Bulletin of the *Transilvania* University of Braşov
CIBv 2015 • Vol. 8 (57) Special Issue No. 1 - 2015

ASPHALT PAVEMENT RECYCLING

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Abstract: *These paper presents the specific methods of asphalt pavement recycling, considering the benefits of the recycling like cost reduction, cconservation of aggregate and binders, preservation of the existing pavement geometrics, reservation of the environment, conservation of energy, less user delay. After the introduction in the asphalt pavement recycling is presented a guide for selection of recycling method and the Applicability for the use of different recycling techniques. In the following part are considered: the recycling technology in Romania and the structural design of recycled pavement.*

Key words: *road pavements, recycling, structural design*

1. Introduction

Recycling or reuse of pavement material is a very simple but powerful concept. Recycling of existing pavement materials leads to new pavement materials that considerable saving material, money, and energy [1]. At the same time, recycling of existing material also helps to solve disposal problems. Because of the reuse of existing material, pavement geometrics and thickness can also be maintained during construction. In some cases, traffic description is less than that for other rehabilitation techniques. The specific benefits of recycling can be summarized as follows:

- reduced costs of construction;
- conservation of aggregate and binders;
- preservation of the existing pavement geometrics;
- preservation of the environment;
- conservation of energy;
- less user delay.

2. Recycling as a Rehabilitation Alternative

Recycling is only one of the several rehabilitation alternatives available for asphalt pavements [2]. The choice of rehabilitation alternative depends on observed pavement distress, laboratory and field evaluation of existing material, and design parameters [3]. Also, maintenance of geometrics and original thickness of pavements, especially in underpasses, influence the choice of rehabilitation method. However, recycling has some unique advantages which are not available with other types of rehabilitation techniques. For example, recycling can result in savings, help in conservation of natural resources, and can maintain pavement geometrics as well as thickness.

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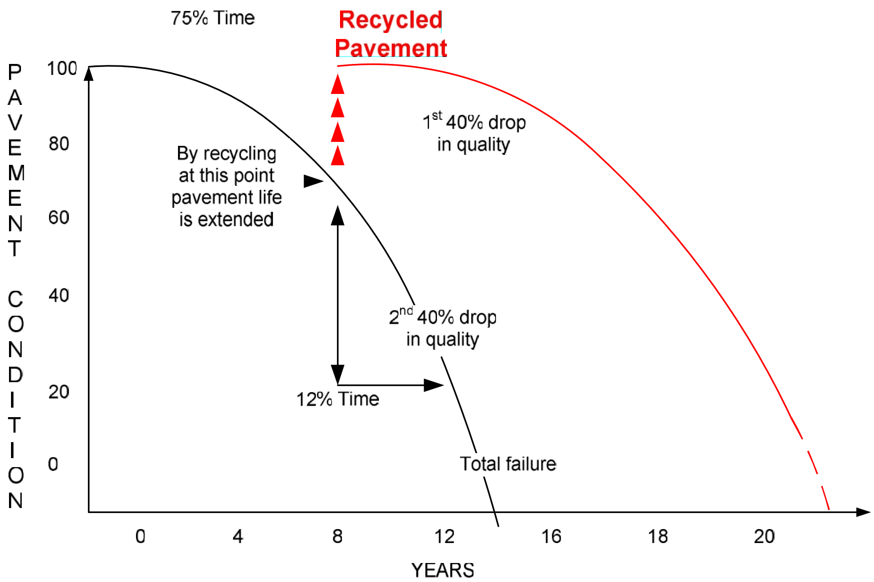

Fig. 1 *Plot of pavement condition versus time[4]*

It is well recognized that a sound infrastructure, including roadways, is required for a good economy with an adequate level of growth. Studies have indicated that if a roadway is maintained, at an acceptable level of service, it will ultimately cost less.

Different recycling methods are now available to address specific pavement distress and structural needs. All pavements deteriorate over time due to traffic and environmental factors [1].

Rehabilitation is needed to maintain the pavement at a certain condition. Rehabilitation may be required in case of, inadequate ride quality, because of excessive pavement distress. It also may be required when the coefficient of friction between tire and pavement is reduced, or when there is low structural capacity or inadequate capacity to carry projected traffic volumes.

3. Recycling Methods and Processes

The Asphalt Recycling and Reclaiming Association [5] define different types of recycling methods as follows [1]:

Hot mix asphalt recycling
Hot in-place recycling
Cold in-place recycling
Full depth recycling

Hot mix asphalt recycling is the process in which reclaimed asphalt pavement materials are combined with new materials, sometimes along with a recycling agent, to produce hot mix asphalt (HMA) mixtures. Both batch and drum type hot mix plants are used to produce recycled mix. The reclaimed asphalt pavement material can be obtained by milling or ripping and crushing operation. The mix placement and compaction equipment and procedures are the same as for regular HMA.


Fig. 2. *Hot mix asphalt recycling [1]*

Hot in-place recycling consists of a method in which the existing pavement is heated and softened, and then scarified/milled to a specified depth.

Cold in-place recycling involves reuse of the existing pavement material without the application of heat.

Fig. 4. *Hot in-place recycling [9]*

Except for any recycling agent, no transportation of materials is usually required, and aggregate can be added, therefore hauling cost is very low. Normally, an asphalt emulsion is added as a recycling agent or binder.

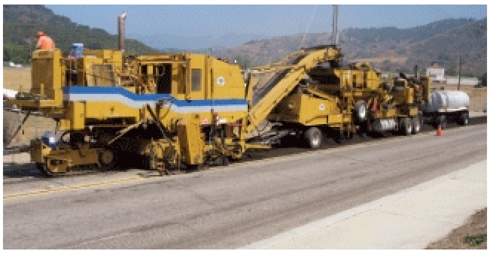

Fig. 5. *Cold in-place recycling [10]*

Full depth recycling has been defined as a recycling method where all of the asphalt pavement section and a predetermined amount of underlying base material are treated to produce a stabilized base course. It is basically a cold mix recycling process in which different types of additives such as asphalt emulsions and chemical agents such as calcium chloride, Portland cement, fly ash, and lime, are added to obtain an improved base.

4. Selection of a Recycling Method

If recycling is chosen as a rehabilitation alternative, there is a variety of recycling methods available for rehabilitation of HMA pavements.

Fig. 6. *Full depth recycling*

These recycling methods offer a number of advantages, which include the following [5]:

- allow the use of existing material with the elimination of disposal problems.
- the asphalt mix may be improved through changes to the aggregate and/or asphalt binder.
- the pavement profile may be corrected and the ride improved.
- cost reductions may be achieved over conventional rehabilitation methods.

In Table 1 from below it is presented the guide for the selection of the method according to the literature.

5. Structural Design of Recycled Pavements

Structural design of pavements takes into consideration those aspects of design which provide required strength or stiffness to the pavement structure. The design method has evolved from the application of engineering judgment to predominantly mechanistic or semi-mechanistic procedures. Pavement materials can be characterized by resilient modulus and fatigue characteristics.

Guide for selection of the recycling method [5] Table 1

Type of Pavement Distress	*Hot Recycling*	*Hot In-Place Recycling*	*Cold In-Place Recycling*	*Full Depth Reclamation*
Surface Defects				
Raveling	*x*	*x*		
Bleeding	*x*	*x*		
Slipperiness	*x*	*x*		
Deformation				
Corrugations	*x*	*x*		
Rutting - shallow	*x*	*x*		
Rutting - deep	*x*		*x*	
Cracking/Load Associated				
Alligator	*x*		*x*	*x*
Longitudinal - wheel path	*x*	*x*	*x*	*x*
Pavement edge	*x*		*x*	*x*
Slippage	*x*	*x*		
Cracking/Non-Load Associated				
Block (shrinkage)	*x*		*x*	*x*
Longitudinal-joint	*x*	*x*		
Transverse (thermal)	*x*		*x*	*x*
Reflection	*x*		*x*	*x*
Maintenance Patching				
Pothole	*x*		*x*	*x*
Problem Base/Subgrade (Soft, Wet)				*x*
Ride Quality/Roughness				
General unevenness	*x*	*x*		
Depressions (settlement)	*x*	*x*		*x*
High spots (heaving)	*x*	*x*		*x*

Pavement materials with different strength and structure can be considered by appropriate “structural numbers”.

Recycled asphalt materials can provide pavements similar or even better than pavements constructed with conventional hot mix asphalt. However, the wide range of properties of recycled mixes, resulting from variation in material and construction methods must be considered during structural design of recycled pavements [7].

On an average, the coefficients for both recycled surface and recycled base courses are found to be greater than the coefficients for respective conventional mixes determined in the AASHTO Road Test. The AASHTO guide indicates that in essence there is no difference between hot recycled and virgin HMA material, and recommends the structural rehabilitation analysis method (for conventional mix) for design of recycled pavements as well. However, it also cautions that since long-term performance data is not available for recycled mixes, engineering judgment should always be applied for design of such mixes.

The AASHTO guide [7] proposed a method of overlay design based primarily on structural number, thickness of underlying layers, and drainage coefficients. Basically, a monograph is used to calculate a combined total structural number for the whole pavement section, based on performance period, traffic, and change in Present Serviceability Index (PSI). The structural number can be represented by a combination of product of depth, structural number, and drainage coefficients for each of the pavement layers. The structural number of the recycled layer required is calculated by subtracting the effective structural number of the existing pavement from the structural number required by the "new pavement," which includes the recycled layer. The effective structural number of the existing pavement is modified by a remaining life factor for the existing pavement. The equation is as follows:

$$SN_{OL} = SN_Y - (FRL\ X\ Sn_{xeff})$$

where:

SN_{OL} = structural number of the required overlay

SN_Y = structural number required for a "new" pavement to carry the estimated future traffic for the prevailing roadbed soil support conditions

F_{RL} = remaining life factor

Structural Design of Recycled Pavements

Sn_{xeff} = effective structural number of the existing pavement at the time the overlay is placed

Structural number (SN) is defined as follows:

$$SN = a_1D_1 + a_2D_2m_2 + a_3D_3m_3$$

where:

a_1, a_2, a_3 = layer coefficients representative of surface, base, and subbase courses, respectively

D_1, D_2, D_3 = actual thickness (in mm, inch) of surface, base and subbase courses, respectively

m_2, m_3 = drainage coefficients for untreated base and subbase layers, respectively

One important feature of the design method is the inclusion of reliability factor in traffic and performance prediction.

According Asphalt Institute recommendations [8] for hot-mix recycling the design procedure shows the same as for conventional mixes. The parameters required for designing the pavement thickness include the following:

- the equivalent 18-kip single-axle load (ESAL) applications. The design ESAL is calculated by the summation of the products of number of vehicles and the corresponding truck and growth factors.
- the Resilient Modulus, MR of the subgrade. This can be determined by testing or through correlations with CBR or R-value.
- the type of surface and base. The total required pavement thickness can be calculated by entering the design traffic and MR values in the design charts.

In the comparison of properties of recycled materials to those of new materials, the recycled materials have been considered equivalent to the conventional mix.

The overlay design procedure can also be used for thickness design. The overlay thickness is calculated as the difference between the thickness required by a new pavement to the design traffic ESAL and the effective thickness of the existing pavement.

The effective thickness of the existing pavement can be determined based on the Present Serviceability Index, and equivalency factors for converting various pavement materials to equivalent thicknesses of asphalt concrete are used. Also the conversion factors for each pavement layer (based on the condition of each layer prior to overlay) can be used to convert each layer to an equivalent thickness of asphalt concrete.

The effective thickness of the existing pavement should be subtracted from the thickness of the recycled layer.

6. Conclusions

The Romanian existing roadway infrastructure has aged, and a significant number of roadways are nearing the end of their service life. Limited funding and demands on existing resources have shifted the emphasis from new construction to preservation and extending the service life of the existing roadways.

The implementation of more timely or proactive preventative maintenance and rehabilitation treatments is being used as a means of preserving the existing roadway infrastructure. Therefore the application of asphalt recycling technologies are more often use in our country.

According Romanian technical norm [8], hot in place recycling technology of bituminous road pavements can be applied in the following alternatives, working principle:

a) by cold milling of the existing bituminous layers, followed by recycling itself, made by mixing of added material in a mobile plant.

b) by infrared heating of the existing bituminous layers, followed by their scarification and mixing with added materials over the sub base.

Compacting operation is performed under the same conditions as for conventional asphalt mixes.

The bituminous layers made by hot recycling may serve as wearing or base course layers.

Hot recycling road pavements are constructed during the hot seasons, between April 15 and October 15, when the atmospheric temperature is at least +5°C.

When the bearing capacity of road structure is appropriate, the hot recycled road layers will be covered with wearing course.

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