SBUF

PROJEKTNR. 14066

Fibernätsarmering i asfaltbeläggningar

En förstudie

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2024-06-28

Preface

This pilot study was initiated by InfraCare Sweden AB together with VTI to get a picture of the use of fiber mesh reinforcement in Sweden. Such reinforcement is applied in different projects, mainly in maintenance project where the pavement suffers from distresses such as surface cracking, or when widening an existing road. To get an overview of the use and to decide how to progress with the next step, this pilot study is intended to describe the possibilities and what is lacking for it to become a standard tool in the road designer's toolbox.

Tony Svensson at InfraCare Sweden AB, Klavs Olsen and Jens Adamsen at S&P Reinforcement in Denmark and Stepan Bohus at Adfors in the Czech Republic are gratefully acknowledged for their valuable input during the work with this project. A large thank you to SBUF for their financial support for making this study possible.

Stockholm, June 2024

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Abstract

Fiber mesh reinforcement is known to strengthen the road and extend its lifespan. Although the positive effects of fiber mesh reinforcement have been demonstrated through different tests, there is no Swedish design guide that allows the reinforcement to have a strengthening effect in the bearing capacity calculations. In order to reach consensus regarding the benefits of fiber mesh reinforcement and how and when it may be utilized, extensive testing along with reliable methods, developed on how to include the fiber mesh in a design model, are needed.

The use of fiber mesh reinforcement is studied in this report, when and how it is used. Representatives for clients and contractors are interviewed to collect experiences from staff that worked with fiber mesh reinforcement. A literature survey is also performed to identify what evaluations have been done and how fiber mesh is applied.

The results show that most tests are performed on specimen in a laboratory environment. Real pavement constructions have also been built and instrumented with strain gauges to enable readings of stresses and strains inside the AC where they are largest. However, full scale tests where pavements may be followed while they are exposed to real traffic and climatic loading are still missing. Photos taken before and after maintenance works, where fiber mesh reinforcement were applied, and road surface data from such sections, have been studied to get an overview of how effective fiber mesh reinforcement is regarding deterioration on the road surface.

Keywords
Fiber mesh reinforcement, asphalt concrete reinforcement, glass fiber reinforcement, carbon fiber reinforcement

Sammanfattning

Fibernätsarmering används i asfaltöverbyggnader för att stärka vägen och förlänga dess livslängd. Även om fibernätsarmerings positiva effekter påvisats genom olika tester så finns ingen svensk dimensioneringsmetod där konstruktionen tillåts tillgodoräkna sig någon förstärkning i bärighetsberäkningarna. För att nå konsensus angående fördelarna med armeringen samt hur och när den ska användas så behövs omfattande provning tillsammans med pålitliga metoder som utvecklas för att inkludera armeringen i dimensioneringen.

Användningen av fibernätsarmering studeras i denna rapport, när och hur den används. Representanter för beställare och entreprenörer intervjuas för att sammanställa erfarenheter från personal som använt fibernätsarmering. En litteraturstudie genomförs också för att ta reda på vilka utvärderingar som har gjorts och hur användningen ser ut.

Resultaten visar att de flesta tester är genomförda på provkroppar i laboratoriemiljö. Riktiga vägkonstruktioner har också byggts upp och instrumenterats med töjningsgivare för att kunna läsa av påkänningarna i asfalten där de vanligtvis är som störst. Fullskaleförsök där vägkonstruktioner kan följas medan de utsätts för verklig trafik samt klimatlaster saknas dock. Foton tagna innan och efter åtgärder där fibernätsarmering använts, samt vägytedata från sådana sträckor, har studerats för att skapa en bild över hur effektiv fibernätsarmeringen är avseende nedbrytning på vägytan.

Slutsatser

- Fibernätarmering har visat sig minska dragpåkänningarna i botten av asfaltbetong i laboratorietester och i instrumenterade vägbeläggningar, vilket har en positiv effekt på en dess livslängd.
- Det finns ingen accepterad nationell metod där asfaltarmeringens förstärkande effekt får tillgodoräknas i konstruktionen. Detta gör att armeringssystemen endast används i begränsad omfattning.
- Att applicera fibernätarmering initieras ofta av personal med tidigare erfarenhet av liknande produkter. Även om inga objektiva tester eller mätningar i full skala har tillhandahållits, visar intervjuer med beställare och entreprenörer positiva erfarenheter om resultaten.
- Doktorsavhandlingen av Julius Nielsens viskoelastiska beräkningsmodell är visar på god överensstämmelse mellan beräkningsmodell och fältmätningar. Om modellen kan verifieras med ytterligare testresultat finns god potential att implementera fibernätarmering i det nya kommande dimensioneringssytemet (ERAPave). En ökad användning av fiberarmerningsnät förväntas bidra positivt till Trafikverkets ambitiösa klimatmål 2040.

Nyckelord

Fibernätsarmering, asfaltarmering, glasfiberarmering, kolfiberarmering

Content

Introduction

Background

Pavements deteriorate continuously under traffic loading, climate, and ageing and require regular maintenance. Cracks are often initiated from the bottom of the bound asphalt concrete (AC) layer where the strains are largest. This phenomenon is known as bottom-up cracking and the cracks steadily grows until they reach the AC surface. Once the crack reaches the surface, the pavement is open for water to enter, and the deterioration will accelerate. Common maintenance actions consist of simply adding a fresh AC layer on top of the old and deteriorated AC, or more commonly, milling a part of the old AC from the top and replacing it with a fresh top layer. These actions are rarely long-term efficient since old cracks in the underlying layer propagate through the new top layer due to thermally induced stresses and traffic loading. The old underlying asphalt concrete is often severely cracked and has low bending rigidity. The cracks in the aged asphalt concrete can easily transfer into the fresh top layer and are referred to as reflective cracks.

Interlayer systems have been implemented for decades in order to delay crack initiation and propagation. One such interlayer system is referred to as fiber mesh reinforcement and is constructed as a web of high modulus glass fibers or carbon fibers. The fiber mesh's task is to transfer the stress from the AC to be absorbed by the reinforcement and mitigate the crack growth.

In Sweden, reinforcement systems in pavements have been tested and applied for a long time. Glass and carbon fiber mesh form a stiff product together with the asphalt concrete that are applied to reduce the tensile strains in the pavement and therefore increase its life length. Fiber mesh reinforcement have been utilized to:

- Mitigated reflective cracking from the underlying layer
- Increase the bearing capacity
- Reduce rut depth development
- Stop frost heave cracking.

The reinforcement may be applied in both new constructions and in maintenance works. However, the mesh should always be placed between two bound asphalt layers. It is commonly applied when dealing with a road with prior problems, where conventional maintenance doesn't seem to meet the expectations on prolonged life span. Another typical project is widening of existing roads, where the existing shoulder is included in the carriageway or when longitudinal cracking between existing and new AC needs to be avoided.

Since there are no Swedish design guides or regulations on how fiber mesh reinforced can be utilized in asphalt layers in the pavement design to strengthen the road, it is rarely applied in new constructions. It is e.g. not possible to apply reinforcement in order to decrease the layer thicknesses and save costs. The main reason for not allowing any strengthening effects in the design work is the lack of reliable calculation models.

If reinforcement could be utilized to decrease layer thicknesses, extraction of virgin materials could be limited along with greenhouse gas emissions and energy consumption since less materials need to be manufactured and transported.

Aim and purpose

The purpose of this study is to create an overview of the state of knowledge and the use of fiber mesh reinforcement today in Sweden and abroad. There is no Swedish design guide that regulates the use of fiber reinforcement. Therefore, a literature study is made to gather information on what tests and evaluations that has been performed internationally.

Limitations

The idea of the project is to perform a literature study in order to see where Sweden stands in terms of using fiber mesh reinforcement.

There are other types of reinforcement for asphalt pavements, such as steel reinforcement and geotextiles; however, these types of reinforcements are outside the scope of this study.

Literature study

Any kind of reinforcement is rarely used in AC in Sweden today. In Sweden it is allowed to include different kinds of reinforcement in asphalt pavements, such as steel reinforcement bars, geogrids and geotextiles; however, they are not allowed to enhance the bearing capacity in the design calculations according to the standards from the national road administration (NRA). This is due to the lack of reliable calculation methods. That means reinforcement will mostly be applied in design and construct contracts where the contractor has the responsibility to maintain a certain quality for a specified time.

Tests on AC behavior when including fiber mesh reinforcement have been conducted internationally. Using a test carousel, multiple large-scale pavements may be constructed at once, exposed to realistic traffic volumes and the evolution of distresses monitored. An accelerated full-size test was performed at IFSTTAR in Nantes in 2011 (Sohm et al., 2012) to evaluate the influence of fiber mesh reinforcement on distress modes like rutting and crack evolution. Two similar pavements were constructed within the carousel, both consisting of a 70 mm bound asphalt layer on top of an unbound base layer. The bound asphalt layer was divided into a 20 mm bottom layer paved topped with a tack coat, followed by a 50 mm upper layer. One of the pavements was reinforced with a glass fiber mesh with a E-modulus of 73 000 MPa in between the lower and upper asphalt layers.

Comparative measurements regarding deflection, rut depth, surface distress observations and bearing capacity (falling weight deflectometer) were applied throughout the test. Deflection measurements using a Benkelman beam demonstrate similar deflections in both constructions. Towards the end of the test, the unreinforced structure demonstrates a bit higher deflection which is believed to be caused by the bottom-up cracks starting to propagate. No significant difference in rut depth between the two structures could be found. Regarding the extent of cracking, a significant difference was demonstrated between the reinforced and unreinforced structures. While the reinforced structure remained without cracks throughout the test with 1.2 million load cycles, the unreinforced started cracking after 0.8 million load cycles, leaving the larger part (70 percent) of the surface cracked after the full test. Falling weight deflectometer test showed no significant difference between the two structures regarding back-calculated layer moduli.

After the test was finished, core samples and slabs were collected and examined. The interface between the two bound asphalt layers appeared to be in good condition on all samples. The reinforced structure was finally milled without any problems although large pieces of grid fibers could be found in the milled material.

Romeo and Montepara (2012) demonstrated the strengthening of AC by fiber mesh reinforcement through laboratory tests on beam and slab specimens. Three different glass fiber meshes were installed along a twisted steel net inside 60 mm thick beams and slabs. Unreinforced reference specimens were also manufactured and tested. Strain localization and damage distribution were utilized by a Digital Image Correlation System, specifically developed to image asphalt specimen. The three glass fiber meshes differ from one another by mesh dimensioning, 12.5x12.5 mm and 25x25 mm, and also in their design regarding coating. All fiber glass reinforcements have the same tensile strength and maximum tensile elongation. The slabs were constructed by a lower 20 mm thick fine graded leveling course, an interlayer fiber mesh reinforcement, and an upper 40 mm thick wearing course.

It was concluded that all reinforced beams managed to withstand approximately 50 percent higher maximum peak load compared to the unreinforced specimen. Although the behavior at strains after the peak forces are considerably different from one another, it can be concluded that the energy dissipation is significantly better in the reinforced specimen compared to the reference. The slabs behaved similarly to one another up until crack initiation, they all demonstrated an elastic behavior even if the reinforced slabs managed to withstand about 50 percent higher loading before the cracks start to develop. All reinforced samples demonstrated a peak load about twice as high as the reference slabs. In terms of energy needed to deflect the specimen, denoted as fracture energy, it was shown that the presence of reinforcement managed to increase the cracking resistance from 3 to 10 times. The main benefit of including reinforcement is to reduce the stress in the surface layer and instead shifting it to be absorbed by the fiber mesh. The best performing fiber mesh regarding fracture energy was concluded to do so due to its design where the fiber mesh was coated with a thermoplastic film which acts like a tack coat, ensuring proper adhesion between the AC layers.

Graziani et al. (2014) installed strain gages and pressure cells in a real pavement construction on a test facility to evaluate the influence of fiber meh reinforcement. Using data collected from this instrumentation along with falling weight deflectometer data, a model was developed using linear elastic theory (LET). The model simulated multiple AC layer with an interlayer fiber mesh as a single homogeneous layer with an equivalent modulus. Despite that this model wouldn’t allow to catch the authentic materials’ behaviors, it was concluded to supply a straightforward technique to estimate the improvements of including fiber mesh reinforcement.

During the second part of the study, instrumented pavements were exposed to real-scale vehicles. The measured strain field was then analyzed using both the homogeneous LET model developed in the first part of the study, then analyzed using a double-layer LET model to enable catching the reinforcement and possible debonding effects from the grids.

The test section was divided into three parts: one reinforced with a glass fiber polymer grid, another reinforced with carbon fiber/glass fiber hybrid mesh, and the third subsection was left unreinforced for reference. Two layers of identical AC were paved, a lower 40 mm thick layer and an upper 50 mm thick layer with the two fiber mesh reinforcements in between the two layers. Beneath the bound layers, the existing 200 mm granular base layer and the subgrade were kept untouched. The hybrid fiber mesh was manufactured with a high modulus (240 000 MPa) carbon fiber in the transversal direction and a glass fiber (73 000 MPa modulus) in the longitudinal direction. The other mesh installed in the second subsection was a glass fiber reinforced polymer with a modulus of 23 000 MPa. Response from both falling weight deflectometer (FWD) and from real-scale truck loads were measured and evaluated. The carbon/glass fiber mesh test section demonstrate an overall strain field 65 percent lower than the unreinforced section under the FWD load. The glass fiber polymer mesh didn’t show any significant strain reduction. Similarly did the carbon/glass fiber mesh reduce the strains under the real scale truck load, while horizontal strains in the longitudinal direction were higher on the glass fiber polymer meshed test section compared to the unreinforced section. The higher strains were believed to be caused by an interlayer slip between the two asphalt concrete layers due to a much too stiff glass fiber polymer mesh, as opposed to the more flexible carbon/glass fiber mesh.

Nielsen et al. (2021) explored how fiber mesh reinforcement may be introduced when modelling pavements. They modelled three different pavements, all with a fractured old AC layers and a new AC top, with a total thickness of 150 mm. They were all modelled to simulate a mill and overlay maintenance work. The tree models all had different mill depths (and new top layer thicknesses): 30, 60, and 90 mm. Beneath the bound layers, a 500 mm unbound base layer and a seni-infite soil subgrade were modelled. The fiber mesh reinforcement was placed in between the top layer and the existing cracked pavement as a layer with an effective thickness equal to the smeared thickness of the fiber mesh. All layers were modelled to be fully bonded to each other.

Results from the study demonstrate reduced stresses and strains in thick overlays, which indicates a mitigated risk of cracking and rutting. The reduction of stresses and strains was found to be neglectable for thinner overlays, indicating limited effect of the fiber meh. Vertical stresses were not affected by inserting a fiber mesh, neither in the base layer nor the subgrade.

Nielsen et al. (2022) developed a computational model based on mechanistic-empirical (ME) design in which fiber mesh reinforcement may be included in order to strengthen the construction. A viscoelastic component was introduced in the computational model to enable time and temperature dependency along with the effects of moving loads. Two pavements were simulated, both designed with a 200 mm old, fractured layer, a 500 mm granular base and a semi-infinite subgrade. The models were simulated to have a mill-and-overlay maintenance work where the top 100 mm were milled and replaced with a new AC top layer. In one of the pavements, a carbon fiber mesh was simulated between the old, fractured layer and the new top. Results demonstrate a significant reduction in horizontal strains at the interface between fractured layer and new top when applying a low loading speed/high temperature scenario. This indicates a possible prolonged life length for the overlay in terms of bottom-up cracking. At higher speed and/or lower temperature the differences are smaller. No effects on vertical deflections were obtained.

In another study by Nielsen and Levenberg (2023) an instrumented asphalt road was constructed and divided into four subsections, each 100 m long. Three subsections were constructed with a carbon fiber mesh at different depths. The authors present results from the subsections with fiber mesh at the bottom of the 150 mm thick bound surface layer along with results from the unreinforced subsection. The AC rested on top of a 750 mm thick base layer on top of a subgrade. Responses from strain gauges were recorded during the passage of a slow-moving heavy forklift. Results demonstrate that their data model presented by Nielsen et al. (2022), including fiber mesh reinforcement manages to fit the readings from strain gauges far better than a similar model excluding the fiber mesh. This indicates that the model is capable of simulating the pavement's behavior including reinforcement.

Fiber mesh reinforcement used today

Placement inside pavement

Fiber mesh reinforcement should always be installed between two bound AC layers. Generally, the lower a fiber mesh reinforcement is placed within the AC, the more effective it is when it comes to absorbing tensile stress and limit the strains. One of the most important aspects of integrating a fiber mesh inside the AC is to ensure sufficient adhesion between the AC layers and between AC and fiber mesh. There are no specifications when it comes to adhesion levels in the Swedish design guide. However, it is mentioned in Andersson (2012) that to maintain full function of the fiber mesh, it is important to verify proper adhesion between the asphalt layers. A suggestion given by Andersson (2012) is to follow the German design guide and make sure that the adhesion is minimum 15 kN according to the Leuthner test on a 150 mm core. This is suggested to apply to all layers withing the construction. If this minimum value can't be fulfilled there is a high risk that the asphalt layers don't act as a single unit but rather as multiple thinner layers which implies an increased risk of cracks.

Material

Fiber mesh reinforcement structures may be manufactured with various materials. The mesh reinforcements discussed in this pilot are either glass fiber or carbon fiber, or a combination of the two materials. In the Swedish guide on reinforcement measures (Andersson, 2012), published by the NRA, there is a recommendation when it comes to Young's modulus for fiber mesh reinforcement, that it should be at least 70 000 and 210 000 MPa for glass and carbon fiber meshes respectively. Different manufacturers use different materials with different Young's moduli but most products are declared to exceed these limit values in their technical data sheets. To ensure that the materials have the correct tensile strength, it should be certified according to ISO 10319 (Geosynthetics) and have a CE marking.

Recycling

It is crucial that the fiber mesh doesn't impair the possibly for recycling of the pavement. At the end of the pavement's life, the surface layer either gets a new surface layer on top of the old one or a mill-and-overlay is executed. If a new top layer is simply added, the fiber mesh is not a problem since it will stay in the old deteriorated top layer. The other option is to mill the old top layer and used it as reclaimed asphalt concrete. The milling machine will tear the fibers apart, leaving fibers with a maximum length equal to the distance between two teeth on the milling machine, ~5 cm. This will neither cause problems since the fibers will mix into the new asphalt concrete and constitute a part of the new layer. Multiple fiber mesh manufacturers proclaim through their environmental product declarations (EPD) that their products are 100 percent recyclable.

S&P Reinforcement has performed accelerated rut depth tests in a laboratory facility with different amounts of milled reinforced asphalt concrete included in the new mix (Olsen and Frost Kamphøvener, 2019). Results show similar rut depths when including

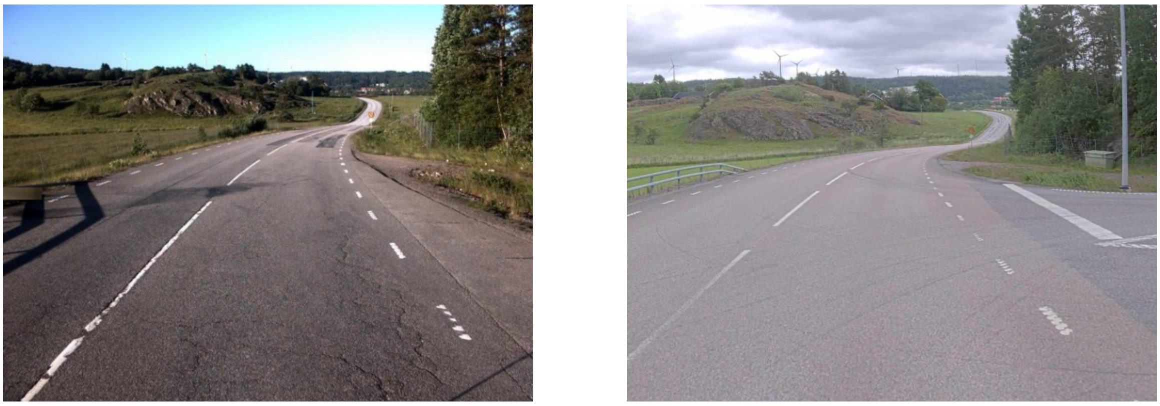
10 percent of old milled reinforced material compared to the standard mix. Including 30 percent of milled reinforced material lower the rut depth, indicating a more resilient structure compared to the standard mix regarding rut depth development.

Swedish experiences

Use of fiber mesh reinforcement in Sweden is today based on experience of such products from the client or contractor. To the author's knowledge there are no national real test sites where a pavement has been designed in sections with and without fiber mesh reinforcement. Neither have any full scale tests at test facilities been executed within Sweden. International tests demonstrate lower stresses and strains inside AC when performing laboratory testing or accelerated tests at test facilities. Due to the lack of comparable data from real roads exposed to real traffic loads and climatic loads, photos and surface data have been evaluated. Studying deterioration from year to year through the NRA's public database PMSv4 may give indications of changes in strength after laying fiber mesh reinforcement. It must be noted that there is no reference section to compare to, but the photos and data can still be considered as indications of improvements.

Fiber mesh reinforcement was placed in 2018 on a 225 m long stretch on road 174 (partly on the bridge over the E6) where severe alligator cracking could be seen on photos from 2017. The old pavement was laid in late 2000 and a part of the stretch got an ultra-thin asphalt layer in 2003. The old pavement was milled and replaced with a new binder layer and a dense graded surface layer. Photos from two locations, a) and b), along this section are shown in Figure 1 below. In both locations it can be seen how the pavement has deteriorated (left column) with severe alligator cracking as a result. Photos from 2022 show the condition four years after construction and no cracking has reoccurred. The road has an AADT of 1450 vehicles. No information on type of reinforcement was provided.

a)



b)

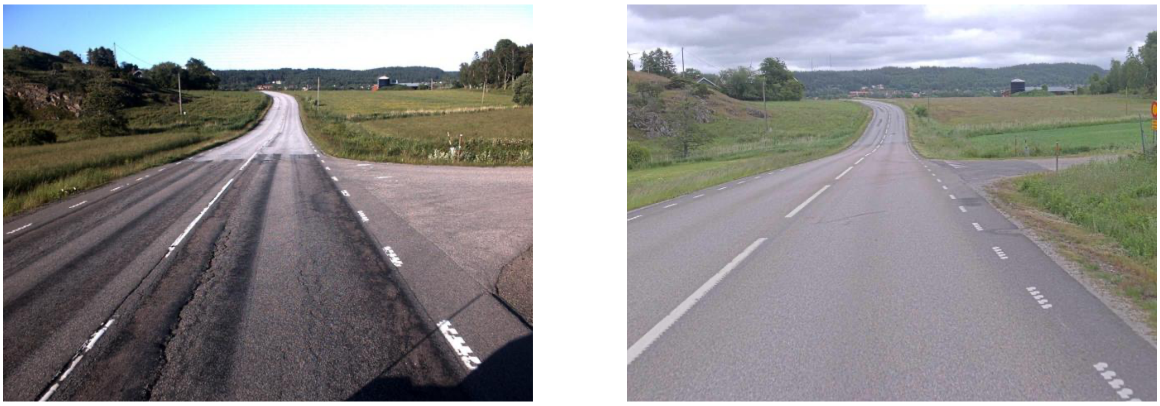
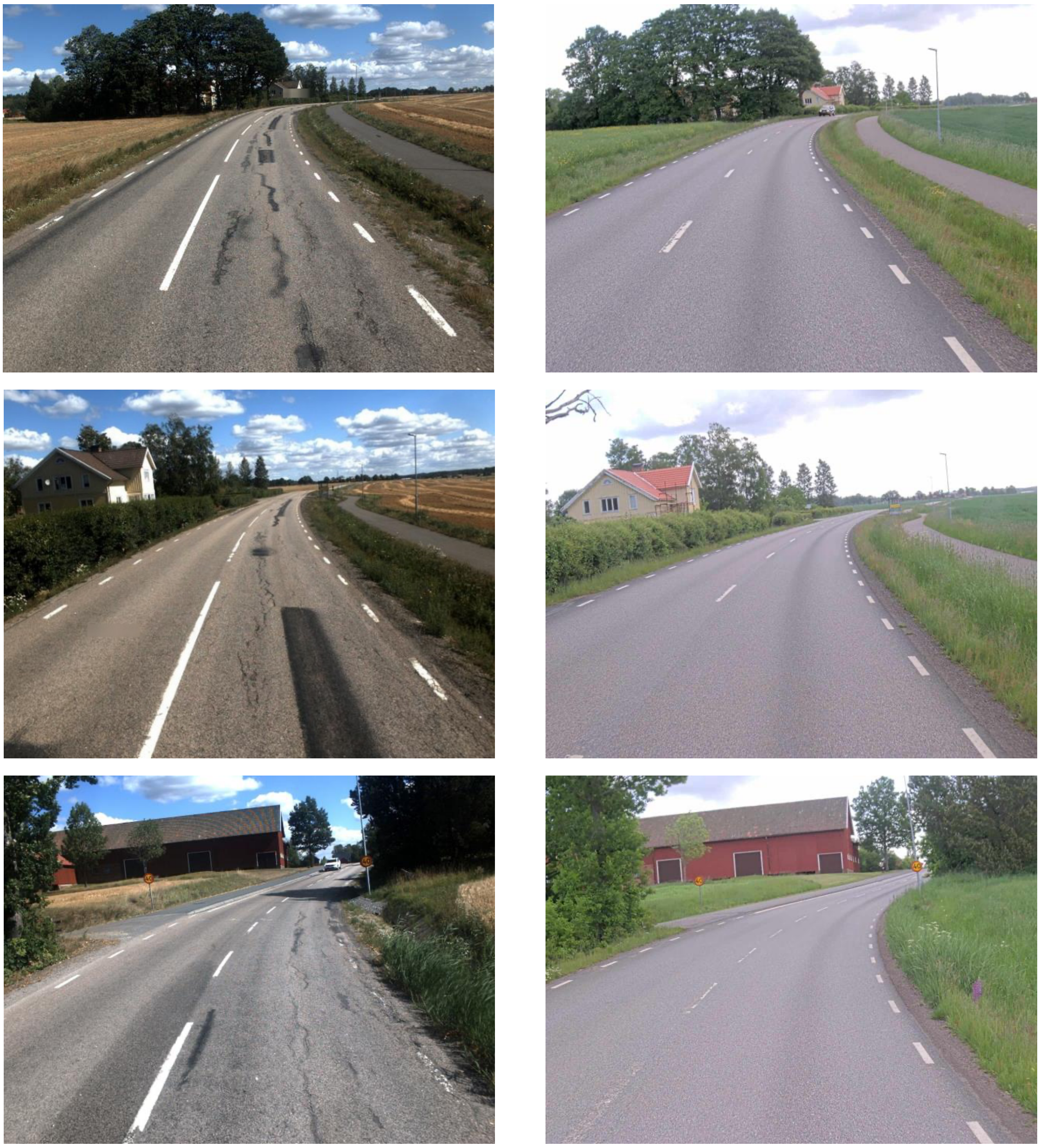


Figure 1. Photos from road 174 a) close to the bridge over the E6 and b) a little bit further down the slope. The left photos are taken in 2017 before the maintenance work and the right photos are taken in 2022, four years after the maintenance work. Photos: Trafikverket, PMSv4.

Another road that got fiber mesh reinforcement in 2018 is road 190, on a stretch of 2.6 km outside the village Stora Mellby. The old binder and surface layers were paved in 2004 and had severe cracks and large rut depth (mostly 10–20 mm) in 2018 before repaving. In 2018 a new 40 mm binder layer, fiber mesh reinforcement and a 40 mm dense graded surface layer were paved. From photos taken four years after the maintenance work, shown in Figure 2, no cracks are visible.



a)

b)

c)

Figure 2. Photos from road 190 in three different locations. The road is in poor condition with severe cracking, alligator cracking and large rut depths. Photos taken in 2018 before the maintenance work are shown in the left column and the most recent photos, taken in 2022, are shown to the right. Photos: Trafikverket, PMSv4.

Road 26 between Skövde and Mariestad is a fairly large 2+1 road with an AADT of ~3500 vehicles. Fiber mesh reinforcement has been applied in several maintenance works between 2019 and 2023. Looking at the oldest part, from 2019, and the northbound direction on the section with one driving lane, the rut depth growth has decreased after the fiber mesh was applied. Between 2015 and 2019 the rut depth increased on average 0.9 mm per year before the fiber mesh was applied. Comparing that to the years 2020–2023 after the fiber mesh, the rut depth growth was 0.3 mm on average. In the southbound direction the difference before and after fiber mesh reinforcement is lower, the corresponding figures on the section with a single driving lane is 0.74 mm before and 0.48 mm after the fiber mesh was applied.

Interviews were conducted with people in the business with experience of using fiber mesh reinforcement. The interviewees were not selected for any other reason than that they had all been involved in projects where fiber mesh reinforcement was applied. They were mainly project leaders at the NRA or contractors and the projects were either widening of existing roads or construction of roads on very poor subgrades. A common factor was that all interviewees were satisfied with the results overall. The importance of proper bonding was mentioned in multiple interviews. The fiber mesh needs to be attached properly to the underlying layer and the fiber mesh shouldn't be exposed to loading by working vehicles to avoid the mesh sticking to the tires and get folded. A risk commonly encountered at road construction is that everything needs to move fast, and problems could be neglected due to a tight time schedule. In the case of using fiber mesh reinforcement in pavements, a badly applied mesh could do more harm than good. However, all interviewees reported that they were satisfied with the results. They reported that they all regularly travel on these roads and that no major surface distresses have reoccurred even after several years.

Summary

Fiber mesh reinforcement is applied to mitigate distresses of various modes. Multiple laboratory tests repeatedly demonstrate how introducing fiber mesh reinforcement strengthens AC pavements, mainly by limiting tensile strains in the bottom of the AC layer and stops bottom-up cracking. Instrumented pavements also demonstrate lower strains in the bottom of AC layers as the tensile forces are focused into the fiber mesh. Yet, there is still no accepted design tool that includes the use of fiber mesh reinforcement as a strengthening component.

When looking at projects where fiber mesh reinforcement has been applied, it turns out that it is often some project staff with prior experience from fiber meshes who sees a possibility of avoiding recurrent distresses.

Since no tests from real roads were found for this study, indicative data were collected from multiple objects around Sweden. Photos before maintenance works have been compared to photos taken a number of years afterwards. Rut depth growth has also been compared before and after maintenance works where fiber mesh was installed. These comparisons indicate that the fiber mesh slows down the deterioration of the AC. However, it must be emphasized that these results are manual assessments and that no actual test data were found and compared from real traffic situations.

Conclusions

Fiber mesh reinforcement isn't allowed to be included as a strengthening component in the design work of AC pavements. This is due to the lack of reliable computational models that correctly can catch the behavior of the reinforcement. By the Ph.D. work of Julius Nielsen, a data model was presented that seems to correctly catch the viscoelastic behavior of AC with the presence of fiber mesh reinforcement. Further development of the model and further verification using various materials and load cases will certainly help the model to gain acceptance and open up possibilities to also include reinforcement into a future design tool.

To the author's knowledge there is no real test road where fiber mesh reinforcement has been installed in one subsection along a subsection without reinforcement as reference. Test roads are commonly used when new products or techniques are compared under the same conditions, e.g. evaluating the performance of cold reclaimed asphalt as base layer and comparing it to a conventional base layer (hot mix asphalt) (Lundberg, 2014 and Lundberg, 2016). With such a test road, long term behavior would be demonstrated for a reinforced road under realistic conditions regarding traffic loading, climate conditions, etc. A test road would also be directly comparable to the reference section, constructed next to the test section, and could lift any good (or bad) aspects of the evaluated property.

Most experiences about the performance of fiber mesh reinforcement inside AC pavements in Sweden are personal. Staff with experience from fiber mesh projects were interviewed for this pilot study and most comments were positive; however, these statements are based on feelings and beliefs. A test road would provide some hard facts and the influence of an installed fiber mesh could be followed over time.

References

Graziani, A., Pasquini, E., Ferrotti, G., Virgili, A., and Canestrari, F. (2014). Structural response of grid-reinforced bituminous pavements, Materials and Structures, vol. 47, pp. 1391–1408.

Lundberg, R. (2014). Energisnåla asfaltbeläggningar – kalltillverkad asfalt. Etapp 1. *SBUF report for project no. 12702.*

Lundberg, R. (2016). Energisnåla asfaltbeläggningar – kalltillverkad asfalt. Etapp 2. *SBUF report for project no. 12971.*

Nielsen, J., Levenberg, E. and Skar, A. (2022). Mechanistic modelling of grid-reinforced milled-and-overlaid asphalt pavements. *International Journal of Pavement Engineering*,

Nielsen, J. and Levenberg, E. (2023). Full-scale validation of a mechanistic model for asphalt grid reinforcement, *International Journal of Pavement Engineering*, vol 24 (1), DOI: 10.1080/10298436.2023.2220064

Nielsen, J., Olsen, K., Skar, A., and Levenberg, E (2021). Analytic analysis of a grid-reinforced asphalt concrete overlay. Proceeding of the *Eleventh International Conference on the Bearing Capacity of Roads, Railways and Airfields, 1st Edition, CRC Press.*

Romeo, E. and Montepara, A. (2012). Characterization of reinforced asphalt pavement cracking behavior using flexural analysis. *Procedia – Social and Behavioral Sciences*, vol 53, pp. 356–365.

Olsen, K. and Frost Kamphøvener, M. (2019). Asfaltarmeringshandboken. S&P Reinforcement Nordic 1st Edition, 2019.

Sohm, J., Kerzrého, J.-P., and Hornych, P. (2012). Full scale tests on Saint-Gobain's grid reinforced flexible pavements on the French fatigue carousel. IFSTTAR Report dated 2012-07-30.