CONTRIBUTION OF ASPHALT MIXTURE RECYCLING FOR SUSTAINABLE ROAD INFRASTRUCTURE

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ABSTRACT

In today's global economy, rational use of resources occupies one of the first places among researches in the field of asphalt mixtures. The demand for aggregates for asphalt mixture is increasing, a trend that has a negative impact on the environment. A reasonable solution to reduce environmental impact is to use recycled asphalt mixture that results from milling layers of degraded asphalt road structure. This technology requires attention since the design phase to phase mix asphalt and mix asphalt production in the asphalt mixture plant. Recycling of asphalt mixture not only reduce the need of virgin materials but also reduces emissions, traffic and energy consumption associated with the transport and production of these materials. One the key element to an appropriate recycling project is proper evaluation and characterization of materials involved in this process.

INTRODUCTION

The construction sector plays an important role in implementing the Europe 2020 strategy for smart, clean and sustainable development. Transport infrastructures have a huge impact on the environment through consumption of energy and raw materials and generation of large amounts of waste. Currently, about 90% of aggregate production in Europe comes from natural resources extracted from quarries and gravel pits. The remaining 10% of European production comes from marine deposits of aggregates, recycling industrial waste such as slag (steel or furnace), ashes and from recycling of construction and demolition waste. The production of marine aggregates and those derived by recycling activities will continue to increase; however, long-term, about 85% of the requirements will still need to be covered with aggregate quarrying extraction products. Aggregates produced from recycling should not be viewed as competing products aggregates quarries, but rather using them together is strategic to ensure supply from multiple sources [1].

Aggregates are also very important for infrastructure works, for example about 30,000 tonnes of aggregates are needed to complete construction of 1 km of highway, aggregates being present in the road foundation and concrete or bituminous mix road surface. Amounts equivalent to 20% of annual European consumption of aggregates are used in construction of roads, runways, railways and canals.

Due to shrinking supply of natural aggregates and increasing environmental protection, a proper method used more often in roads construction technology is recycling of asphalt pavement and reuse it in combination with virgin aggregate and bitumen. Reclaimed asphalt pavement (RAP) is represented by existent asphalt mixture, at different stages of distress, milled in partial or full depth. Different percent of RAP can be reused to optimise the use of natural resources by few common road pavements techniques: in place hot recycling, hot recycling in asphalt mixture plants, in place cold recycling and full depth recycling [2]. In Europe, the using of RAP for asphalt mixtures it is used frequently and with very good results in Germany, Netherlands and Austria where more than 75% it is used in bituminous applications [3].

Toxic and greenhouse gas emissions are reduced due to less traffic and less emissions during production. The energy consumption without RAP is 98,7 GJ, using 50% of RAP we gain 14% (86.3 GJ). Without RAP, 6.3t eq CO_2 is produced, with 50% of RAP this figure lowers to 5.7 t eq CO_2, a gain of 11% [4].

MIX DESIGN

No matter if new or recycled asphalt layers, they must meet certain basic technical requirements:

- to present a bitumen content appropriate to ensure the achievement of a sustainable road surface;
- to provide sufficient mechanical stability under the action of traffic load;
- to provide a sufficient air voids volume between an upper limit value to prevent the excessive influence of environmental factors that can damage roads surface and a lower limit value, enabling takeover effects of initial compaction (densification) caused by traffic;
- to provide sufficient workability.

Composition, design of asphalt mixtures, as well as laying down mode have a significant influence on its behaviour. To know the characteristics of the mix asphalt, if it meets the conditions required by the standards and regulations in force, during work samples are taken (core) which are subject to a series of laboratory tests.

So, on existent asphalt mixture, prior to design step, the following tests are conducted:

- study of grading curve: the survey is based on both the aggregate results of particle size analysis of the milled asphalt mixture and those on aggregates to be added;
- bitumen content;
- physical characteristics oobtained on cores extracted from road layers: density, degree of compaction and water absorption;

Design of the asphalt mixture consists in selecting a suitable mix of aggregates and an optimum percentage bituminous binder so that the resulting mixture to be as sustainable as possible. The most critical factor is the bitumen content, since a deviation of 0.5% compared to the optimal percentage may result in either too much or too little biding agent. A too high bitumen content results in a mixture with low air voids volume, which is susceptible to permanent deformation and exudation. A too low content of bitumen can produce an under compacted mixture (with high air voids volume) and cause damage to the road pavement layers. The optimum bitumen content is the variable most difficult choice in the design of an asphalt mixture. Selecting a binder grade is essential in insuring that the asphalt will not experience significant levels of distress at the prevailing climatic condition.

Particularly, when we are talking about asphalt mixture with addition of RAP, there are several specific issues that must be considered:

- Moisture content of RAP can have significant influence on asphalt mixture production;
- The properties of aged bitumen from RAP can cause early pavement cracking failures;
- The degree of blending and diffusion that occurs between RAP and virgin aggregate during mixing operations;
- Fines parts from RAP can have high values with significant influence on asphalt mixture behavior and may not allow to meet the aggregate size distribution requirements, dust to binder ratio, air voids and voids in mineral aggregate;
- Possibility of adding a special type of bitumen or a special rejuvenator.

CASE STUDY

On a Romanian national road, the state agency ask contractor to recycle existent asphalt pavement layers and to add a maximum 25kg/m^2 of additional aggregates and not more the 2% of new bitumen. The existing asphalt layer of road structure, by recycling, will be transformed in new layers. For this operation there were used crushed stones aggregates (0-4 mm, 8-16 and 16-25 mm) and a soft bitumen (D 80/100 type) as additional materials.

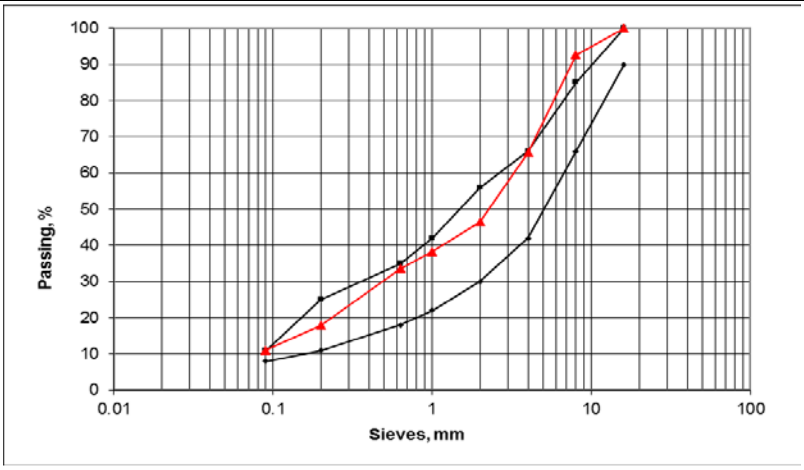

Figure 1. Typical granulometric curve

The study was conducted on a 14 km length sector and at every 500 m were took out cores to find out the composition of existing asphalt mixture. In figure 1 it is an example of granulometric distribution of existent asphalt mixture. One of the key properties of aggregates which influences the quality of asphaltic mixtures is granularity. This is graphically represented through a granulometric curve, which has on vertical the passing from the sieves in percentage (arithmetic scale), while on the horizontal are represented the sizes of the particles (logarithmic scale). With few minor exceptions all the cores present almost the same particle size distribution.

The bitumen content of asphalt mixture from all cores it is between 5,8% and 8,5% which means a relatively high dispersion of bitumen percentage (figure 2).

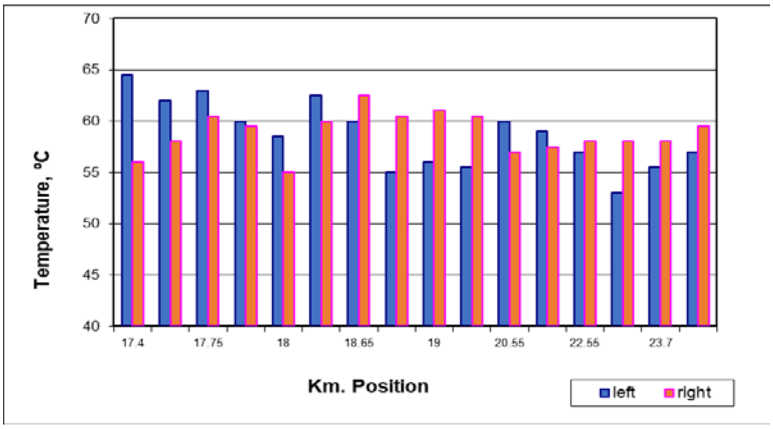

Figure 2 Ring and ball temperature

For all cores there were conducted test on bitumen to determine their ageing characteristics (figure 3).

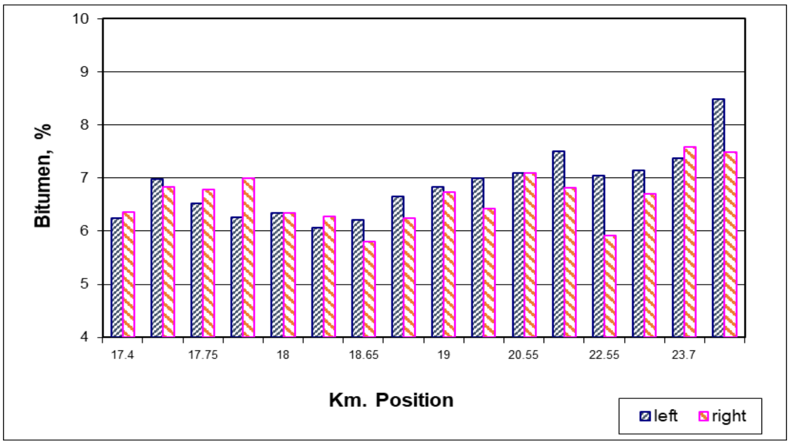

Figure 3 Residual bitumen content

By conducting laboratory tests, the goal of this study is to highlight the properties of recycled asphalt mixtures. The experimental results obtained on BAD25 (recycled asphalt mixture for binder course) asphalt mixture samples, through laboratory tests, are presented below.

In figures 4, 5, 6 and 7 are presented the results obtained for recycled asphalt mixture for: apparent density according to SR EN 12697-8, Marshall test on cylindrical specimens, according to SR EN 12697-34, at 60ºC test temperature for Marshall stability and index flow, water absorption according Romanian norm AND 605.

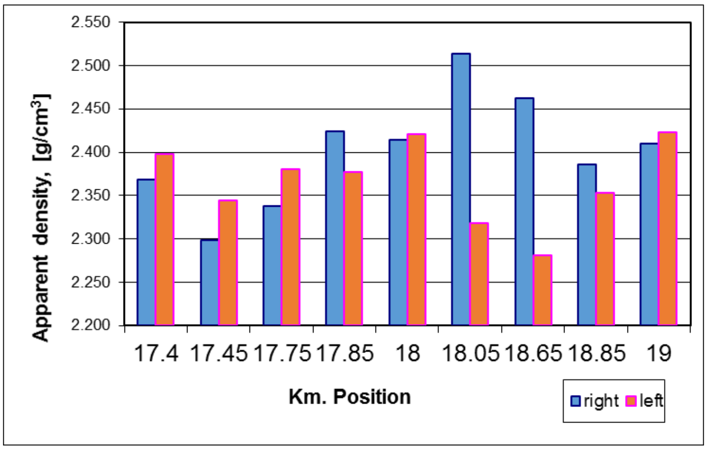

Figure 4 Apparent density

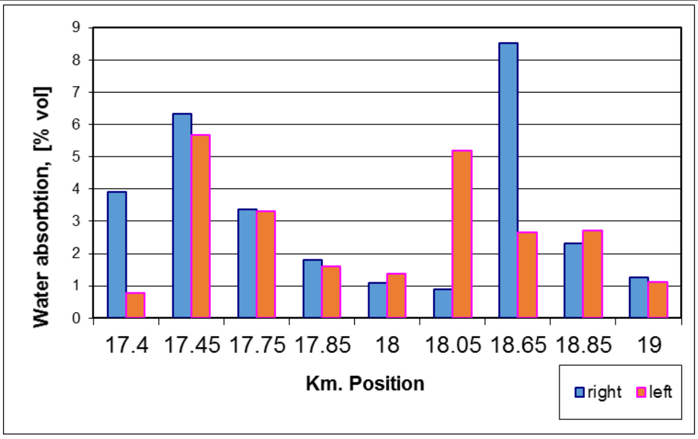

Figure 5 Water absorption

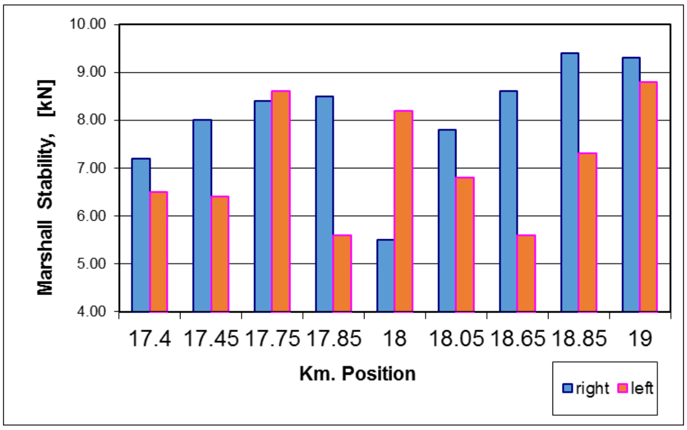

Figure 6 Marshall stability

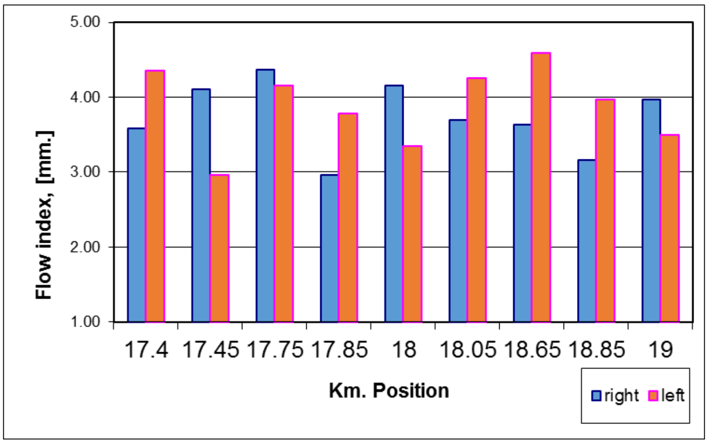

Figure 7 Flow index

CONCLUSIONS

Recycled asphalt mixture is a promising approach to production and placement of paving materials. Research work from all over the world is demonstrating that recycled pavements are providing significant benefits with regards to the environment, in facilitating paving practices and, with regards to field performance. Significant evaluation work has been completed and the benefits associated with recycled asphalt mixture are well documented. However, there is still a significant challenge ahead to move recycled asphalt mixture from trial projects to main stream pavement products in our country.

From figures presented in this paper we can conclude that volumetric properties of recycled asphalt mixture are, for most of the position, in range of Romanian norms. Regarding the mechanical characteristics of the mix, there are some problems with Marshall's stability, which does not fully meet the requirements Romanian norms. Although the S/I report is respected, there is a caution on the possibility of problems occurring during operation. In this regard, we propose to monitor the area for a prompt intervention, if necessary.

The results presented in this paper highlight the homogeneity of the resulted asphalt with recycled mixture, even the accurate measurement of recycled material properties can be difficult because traditional test methods were developed using virgin aggregates and bitumen.

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