WARM WASTE ASPHALT RECYCLING IN BELGIUM – 30 YEARS OF EXPERIENCE AND FULL CONFIDENCE IN THE FUTURE

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ABSTRACT

The text deals with in plant production of hot asphalt mixes with recycled materials coming from deconstruction of asphaltic roads.

In the early eighties of the previous century, the idea grow in Belgium that used materials couldn't be put away as a waste anymore. Two principal reasons were at the origin of this:
1. Bitumen prices raise due to the fact of the evolution of the crude-prices
2. Dumping of waste materials had to be stopped
In 1980 the plant production of hot asphalt mixes with recycled materials was introduced in Belgium. It became very popular between 1983 to 1985. Since then the prices for dumping waste materials and the bitumen prices rose in such a way that it became more and more interesting to recycle old asphalt in new mixes. Nowadays Belgium recycles a maximum of 50% RAP in new hot asphalt mixes. This is not a technological limit but is imposed by the Road Administration. In 2007, 38% of all the hot mixes contained RAP.

The text further describes the latest technology used in Belgium to produce the asphalt mixes with RAP. This includes the management and control of the different RAP sources in the asphalt plant in accordance with the Belgian and European rules including the problem of tar-containing recycled asphalt.

The environmental benefits of the use of RAP are showed using software for calculation of energy and the emissions of Carbon dioxide related to road structures.

Future developments are described.

Keywords: ASPHALT, BITUMEN, RECYCLING, HOT MIXES, RAP

1. INTRODUCTION

Recycling of asphalt granulates in new asphalt mixes is nowadays common business in Belgium. Rather high rates of recycling are reached : 38% of all hot mixes produced in the country in 2010 contained between 20% and 50% of RAP (Reclaimed asphalt pavement). 85% of the RAP on the market is reused in the production of new asphalt mixes.

It took about two decades of research and development to reach these high figures but, even now, we feel that further research is necessary to increase our knowledge on the influence of RAP on the characteristics of the new mix. Bitumen resources are gradually but certainly becoming scarce and prices are raising permanently. The renewal of highways built in the sixties and seventies puts a lot of new RAP on the market, so the pressure is high to use even more of it. A thorough knowledge of the use of RAP and a performing quality control are important to gain the client's confidence and go further in recycling techniques.

2. HISTORY

2.1. Introduction

Before the first petroleum crisis in 1973, there was little or no interest in recycling techniques for bituminous bound pavements. Dumping thousands of tonnes of these materials also wasn't a big problem; there was enough place and it was cheap. Asphalt production quite happened to be easy with good quality, low priced natural materials. But after 1973, times changed…

The Bitumen prices raised due to the fact of the evolution of the crude-prices and the population became more and more sensitive to environmental issues. Belgium is a small country with a very dense population and opening new dump sites is extremely difficult or even impossible in some regions. Transportation distances increased and so did the transport price.

The first trials to reuse RAP were performed around 1975. At that time, four different ways of recycling RAP were investigated. These are detailed in the following paragraphs. In the first two methods RAP is used as a granulate for foundation. In the last two, RAP is used in new bituminous layers. This last recycling method is much more interesting because the reclaimed asphalt stays at the same level of use : it is not downgraded to a simple granular materiel.

2.2. Unbound foundation material.

The use of RAP as a granulate for foundations was a rather straightforward and easy application. It was introduced for the first time in 1975. No further handling of the RAP was necessary. Two different ideas were followed to do the investigations :

1. Simple use of the cold milled material as a granulate for foundations.
2. Warm milling of the material and laying of a new layer with a finisher at a temperature above 90°C.

Both applications appeared to be not always successful. The high pore percentage and the low degree of compaction of the bad graduated material caused long term deformation of the layers. The same conclusions were found in The Netherlands (ref. 1, 4). It was possible to improve the grading curve by adding 10 to 20% of sand to the material, but this was not found very easy to do on a construction site. Though, this kind of application is still used today for private car-parking areas and other low trafficked areas by road contractors. They appreciate the binding effect of the bitumen that sticks the stones together and thus stabilises these layers on the long term.

2.3. Bound foundation material.

Some trials were also done in the seventies to mix RAP with a bituminous emulsion. This permitted to work with cold materials but the problems associated to the imperfect grading curve persisted.

A more successful application was the mixing of a RAP 0/40 with sand, cement and water. This product was used for building high quality cement bound foundations. This kind of application is still used in 2010. It is the only application where the use of tar-containing RAP is permitted in Belgium, albeit under certain conditions. This kind of product is fabricated without warming and thus does not release carcinogenic gases during production and laying. Warm reuse of tar containing RAP is strictly forbidden in Belgium.

This cement bound foundation material appears to be quite successful. The combination of the cement and the bitumen bond between the granulates produces a stiff layer that still has some flexibility and is less sensitive to cracks than a classical cement bound material. One million of tonnes of RAP are used annually in this type of application. For reference, the total amount of HMA produced yearly in Belgium is about four million of tonnes.

2.4. In situ recycled material in bituminous layers (ref. 1).

In situ recycling of asphalt pavements was used in Belgium between 1977 and 1985 in three different forms :

- *Reforming* : existing pavement was heated, milled and put in place again. Only 16.000 m² of pavement was reused in this way in Belgium, because the amount of heating energy necessary for the operation was too high.
- *Remixing* : the in situ scarified material was mixed with new asphalt. This technique was used on highways and performed quite well. Again, the energy for reheating the old material was high and thus not very economical.
- *Repaving* : the old pavement was first milled and put in place again. Then a thin wearing course was put on it. 345.000 m² of pavement was recycled on 12 construction sites during these 8 years.

These techniques are practically not used anymore in Belgium since 1986 because of the appearance of RAP recycling in hot mix installations. Though, some benefits of the methods could make them reappear again in Belgium, i.e. :

  - No road transport of RAP because of in situ reuse,
  - the greenhouse gas production is lower,
  - the RAP stock management on the mixing plant is seriously reduced,
  - the finding that other countries nowadays use some of these techniques and seem to be satisfied with their technical and environmental sustainability.

2.5. Processing of the material in a hot mix installation

The reuse of RAP in hot mix plants began in the early eighties of last century. Between 1983 and 1985, its development became very successful because of ecological and economical reasons. Around 1986 the process slowed down due to very low bitumen prices that encouraged the easier way of producing asphalt from new aggregates.

A number of methods were developed for mixing RAP in a hot mix installation. Certain methods involved heating the virgin aggregate to higher temperatures. The transfer of heat through either conductive or convective methods also was a factor in the mixing process.
The mixing with the natural aggregate took place in a batching tower or in a drum mixer.

The first trials in Belgium where done with drum mixers. They were very versatile for use with RAP. All that was needed was an opening in the drum where the RAP could be added into a cooler zone, downstream from the hot gases of the burner.   In a traditional parallel-flow drum mixer the aggregate is fed into the drum at the end where the burner is located. The aggregate is then dried and heated travelling through the dryer in the same direction as the exhaust gases. The RAP is added into the mid-section of the drum. This is done to keep the high temperatures in the combustion and drying end from damaging the hydrocarbons in the RAP.   This method is still used in some mobile hot mix plants in Belgium but disappeared in the stationary plants. The reasons therefore were that the batching towers proved to be more versatile in production, given the high amount of different mixes asked by the customers, and that the percentage of RAP in the mixes was limited to 20% when using drum mixers.

Today, practically all stationary plants in Belgium are of the discontinuous batch type. Some plants use cold RAP but most of the plants can perform warm recycling. When RAP is cold, the batching tower methods use conductive heat transfer to heat it. The virgin aggregate is overheated and then added to the weigh bucket along with the RAP. Conductive heat transfer takes place in the weigh bucket and the pug mill throughout the dry-mix cycle. As the water evaporates from the wet RAP a steam explosion results causing a potential emission problem. The percentage of RAP that can be added in the mix is limited to 20% maximum.

Therefore, in the modern batch plants, RAP is now heated into a parallel drum (temperature between 110 and 160°C) before mixing it with the virgin aggregate. This process allows high ranges of recycling (50% or even more). It will be detailed in the next paragraph.

3. PRODUCTION

3.1. Production of RAP

The reclaiming of the old asphalt pavements can be done by two methods :

- Milling
- Removal in slabs.

When milling, the removal may be accomplished at partial or full depth of the asphalt layer. Partial depth removal is performed when the pavement is constituted of layers with different virgin stone quality and separation is economically significant, for example for reuse in wearing courses. The RAP from a single layer has homogenous properties (aggregate type and grading curve, bitumen content and bitumen characteristics). This is because the RAP typically comes from a specific site where the pavement was consistent when placed. For this reason, millings are segregated and identified in separate stockpiles at a storage location. Milling is frequently used in rehabilitation works where an upper layer of an existing pavement is removed and replaced with new pavement to lengthen the road structure's service life. Milled RAP has the additional benefit of being immediately ready to recycle without additional processing. In this case, a good mastering (depth, speed, used tool…) of the milling operation is necessary to be sure to produce a good quality RAP.

The pavement can also be removed completely in a total reconstruction. Here, bulldozers or front-end loaders break the entire pavement structure into manageable slabs and load them into trucks for transportation to a reprocessing site. The slabs are then crushed to a usable size for recycling. This involves a supplementary operation, but the quality of the crushed material is quite good and homogenous.

3.2. Production of HMA with RAP.

As we want to attain high levels of RAP-recycling (50%), hot recycling is necessary. Therefore, the asphalt plants have a large volume drying drum featuring a special burner. Direct contact of the flame of the burner with the reclaimed asphalt must be avoided, not to burn the old bitumen. After heating, the RAP is stored in an insulated silo until it is weighed and mixed with the virgin granulates. The temperature of the RAP lays between 110°C and 160°C. They tend to be at the lower end of this interval to avoid clogging in the installation.

4. QUALITY ISSUES

4.1. Regulations.

The use of RAP is described in the standard tender texts of the different Belgian regions, Flanders, Wallony and Brussels (ref. 6, 7). These documents form a part of the contract between the administration and road builder in all public road works and thus are mandatory. They also comply with the European standard EN 13108-8 for Reclaimed asphalt. Further the environmental regulations for RAP are described in several regional laws, since environmental matters are ruled by the regional governments.

4.2. Quality control.

Using RAP is not as straightforward as it seems. As long as the recycling stays below 20%, no big difficulties are encountered to produce qualitative asphalt. On the other hand, recycling percentages of 50% and even more, require a thorough management of the quality of the RAP. Indeed, to produce a qualitative recycled product one must know the stone and bitumen properties of the reclaimed pavement. When large quantities of RAP from different sources are available, stockpiles must be separated and identified by source. Separate RAP stockpiles are foreseen for wearing courses (mostly containing porphyry or sandstone) and base course (containing limestone). Handling this way permits to produce good quality of RAP containing wearing courses. However, this seems to be difficult to achieve and the Flemish Region as a consequence decided to forbid RAP in all wearing courses in its new SB 250 standard tender (RAP was already forbidden before in draining asphalt and SMA). On the other hand, RAP will be allowed in high modulus asphalt (max 20%). Until now this was forbidden.

To increase the client's confidence in the RAP-containing products, it is possible, and even mandatory in the Flemish region, to have the use of RAP certified at the plant by an independent certification body. They control the whole cycle of the RAP product quality control and stock management by periodical control visits and tests. This organism wrote its own regulations to organise the controls on the plant (ref. 8). Not all production sites in Belgium are certified this way.

The strict application of the EN13108-8 standard - certainly when recycling rates exceed 20% - implies performing a lot of control tests. The presence of a control laboratory dedicated to the plant is then mandatory.

4.3. Detecting Tar in RAP

An important part of the acceptance controls on the sites where RAP is collected, is the tar detection. Tar containing RAP is namely forbidden in warm mixes. The "Pak-Marker" method is used in Belgium and control is done when the truck carrying the RAP is entering the site. When the presence of tar is detected, the truck must return to the construction site where it came from. This refusal has a serious economic impact for the construction site management. Forecasting the presence of tar is possible but is not 100% reliable for now. Asphalt cores are taken from the road and tested but some binders between the different asphalt courses contain tar and are not always detected during the tests.

5. ADVANTAGES OF USING RAP

5.1. Economical (ref. 1)

The use of RAP has a positive economical impact on the price of the finished product. These are the parameters influencing the price :

- Amortization : raises the price, because of the installation of supplementary recycling devices (parallel drum, sieves, ...)
- Use of virgin aggregates and new bitumen : the more one recycles, the less new materials are needed. The price of the mix is thus lowered.
- Fuel or gas : raises the price, because one has to warm up the RAP
- Other energy : raises the price, because the supplementary equipment needs supplementary energy.
- Maintenance : higher, because of supplementary equipment
- Production personnel : amount of personnel stays the same, in general
- Laboratory : higher price, because the RAP must be analysed and managed.

Only the difference in amount of new materials (aggregates and bitumen) causes a positive economical impact.

5.2. Environmental.

The impact of the use of RAP on the environment is high :

- Non-renewable natural resources such as aggregates and bitumen are preserved
- Landfill space is preserved
- Reduced wear on roads and less accidents due to less transport of materials
- Toxic and greenhouse gas emissions are reduced due to less traffic and less emissions during production. The charts hereafter were produced with the Ecologiciel© of Colas SA and illustrate the difference in needed energy and greenhouse gas emissions for a typical belgian bituminous base layer (type 3A) of 6 cm thick without RAP and with 50% of RAP. The calculation was made for a surface of 1000 m² and a distance of 25 km between plant and construction site. Virgin aggregates and sand are transported by boat to the plant. 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%.

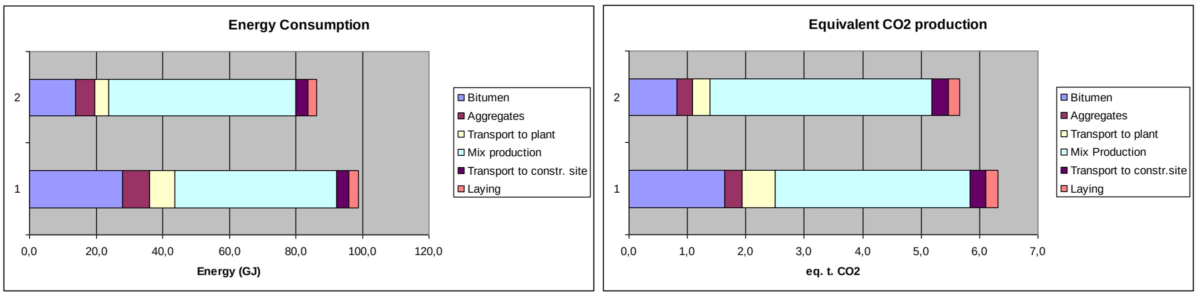

Chart 1 : energy consumption and equivalent CO_2 production for a bituminous base course layer of 6 cm thickness without RAP and with 50% of RAP.
(1 = Mix without RAP, 2 = with 50% of RAP)

6. THE FUTURE

Further steps and consequent research are necessary at the short term. We distinguish following items to be assessed in the near future :

- *The use of better quality RAP.*
  The actual practice shows that some road builders are not giving enough attention to the quality of the RAP they use in new mixes. This phenomenon leads to less confidence at the customer level and as a consequence to restrictions in the use of RAP. The challenge is now to strengthen the RAP quality management to regain this customer confidence. This can be done by :
  - Performing additional operations on the material (breaking, sieving, …)
  - Having a thorough follow-up
  - Product certification by a third party
- *RAP in (half)warm mixes.*
  At this moment some trials already have been done to use RAP in (half)warm mixes and the future looks bright. But one has to wait to see how these kind of mixes will perform at the long term and what will be the best method to produce the half(warm) mix with RAP. It is certainly necessary to do a follow-up of the different construction sites to be sure that the performances of these mixes are at least equal to those of classic mixes.
- *100% recycling*
  The big amounts of RAP on the market and the raising prices of bitumen instigate to use more and more RAP. In that vision, a 100% recycled mix would be very welcome. Thorough research is necessary to see if this is possible, for example by using rejuvenating products for the bitumen. In that same perspective, the question can be asked if would be possible to eternally recycle asphalt. Of course this would greatly contribute to sustainable roads by saving raw materials and energy and reducing CO_2 emissions.
- *Tar problems*
  The presence of tar in old mixes stays a problem. The solution of using tar containing RAP in cold applications is not seen as a sustainable one because this dangerous product stays into our environment and will again give problems when those road structures will have come to their end of life. The question can be asked if it wouldn't be better to follow the Dutch example and burn al the tar containing RAP in an appropriate installation and so remove as much as possible from the environment. This is a decision to be taken by the legislator because no one will invest in this kind of expensive installation unless there is some certainty about the turnover of his investment.

7. CONCLUSIONS.

In this paper we described the evolution of the use of reclaimed asphalt pavement in Belgium. This country actually belongs to the leaders in the world regarding recycling rates of RAP in new asphalt products. The growth in use of RAP was enormous from the early seventies until now.

At low recycling rates (≤ 20%), there are not much technical problems to use RAP. Once we want to reach higher levels of reuse (50% or even more), a good product quality control and management is imperative to guarantee the conformity of production of the new bituminous layer.

The environmental and economic benefits make that it is unthinkable not to reuse RAP in a world where durable development is a major concern.

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