Environmental assessment of existing pavements asphalt layers for production of new asphalt mixtures

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Abstract. Road construction requires a large amount of construction materials. During asphalt pavement construction it is natural aggregate and asphalt binder in particular. Their ratio varies depending on whether they are applied in an asphalt pavement as a wearing, binder or base course. Nowadays, pressure of public opinion on responsible environmental behaviour and effective use of financial resources create an optimal space for assessment of building materials from pavement layers. According to the EAPA (European Asphalt Pavement Association) data from 2017 the wearing courses accounted for 90\% of all pavement layers in European Union. In Slovakia their representation is also dominant. While in Western Europe reassessment of existing asphalt layers by recycling technologies has been used to the maximum, in Slovakia the reassessment was out of interest of construction companies. With the arrival of new machinery, legislation amendment and social pressure on responsible environmental behaviour, the strategy of some construction companies in Slovakia is also changing. The reassessment of existing asphalt layers for production of new asphalt mixtures goes to the forefront of the interest. This article summarizes necessary steps to achieve an increase in the re-use rate of R-material by hot-mix asphalt recycling technology in asphalt mixing plants.

1. Introduction
Since 2006, when EN 13108-8 came into force, the hot-mix asphalt recycling technology in asphalt mixing plants in Slovakia has begun to develop. After the initial enthusiasm of new technology introduction, its use has been minimalized over time. Crucial influence, apart from economic efficiency, was the difficulty of extracting materials from an asphalt pavement. Demolition, loading and transport to a reprocessing site using inefficient mechanisms was complicated and largely ineffective. Asphalt mixing plants were equipped only with cold batching technology, which limits them in adding a higher percentage of R-material in the production of new asphalt mixtures. In principle, they copied the requirement of TKP 6 for batching of R-material in quantities 10\% for wearing courses and 20\% for binder and base courses.

In Western Europe, the hot-mix asphalt recycling technology in asphalt mixing plants has progressed by big stride. For instance, in Germany the use of R-material achieves 85-90\% of reprocessing in pavements. Other Western countries in Europe like Switzerland or France are in similar position. The Czech Republic has also made a great progress in reprocessing of R-material in new asphalt mixtures. By Decree 130/2019 the Ministry of the Environment set environmental criteria, after which achievement a milled asphalt mixture become a by-product. Technical limitation of the highest acceptable amount of R-material is set by ČSN 73 6121/2019.
2. Current use of R-material in Slovakia

The legislation in Slovakia, Act no. 79/2015 on Waste and on amendment to certain acts in § 2, paragraph 2 states „Waste is not“ according to letter c) waste which go through a preparation process for re-use and meets requirements for the launched product set by special separation. Technical specification limiting the acceptable amount of R-material do not dictate them.

Recently, the Government of the Slovak Republic has committed itself to support circular economy in order to reduce negative environmental aspects in relation to natural resources, but also to increase economic efficiency of spending financial resources. Appropriate management with R-material can help to achievement both of these goals. It requires a change in approach and an awareness of the potential in using a high amount of re-used R-material. Current approach to obtaining high-quality R-material is practically impossible. The way, when the individual courses of a pavement are milled to the maximum thickness, damage high-quality wearing course, e.g. SMA type or AC type containing modified asphalt binder. The sorting and storage of the milled asphalt layer has also large reserves – figure 1.

![Figure 1. The current way of R-material storage.](image1.png)

![Figure 2. Cold batching technology.](image2.png)  ![Figure 3. From hopper to elevator.](image3.png)
The key to the successful application of this challenge is an investment to technological equipment of asphalt mixing plants and change the way R-material is obtained and managed.

The main barrier to increasing a ratio of batching is the cold batching technology of R-material in production process of a new asphalt mixture – figure 2 and 3.

3. Conditions for using a higher ratio of R-material in production of a new asphalt mixtures
To meet the goal of maximum efficiency in the process of re-use existing asphalt layers, it is through the management with R-material. As a good manager, it is necessary to plan entire process of assessment of existing pavements asphalt layers for production of new asphalt mixtures, which include the following:
- selection an appropriate compact section
- diagnostic research of individual layers
- milling in layers
- sorting and storage by fractions
- design of compositions with R-material
- production, laying and compaction of asphalt mixtures with R-material.

3.1. Selection an appropriate compact section
The final quality of obtained R-material depends on this decision. In ideal cases, an administrator of pavement is able to provide relevant data about age, thickness and identification built-in materials in a pavement. If these inputs are missing or they are insufficient, in these cases he relies on a result from a diagnostic research.

3.2. Diagnostic research of individual layers
This operation has to be made in any case. The difference in delivery of input data from an administrator of pavement can only be at the individual steps (distances) of diagnostic well compared to the condition, when relevant input data from an administrator of pavement are missing. Very important element is a visual inspection of a selected section. This operation is mainly about a research of a pavement surface and determination of an overall section homogeneity. If repairs are identified in the section (e.g. filled potholes), they inevitably reduce a quality of a milled material.

3.3. Milling in layers
It is essence of effective use of a milled material. Based on the results of the diagnostic research, the composition and thickness of individual layers is known. The result of the milling in layers is effective obtained material with maximum added value.

a) Example of the right practice – milling in layers:
1. a layer in thickness 40 mm is diagnosed on AC 11 wearing course containing 5.3% of PMB binder,
2. a layer in thickness 60 mm is diagnosed on AC 22 binder course containing 4% of asphalt binder.

The fraction of R-material thus obtained can be re-used with minimal addition of asphalt binder in layers.

b) Example of the incorrect practice – milling in single layer:
1. a layer in thickness 100 mm with mixed granulometry and approximate content of mixed binder 4.5%.

The fraction of R-material thus obtained is already considerably degraded and cannot be re-used as wearing course with a higher batching.

3.4. Sorting and storage by fractions
It is the next step to ensure a high-quality R-material. Under the proviso that the previous step of the milling in layers was strictly observed, it is not necessary to sort a milled material. Storage of milled material under a roofed landfill is a necessary condition its effective use – figure 4. Subsequently,
sampling is performed and based on the results of prescribed laboratory tests the classification of R-material according to the STN EN 13108-8 take place. Examples of R-material label:

32 RA 0/16 or 22 RA 0/11

Note: 32 RA 0/16 is R-material whose largest aggregate size is 16 mm and pieces of asphalt mixture have a maximum size 32 mm. The material thus classified and certified is prepared for re-use.

Figure 4. Storage of classified R-material.

3.5. Design of compositions with R-material

STN EN 13108-8 defines R-material as a component that can be used in asphalt mixtures manufactured in asphalt mixing plants in accordance with the specifications for these mixtures. The requirements for asphalt mixtures are the same for asphalt mixtures with R-material or without R-material and therefore the level of material homogeneity is determined by the maximum amount of R-material that can be used. When design asphalt mixtures with a ratio of R-material higher than 20%, its properties have to be taken into the account. In general, the mentioned material contains an aged asphalt binder with which an asphalt mixture has stiffness, but it is prone to formation of fatigue and low-temperature failures. Therefore, the material has to be adjusted. There are two options. One of them is that a rejuvenator is added to the R-material to achieve a recovery of aged asphalt binder or the second one is the use a soft asphalt binder. Recent researches focused in this field suggests more stable results with using soft asphalt binders with which is possible from an aged asphalt binder make a stable material. With rejuvenators similar results can be obtained. However, they are very prone for exact batching and their lifespan is questionable.

Worldwide, there are cases for use of 100% R-material only with the help of rejuvenators. Last year, in the Czech Republic the norm for specification the maximum ratio of using R-material in manufactured asphalt mixtures was published. In table 1, there is a possible proposal of using R-material in Slovakia.
### Table 1. Proposed batching of classified R-material in percentage by weight of asphalt mixture.

| Wearing courses | Binder courses | Base courses |
|-----------------|----------------|-------------|
| AC 8 II         | 25             | AC 16 I     | 30          | AC 16 I     | 50          |
| AC 11 I         | 15             | AC 22 II    | 40          | AC 22 II    | 60          |
| AC 16 II        | 20             |             |             |             |             |

The proposed batching of R-material takes into account a quality criterion for asphalt mixtures according to the TKP 6. Asphalt mixtures of quality class I are used to construction pavements asphalt layers with traffic load classes I-VI and asphalt mixtures of quality class II are used to construction pavements asphalt layers with traffic load classes IV-VI.

3.6. Production, laying and compaction of asphalt mixtures with R-material

The current production facilities in Slovakia are not able batching R-material with ratio higher than 20%. In order to achieve this, it is necessary to invest in parallel drying drum technology – figure 5.

**Figure 5.** Asphalt mixing plants equipped with parallel drying drum technology.

Laying and compaction of asphalt mixtures with R-material does not require modification of laying and compaction technology. The attention should be taken only when the amount of used R-material is higher than 50% depending on whether rejuvenators or only soft asphalt binders have been added to the mixtures.
4. Conclusion
In respect to effective pavement management in Slovakia it is time to increase the ratio of recyclation of construction layers from existing pavements by hot-mix asphalt technology in asphalt mixing plants. By responsible behaviour towards to natural resources, which also include aggregates, will also bring an economic return on the mentioned R-material batching in increased quantity. This model is not experimental, it has been successfully working in Western Europe for years and it has been introduced in the Czech Republic in recent years. This article should be an impulse for effective processing of R-material which is a valuable feedstock for the production of new asphalt mixtures and also motion for construction companies that operate in Slovakia.

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