Minimizing CO_2 emissions by maximizing the incorporation of RAP

Maximizing the reuse of reclaimed asphalt pavement at the highest possible added-value level is a ***technical, economic*** and also ***environmental*** challenge. In addition to conserving finite natural resources, this can also significantly reduce CO_2 emissions.

STORIMPEX AsphalTec GmbH and Sasol WAX GmbH have successfully developed an innovative additive called **STORBIT**, which allows the reuse of reclaimed asphalt up to 95 %. **STORBIT** consists of a special regenerated oil and a Fischer-Tropsch wax. The additive can be added in liquid or solid form during the asphalt mixing process. The oil rejuvenates the bitumen of the reclaimed asphalt to a predetermined degree of softness, while the Fischer-Tropsch wax significantly improves the mixability and workability of the asphalt. The improved mixability and workability allows the production temperature to be reduced by up to 30 °C to between around 140 °C and 150 °C. The process even allows the reuse of reclaimed asphalts with a heavily aged binder with a softening point R&B of > 70 °C.

To study the effects of the process on CO_2 emissions in asphalt road construction, STORIMPEX AsphalTec GmbH and SASOL WAX GmbH commissioned the renowned ÖKO-INSTITUT e.V., Institut für angewandte Ökologie in Freiburg, to investigate the following scenarios:

	A	B_{15}	B_{30}	B_{40}	C_{90}
RAP in %	**0**	**15**	**30**	**40**	**90**

In scenarios B_{15} and B_{30}, the reclaimed asphalt is added in the cold state while, in scenarios B_{40} and C_{90}, the reclaimed asphalt is gently heated in a parallel drum.
The following remarks are based on the final report from Öko-Institut. Scenario **B_{40}** was interpolated.

The present study is based on the established life cycle assessment method according to DIN EN ISO 14040:2006 and DIN EN ISO 14044:2006.

A life cycle assessment measures and evaluates the environmental impacts of the products under study, starting from their raw material extraction through transport, production and use to their disposal.

In the present case, the study of CO_2 emissions was confined to the production process as far as the point at which the asphalt mix leaves the asphalt mixing plant, because the production process thereafter, i.e. transport and laying of the mix, is identical for all scenarios.

Germany produces around 45 million tons of asphalt every year. The same period sees an arising of some 15 million tons of reclaimed asphalt, around 11 million tons of which are reused in asphalt production, mainly in asphalt base courses. As the future renewal of asphalt pavements will focus primarily on asphalt surface courses and asphalt binder courses, the proportion of mix for asphalt base courses will fall significantly. Therefore, it becomes all the more important to come up with a method that will allow the reuse of high-grade reclaimed asphalt pavement. According to scenarios A to B_{40}, this may not be possible, as surplus quantities of high-grade milled reclaimed asphalt pavement consequently are being reused in other less beneficial ways, e.g. as gravel substitute. It has been conservatively assumed that 50 % of reclaimed asphalt pavement will find such other form of reuse. This leads to a CO_2 emissions credit for scenarios A to B_{40} (see Table 1).

According to ISO 14040, the purpose of a functional unit is to create a quantified reference on which input and output flows in the life cycle assessment can be based and which can serve as a basis for the comparison of different variants.

For the purposes of the present study, a functional unit has been defined as the renewal of a 4-cm-thick asphalt surface course in Hamburg[1], with 90 % of the existing surface course being reused. The highway in question is a heavily trafficked ***main road of load class BK 10*** with 3.10 million equivalent 10-tonne axle crossings according to RSTO 12. The length is 1 km, the width is 7.5 m, and 721 tons of asphalt surface course AC 11 DS were laid.

Fig. 1 presents a chart of the CO_2 emissions for the five scenarios.

[1] Pollhornweg, port area in Hamburg

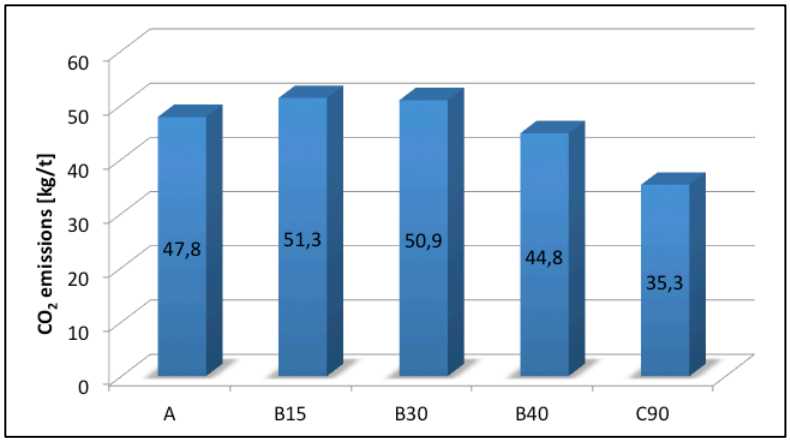

Fig. 1: CO_2 emissions in kg/t of asphalt according to reuse method

In scenarios B_{15} and B_{30}, respectively, 7.2 % and 6.5 % more CO_2 was emitted than in scenario A. This is because, when the asphalt is added in the cold state, the unused minerals need to be heated to a significantly higher temperature, which requires a disproportionately high energy input. In scenarios B_{40} and C_{90}, respectively, there are 6.2 % and 26.2 % savings of CO_2 emissions.
One of the reasons for the high rate of savings in scenario C_{90} is that the RAP needed to be heated to only around 145 °C, because the STORBIT additive was incorporated.

Table 1 presents the emissions contributed to the total life cycle by the individual stages across the entire production process.

	A	B_{15}	B_{30}	B_{40}	C_{90}
		Cold addition		Parallel drum	
	kg CO_2 emissions / t of asphalt				
Raw materials	34.2	30.2	25.9	25.2	11.8
Mix production	19.0	24.8	27.5	20.8	23.4
Credit	-5.4	-3.8	-2.5	-1.2	0.0
Total kg CO_2	47.8	51.3	50.9	44.8	35.3

Table 1: CO_2 emissions by origin in kg/t of asphalt

It is striking that, in scenario C_{90}, production of the asphalt mix makes a bigger contribution to CO_2 emissions than in scenario A. This is attributable to the fact that it was conservatively assumed by ÖKO-Institut that the collection point for the RAP was 50 km away from the mixing plant. As the collection point is normally directly at or in the immediate vicinity of the mixing plant, the CO_2 emissions in scenario C_{90} would be reduced by around 2.1 kg/t of asphalt and would then be within the range of the other scenarios. Across the total life cycle, the CO_2 emissions would then be reduced by not just 26.2 %, but by 30.5 %.

It is interesting to note the contributions made to CO_2 emissions by the raw material components (see Fig. 2)

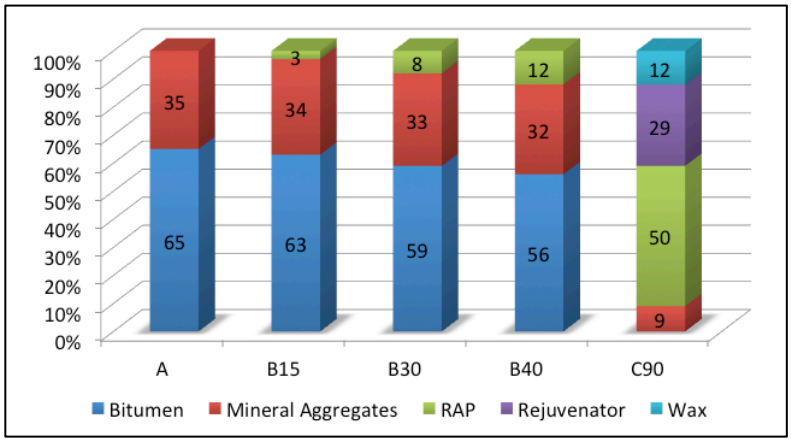

Fig. 2: Contributions of raw material components to CO_2 emissions in %

It is clear from Fig. 2 that bitumen is the biggest contributor to CO_2 emissions.

Besides the environmental issues of the maximum recycling technology the technical aspects of asphalt mixes incorporating a high amount of RAP also need to be taken into consideration. This technology will only become accepted if one achieve both environmental benefits and equal or even superior quality of the resulting asphalt mix compared to conventional types of asphalt. Extended check testing was carried out to survey the deformation resistance and the low temperature performance of asphalt mixes containing a high amount of RAP. The results clearly showed that such mixes fulfill both deformation resistance and low temperature requirements in an extraordinary good way.

It would be beneficial, not only from an environmental perspective, if maximum recycling was made a requirement in the Technical Code and if it was included as a scoring criterion in competitive bidding processes. Innovative authorities, including the *Hamburg Port Authority (HPA)*, have already adopted such an approach. In 2013, the German state of Baden-Württemberg published ***Supplementary Technical Terms of Contract***[2]***,*** which allow a maximum recycling rate of up to 90 % RAP for asphalt base courses and asphalt binder courses and up to 50 % for asphalt concrete surface courses.
The city of Dortmund[3] has amended its public procurement guidelines to the effect that the increased reuse of RAP is scored at 10 % of the bid price for every 20 % of asphalt granulate. It would be desirable for such a public procurement practice to be made an everyday reality across the whole of Germany.

[2] ETV-StB BW, 02.12.2013

[3] Uehlendahl, Zeiler: Hochwertige Wiederverwertung von Asphaltgranulat in der Stadt Dortmund, Straße und Autobahn, 10/2012