APPLICATION OF COLD REMIX TECHNOLOGY IN THE HUNGARIAN ROAD BUILDING

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Summary

In Hungary the existing main road network have asphalt pavement, but dense bitumen macadam pavements made with cut-back bitumen can be found in large quantities on the secondary road network. These macadam pavements are mostly covered with one layer asphalt or surface dressing. The dense bitumen macadam pavements are characterized with postcompaction which are taken place by the compaction effect of the traffic and this is existing during the whole life-time of the road. Because of the postcompaction the profil of the macadam pavements are uneven, they are from aspects of riding quality and bearing capacity inadequate.
There are not constructing nowadays in the Hungarian network, but the rehabilitation of these structures are troublesome.

For the rehabilitation of these pavements three different in place recycling methodes can be applied in Hungary

- recycling asphalt with binder spraying
- remix technology with mixed recycling asphalt
- deep remix technology in place

In case of each method the bituminous binder is bitumenemulsion or foamed bitumen. The first two technologies are used for the rehabilitation of low trafficed roads the third technology is applied to low and heavy trafficed roads as well.

The report summerizes generally the three possible variations of technology, gives concrete examples for the applications, makes a comparison between the economical aspects of the methodes, mentions the Hungarian enviromental operativ regulations and logistical situations for milled/recycled asphalt.

1. Introduction

The length of the pavement types on the Hungarian road network are given in the Table 1 (1).

Table 1.
Length of the pavement-types on the road network in Hungary

Type of pavement	Length of main roads (km)	Length of secondary roads (km)
Asphalt concrete	6846	8021
Macadam	78	14867
Others	60	68

It can be seen that the structures of the secondary roadnet are mainly bitumen macadam pavements coated by surface dressing or an asphalt layer. The dense bitumen macadam pavements are characterized with postcompaction which are taken place by the compaction effect of the traffic and this is existing during the whole life-time of the road. The postcompaction results the uneveness of the surface and therefore it has inadequate riding comfort and besides bearing capacity problems can also happen. The Table 2. (1) shows the % rate of uneveness of the secundery network.

Table 2.

Condition of the surface eveness on secundary network

Condition of surface eveness	% rate of surface eveness
Good	14,0
Adequate	16,9
Bearable	15,7
Insufficient	18,2
Bad	34,2
Not mesured	1,0

The data were determined from the values obtained by IRI ((International Roughness Index) measurements of the RST equipment. It can be seen that the eveness of secondary roadnet gets mainly the „bad” qualification.

The % rate of the 2000 years costs for „big surface” rehabilitation in Hungary is given in Table 3. (1).

Table 3.

Costs of „big surface” rehabilitation (in year 2000)

Type of rehabilitation techniques	Costs, %
Surface dressing	24,5
Profiling	46,6
Construction of base course	1,4
Thin asphalt layer	1,6
Strengthening of pavement	25,9

It can be seen that the rate of financing is the highest for profilizing on the network. The profilizing means generally the frasing of the surface and the applying of 4 cm hot asphalt layer. These type of profilizing has a short duration. The uneveness and deterioration begins in 3-5 years after rehabilitation. Therefore cold recycling techniques were experimented in 1999 on the Hungarian network.

2. Applied techniques

- **recycling asphalt with binder spraying**: milled/demolished asphalt spreading, bitumenemulsion spraying, 2/5 mm chipping spreading, rolling the layer

- **remix technology with mixed recycling asphalt**: milled/demolished asphalt spreading, bitumenemulsion spraying, in place milling and mixing 6 cm deep part of the existing layer with the spreaded asphalt, laying the new mixture, rolling the layer

- **deep remix technologies in situ** (2)**:**
    - reparation adding water and bitumenemulsion
    - reparation with cement
    - reparation adding cement slurry
    - reparation adding cement slurry and bitumenemulsion

- reparation with foamed bitumen
- reparation adding cement and foamed bitumen

A recycler used for the above techniques is suitable for the scarifying of existing layer, for mixing of the components, adding of the bitumenemulsion or foamed bitumen and/or cemet slurry and water by its microprocessor operated pumps.
The recycler scarifies the existing pavement in the determined thickness, gives the bitumen and/or cement binder to the loose material and mixing it produces a homogeneous mixture. The laid mixture is profilized by grader and compacted by rollers.
The thickness of the scarified part of the existing pavement will be determined from the composition of the pavement and from its condition. The amount of needed crushed stone for the reparation of grain size distribution should be determined before scrarifying the layer. If crushed stone is needed the scarifying and mixing contains the added crushed stone too.
The cement slurry is produced in a separate slurry tank and is forwarded to the pumps of the recycler. The foamed bitumen is produced by the recycler.
Before construction the technique should have a careful preliminary laboratory preparation. The aim of the preliminary laboratory tests are the determination of the thickness of the milling, the needed amount and grading of the crushed stone, the amount of binders (bitumenemulsion, foamed bitumen, cement slurry, cement) and water (according to Proctor test) based on the traffic load, the structure, bearing capacity and composition of the existing pavement.
For the construction of the different thicknesses and widenesses different types of recyclers can bee obtained (2). These are given in the Table 4.

Table 4.

Recyclers

Type	Width (mm)	Deep of mixing (mm)
Recycler 2500	2500	500
Recycler 1000	1000	180
Recycler 2100	2100	300
Recycler 4500	4500	300

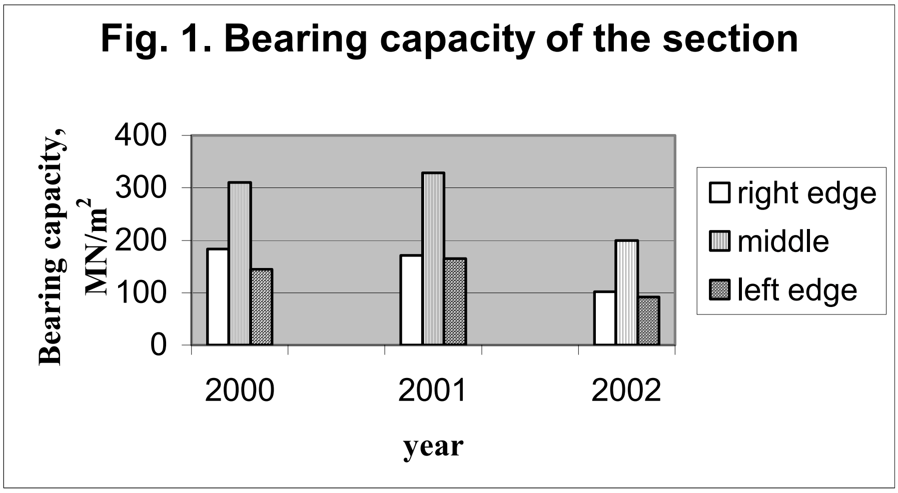
Layers produced by deep remix technologies are functioning as base courses and the wearing course according to the traffic loading can bee surface dressing or asphalt layer(s).

3. Study cases

3.1. Remix technology with mixed recycling asphalt

The experimental section was constructed in 1999 (3). The section is 1, 6 km long, the traffic loading is AADT = 520 PCU/day, heavy traffic = 147 V/day.
The existing layer was originally 3,5 – 4, 0 m wide. Before the cold remix procedure the pavement was widened on both sides altogether to 6 m. The existing structure was 7-10 cm coated macadam and 15 cm crushed stone base. The widening was produced of 20 cm lime crushed stone. On the widened surface a finisher laid 6 cm thick 0/25 mm grain size old asphalt granulate and the recycler mixed it thogether with 6 cm thick milled layer of the existing pavement. After precompaction of the layer by rubber roller it was stabilized with special kationactiv bitumemulsion. The binder was spreaded in 2x2 l/m^2 amount on the surface of the cold remix layer and 10 kg/m^2 UKZ 2/5 crushed stone was layed on top of it and it was compacted. The binder was a special – patented – bitumenemulsion wich is suitable for the rejuvenation of the aged asphalt layer.

Our Institute is surveying the section since 2000. Plate bearing capacity and texture depth were measured yearly (4). The change of bearing capacity is given in Figure 1. The results of texture depth measurements are given in Table 5.



From the results can bee seen, that the widened parts provide weaker bearing capacity results than the middle part having macadam base. The bearing capacity of the section decreased in 2002 but it is still higher than the prescribed E_2 = 80 MN/m^2 value.

Tabl 5.

Texture depth data of surface

Year of mesurement	Texture depth (mm)	
	Right side	Left side
2000	0,39	0,43
2001	0,45	0,38
2002	0,44	0,53

The texture depth is slightly increased because of the insignificant (minimal) deterioration of the surface. The texture depth is equal to the surface mean texture depth of an AB-20 type asphalt concrete where the required value is MTD = 0,50 mm.

3.2. Deep remix technology with foamed bitumen and cement

The 4,9 m long experimental section was also constructed in 1999. The traffic loading of the section is AADT = 2842 PCU/day, heavy traffic = 427 V/day.

The perliminary tests were carried out on core samples (5). The structure and thickness of the existing layer and the composition of the layers were determined. The mixdesign was based on Proctor tests and on the criteria of unconfined compressive strength after 7 days on 5 ^{o}C must be min. 1,5 MN/m^2. According to tests reults the optimal mix contained 85 % existing material, 15 % 0/20 mm crushed dolomite, 3 % cement (CEM 32,5 type), 3 % foamed bitumen. The water content (w_{opt}) was 6 %. The foamed bitumen was produced on 170-180 ^{o}C of B 70/90 bitumen type. The needed water for foaming was 2 % based on bitumen.

The procedure was the laying of cement and crushed dolomite on the existing surface. The 17 cm thick part of the existing pavement was milled by the recycler (Recycler 2500) and after adding the water and foamed bitumen the materials were mixed. Determining the deep of milling the thickness of the spreaded crushed stone and cement must be taken in to consideration. This was appr. 4,5 cm. As the water content of the milled material can change the needed amount of water should be determined by continous moisture contant measurements. The treated materal was layed by the equipment and precompacted by rubber roller. The required surface was shaped by grader and compacted by vibrating rollers.

The quality requirements and the data of the quality controll carried out during construction are given in Table 6.

Table 6.

Qulity reqiurements and test results

Parameter	Frequency	Pescriptions	Test results
Unconfined compressive strength (after 7days)	every 2000 m^2	1,5-3,5 MN/m^2	1,52-2,37
Compaction rate	1000 m/cuts	97 % (min. 95 %)	97,1-101,0
Thickness	1000 m/cuts	prescribed value –15 %	18,1-23,1
Bearing capacity (light falling weight deflectometer)	200m/ cuts	min. 120 MN/m^2	102-187

In the top of deep remix course was the wearing course 6 cm AB-16/F asphalt concrete type.

In a certain part of the section rutting was developed in 2000 year. The reason of it was tested by our Institute (6). To determine the origin of failure core samples were taken of the faulty and proper sections and on the samples of the AB-16/F wearing course layer dynamic creeping tests, on the deep remix layers wheel tracking test were carried out. Besides the laboratory tests deflection test were carried out on the rutted sites and proper sites by KUAB deflectometer. The results of the rutting tests are given in Figure 2. and Figure 3., the results of deflection measurements are given in Table 7.

Fig. 2. Dynamic creep test

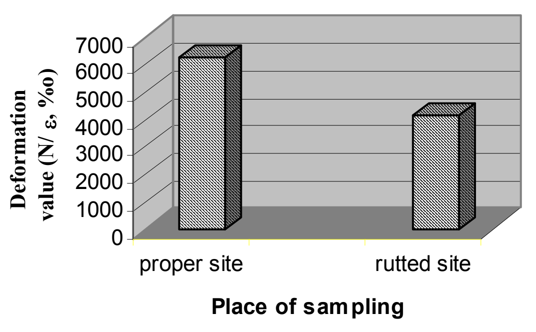


Fig. 3. Wheel tracking test

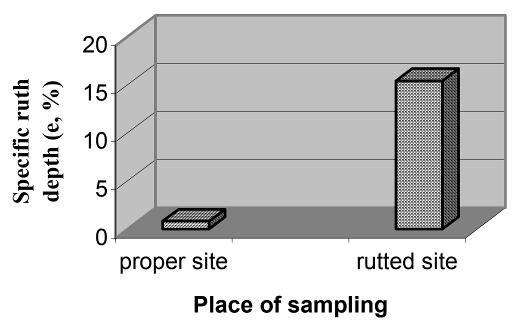


Table 7.

Deflection data

Place of measuremet	Deflection (mm)	
	Outer wheel track	Inner wheel track
Correct site	0,34	0,28
Faulty site	0,67	0,60

The conclusion coming from test results was that the development of rutting was caused by the considerable deformation susceptibility of deep remixed layer. The reason of the deformation susceptibility was the altering of the cement-bitumen rate for the amount of bitumen. The grading and the bitumen content could not be determined of the mixture because of the cement binder therefore only the inspection of the cores proofed that there was a locally plus addition of bitumen and the mixing was insufficient. The cause of the decreased deflection was altering of the character of the deep remixed layer. The originally semirigid layer in the faulty site changed to flexible one having lesser bearing capacity and could not bear traffic loading without damaging.

4. Conclusions

- The behaviour of the experimental sections since the constructions time, wich is three years was generally favourable.

- Desining the rehabilitations works it is very important the sufficient dewatering of the existing pavement structures and the equal bearing capacity. The sites having weak bearing capacity should be repaired before constructions

- It is very important if using cement-bitumen deep remix techniques the keeping of the determined cement-bitumen rate. Altering of the rate will result either a rigid, susceptible for cracking mixture or developing of site having weak bearing capacity.

- Because of different bearing capacity the techniques using bitumenemulsion can be applied on light trafficed roads and the cement-bitumenemulsion/foamed bitumen techniques are suitable for light and heavy trafficed roads as well.

- The utilization of milled/demolished asphalt materials for cold recycling techniques is favourable in Hungary because of the milled/demolished asphalt is qualified as „dangerous waste product" and therefore its deposition is strictly regulated. The technical prescription for hot asphalt mix productions makes possible the utilization of milled/demolished asphalt but practically because of investment reasons the hot plant recycling is not operating.

- From costs aspects the techniques using bitumenemulsion are appr. 30 % more expensive, the cement-foamed bitumen techniqeus are appr. 80 % more expensive than the conventional rehabilitation of big surfaces (preshaping and laying of 4 cm hot asphalt mixture). Because of the cost aspects the cold recycling techniques are still experimental state in Hungary.

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