 kN/m with 50 % elongation.

The levelling coarse was tack coated with one layer of bitumen emulsion, 0,3 kg/m^2, the fabric was rolled out and sprayed with two layers of bitumen emulsion, together 0,6 kg/m^2.

3. Geonet of polyester, meshes # 30 mm, 333 g/m^2. Tension at break 60 kN/m with 12 % elongation.

After tack coating with 0,3 kg/m^2 bitumen emulsion the geonet was rolled out. The net was attached to the pavement with steel bands nailed with steel nails.

4. Geonet of polypropylene, meshes 60x75 mm, 210 g/m^2. Tension at break 16 kN/m with 11 % elongation.

After tack coating the geonet was nailed to the pavement with steel bands and steel nails. The net was very stiff and that caused problems when the wearing course was laid. The heat from the wearing course made the net to expand and form waves which were folded together in the mix. The net in places came up to the road surface and a lot of cracks arose.

2.7 Test slabs

On an adjusted road surface on o small side road next to the test road small test areas were constructed on a bed of plywood boards 2,40x1,20 m. Three slabs of each rehabilitation method and three slabs without geotextile included were constructed with the same material, the same equipment and the same process as on the test road. As a bottom layer though we laid a 50 mm thick layer of asphalt concrete MABT16. The slabs were lifted up with a tractor on a truck and transported to Swedish Road and Traffic Research Institute (VTI) in Linköping, about 40 Swedish miles away to be tested.

3. LABORATORY TESTING

3.1 Test bench

The test bench is designed and constructed at VTI. It was rebuilt for this purpose by eng Lars-Olof Svensson who also performed the tensile tests and put the results together in a very deserving manner. The test bench is shown in fig 4.

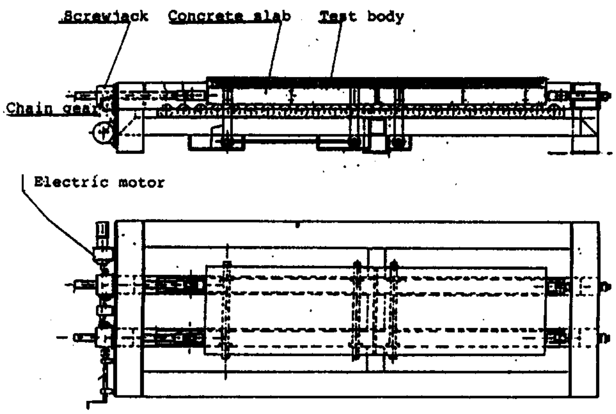


Fig 4. Test bench in profile and plan

3.2 Test bodies

In the laboratory the test slabs were cut down to 2,0x1,0 m and a waist was cut in the middle part of the test body to ensure a break in that area (fig 5).

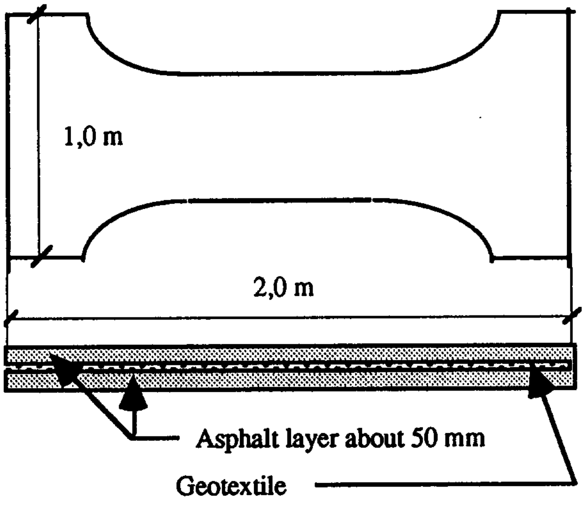


Fig 5. Test body in plan and profile

3.3 Test results

The test was done at - 10 °C which was thought to correspond to the worst conditions in the field. For practical reasons the tensile speed was set to 0,5 mm/h.

The tensile strength and the elongation was measured during the whole process. An example is given in fig 6.

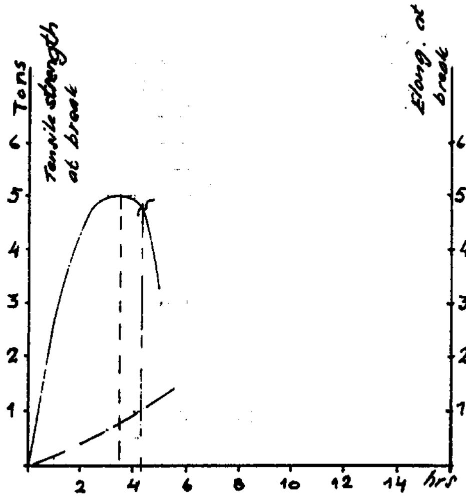


Fig 6. Strength and elongation curves

The results are shown in table 1.

Testbody	Tensile stress at break		Elongation at break	
	kp/cm^2	% of ref	µStrain	% of ref
Fab of polyester	10,8	115	5090	83
Fab of polyprop	10,9	116	5316	87
Net of polyester	11,4	121	6174	101
Net of polyprop	12,1	129	5759	94
Reference	9,4	100	6129	100

Table 1. Results from tensile test

The results, which are the average of two tests of each kind, indicate that a fabric has roughly 15 % higher tensile stress at break than the referance. The geonets have between 20 and 30 % higher tensile stress than the reference and all at less or similar elongation.

4. FIELD TESTS

4.1 Measurement sections

Each test area was divided into 5 measurement sections according to fig 7.

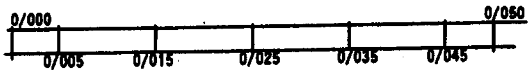


Fig 7. Measurement sections

Those sections were painted on the road before the maintenance operation and were repainted at the same spots after the operation was finished. In these sections the bearing capacity was measured with a falling weight deflectometer and the rutting was measured by a laser profilometer.

4.2 Deflection measurements

The Falling Weight Deflectometer was used to measure the bearing capacity. In this case we choose the autumn measurements because we know that the conditions are normally much alike in the autumn from year to year.
The most comman way to analyze FWD results is by back calculation. By that method it is possible to bring out the elastic modulous in every layer and may be even to forecast the remaining lifetime of the road construction. Anyhow we think this method is a little too complicated and a bit difficult to understand for the man in the street. Therefore we have tried to find other ways to express the bearing capacity and to forecast the road performance.

The FWD is a try to equal in one spot what happens when a lorry is driving with full load on the road. It is accomplished by a falling weight on a round steel plate with a diameter of 300 mm. The force is 5 tonnes to equal a 10 tonnes axle load. This falling weight will create a deflection basin on the road surface. In this case we measured the deflection in the center, 200 mm, 450 mm and 900 mm from the center.

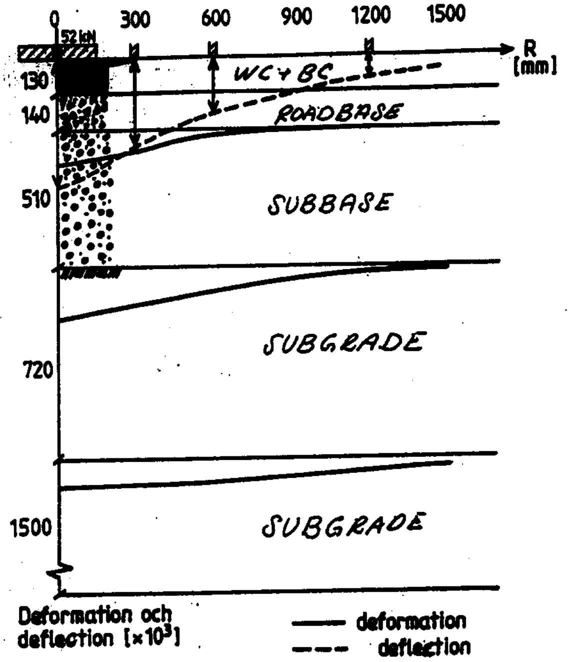


Fig 8. Deformation and deflection in a road

In a Swedish report (Jansson et al, 1988) it was stated that results from deflection measurements on a similar road constraction indicated that the sensor in the deflection center will give information mostly of the deformation in the top layer, and the sensor most distant from the deflection center will give information of the deformation mostly in the subgrade (fig 8).

It could be interesting to see how the deflections in our road have changed since before any treatment in July 1987 to 1993. We show this in fig 9 on test area 1, a reference.

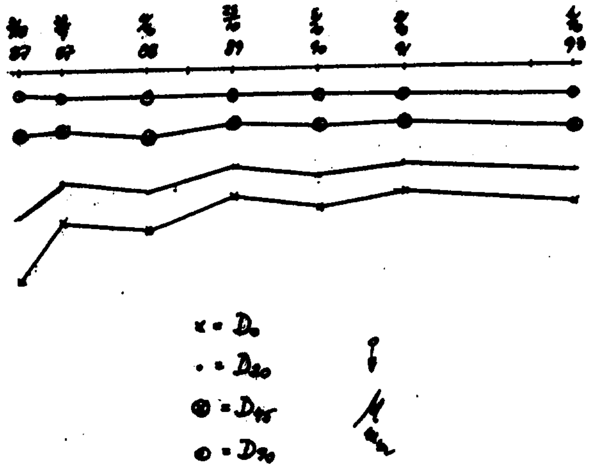


Fig 9. Deflections on test area 1, ref.

From fig 9 we can see that D45 and D90, defl. 45 and 90 cm from deflection center, are not affected by the maintenance made on the road surface, which also was expected according to fig 8. We can also see that D0 and D 20 both have a strongly reduced deflection after the maintenance. Fig 8 shows us that the closer we measure to the deflection center the better the result will represent the top layers. Therefore we presume that D0 - D20 will represent the new wearing course including the geotextile. The difference between D20 and D45 is explained with the levelling course which was rather thick in the wheel paths as they had deep ruts and the FWD measurement was made in the outer wheel path. Fig 9 also indicates that the maximum bearing capacity after the maintenance will not arise until 1-2 years after the maintenance operation. That is possibly depending on the traffic compaction and the hardening of the bitumen. If we look at the difference D0-D20 on test area 8 and 9 for all autumn measurements (fig 10), we can notice that we have maximum bearing capacities after 1-2 years and at the last measurement in October 1993 it seems like the bearing capacity is going down.

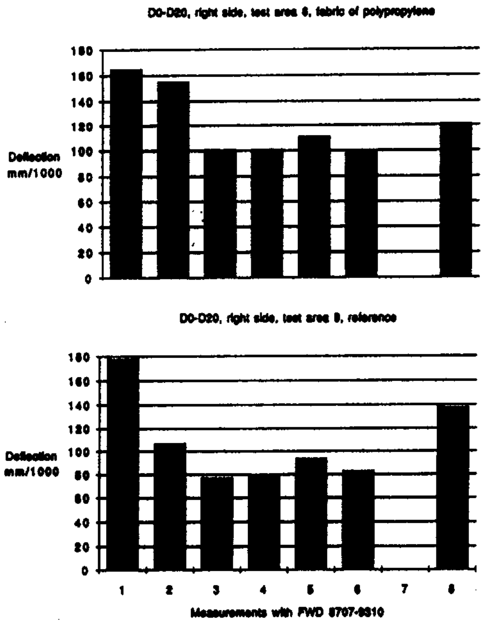


Fig 10. Test areas 8 and 9, D0-D20.

We can assume that when the difference has reached the same level as the first measurement in July 1987 the road has reached just about the same level of distress as it had at that time. We do not know though how the breaking down process will progress, so it is difficult to forecast the construction life time. Probably it will be an accelerating process in the end.

It is a bit surprising that the deflection on test area 8 is just about the same before and after maintenance in 1987. There is a possibility that this fact is due to a compression in the reinforcement layer consisting of a fabric and bitumen. The last FWD measurements on test area 1-9 is shown in fig 11.

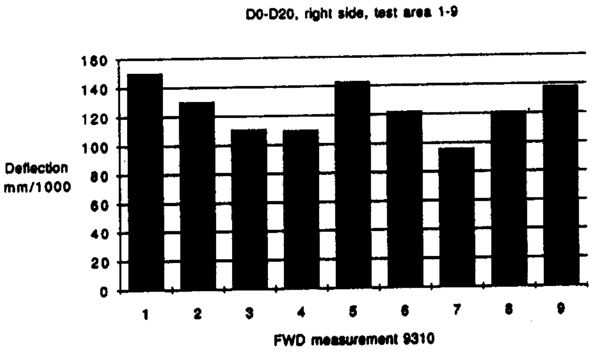


Fig 11. FWD measurements test area 1-9.

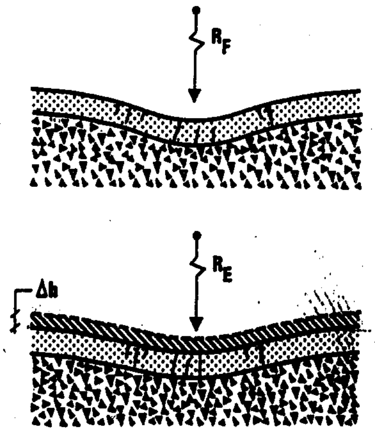
The results from test area 1, 5 and 9 have the highest value of D0-D20 which might mean that they are closest to a break down.

Another way to describe the effect of a reinforcement operation is described by (Djärf et al, 1993) researcerhers at Swedish Road and Traffic Research Institute is by the "radius of curvature". That "radius" is calculated by means of the deflection in the center, D0, and the deflection in a spot on a suitable distance from D0. The mathematical expression has the formula:

$$R = \frac{r^2}{2 \cdot D0 \cdot \left({D0}/{Dr} - 1 \right)}$$ where

R = radius of curvature (ROC)
r = distance from D0 to defl nr 2 (in our case 20 cm to D20)
D0, Dr = deflection in the load center (D0), and at distance r from D0 (Dr).

The modell is illustrated in fig 12.



R_F=ROC before reinforcement
Δh = reinforcement layer thickness
R_E=ROC after reinforcement

Fig 12. Illustration of radius of curvature

The "radius of curvature" for test area 8 and 9 for D0-D20 is shown in fig 13. By many measurements it is found that a road in bad condition most often has a ROC of less than 100 m. Both the test areas confirm this at the first measurement before the maintenance in July 1987. At the last measurement in 1993 both test areas has passed their maximum ROC and are going down towards the 100 m limit.

From fig 14 we can see the last measurement on test area 1-9 from October 1993. Test area 1, 5 and 9 are close to 100 m, but the other 2 references, 3 and 7 are still high up. The 4 geotextile reinforced test areas are laying somewhere in between.

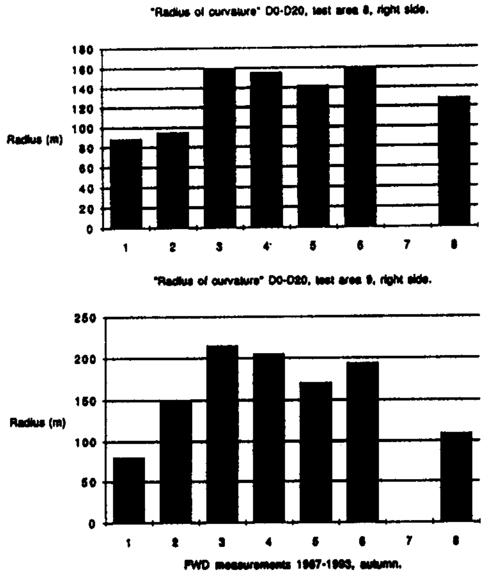


Fig 13. "ROC" for test area 8 and 9.

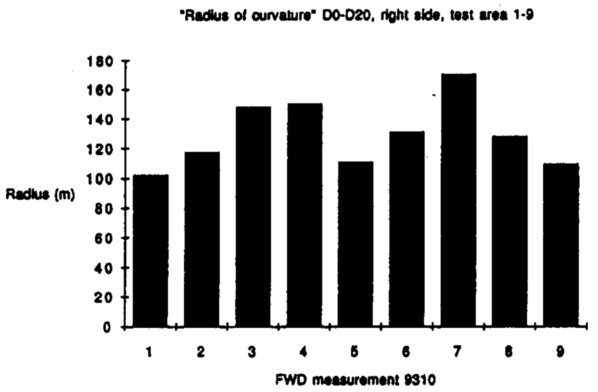


Fig 14. "ROC" for test areas 1-9.

As we do not know how long it will take for the different test areas to come back to the same "ROC" as before the maintenance, it is not possible to estimate the remaining life time for the different areas. We will have to wait and see.

4.3 Rut measurements

The measurements have been made with a laser profilometer Last measurement was made in 1991, which shows that the only thing happened so far is the normal wear from the studded tires (fig 15).

4.4 Crack registration

Every spring a crack mapping was made and registrated. A crack length calculation has been made which is shown in table 2.

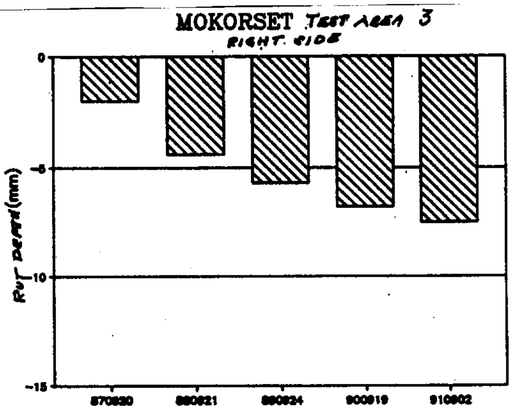


Fig 15. Rut measurements on test area 3.

Test area	Cracks 8707 (m)	Cracks 9305 (m)	% of 8707
1	85,4	34,0	39,8
2	119,0	5,0	4,2
3	86,8	41,2	47,4
4	116,0	90,0	77,5
5	103,1	48,2	46,7
6	108,0	41,9	38,7
7	115,0	54,1	47,0
8	81,9	45,1	55,0
9	94,6	64,2	67,8

Table 2. Crack length test area 1-9.

The crack mapping will say nothing about the severity of the cracks. Generally the geotextile treated test areas have less alligator cracking than the references.Test area 2 has performed extremely well. It is a fabric of polyester richly impregnated with bitumen emulsion. On the other hand test area 4 has performed extremely bad and was cracked directly after the maintenance.

5. CONCLUSION

This is an attempt to get measurable effects from geotextiles built into the bituminous layers, and to make the effects more understandable for ordinarie people. So far we have not reached the goal but we will continue our efforts to get there.

References

Jansson, H and Wiman LG (1988) *Deflections in a road subjected to test loading*. Swedish Road and Traffic Research Institute.

Djärf, L et consortés (1993) Project "*Model development*". Work report in March 1992. Swedish Road and Traffic Research Institute.