Special materials in the road building – Grids and netts application terms for improving the pavement structures

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In the last few years asphalt grids and nets have been used in enormous amount in hungarian road construction, without any overall laboratory researches. In this article, we want to clarify conceptual confusions about grids and nets, define the repairing and –in some cases- damaging effect of grid usage. The biggest question in fortification of pavement, is the possibility of mixure of grid and net with the apshalt layer below. To observe these attributes we used the methode used at bridge lining: slide methode. Small and large wheel observations have been made to research track appearances in fortified construction. The lifetime of the construction have been observed by a fatigue methode: the standard four point bending methode.
The computer limited number modell have been used to prove fatigue results, and with the adequate material modell developement used at different type of ashpalts showed how gross aspalt can be replaced by the nets and grids usage.

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1. Foreword

Important changes happened lately in fortification of asphalt not only in Hungary but also in Europe. New materials and technology innovation has appeared searching for best practice in methods for avoiding errors in the asphalt pavement.

In the last decade, the era of build in net has commenced. In this period different type and quality of net had been built into all asphalt reconstructions all around the country without any technological experience and quality control considering the implementation.

Different distributors advertised that fortification nets are the solution for all asphalt pavement construction errors. Recently more and more errors have been registered at pavement with build in net and also new laboratory researches has been made to map all characteristics of build in nets.

The purpose of this script is to make a clear image about the pros and cons of net fortification in asphalt, and to make a proposal about the methods and environment where using net is possible and where the usage of net is forbidden.

For introduction Fig. 1. and Fig. 2. shows what kind of errors could happen if net is built in with non appropriate way, not the right placement and not the best type of net had been chosen.

Fig. 1. An extreme example: because of the net usage there is no cohesion between the layers
1. ábra Extrém példa a meghibásodásra: a háló beépítés megszüntette a rétegek közötti kohéziót

Fig. 2. Because of the build in tissue net, the abrasial layer slipped and a rut has appeared (route 21.)
2. ábra A szőtt háló beépítése miatt a kopóréteg elcsúszott, és keréknyomvályú jelent meg az úton

The inspections of this script have been made between 2003 and 2009. The sampling method has been researched in 2003. The usage of the different asphalt mixtures varied, but we intend to use the common used materials in the research.

In 2003 AB-12 and AB-12/F, in 2007 AB-11/F and mAB-11/F for bending AB-8 materials had been used. In 2008–2009 low quality materials had been used, for better modelling, so in this period AC-11 material has been used for the experiments.

For the experiments we used different tensile strength, fiberglass, and carbon fiber materials. Before the experiments, it is necessary to define the difference between net and grid. Fig. 3. shows a net with bearer material and Fig. 4. shows a grid without bearer material.

Henceforward the net is defined by a net with tissue bearer material and the grid is defined by a net without bearer material, usually coated with sticked plastic [1].

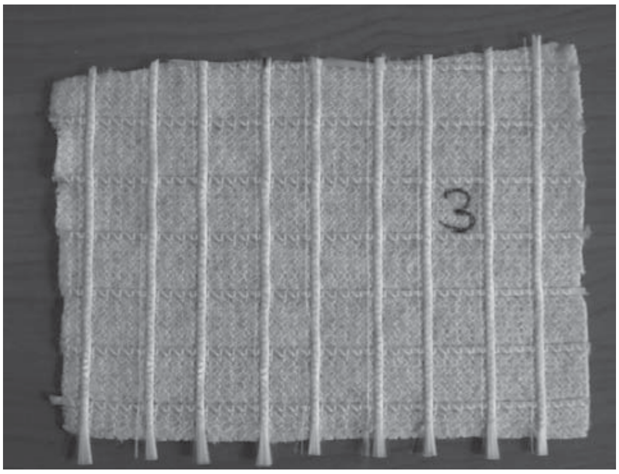

Fig. 3. Net with tissue bearer material (komposit material: net and tissue)
3. ábra Szövet hordozó anyagú háló (kompozit anyag: háló és szőtt szövet)

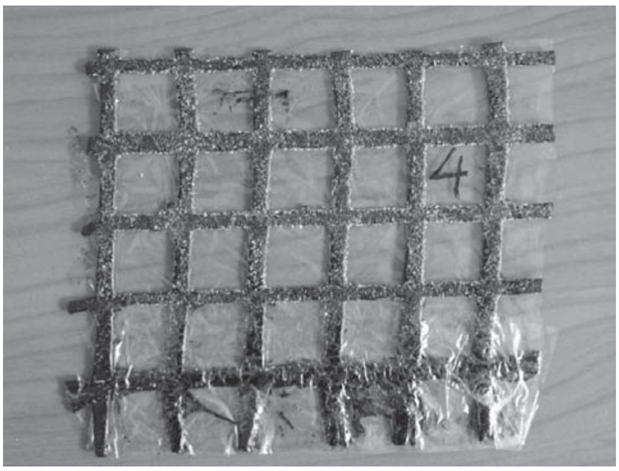

Fig. 4. Grid without bearer material
4. ábra Hordozóanyag nélküli rács

Beacause of the shortage of this script, the most important results of asphalt strengthening researches, the slipping and mixing extraction researches, the material fatigue revealing bending and the most important asphalt behavior problem the rut formation will be presented. At laboratory work we experimented low temperature behavior characteristics of break temperature, drag examination, triaxial examination, but the shortage of the script these methods will be presented in articles in the future.

In the script the fortification structure modelling will be presented.

2. Mixture experiment

The asphalt layers mixture, cohesion of two layers are the most important construction requirements. It is highly recommended to assure when a different material is built in between the asphalt layers. The mixture can be examined by three different methods: drag experiment, break experiment, and the Leutner method trimming experiment.

Below, the results of drag and experiments are presented.

Drag experiment

The drag experiment characterizes the connection between two layers, the quality of mixture and support with information about the effect of perpendicular cohesive duration to the layer.

Multiple drag experiments has been made recently, among these, laboratory experiments have been made with sample materials and also already constructed pavement structures in use had been tested.

During the experiments the sample materials without fortification had been above the 1,0 N/mm² level, but and the tissued nets did not reached this requirement, the grid usage however almost reached the level and always ranked better then the tissued sample materials.

The sample from M1 highway could not have been tested because the layers are separated which is caused by the bad mixture [2, 3].

Slipping experiment

The mixture and the non mixture is defined by the so called experiment the slipping experiment, which is used for bridge lining and pavement stickiness level measuring.

The scope of experiment is to define the maximum of trim power which appears between two layers at perpendicular usage.

This experiment is not like the well known layer limit trimming experiment; the difference is that in this technique the layer is under pressure. Usually bridge lining researches are made in base of this method [3, 4].

In 2004 we firstly finished experiments with tissue bearer net and grid fortified sample materials. The net sample material trim durability grades always stayed behind not only the reference sample material but also the grid fortified one.

Table 1. shows the results of 2008–2009 experiments.

Sample material	Trim durability (N/mm²)	Slip at max. force	Trim module measures (N/mm²)
End of year 2008			
„A"sign, without bearing material, fiberglass asphalt grid	0,92 N/mm²	18,2%	50,5 N/mm²
„B" sign, without bearing material, carbonfiber asphalt grid	0,87 N/mm²	15,0%	59,03 N/mm²
„C" sign tissue, fiberglass asphalt grid	0,60 N/mm²	31,3%	19,19 N/mm²
„D" sign tissue, carbonfiber asphlat net	0,52 N/mm²	40,6%	12,85 N/mm²
Without net – sample	0,88 N/mm²	18,4%	48,69 N/mm²
Beginning of year 2009			
Dense doublewire asphalt grid (GlasGrid 8501)	0,83 N/mm²	23,5%	36,31 N/mm²
Loose doublewire asphaltgrid (GlasGrid 8511)	1,21 N/mm²	24,9%	42,71 N/mm²
Irongrid	1,10 N/mm²	21,9%	41,16 N/mm²
No grid - reference	1,25 N/mm²	16,0%	55,69 N/mm²

Table 1. Slipping experiment from 2008–2009
1. táblázat A 2008–2009-es elcsúszás vizsgálat eredményei

At the end of 2008 and the beginning of 2009 we elaborated more slipping experiments. These results appear in Table 1. Based on the experiments of 2008 that all of tissue bearer material works as a dividing layer and has bad effects for mixture and for trimming resistance. The asphalt grids with non bearer material produced the same results as the sample materials without net.

3. Wheel tracking experiments

Rut appearance is the most important characteristics of asphalt pavements, which reflects the hot resistance level. The aim of fortifications with nets and grids is to reach a resistance for rut appearance and that the intensity of tracks. Recent years we made tests to prove these concepts, but the results reflected a wide variety of measures, but the sample materials with net showed better rut appearance characteristics, than the non net material results. The best results came from the grids without bearing material. Last year we experimented big and small wheel rut appearance tests in AC-11 asphalt mixture, tissued net, grids without bearing material, and ironnet. Table 2. shows the results of small wheel rut appearance test. The results of different type of net and grid are so close to each other, but the grids reach a better rut appearance results, comparing to the sample material the strength of nets is clearly visible.

Type of net	Net track (%)	Net track (%) average
tissued net	2,82	2,68
tissued net	2,54	
100/200 dense tissued grid	3,09	2,65
100/200 dense tissued grid	2,21	
100/200 dense tissued grid	2,11	2,22
100/200 dense tissued grid	2,33	
100/200 dense tissued grid	2,03	2,04
100/200 dense tissued grid	2,04	
100/100 loose tissued grid	2,32	2,16
100/100 loose tissued grid	2,00	
100/100 loose tissued grid	2,03	2,11
100/100 loose tissued grid	2,20	
100/100 loose tissued grid	2,86	2,55
100/100 loose tissued grid	2,25	
Without net – reference	4,03	4,25
Without net – reference	4,48	
Without net – reference	4,29	4,43
Without net – reference	4,57	

Table 2. Wheel tracking experiment results from March 2009.
2. táblázat A 2009. márciusi keréknyom-képződési vizsgálat eredményei

Because of the wide variety of the results and to reach better and reliable result for rut appearance we also made big wheel test respecting the MSZ 12697-22 standards. They were made in two periods, with different type of nets. At the end of 2008 the test has been made with a 6 cm AC-22 mixture with net, covered by 4 cm AC-11 wearing course layer, in March 2009 both layers have been made from AC-11 layer.

The 2008 and 2009 big wheel rut appearance tests were made with the following type of nets and grids. We also made the non-commonly used Bitufort iron grid test.

- S&P Glasphalt G fiberglasss asphalt grid (without bearer material)
- Gradex Alpha Mesh GR-G (tissue, fiberglass)
- GeoGrid Bitutex GMC 50/50 (two layer tissued)
- Bekaert Bitufort (irongrid)
- Sample without a net
- GlasGrid CG100 (25 mm x 25 mm grid) tissued net
- GlasGrid 8502 dense tissued (25 mm x 25 mm grid) asphaltgrid (without bearer material)
- GlasGrid 8511 loose tissued (12,5 mm x 12,5 mm grid) asphaltgrid (without bearer material)

The results of the 2008 tests are showed in Fig. 5. It is surprising that S&P grid without bearing material produced the worst results, which is possible because of a construction problem with one of the tests. The other nets produced a better result as the sample material. A Gradex Alpha Mesh GR-G tissued net reach a surprising good result, which is contrary to its small wheel test result.

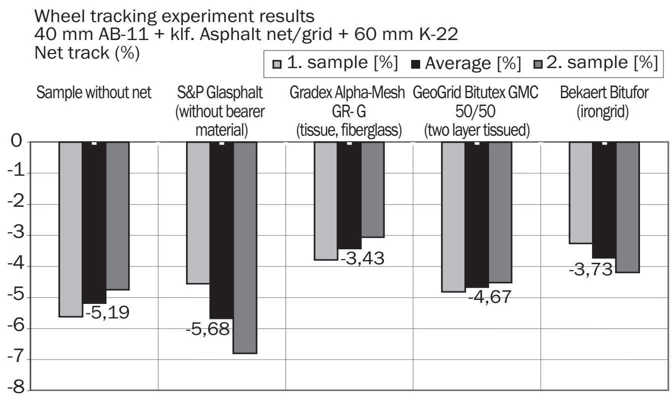

Fig. 5. The results of rut appearance tests in 2008
5. ábra A 2008-as keréknyom-képződési vizsgálatok eredményei

At Fig. 6. the result of 2009 are showed. This experiment reflected our assumptions that the tissued net could produce worse results than the asphalt without a bearing material. The small hole size GlasGrid 8502 and the big hole size GlassGrid 8511 asphalt grid difference is eligible. However doubt is also a result of this test, because – with little difference – the best result are given from the sample materials without any net.

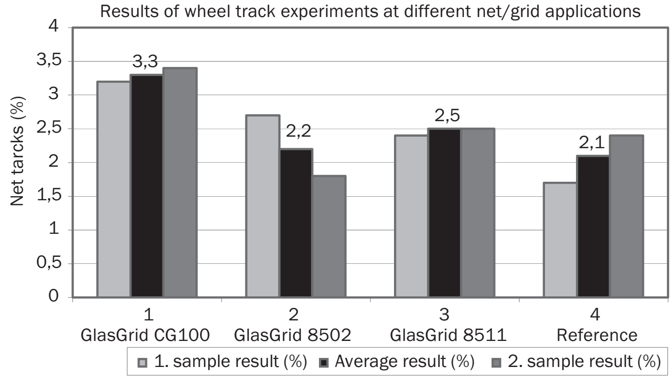

Fig. 6. The rut appearance test result of March 2009
6. ábra A 2009. márciusi keréknyom-képződési vizsgálatok eredményei

4. Fatigue life – 4-point bending beam test

To characterize nets, grids result, endurance test has to be made respecting MSZ EN 12697-24:2005 standards. This standard describe the properties of asphalt mixture fatigue, we have chosen the four point bending technique as testing method. The experiments are made with controlled strain driven mode or controlled stress mode in 10 °C, 10 hz frequency. Fatigue is defined by the decrease of durability of the material because of multiple endurance tests, compared to the first endurance test. The criterion of ruinment is defined by the (in case of constant shift) endurance test number $N_f/50$, in which the complex endurance rate fall to the half. For measuring the experiment, we observe de rate of complex endurance, which is the rate of 100 endurance test repeat.

In the last five years large number of bending beam tests have been made, but these test are incomparable with each other, because they are made in different years and with different asphalt mixture materials. (The sample material of the year 2007 was AB-8 type asphalt, in 2004 AB-12, but in this year was also incomparable because of the different asphalt mixture.) Table 3. shows the difference of net and without net sample material results, and show the current tendencies.

The results show clearly that the tests made without net produced less stress and strain, and the fatigue lines reflect that net fortified materials durability and lifetime is raised.

The result of the May 2004 test shows that tissued nets raise the results with only a few percent, but in other cases a serious 15% results appear. It is clearly visible that the nets without bearing materials are the most resistance to stress and strain. (The 2007 pavement sticking grid worse results are caused by non appropriate construction technology.) [1, 2]

5. Finite element modelling

The associates of Department of Structural Engineering and the Department of Highway and Railway Engineering have made an experiment parametric to the asphalt pavement limited modelling. The task was to define the effect of different rigidity nets to asphalt stretching. For all layer construction and net pairing we wanted to reach equivalent asphalt thickness where we can reach the without net low asphalt layer stretching, and we wanted the observe if the usage of net or the grid is able to reach thinner asphalt layer thickness.

The experiment aimed to define of strain and the asphalt fortification net usage equivalent thickness definitions are showed different layering pavement structure. The most complex pavement is shown in Fig. 7.

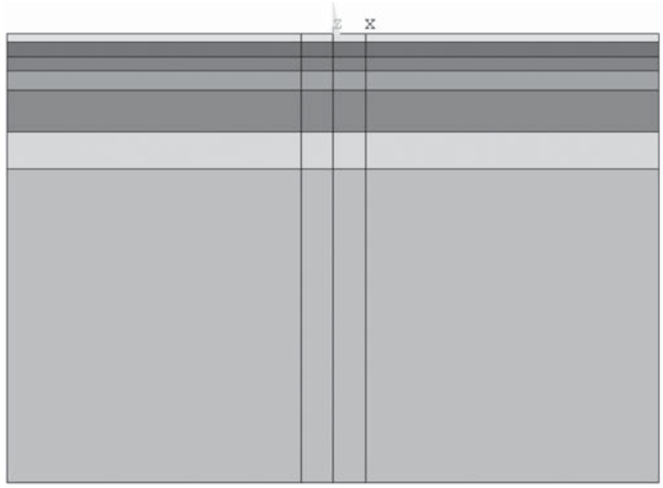

Fig. 7. Geometry of modell 1
7. ábra Az 1-es modell geometriája

Type of net	Result: strain or stress	Difference of without net results	Date of experiment
without net	142,00 µstrain	-	May, 2007
“3” Gradex tissued, fiberglass net	167,00 µstrain	17,6%	May, 2007
“4” S&Pfierglass grid, bitumen-emulzióval sticked	150,00 µstrain	5,6%	May, 2007
“4” S&P fiberglass grid, hőlég-fúvóval sticks	170,00 µstrain	19,7%	May, 2007
without net	1,29 N/mm²	-	May, 2004
Roadtex GR-G50	1,31 N/mm²	1,5%	May, 2004
Roadtex GR-G100	1,35 N/mm²	4,6%	May, 2004
Roadtex GR-G200	1,46 N/mm²	13,1%	May, 2004
S&P Glasphalt G	1,55 N/mm²	20,1%	May, 2004
S&P Carbophalt G	1,56 N/mm²	20,9%	May, 2004
without net	1,36 N/mm²	-	May, 2004
ARTER GTSA (without bearer material)	1,96 N/mm²	44,1%	December, 2004
ARTER GTSV (tissued)	1,68 N/mm²	23,5%	December, 2004
Without net	1,34 N/mm²	-	March, 2008
“7” Carbophalt G type grid, without bearer material	1,56 N/mm²	16,4%	March, 2008
“2” Gradex tissued carbon net	1,28 N/mm²	-4,4%	March, 2008

Table 3. Summarized table of bending experiments [1, 2]
3. táblázat A hajlítás vizsgálatok összefoglaló táblázata

In this modell the upper four layers is asphalt, the next is sub-base, and the lowest is subgrade. The asphalt and the base layers thickness is changing during the tests, but the subgrade thickness is 3000 mm in all tests.

The limited component modell is the 2 dimensional segment of a sectormodell. Between the different material layers we can find contact lines where the limited component slipping and derivation is allowed and the layers mix in case of pressure. Total slipping is supposed between the contact lines.

In case of the asphalt fortification net equivalent thickness definition a net is placed below the lowest asphalt layer which has a 0,5 mm thickness. Ansys common limited component modelling software was used for asphalt pavement modelling.

All the two modell structure was based on the same limited component types. The pavement components (asphalt, pavement bases, subgrade) modelling was made with Ansys PLANE 42 plane strain state face, which has 4 junction, and the entire junction has 2 free levels.

We defined for the modelling the 3x12 type different asphalt pavement characteristics (thickness, rigidity, poisson component) with 3 different rigidity modul in the same temperature, and 12 different layer structure.

Utilizing net in modelling results in most cases only a few millimeter asphalt decrease, more than a centimeter is allowed with 10–2000 MPa stiffness nets and 30–50 °C pavement structure was reached. The question is that if 0,5 mm thickness covered net is capable of getting 10000 or 20000 MPa stiffness module.

6. Resume

Between the tissue bearing material nets and the asphalt layers there are no mixture, this type of built in net works as a separator. At the non tissue bearer grid case the mixture is lower than the non-net asphalt structures.

The tissue bearing material nets are not able to produce the requested 1,0 N/mm^2 trimming durability, so between the layers slipping is highly possible, there is no mixture. Opposite the last mixture proven experiments, the asphalt grids without bearing material are reach the same measures as the non-net sample materials, and these results are reach the acceptance trimming durability levels. This is possible because opposite to the rip up experiment, in this case the asphalt layers are under perpendicular pressure.

The small wheel track experiment showed that the build in bearer materials are fortify the asphalt grid to resist rut appearance. Asphalt grids without bearing material showed better results for rut appearance resistance than the tissue bearing fiberglasses. Because of the tissue bearing net results differences, their usage is only advised in lower layers. Because of the big wheel experiment result contradictions, these tests should be remade with different type of asphalts.

With build in net asphalt pavement, the resistance is better for strain and stress than the non net types, so tissue fortified asphalts durability is better. Grid without bearing material, asphalt grids has the best resistance for strain and stress, and these materials strengthen the durability of asphalt pavement.

The limited component modelling shows that grids can be considered as replacer if ther stiffness is bigger than 10 000 MPa. The modelling showed that fortifying effects came in above 30–50 °C, which shows that net should reach a better heat resistance for asphalt pavement.

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Speciális anyagok az útépítésben – aszfalterősítő hálók és rácsok alkalmazása az útszerkezet javítása érdekében

Az elmúlt évtizedben hatalmas mennyiségben kerültek beépítésre aszfalterősítő hálók és rácsok a magyarországi közutakon, anélkül, hogy átfogó laboratóriumi vizsgálatok álltak volna rendelkezésre a témában. A cikkben a hálókról és a rácsokról kialakult fogalmi zavarokat tisztázzuk, meghatározzuk, hogy milyen javító és esetlegesen milyen károsító szerepe lehet a hálóbeépítésnek. Az aszfalterősítésnél az egyik legfontosabb kérdés, az, hogy a beépített háló vagy rács képes-e együtt dolgozni az alatta, illetve felette lévő aszfaltréteggel. Ezt a hídszigeteléshez alkalmazott elcsúszás vizsgálattal bizonyítottuk. Kiskerekes és nagykerekes berendezésen egyaránt vizsgáltuk az erősített szerkezet keréknyom képződési tulajdonságait. Az élettartam növekedés nagyságát fárasztási vizsgálattal, a hagyományos négypontos hajlító vizsgálattal mutattuk ki.
A számítógépes végeselem modellel a fárasztási eredményeket kívántuk visszaigazolni, valamint megfelelő anyagmodell felállításával bemutattuk, hogy a különböző aszfalttípusoknál a különböző hálók/rácsok szerepe hány cm aszfaltvastagságot képes helyettesíteni.