Industry Statement on the recycling of asphalt mixes and use of waste of asphalt pavements.
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"Asphalt 100% recycling"
Industry Statement on the recycling of asphalt mixes and use of waste of asphalt pavements

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**General statement on the recycling of asphalt mixes and use of waste**

EAPA as a responsible industry organisation taking into consideration the current trends towards:

- sustainable development;
- minimizing environmental impact;
- optimising the use of natural resources;
- increased restrictions on the dumping of reusable material, possibly leading to a ban on their disposal into landfills;
- potential economic incentives to encourage the recycling and/or re-use of material.

Remotes increased recycling of asphalt mixes and constructive evaluations of the suitability of, alternative sources of recyclable material into asphalt mixes.

These materials must be combined with technical innovation and enhanced quality management systems in order to generate a product that retains the potential for 100% re-usability.

The European asphalt industry is environmentally conscious and feels responsible for its product during its whole lifetime. EAPA therefore strongly supports, where economically and technically feasible, all efforts to optimise the recycling and re-use of asphalt. In addition EAPA holds the position on so-called "Construction and Demolition Waste", that it is a potentially re-usable/recyclable product, and therefore should not automatically be defined as a waste, where doing so would restrict or prevent its subsequent use as a secondary material.

Further information is given in the "EAPA Environmental guidelines on Best Available Techniques (BAT) for the production of asphalt mixes".

Whilst pursuing the above objectives the asphalt industry encourages continuous improvements in the workplace health and safety and promotes the reduction of the overall impact on the natural environment.

These principles will determine whether in addition to reclaimed asphalt, by-products from other sources can also be incorporated into new asphalt.

The suitability for inclusion will be determined by technical performance, possible future recycling, and economical assessment, along with potential environmental, health and safety constraints for both construction workers and road users and/or the general public.

Today, asphalt mixes are made with bitumen but, in the past, coal tar and other tar distillates were in great use, which has left the troublesome legacy of high PAH content in some asphalt pavement mixes considered for recycling and/or re-use. In some countries coal tars coming from brown coal (pit coal) were used and this type of coal tar has a relatively low PAH content, but a relatively high phenol content. EAPA strongly supports the European drive to identify such mixes, in order to reject them from the hot recycling/hot re-use material streams.
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1. Background

The Commission of the European Union established, in 1993, a working group on Construction and Demolition waste. This waste has been identified as a priority waste stream, because of its quantity and potential to include hazardous components. The group, in which the Commission participated as well as representatives from national governments, industry, consumers, research institutes etc., was to advise on a European strategy and implementation plan on how to significantly reduce the quantities of construction and demolition waste to be dumped.

The asphalt industry has already built up an important record in recycling old asphalt and in using several other waste materials as a secondary raw material into new asphalt. In doing so, the industry has gained experience on the limitations that exist and has also expressed on several occasions that "asphalt should never be seen as a country landfill in solving the problems of other industries, or waste generators".

This position paper has been developed, to positively contribute to the discussion on the possibilities, and limitations of increased recycling of asphalt mixes and use of waste in asphalt pavements.

Since the first publication in 1995, this document has been updated in 2003 to take into consideration the latest trends in recycling/re-use for and into asphalt mixes, as well as the more recent European regulations on waste, particularly:

- Waste classification which labels differently asphalt waste from tar containing asphalt waste. (European Waste Catalogue)
- Working Document of the Commission services on landfill of waste in which it is stated that bituminous mixtures considered as inert waste may include no more that 25 mg/kg PAH. (“Criteria and procedures for the acceptance of waste at landfills”, Committee for the adaptation to scientific and technical progress of EC-legislation on waste, March 2002)

This paper may also contribute to determining an overall European strategy document on construction and demolition waste.
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2. Description of the asphalt industry

EAPA
The European Asphalt Pavement Association (EAPA) is the European industry organisation representing manufacturers of bituminous mixes and companies engaged in asphalt road construction and maintenance. There are 3 types of members:

- Ordinary Members (National Associations)
- Associated Members (Companies and Associations outside of Europe)
- Observers

At this moment the ordinary members (national industry associations) originate from 19 European countries: Czech Republic, Denmark, Estonia, Finland, France, Germany, Hungary, Ireland, Italy, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Sweden, Turkey and United Kingdom.

The associate members are located in Austria, Germany, Russia, the USA, Australia, Canada, Japan and South Africa.
The EAPA Observers are Belgium and Switzerland.

The Asphalt Industry
In Europe, approximately 300 million tonnes of hot mix asphalt was produced in 2001. Table 1 (Annex E) indicates a breakdown per country. Since 1973 this figure has been decreasing but seems to have arrived at a more or less stable level, because of the volume of the maintenance works related to road construction. Today 90% of the roads in Europe are made of asphalt material.

Asphalt is a mixture of aggregates, sand, filler, the bitumen binder and occasionally a number of additives.

Along the years the asphalt mix has become a highly technical product, using strictly specified materials under rigorous quality assurance programmes; for instance the tolerance for the aggregates are often less than 5% for the shape, size, hardness, wear index, etc., while the variety of mix types is itself almost limitless: depending on its position in the road structure (base or wearing course, for example), on its particular function (intensity of traffic, anti-skid properties, noise reduction, etc.), on climatic conditions (from freezing to high temperatures) and on the nature of raw materials locally available (limestone or granite quarries, types of bitumen etc.)

In an increasing number of countries reclaimed asphalt and/or demolition waste is recycled to replace virgin aggregates and part of the binder.

In Europe there are at the moment approximately 4,500 mixing plants (see annex F). The production rate of these installations may vary between 25 and 800 tonnes per hour.
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Production takes place in a fixed or mobile mixing plant. There are two main production processes namely in batch plants and in continuous mixing or drum mixers. In addition to the different types of plant for hot mixed materials, there are also cold mixes, emulsions slurries, oil gravel and hot and cold in-situ recycled mixes.

Raw materials may be transported over long distances. The finished product however is normally applied within 30-50 km of the mixing plant. Distances up to 100 km may exist however.

In the last decades, the re-use and recycling of reclaimed asphalt has become more widespread. A distinction should be made between recycling and re-use.

- Recycling means adding the reclaimed asphalt to new asphalt mixes, with the aggregates and the old bitumen performing the same function as in their original application.

- Re-use means the utilisation of reclaimed asphalt as foundation, fill or base course material, with the recovered aggregate and bitumen performing a lesser function than in the original application.

A potential complicating factor in the recycling process may be the presence of contaminants such as tar, whose higher concentrations of PAH's and/or phenol content led to its use being abandoned. Although it ceased to be used as a binder many years ago, in some areas it may still be encountered in various proportions when old pavements are recycled.

In (hot) recycling, due recognition must be made of the amount of tar and other tar distillates present and appropriate process measures must be taken.

When tar or other tar distillates are present in reclaimed asphalt, the use of hot recycling is restricted. In some countries, it is allowed to rely on cold techniques with or without binder (emulsion, foam bitumen and/or hydraulic binders) in road base applications.

In case of recycling, screening and crushing of the reclaimed asphalt will be needed and special storage facilities at the hot mixing plant may be necessary; furthermore modifications to the hot mixing plant are needed if quantities of more than approximately 10% of old asphalt are to be added to the mixing process.

Modern plants are engineered to facilitate the addition of reclaimed material.

The maximum amount of recycling is determined by the mixing equipment but also by certain parameters related to the old asphalt like consistency of material, moisture content, etc.

In some cases, the location of a given project however does not make it feasible to return reclaimable material to a plant for recycling. In such instances there are both hot and cold processes available that allow the asphalt pavements to be recycled in-situ or beneficially reused instead.
3. The recycling of asphalt mixes

If reclaimed asphalt is recovered and free of contamination, it can be guaranteed that the total amount of this reclaimed asphalt can be reused as construction material. It should be the obligation of the owner of the asphalt to be reclaimed to certify the absence of contamination, before it is offered to the asphalt industry for processing; this is the normal procedure for any waste stream, as the characterization is the holder’s/generator’s responsibility. The potential of contamination will then determine the possible level and method of recycling or re-use.

The industry strongly supports all efforts to increase the percentages of reclaimed asphalt into new hot mix asphalt. It is the aim of the industry to reuse reclaimed asphalt at the highest possible level. This is economically (because of the reuse of the bitumen as well as the aggregates) and environmentally desirable.

If the amount of reclaimed asphalt is so high, that it is not possible to reuse it in another way, it is necessary to have the option to utilize it as a secondary raw material in other fields of construction.

Standards and tender documents should be more often formulated in performance terms so as to make the application of secondary raw materials possible on an equal basis with primary raw materials. The owner should take all necessary steps to implement recovery-oriented separation of reclaimed asphalt.

The industry could recycle a greater amount of reclaimed asphalt providing a stronger support from the authorities and the engineering community to adapt asphalt specifications and pavement design to the progress of recycling techniques and available production capacity.

Rather than quotas and mandated minimum quantities requirements, the amount of potential recycling should be steered by general market forces, once adapted specifications and tender documents provide a “plane level playing field” for secondary materials. In this respect, geographical availability of reclaimed asphalt and technical practicalities should be considered.

The industry prefers to give priority to increasing the use of reclaimed asphalt rather than actively pursuing the opportunity to incorporate other secondary materials (from other industries) into asphalt.

For its part, the industry has developed the necessary technical knowledge for a successful recycling, with strict guidelines on the nature of the reclaimed material (size distribution, bituminous content, filler content, bitumen viscosity or hardness etc.)
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4. The case of old pavements containing tar

There is a general confusion between tar and bitumen. The two products however are quite different: tar is the result of the distillation of coal, while bitumen is the result of the distillation of crude oil.

Tar was used predominantly in the past, while only bitumen is now used for asphalt mixes in Europe. One of the reasons for abandoning tar, despite its good technical performances, was its impact on human health due to its high contents in carcinogenic PAHs (Polycyclic Aromatic Hydrocarbons) and/or phenol. Other tar distillates (lighter oils) have also been used as additives and have been improved continuously in order to keep up with stricter regulations on PAHs content.

In case of asphalt containing tar, the waste is considered hazardous and the hot recycling is not allowed. If a reclaimed asphalt contains more PAH’s and/or phenol than a certain limit value, it is considered as “asphalt containing tar”. In some countries it is allowed to rely on cold techniques with or without binders (emulsion, foam bitumen, and or hydraulic binders).

The definition of ‘asphalt containing tar’ can differ from country to country because there are different limits in several European countries. These limits are mentioned in the national legislation. Beside that there is a definition in the EURAL waste list: Reclaimed Asphalt containing more than 0,1 % coal tar should be regarded as hazardous waste.

The Working Document of the Commission services on landfill of waste states that bituminous mixtures considered as inert waste may include no more that 25 mg/kg PAH. (“Criteria and procedures for the acceptance of waste at landfills”, Committee for the adaptation to scientific and technical progress of EC-legislation on waste, March 2002

For the identification of the possible presence of tar before the recycling/re-use of reclaimed asphalt, a number of best practices are recommended:

- Identify the history of the construction of the road section considered for excavation or milling. It is the responsibility of the road owner to provide the information, as per the general responsibility of any potential generator of polluted material. Usually this research will provide a very useful insight on the probability of finding tar on a particular project.
- Before beginning the project develop a two-tier testing plan relying on a few complete laboratory tests supplemented by semi-quantitative field methods.
- The semi-quantitative methods available in Europe are usually reliable at thresholds that are sufficient to identify tar containing layers in pavements that register in the 10s of thousands mg/kg PAH.

Annex H provides more details on the process to detect the possible presence of tar in existing pavements.
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5. The use of waste in asphalt pavements

Along with the incorporation of reclaimed asphalt into new asphalt, the European asphalt industry is equally careful about the use of waste from other industries, of which it has not the same intimate knowledge.

Examples of waste materials that have been used in asphalt mixtures are shown in appendix G.

Waste, which is offered to the asphalt industry, should only be incorporated in asphalt mixtures if:

- There are no disadvantages with respect to health and safety of workers and the general public as well as other environmental impacts, now and in the future.
- There are no environmental impacts, now or in the future.
- The future recyclability and reuse of asphalt is not endangered.
- There is no negative impact on the technical product performance of asphalt.
- It can be used without affecting the competitive position of asphalt.

In the past, the inclusion of various additives, products or waste into asphalt, has sometimes led to difficulties with the recyclability and/or environmental impact of such modified asphalt mixtures. In order to have a better control on this issue, the industry supports the systematic use of the product safety and environmental data sheet, supplied by the suppliers and generators of such additives or substitute materials.

The industry has developed a successful track record in mixing waste/residual material with new raw materials, such as bitumen itself, steel furnace slag, crumb rubber, power plant fly ash etc.
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Annex – state of the art in recycling & re-use

1. General introduction

The recycling of road materials has been practiced for over a hundred years. In this time, a range of techniques has been developed to provide an economically and environmentally suitable method for every type of project and location.

The recycling processes can be divided into two major methods: hot or cold techniques. These can be further sub-divided into central plant or in-situ recycling. Central plant recycling (or “Off-site recycling”) consists in removing the material from the site to a plant located elsewhere which recycles the reclaimed asphalt in order to re-use it either on the original project or on other projects. In-situ recycling allows the reclaimed material to be incorporated directly back into the new asphalt pavement under construction or maintenance.

The choice of process will depend on several factors:

- the proximity of a suitable recycling plant,
- the nature, quantity and quality of the reclaimed asphalt,
- the amount and type of possible contaminants within the reclaimed material
- the programmed duration of construction
- the availability of space for interim storage of reclaimed asphalt prior to recycling
- and the engineering performance required from the new pavement… etc.

For all options, it is important to be able to determine the consistency of the source of reclaimed asphalt. To achieve the highest levels of recycling it is necessary to either confirm the lack of variability in the feedstock or to have precise data on its range of properties.

2. Hot mix recycling technologies in a Stationary plant

Asphalt batch mixing plants designed for recycling

The recycling techniques include "cold" and "hot" methods. For all methods the broken up material must be crushed and screened into correct sizes before further processing. Cold milling of asphalt pavements leads to material (RAP) that can be used in the recycling process without further processing (crushing).

"Cold" methods refer to the addition of the reclaimed asphalt pavement (RAP) either at the discharge of the dryer into the hot elevator, or in the aggregates weighing scale, in these cases, the material is heated by the virgin aggregates before entering the pug mill (see figure 1) or directly into the pug mill. Here, the appropriate amount of new bitumen is added to the mixture according to desired end properties. It is important to avoid super heating of the added RAP. "Cold" methods imply recycling percentages of 10-40%, depending on the RAP moisture content the type of the plant’s vapour extraction system, the RAP quality in relation to the required specification the new hot mix and the technical process limitations regarding maximum permitted temperatures.
Employing the hot method means that the RAP is directly preheated (see figure 2). This method relies on an extra dryer (tandem TM drum). The RAP is metered, heated and dried in the second drum and transferred via a buffer silo to the mixer.
Virgin aggregates are superheated in the first drum and conveyed to the pug mill mixer in the “cold” method above. The hot gases from the recycling drum are either directed to the first drum as secondary air near the burner or to the baghouse. Recycling percentages for the hot method are typically 30-80%, the upper limit being determined by the quality requirements of the mix specification in relation to the properties of the old asphalt.

For the continuous production of larger quantities of RAP-containing asphalt, the RAP percentages at the heating and mixing stages have to be kept in balance.

**Figure 3**

Another variation on warm recycling is feeding the RAP into the dryer via a recycling ring (see figure 3). In this variation the virgin aggregates and the RAP are introduced in the same drum but in two different places. The heating of the RAP takes place behind the flame, ensuring that it does not overheat. This method allows up to 35% recycling.

It is possible to use a recycling ring in combination with a rotary drum dryer as shown in figure 1. In that case recycling up to 50% is possible.
3. **Asphalt Drum mixing plants designed for recycling**

Many recycling techniques have been developed throughout the years. This presentation mentions only the most successful ones. In a drum mixer, both the heating (and drying of aggregates) and the mixing (of aggregates, filler and bitumen) take place inside the drum.

Basically it is possible to identify three different methods of heating recycled material before the bitumen is added: depending on the type of drum mixing: parallel flow, counter flow or Double Barrel™.

The most common design for drum mixers today (parallel flow) uses both the direct flame heating and superheated aggregates principles. In so-called split feed drum mixers the processed reclaimed asphalt is introduced at about the midpoint (“RAP ring”) of the parallel flow drum (see figure 4): both the superheated virgin aggregates and the hot burner gases heat the bituminous material.

**Figure 4**

![Drum Mixer Plant (RAP)](image)

Another method is the counterflow mixer. Counterflow mixers differ from traditional parallel flow plants in that the flow of hot burner gases and aggregates occur in opposite direction (see figure 5). Technically the counterflow principle enables a reduction of the exit gas temperature, and an improved environmental performance through less heating of the recycled asphalt.
Virgin aggregates are introduced at one end of the drum (opposite burner) and RAP is introduced into the drum about midway (“RAP ring”). The burner nozzle is extended so long into the drum that preheating of recycled material takes place behind the flame before entering the mixing zone. Consequently bitumen and recycled material are never in direct contact with the flame and heated gases. Under optimal conditions this process allows up to 50% recycling.

**Figure 5**

**Double Barrel™ plant:** figure 6 shows a Double Barrel™ drum mixer. The system consists of an ordinary revolving counterflow drum surrounded by a fixed outer drum. Recycled material is introduced in the outer shell outside the hot gas stream. The virgin material is dried and superheated in the inner drum. It then enters the outer drum by falling through openings in the inner drum. Virgin aggregates then travel in opposite direction to be mixed with injected bitumen and recycled material.

Mixing thus takes place in the space between the two drums through blending flights mounted on the exterior shell of the inner drum.

Other techniques of indirect flame heating principally comprise arrangements with heat exchanger tubes preventing the mixture of reclaimed asphalt and virgin aggregate from coming into direct contact with the flame.
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4. **Hot mix technology in in-situ recycling**

The techniques are all similar in concept and require the use of special sets of equipment which have several brand or patent names, among them are Road train, Reshape, Repave and Remix (see figure 7).

The specialised nature of the plants and the size of economically viable contracts has widely limited their use widely throughout the European Union, however they are an important maintenance tool, where successfully established.

They all involve the part removal or scarification of the existing pavement to a controlled depth: then they heat and mix the RAP, to which bitumen and/or virgin aggregates can be added, before laying back the reclaimed mixture.

Among their advantages there is the reduction in RAP transportation to an off-site recycling facility and the rapid re-opening of a new road surface with improved riding qualities to traffic.
5. **Cold mix recycling technologies in a stationary plant**

The cold mix technology in an off-site central plant is a recent development that had been successfully used for several years already.

Reclaimed asphalt is returned to off-site plants with the same controlled crushing and screening process as for hot mix recycling, so as to produce a consistent feedstock the similar requirements of the feedstock for hot and cold mix plants make it feasible to operate both processes on the same location.

Two types of binder, foamed bitumen and bitumen emulsion, have been used combined with the recycled asphalt in a pug-mill. The methods are both able to accommodate over 90% of recycled asphalt producing materials at a low energy cost with an appropriate design life.

The final engineering properties may in some cases be inferior to that of hot mix, but in others cases when using end-product specifications can be at least equal.

The smaller number of components and less complex nature of cold mix plants has led to their successful adoption when needed in remote locations for short-term reconstruction programs.

6. **Cold mix technologies in In-situ recycling**

The same two techniques that have been successfully adapted for off-site plant recycling were originally developed for in-situ recycling using specialised plants.

The bitumen emulsion based system involves the scarification bitumen emulsion mixing and compaction of RAP before overlay with a new wearing course. The foamed bitumen process requires the use of an improved milling machine, which pulverises the existing pavement in a hood that also acts as a chamber in which the bitumen is foamed and mixing takes place. The recycled pavement is then spread ready for compaction and the application of a new running surface (fig. 8 and 9).
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The processes both allow for the rapid reconstruction of existing pavement and a significant reduction in the quantity of material removal from the site for reprocessing elsewhere. Some current internationally coordinated research projects are aiming for further improvement of this technology.

In some areas and particularly the Nordic countries, the oil gravel process is used to reconstruct in-situ pavements in remote locations where plants are not available either for hot mix production or cold mix recycling.

**Figure 8**

**Cold-mix Recycling Without Paving Screed**

**Figure 9**

**Cold-mix Recycling With Paving Screed**
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7. Total Production of Hot Mix Asphalt in Europe

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8. Actual use of reclaimed asphalt in asphalt (2001)

Recycling

<table>
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<tr>
<th>Country</th>
<th>available materials (x 1.000 tonnes)</th>
<th>% actually used in warm recycling</th>
<th>% of the new production which contains reclaimed material</th>
<th>Total HMA (in 10^6 tonnes)</th>
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Figures are in millions of tonnes for 2001.
Industry Statement on the recycling of asphalt mixes and use of waste of asphalt pavements

9. **Number of production sites and number fit for warm recycling**

<table>
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<tr>
<th>Country</th>
<th>Stationary plants</th>
<th>Mobile plants</th>
<th>Number fit for warm recycling</th>
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</table>

Figures are for 2001
Industry Statement on the recycling of asphalt mixes and use of waste of asphalt pavements

10. **Actual use of other by-products in asphalt**

At this stage the Asphalt industry has build up an extensive experience with the incorporation of a variety of by-products in asphalt.

Examples of waste materials that have been used in asphalt mixtures are among others:

- Rubber from old tyres
- Glass Blast furnace slag
- Steel slag
- Phosphor slag
- Bottom ash from incineration of municipal waste
- Shingles
- Fly ashes from coal powered electricity plants
- Crushed bricks and/or concrete
- Foundry sand
- Plastics (from electrical wiring)
- …etc.

Inclusion of these products can be successful only after full investigation of their sources and properties and is generally feasible at low levels of incorporation, with continuous checks of the road final performance.
Industry Statement on the recycling of asphalt mixes and use of waste of asphalt pavements

11. Tar detecting process

Historical research. Was coal tar used or not?

- No for sure
  - No further action
    - Suitable for hot mix recycling
  - No tar above threshold

- Yes, Maybe Not sure
  - Sampling and full laboratory testing
    - Yes, tar is present above threshold
      - Identify the tar-containing layer of pavement involved
      - Define a sorting/milling plan for the project relying on control by on-site semi-quantitative methods.

Note: Coal tar also includes ‘Other tar distillates’.

- Contaminated fractions directed to approved landfills or cold beneficial re-use or treatment facilities removing the tar from the RAP.
- Non-contaminated fractions: material is OK for hot recycling.