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# EXPERIENCE OF USING OF COLD EMULSION MIX IN THE REPUBLIC OF LATVIA

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**Abstract.** Technology of preparing and laying the cold emulsion mix in accordance with the General Technical Construction Specification for Road ROAD 94 of the Swedish National Road Administration had not been implemented in Latvia until 2000. Thus the relevant experience is rather limited: six road reconstruction projects have been implemented by using this technology since 2000. The author gives an introduction to the substantiation for selecting the emulsion asphalts in road reconstruction projects, the requirements set for such mixtures, as well as makes an analysis of a particular mixture and the problems related to the mixture usage and formation of defects.
The article provides recommendations for the necessity to start research in order to find a scientifically justified and practical usage of the cold paving technologies by taking into account the peculiarities of the Latvian natural resources and climate.

**Keywords:** cold emulsion mix (AEB).

## 1. Introduction

Since 2000, the Latvian road sector has been trying to adapt the provisions of the General Technical Construction Specification for Road (ROAD 94) of the Swedish National Road Administration, for using the cold emulsion mix (henceforth – AEB), which shall be laid into the road pavement construction course – wearing course, in the Republic of Latvia [1]. In such cases, an additional structural layer shall represent an insulating/wear resistant layer – single-layer surface treatment with a mineral aggregate of 11–16 mm, marked by the standard type Y1B 11–16 in ROAD 94 document.

Cold emulsion mix (AEB) consists of a mineral aggregate with continuous grading and low filler content, and relatively low residual content of bitumen or soft bitumen. Its standard types: AEB 8, AEB 11, AEB 16. It is used on roads carrying little traffic, where the demand on flexibility is great, such as where movements in the substrate can be expected.

According to the general characterisation of cold emulsion mix in normative documents of the Latvian road sector on carrying out the state road construction works and product quality "Road Specifications 2005", one could affirm that the said type of bituminous pavement, which is not resistant to deformation, is envisaged for roads with a low reduced traffic volume: 500–1500 cars/24 h [1, 2]. Its grading curve of mineral aggregate is continuous and characterised by a small amount of filler, as well as relatively low content of residual bitumen or soft bitumen. All those facts indicate that the said type of pavement could become widely useable in reconstruction of the inland road network of Latvia.

The specific selection for construction of bituminous pavement has been determined by the valid design rules and guidelines on design of bituminous pavement determining selection of a base top-base, a binder course and a wearing course of a particular road pavement [1].

Results of road reconstruction works in 2000–2005 have shown the advantages and disadvantages of the emulsion asphalt technology. As the main advantage, the usage of this type of pavement (AEB) is used on roads carrying little traffic, where the demand on flexibility is great, such as where movements in the substrate can be expected. Since the accession of the Republic of Latvia to the European Union (EU), traffic volume has increased rapidly and considerable change of road traffic proportion can also be observed. Thus the main disadvantage of this type of pavement (AEB) – the limited stability – is revealed more clearly.

Unquestionable are the potential possibilities of the cold mix technologies for reconditioning the 1st and the 2nd

class state roads of Latvia, municipal roads, company and private roads, all with comparatively smaller investments.

The goal of the present article is to analyse the experience of usage of cold technologies in Latvia and to outline the main problems in usage thereof.

## 2. Substantiation of the selection of the cold paving technology in road reconstruction projects

The following main conditions determining the selection of this type of pavement structure in road reconstruction projects during 2000–2005 should be referred:

- expected traffic volume and composition have not required the usage of hot asphalt concrete;
- soft and emulsion asphalts have a good bent to deformations, good self-restoration ability and long serviceability on weak foundation;
- cold mixing, spreading and packing technology process which by taking into account a low power-intensity could ensure an economical effect.
- experience of the Latvian road sector in the usage of cold mixes in construction of "black" road pavement till 1991.

ROAD 94 provides AEB characterisation and general recommendations for selecting and using the types of bituminous pavements. Advantages of AEB:

- a good bent to deformation,
- a very good self-restoration ability,
- good ageing properties (long-term retaining of flexibility due to soft bitumen),
- repeated usage,
- cold technology can be considered an advantage in terms of environmental protection,
- easy manual laying,
- low energy-intensity.

As the main disadvantages of cold emulsion mix (AEB), the following should be mentioned:

- limited stability,
- reduced wear resistance,
- risk of formation of water coat on pavement surface, especially on new pavements,
- lower light reflection qualities,
- contains heavy oils which is negative in terms of environmental protection,
- can be with a limited frost resistance,
- can be sensitive to water impact.

## 3. Analysis of problems of emulsion asphalt layer construction, in road reconstruction project of 2004–2005

Requirements set for cold asphalt pavement construction in "Road Specifications 2001" are made according to the provisions of ROAD 94 on the basis of standard type AEB-16 of cold emulsion mix and given in Tables 1–4 [2, 3].

The seasons of 2000–2005 have clearly demonstrated the range of problems, the solving of which will determine the future usage of this cold technology. By taking into account the results and problems in the above-mentioned seasons, by constructing top layers of pavement made of cold mix emulsion and by elaborating "Road Specifications

**Table 1.** Mineral aggregate (Test preparation shall be performed in accordance with FAS Method 207)

| Parameter | Traffic AADT l, adjust (thousands) < 0,5 | Traffic AADT l, adjust (thousands) 0,5–1,5 |
|---|---|---|
| Flakiness index (fractions large than 5,6 mm, in accordance with FAS Method 209) | ≤ 1,50 | ≤ 1,45 |
| Percent completely uncrushed gravel (fractions larger than 4,0 mm, in accordance with FAS Method 243) | ≤ 30 | ≤ 30 |
| Ball-mill value (shall be determined using the 11,2–16,0 mm fraction, in accordance with FAS Method 259) | ≤ 30 | ≤ 18 |
| Aggregate abrasion value (shall be determined on the 9,5–11,2 mm fraction, in accordance with FAS Method 231) | – | ≤ 3,2 |
| Impact value (shall be determined on the 8–11,2 mm fraction, in accordance with FAS Method 210) | ≤ 60 | ≤ 60 |

**Table 2.** Binder

| Viscosity $mm^2/s$ | Residual bitumen % by mass | Calculation value % by mass |
|---|---|---|
| 10 000 | 4,3–4,9 | 4,6 |
| 15 000 | 4,5–5,2 | 4,8 |
| 20 000 | 4,8–5,4 | 5,1 |

**Table 3.** Layer thickness

| Approximately (mm) | |
|---|---|
| Min 32 | Max 46 |

**Table 4.** Requirements for mix size-grading content

| Sieve, mm | 0,063 | 0,125 | 0,25 | 0,5 | 1 | 2 | 4 | 5,6 | 8 | 11,2 | 16 | 22,4 | 31,5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Max % | 7 | 11 | 19 | 28 | 36 | 46 | 58 | 64 | 74 | 88 | 100 | 100 | 100 |
| Min % | 4 | 5 | 9 | 13 | 18 | 26 | 39 | 46 | 57 | 70 | 85 | 98 | 100 |

2005" approved by the Road Traffic Department of the Ministry of Traffic on 14 July 2005, stating the requirements of road construction works and product quality and provides expanding possibilities for usage of local construction materials, the following was accomplished – was dealing with the following bituminous pavement types of ROAD 94 with the cold technology [2]:

- soft asphalt (mix of mineral materials and soft bitumen – SA),
- emulsion asphalt (mix of mineral materials and bitumen emulsion – EA).

This distribution (binder: soft bitumen; bitumen emulsion; mix preparation and spreading temperature: warm (up to +120 °C), cold (below +50 °C)) do not reduce and do not eliminate the impact of the factors and conditions on quality of the final product that have been experienced by the road sector until now. These problems need a complex solution both by analysing local mineral materials, climate peculiarities, and by preventing any negligence during construction planning when making pavement calculations during feasibility and design phases.

Further in this article, reconstruction works on some roads during 2004–2005 will be discussed. The reconstruction works have been performed according to the scope envisaged in the construction plan; simple pavement treatment has not been made. The reconstruction plan envisaged construction of cold mix emulsion AEB-16 of layer thickness 4 cm in the top layer of the structural element. Work formulas No 1, 2 of cold emulsion mix AEB-16 are presented in Tables 5–9 and on Fig 1.

During the season of 2005 and at air temperature +25 °C, temperature of surface of cold emulsion mix AEB-16 reached even +49 °C resulting in 18 mm deep

**Table 5.** Work formulas No 1, 2

| Title, type, producer or supplier of raw material | Fraction (mm) | Quantity (mass %) | |
|---|---|---|---|
| | | Work formula No 1 | Work formula No 2 |
| Crushed dolomite of Lithuanian origin | 11/16 | 23,0 | 28,0 |
| Crushed dolomite of Lithuanian origin | 5/11 | 23,5 | 17,5 |
| Crushed dolomite of Lithuanian origin | 2/5 | – | 15,0 |
| Sieved (natural) sand | 0/5 | 51,7 | 34,7 |
| Limestone flour of Broceni origin | | – | 3,0 |
| Cement CEM II/B-T32,5R | | 1,8 | 1,8 |
| Emulsion BE 60M/5000 | | 8,0 | 8,0 |

**Table 6.** Mineral aggregate

| Sieves, mm | Sieve passing material amount, mass % | | Inspection Allowable deviation from job mix formulas. Gradation, in percentage by mass, mean values for an object (Plant/Road) |
|---|---|---|---|
| | Work formula No 1 | Work formula No 2 | |
| 16 | 98,99 | 98,99 | |
| 11,2 | 77,41 | 73,18 | +/– (8,4/9,4) |
| 8 | 68,01 | 62,42 | |
| 5,6 | 55,04 | 55,43 | |
| 4 | 50,67 | 44,11 | +/– (6,4/7,4) |
| 2 | 41,36 | 36,02 | +/– (5,4/6,4) |
| 1 | 30,38 | 31,39 | |
| 0,5 | 18,03 | 21,90 | |
| 0,25 | 10,22 | 10,46 | |
| 0,125 | 6,49 | 6,64 | |
| 0,063 | 4,59 | 5,36 | +/– (2,0/2,5) |

**Table 7.** Binder

| Inspection. Allowable deviation from job mix formula, % by mass, mean value for object | |
|---|---|
| Plant | 0,49 |
| Road | 0,61 |

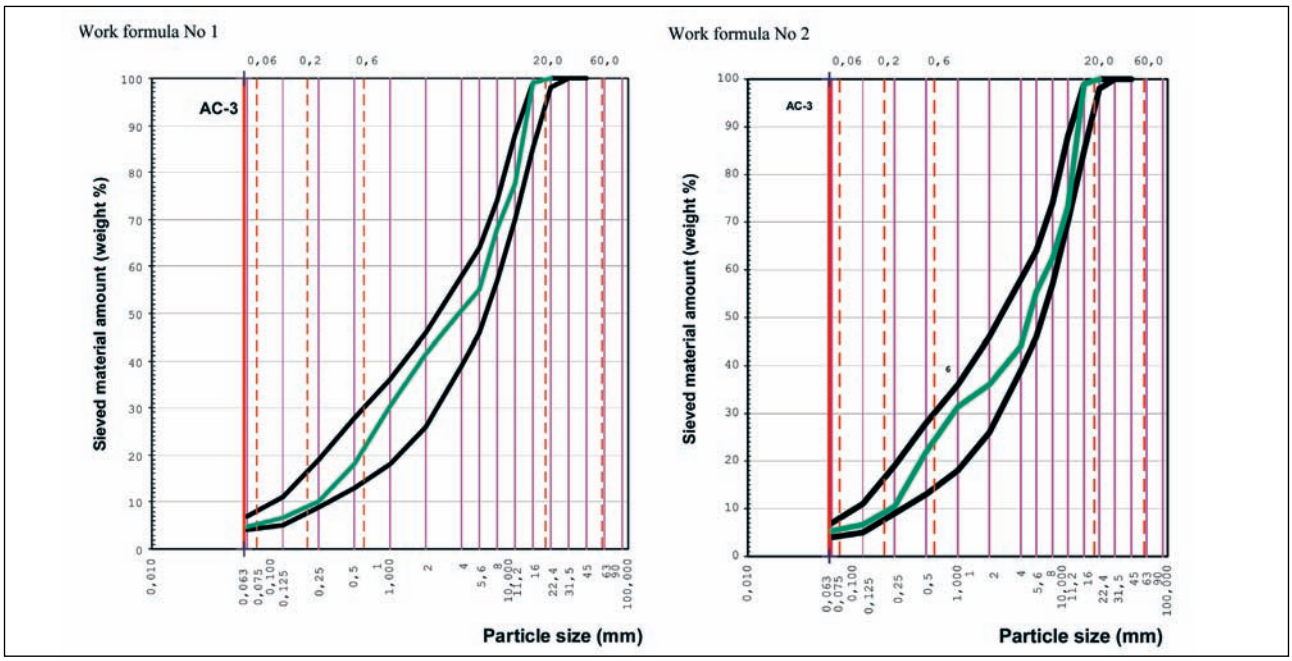


**Fig 1.** Compliance with requirements of the specifications

**Table 8.** Testing of mineral aggregates, Work formulas No 1, 2

| Index | Fraction/Method | 11/16 | 5/11 | 2/5 | 0/5 | Specific requirements |
|---|---|---|---|---|---|---|
| Size-grading content, mm LVS EN 933-1:1997 | 31,5/22,4 | | | | | |
| | 16 | 4,4/3,6 | | | | |
| | 11,2 | 88,9/84,7 | 4,8/11,99 | | | |
| | 8 | 5,0/7,1 | 35,1/49,93 | | 0,1 | |
| | 5,6 | 0,2/1,5 | 51,7/31,0 | 3,7 | 1,5/1,7 | |
| | 4 | 0,1/0,8 | 4,0/4,33 | 59,4 | 6,6/4,1 | |
| | 2 | 0,1/0,4 | 1,9/0,6 | 31,7 | 17,1/9,0 | |
| | 1 | | 0,3/0,16 | 2,9 | 21,1/12,0 | |
| | 0,5 | | 0,2/0,21 | 0,6 | 23,8/27,0 | |
| | 0,25 | | | 0,1 | 15,1/32,8 | |
| | 0,125 | | | 0,2 | 7,2/10,3 | |
| | 0,063 | 0,8 | 0,5/0,41 | 0,2 | 3,09/1,5 | |
| Clay and dust particles, % | LVS EN 933-1:1997 | 0,9/1,0 | 1,5/1,37 | 1,2 | 4,51/1,5 | |
| Clay activity, g/kg | LVS EN 933-9:1998 | – | – | – | 1,0/– | ≤ 10 |
| Dry particle density, kg/m3 | LVS EN 1097-6:1997 | 2,78/ 2,7780 | 2,77/ 2,7704 | 2,7761 | 2,65/ 2,6486 | |
| Lamellar index, % | LVS EN 933-3:1997 | Fr 4/16 7,8/7,8 | Fr 4/10 11,6/11,6 | – | – | |
| Magnesium sulphate test, % | LVS EN 1367-2 | Fr 10/14 5,5 | – | – | – | |
| Los Angeles coefficient, LA % | LVS EN 1097-2:1998 | Fr 11/16 17,8/15,6 | Fr 8/11 17, 2/17,2 | –/– | –/– | |
| Percent completely uncrushed gravel (fractions larger than 4,0 mm, in accordance with FAS Method 243) | FAS 243-98 | Fr 4/16 1,3/96,1 | Fr 5/11 0/100 | | – | |
| Crushed or broken / round surfaces of mineral aggregates | LVS EN 933-5 | 97,4/2,6 | 100/0 | – | – | |
| Pellet mill index, An | LVS EN 1097-9 | 17,8/17,8 | 17,8/17,8 | –/– | –/– | |

**Table 9.** Testing of bitumen emulsion BE 60 M/5000, Work formulas No 1, 2

| Index | Requirements | Actually |
|---|---|---|
| Bitumen contents, % | > 60 | 64,2/63,5 |
| Conditional viscosity, 4 mm diam., 50 °C, s | 10–25 | 11/10 |
| Residuals per 0,5 mm of sieve, % | < 0,1 | 0,0/0,0 |
| Splitting index, g | < 140 | 112/90 |
| Road construction bitumen | MB5000 | MB5000/MB5000 |

**Fig 2.** Borings made in the pavement structural layer and surfacing (structural layer of pavement: recycled mix ($h$ = 2×10 cm) 50 % additive material, cold mix emulsion AEB-16 $h$ = 4 cm)

cracks in the top layer built in 2004, under impact of road vehicles.

In autumn 2005, the determination of physical-mechanical properties of asphalt-concrete samples bored from the road pavement has been made, surfacing has been made in full thickness of road pavement construction (Fig 2).

## 4. Conclusions

The contractor has prepared cold emulsion mix AEB-16 and has laid it according to the requirements of the specifications provided in the contract. The pavement deformation has been facilitated by the following circumstances independent of the contractor:

- calculation of pavement construction has been made on the basis of the traffic counting data in 2001. During the period of 18–25 July 2005, the data collected with mobile traffic registration equipment show a considerable increase in freight vehicle proportion;
- low stability of cold mix emulsion AEB-16 with compliance with the materials used in the mix composition with the contract specifications (evidenced by the laboratory testing reports);
- low shear resistance of cold mix emulsion AEB-16 which is possibly influenced by natural sieved sand fraction 0/5 in the mix composition (the material complies with the requirements set in the contract specification on fine mineral aggregates) the percentage content in the Work formula of which amounts to 51,7 % of the composition (work formula agreed in 2004) and 34,7 % of the composition (fork formula agreed in 2005). Effect of this condition on the quality of final product has been not studied under Latvian conditions (also the recent versions of the specifications do not provide any specific angularity indexes for fine mineral aggregates).

Recommendation for eliminating defects: make double treatment of surface Y2B (sub-layer 11–16 mm, top layer 4–8 mm). Level milling shall be made in some places prior to surface treatment. Treatment shall be made at air temperature not exceeding the temperature stated in the specifications. Road-rollers are to be used for the works that will ensure partial sinking of crushed particles into cold emulsion mix AEB-16.

Possible shortcomings (risks) of the measures for eliminating defects: a complete elimination of deformations will be not achieved. Further development of deformations is not expected.

## 5. Recommendations

In order to show a justified efficiency of the usage of the cold mix technology, an analysis of physical-mechanical properties of soft and emulsion asphalts should be started, as well as an analysis of physical-mechanical properties of mineral aggregates of local origin (sand, gravel, dolomite) and exploration of aggregate resources in the Republic of Latvia.

The presented technology has been characterised by a negative attitude among the Latvian road engineers. It can be explained by the fact that there is a lack of studies on the efficiency of the usage of the cold mix technology, normative documents, clearly defined methods for evaluating the work performance that provides an efficient quality control during works, as well as accurate analyses of causes of defect formation. Impact of the peculiarities of the Latvian climate on the product (soft asphalt or emulsion asphalt) service properties and life has not been studied sufficiently.

Unquestionable is the potential importance of this technology for the Latvian national economy, for reconditioning the 1st and 2nd class state roads of Latvia, municipal roads, company and private roads with comparatively smaller investments, and to develop new types of road pavement suitable for the Latvian conditions.

It is necessary to implement research in order to find a scientifically justified and practical usage of the cold mix technologies by taking into account the peculiarities of the Latvian natural resources (sand, gravel, dolomite) and climate, on a basis of research works.

Further research shall be related to:

1. Development of a new type of road pavement suitable for the Latvian conditions.

2. Analysis of efficiency of using cold mix technologies by taking into account the current condition of state roads, municipal roads, company and private roads.

3. Improvement of road specifications with the purpose to increase work quality, the use convenience and to expand possibilities of local structural materials application.

4. Elaboration of technical normative documents on soft asphalt and emulsion asphalt pavements.

## References

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