

# Asphalt the 100% recyclable construction product

## EAPA Position paper



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Contents	Page
1. Introduction	4
2. What is Asphalt / how is asphalt made?	5
3. Why do roads need repairing?	6
4. What are the asphalt options for road repair?	7
5. How is asphalt <i>material</i> recycled?	9
5.1 <i>Ex situ: (recycling materials)</i>	9
5.2 <i>In situ (recycling roads)</i>	11
6. As good as new	13
7. How is recycling covered in European Standards?	14
8. Asphalt should never be waste to landfill	16
9. Make it last as long as possible (lifecycle and Durability)	17
10. There are big Carbon savings from recycling	18
11. Asphalt and asphalt recycling does not harm the environment	19
12. Make the best use of what we already have. The long term strategy for preserving the asset	20
13. Conclusion	21

## 1. Introduction

Roads are a vital part of modern life which most people take for granted. When we leave our home we need roads to go to work, to the shops, to school, to the cinema or to go on holiday. The goods and services we need are transported by road for at least part if not all of their journeys. In an emergency we rely on roads for the fire service, the ambulance and the police.

The European road network has been developed over centuries, with the majority of the roads having been constructed over the last 100 years, and is the Community's most valuable asset, with an estimated value of around 16 trillion Euros. Progressively road asset management is switching from new construction to maintenance, leading to an essential change approach to resource optimisation.

The dominant road pavement construction material used in the bound layers is asphalt. Around 950 billion tonnes of asphalt is currently incorporated in the European road network. Asphalt is the road construction material of choice, due to its comfortable and safe ride, its value for money, speed of installation, flexibility in construction, performance and maintenance combined with excellent durability.

Asphalt has a key further attribute in that it can be 100% recycled without downgrading its functionality, and is currently the most recycled construction material in the world.

Many other construction materials can claim recyclability but this often involves downgrading, for example as lower grade aggregate.

Most asphalt planings are already recycled and there is a proven track record of performance. There is, however scope to further widen the use of recycling to ensure that this resource and materials are fully valued and the embodied carbon within them is not wasted.

This report is intended to improve understanding of the recycling potential of asphalt and to encourage a more holistic approach to the maintenance of our road asset making use of the asphalt already in place in a planned, progressive structural maintenance system to keep the network sustainable for future generations.

## 2. What is Asphalt / how is asphalt made?

Asphalt used as a pavement material is a mixture of mineral aggregate and fines cohesively bound with bituminous binders, with a binder content typically ranging from 3-7% by weight depending on the mix and application.

Aggregates used for asphalt mixtures are hard minerals selected for their physical characteristics and size classified for a specific asphalt mix design. They may be of natural origin such as crushed rock, gravel, and sand or artificial, such as blast furnace slag.

Bitumens are viscous hydrocarbons derived from refining crude oil. They are produced in different grades with specific engineering and physical properties relating to their viscosity, hardness, or brittleness at a specified temperature. They are sometimes modified with polymers to enhance the performance across a range of in-service temperatures of the asphalt mixes in which they are used.

One key physical attribute of bitumen is that it becomes softer and more fluid when heated and hardens again when it cools (thermoplasticity). Asphalt paving applications are typically carried out at temperatures in the 140°C-160°C range.

Another key attribute is that even at ambient service temperatures, at which bitumen appears to be a solid, it retains some viscous flow and self-healing properties (viscoelasticity) when loaded. This means that asphalt can accommodate a degree of movement by foundations and under traffic with only microscopic but reversible cracking.

Different asphalt mix formulae, blends or “recipes,” are used for the various paving applications. These formulae are engineered to meet the cost and service life objectives of the road owner.

Base mixtures generally provide the stiffer and thickest layers which act as the main load bearing element of a road structure.

Surface courses are used for the thinnest topmost layer and are designed to give the required characteristics for interaction with tyres including grip and skid resistance, evenness and low noise for driver comfort.

Binder courses are used at intermediate thicknesses between the base and surface courses to ensure an even running surface and to deal with load transfer of high traffic stresses.

Mixing of bitumen and mineral aggregates occurs in mixing plants designed to dry the mineral aggregates, proportion the aggregate fractions and fines and mix them with the binder in a heat controlled environment.

The asphalt is transported from the plant to the paving site in covered insulated trucks. Transport distances vary, and are only limited by the need to ensure the appropriate material temperature upon arrival at the paving site for workability for compaction. New technologies seek to extend these delivery and installation timeframes.

Trucks discharge the asphalt mix into a hopper on the paving machine. The material is then conveyed through the paving machine where it is spread across the width of the machine by an auger at the rear, to the screed. As the auger distributes the material along the screed, the paver continues to move forward, so that the screed keeps the paving mat level and smooth.

The asphalt begins cooling rapidly at this stage and must therefore be compacted without delay to the required density and smoothness by rollers following the paver.

### **3. Why do roads need repairing?**

Roads are designed with the understanding that over time there will be some cumulative deformation in, and wear or damage to, the bound asphalt layers in particular the surface course. It will therefore be necessary to periodically rectify these defects at the surface for road user safety. Sometimes the binder layer is replaced as well and very occasionally the lower bound pavement layers are also reconstructed.

In addition, roads are subject to attack from the environment from solar UV rays, oxygen, heat and cold. In particular, water can have seriously damaging effects. The freezing and freeze-thawing of water can rapidly accelerate such damage.

Water effects can be experienced at all levels in the pavement structure. Wet soils and over-saturated granular materials have very poor load bearing capacity. Variations of foundation moisture content can result in seasonal swelling and shrinking. All of these can lead to cracking and failure in the bound layers. It is therefore essential to ensure there is provision of adequate drainage and that this is also maintained as ultimately lack of foundation drainage can result in loss of support for the whole road structure.

If water penetrates into bound materials, between layers, down joints or through cracks, this can result in stripping of the binding agent from the aggregate and degradation to an effectively unbound granular material. If left

unchecked, this can result in total disintegration of the pavement, particularly in winter after a period of freezing.

Bitumen ages slowly over time, and involves a combination of complex chemical and physical processes including ‘evaporation’ of lighter oily components which collectively lead to an observation of hardening of the binder. As it becomes harder and more brittle, it has less adhesion to aggregate and therefore is also more susceptible to damage and with less ability to recover or to resist normal stresses. The level of hardening varies depending on the mixture type (porous asphalt ages more rapidly than dense asphalt for instance) and the position in the asphalt (deep in the pavement or at the surface, exposed to direct sunlight/heat or more mild conditions).

Surface layers can suffer loss of skid resistance through the polishing action of traffic and closing up of surface texture. Deformation from all layers in a pavement will need to be corrected by relaying the surface. It is also important to maintain surface integrity to prevent water penetrating into the lower layers. Where studded tyres are used in winter, there will be a need to regularly replace material abraded from the surface.

Climate change may impact on any of the above mechanisms in the future with more extremes of flooding, storm rainfall, high and low temperatures.

Properly designed and maintained Surface courses can be expected to last for 15-25 years.

Pavement structural layers are usually designed to last for 30 to 40 years. Their condition should regularly be assessed and some significant strengthening or reconstruction anticipated as they approach the end of their design life. Even longer durability can be achieved for “long life pavements” (“perpetual pavements” as they are known in the USA) where the pavement is designed and maintained to only require surface renewal.

Asphalt pavements have an additional flexibility and adaptability in design and construction such that they can be simply overlaid (and /or widened) in order to increase strength and therefore traffic capacity (both volume and load). This may influence the construction and maintenance strategy with a view to extending life and enhancing performance related to availability of funding .

#### **4. What are the asphalt options for road repair?**

A number of possible repair treatments (for all types of pavement materials) are available with asphalt, depending on the nature, size and depth of the defect, as well as the available budget of the road owner / operator. These can be applied as either reactive or preventative treatments, but the principles of their application are the same.

- Patching and filling potholes - small areas of defects.

Potholes are typically 'small' areas (<300mm maximum dimension) and/or shallow (<50mm depth) defects in the surface course of a road, but if left untreated they will expand in both area and depth, often combining with other defects nearby to become more like 'trenches'. Their key characteristic is that they are areas of damage from which existing material has been lost or removed by traffic and/or water, or where the underlying structure has collapsed

Sometimes as a matter of road user safety, potholes are filled temporarily until an effective permanent repair can be put in place. These temporary treatments are carried out using asphalt mixes that have been specially designed to be workable for long periods of time for ease of application and compaction to profile. Full compaction is often not achieved without the action of traffic. The temporary filling of potholes alone will generally not address the underlying cause of the defect and will eventually re-appear, often just 'downstream' from an existing temporarily filled pothole.

Permanent repair of potholes should be carried out as a patch, with the intention of permanently restoring the stability and ride quality of the pavement. Patching includes the repair of discrete areas of defective pavement, but not continuous lengths or full widths. This involves breaking out the material around the pothole, typically by a minimum of 150mm beyond the edge of the pothole or where defective material is found and to a depth such that the material below is still sound. The excavated area should have saw cut straight edges. All broken or excavated material must be removed from the area and the remaining hole swept clean and dried. All surfaces of the excavated area (including new interlayer faces) should be sprayed or 'painted' with hot bitumens or bitumen emulsions to ensure full bonding between the new and existing materials. Materials equivalent to (or one nominal size smaller) than those excavated in all layers will need to be compacted with equipment suitable to the size of the excavated area and to the same level as adjacent areas.

- Inlay

Inlay treatments are similar to patch repairs, but carried out over a more extensive area, typically in or between wheel tracks but not to the full width of the pavement e.g. one (or part of one) lane of a multiple lane road. These areas are often associated with widespread cracking and/or excessive deformation in the line of the road (rutting) but also across the carriageway and are often associated with utility services or drainage paths or the route of heavy traffic. Inlays should be excavated and reinstated following the same principles as patches, but with the awareness that the material failure may be to a greater depth.



- Planing and resurfacing

Pavements where the surface course and/or all or some of the binder course is to be replaced across its full width are considered to be 'resurfaced'. The most efficient method of removing materials is planing using specialist machinery as it can operate to a greater depth - such machinery can also be employed in excavation for inlays. Excavated areas should be swept, also by larger machinery, and bitumen-based tack or bond coat applied to planed surfaces and exposed upstands e.g. kerbs, before laying new asphalt.

Materials used for inlays and resurfacing should be designed to restore initial properties (as a minimum - "like for like") or to deliver enhanced performance properties necessary for changes in traffic type or volume at the same thickness as the material which has been planed out.

- Overlay

Overlays are applied on top of existing pavement surface courses, where the structural integrity is acceptable but re-profiling is needed to improve riding quality, or restore skidding resistance performance while adding thickness to the pavement to extend life. However, overlays less than 40 mm are generally not considered to add structural strength to the pavement. Special attention needs to be paid to road levels, particularly headroom under bridges and gantries, levels of crash barriers and other road furniture and drainage.

- Full reconstruction

If the pavement is determined to have no residual service life and cannot be repaired, then full reconstruction will be necessary. The new pavement, foundations, drainage and materials will need to be designed to ensure that the new structure will perform adequately into the future. Existing materials should be removed for reuse.

Constituent materials in, and mixture design of, temporary or permanent pothole, patch repair, inlay, overlay or reconstruction materials should be appropriate in order to provide the required pavement performance for the area of application.

## **5. How is asphalt recycled?**

Asphalt materials are almost unique among construction products in that they can be 100% recycled, and in many cases re-used directly back into the application and even the site from which they have been extracted. There are two broad classifications of recycling process: in-situ and ex-situ.

### **5.1 Ex situ: (recycling materials)**

Ex situ processes are employed when asphalt materials are excavated from the road and transported (even short distances) to processing units or plants in order to be used as an ingredient in fresh asphalt mixtures. Excavated materials are variously known as '(recycled) asphalt planings', 'RAP (Reclaimed Asphalt Product)' or 'Site-won asphalt', and when used for addition to new asphalt they are Reclaimed Asphalt (RA). For ex-situ processes In particular, careful assessment of reclaimed asphalt feedstock is necessary in order to ensure it is added in the right proportions to the new materials so as to deliver the necessary performance. This will include careful consideration of the amount and type of binder already present in the reclaimed materials, as well as the mechanical properties of the aggregates. In general, it can be broadly assumed that products reclaimed from roads are suitable for re-use in roads.

Amendments will generally be required to the production process to ensure that the addition of RA can be controlled to deliver final product quality and more care and attention is necessary as the content of added RA is increased, but for low volumes this should be quite routine. The RA is likely to be damp and the inherent binder may cause issues with blinding of screens if RA is heated, and potential release of fume if the RA comes into contact with the plant dryer flame.

#### *Hot ex-situ processes - cold RA addition to (batch) mixer*

The simplest process is to add cold RA directly to the batches of virgin aggregate, binder and filler, but after the aggregates have been dried. To compensate for this, the virgin aggregates for the rest of the mixture will need to be further heated than is necessary just for drying ("super-heating") prior to addition of RA in order to perform the drying and heating of the RA required to ensure proper mixing, particularly with higher rates of addition.

#### *Hot- drum mixer*

Certain types of asphalt plant have drums which carry out the drying and mixing process continuously, rather than separately in batches. In this case, RA can be added directly to the mixing section of the drum which is often shielded or separated from the drying section and flame. Again this will require sufficient heating of aggregates in order to dry and heat the RA.

#### *Hot- twin drum dryer*

Other plants may have a twin drum system, in which the aggregates are dried as normal in the inner drum, while the RA is mixed with dry aggregates, bitumen etc. having been subject (in the outer drum) to radiant heat and hot gases for drying from the inner drum. It is also possible, and may be preferable to pre-dry and heat RA in a separate RA dryer before addition to the virgin aggregate and binder.

It may even be possible to remix 100% RA only by blending single size RA feedstocks, but careful consideration is required to determine the need for additional added binder and/or additives to maintain workability and performance of the final mixture.

One of the prime considerations in successful asphalt mixing is to ensure that the binder evenly coats all the aggregate particles, and therefore the viscosity of the bitumen is critical. Reducing viscosity to make coating easier has generally been achieved by elevating the binder temperature.

In order to reduce overall asphalt mixing temperatures, other technologies have been developed to enable this by reducing the viscosity of the bitumen binder without increasing temperature (Warm Mix Asphalt techniques). This equally reduces the need for super-heating of aggregates when using RA and in many cases can enable higher volumes of RA to be used.

#### *Foaming processes*

Foaming is achieved by carefully adding water and air to hot bitumen, resulting in a rapid but temporary expansion in volume of the bitumen, with an associated reduction in the binder film thickness. This enables the bitumen to coat the aggregates at lower temperatures and as such they do not have to be heated as well as dried.

Other foaming technologies employ the inherent moisture, particularly in the fine aggregate fractions, as the water source for foaming the bitumen.

#### *Emulsion processes*

Reduced temperature mixtures can also be produced using bitumen emulsions - in which bitumen is chemically encapsulated in water - to reduce viscosity. In these mixtures the emulsion of bitumen and water is stable for longer than, for example, bitumen foam but the bond between them needs to be broken to ensure the bitumen coats and bonds the aggregates.

Foaming and emulsion asphalt technologies may additionally benefit from the addition of cement or other hydraulic powders to promote early-life strength through chemical reaction with some of the water in the mixture. Such mixtures may be considered to be hybrid hydraulic-bituminous materials.

#### *Additives*

In some cases, additives are used which release water or other viscosity-reducing agents in the presence of hot bitumen and/or aggregates, and result in a lower overall mixture temperature. Other chemical additives change the affinity between the bitumen and aggregate to promote adhesion.

Ex-situ recycling processes will generally provide a greater level of quality control as these are more likely to take place at fixed plants where Factory

Production Controls are already in place and can routinely monitor, for example, the crushing and screening of RA, assessment of RA feedstocks, and investigation of plants outputs.

## **5.2 *In situ (recycling roads)***

In addition to reusing materials derived from existing roads in new materials, the road itself can be recycled in-situ, thereby reducing the need to remove materials from the site to other locations for processing and inclusion in fresh asphalt. This has the benefit of reducing haulage movements of the materials to be recycled and any that need to be discarded and the associated transport emissions. There are a number of processes which can achieve this, using ‘hot’ and reduced temperature technologies.

### ***“Repave”***

Repave-type processes are characterised by the heating and scarifying of the immediate surface of the road to approximately 20-30mm depth. This thin layer is then reprofiled and any material in excess of that required for the final line and level may be removed. Fresh asphalt material is laid on top of the scarified layer and these are compacted together. The process employs a highly specialised machine, typically of considerable length which may restrict areas on which it can be used. The process will provide a new running surface, primarily to replace a surface which no longer has the required texture or skid resistance properties, but in which the existing surface course material is itself in good condition.

### ***“Remix”***

The Remix process is similar to Repave, the main difference being that the existing in-situ material after heating and scarifying, is completely mixed with an appropriate amount of fresh material inside the machine itself. The newly mixed material is laid directly onto the hot, scarified, level surface by the machine.

The new material that is mixed with the existing material from the road is designed so that the resultant blend will be suitable for the site conditions and comply with the appropriate specification.

### ***“Retread”***

The Retread process is carried out to a greater depth than Repave or Remix, typically around 75mm. The road is cold-scarified and the materials homogenised with fresh aggregate and/or binder in the machine before being relaid to full depth. As this is a cold process, the materials may also require the addition of a bitumen rejuvenator / emulsion in order to enhance the workability before compaction in a relatively thick layer. Retread is likely to be appropriate for in-situ recycling of base or binder course materials prior to being overlaid with fresh surface course. In some cases it may even be possible

to Retread both the surface and binder course together, if specifications and surface characteristic permit it.

*Foamed and emulsion in-situ processes / full-depth recycling*

These processes reconstruct the entire road or haunches to a depth of 150mm to 350mm and involves mixed the existing material in-situ with new binders to form a uniform and strengthened structure.

After initial pulverisation to the required depth, the resultant surface is compacted and trimmed. Any excess material is removed before recombining the bulk of the existing materials with emulsion or foamed bitumen. Often hydraulic binders are also added creating Hydraulically Bound or Cement Bound mixes (HBM and CBM) of 100% RA aggregate, similar to the ex-situ 'hybrid' materials, such that the pavement design may also need to be considered differently, particularly if it is to be heavily trafficked.

During the process the road materials are not removed from the site and the sub-grade is not exposed, thereby reducing the risk of soft spots. Once the re-mixing is complete, the material is again compacted and the surface shaped by a grader to the required levels. Finally the surface is often coated with bituminous emulsion and sealing grit after which it can be subjected to traffic if necessary. Depending on design requirements, a final surface course can be laid appropriate to site conditions.

The key assumption in determining the suitability of in-situ processes is that as the materials in the road have been already determined as appropriate for road construction then there is likely to have been little change in their mechanical performance and can continue to be used in that road.

In-situ processes generally address non-structural or surfacing issues such as the need to re-profile or re-shape a road or return surface characteristics (in combination with new surface course materials) and where there is an existing sound and stable foundation. Full-depth recycling will address structural issues and also permit strengthening.

In some cases cold in-situ processes may be preferred where the existing road materials are or may be contaminated e.g. with road tar or other minerals and chemicals and therefore hot in-situ and/or ex-situ processes are not possible due to waste, environmental legislation and practical constraints.

## **6. As good as new**

The fundamental requirement for producing asphalt materials including recycled content and recycling roads themselves by any of the techniques

mentioned is that the resultant material or road have the same or improved properties compared to virgin asphalt and existing roads. Recycled asphalts can continue to, and increasingly, be re-used (back into the same product or application) at the top of the recycling hierarchy, before being recycled as ingredients in new asphalt. These are certainly preferable to them being “down-cycled” as aggregate or in to other construction materials (although after several re-uses and recycling phases this may eventually be appropriate). In an ideal world, RA would also be “up-cycled” into a higher value or performance application.

It is highly unlikely that aggregates in RA will be significantly affected by ageing in use and reprocessing for reuse, and having been previously used satisfactorily in a road it is more than likely that they will remain satisfactory after recycling activity.

More consideration however, needs to be given to the binder in RA, from its aged hardness (penetration) and viscosity to the volumetric contribution of previously coated aggregates. This is particularly important when considering recycling at high levels of RA addition and/or reduced temperatures as the binder may be “inactive” compared to the softening effects of hot recycling processes and the RA may appear to act as “black rock” during mixing but still has thermoplastic and viscoelastic performance in the final asphalt.

It is of great importance for asphalt producers to understand the nature of RA which they intend to recycle. Road owners and clients therefore have an important role to play in maintaining accurate inventories of their networks in terms of materials in them and where and when they were laid. This can also help identify ‘legacy’ materials but will also assist in making appropriate maintenance treatment decisions.

## **7. How is recycling covered in European Standards?**

As has already been demonstrated, asphalt is 100% recyclable back in to asphalt. For this reason, it was appropriate for asphalt materials intended for re-use by many of the methods above to be classified to a European Standard for inclusion in materials specified under other European Standards. For Reclaimed Asphalt that Standard is part of the family of European Asphalt Standards themselves, namely EN 13108-8.

EN 13108-8 requires producers handling RA materials for inclusion in other materials under EN 13108 to assess the suitability of that material as feedstock into the asphalt mixing plant. This will include the size, shape, particle size distribution, aggregate type, binder content and grade in the RA. In addition, because RA is often associated with mixed sources of construction and demolition waste, it is necessary to determine the level of contamination by

other materials (e.g. uncoated aggregate, soils, concrete, ceramics, plastics, wood etc.). Quality control limits in EN 13108-8 determine which, and the levels to which, contaminants will need to be separated out of the feedstock to ensure best compatibility with the new asphalt. Ideally, all contaminants will be removed before being assessed for suitability as RA.

Provision is made in all the EN 13108 standards to ensure the appropriate quality and performance level of materials produced including RA to EN 13108-8. Aggregates in RA should conform to the aggregates Standard, EN 13043, and bitumen (generally) to EN12591. This is particularly important in the case of asphalt intended for use in surface courses where aggregate properties such as Aggregate Abrasion Value (AAV) and Polished Stone Value (PSV) are vital for safety. For this reason it is currently generally permitted to include higher percentages of RA into base and binder course materials (typically 30%) than in surface courses (typically 10%). These percentages have been exceeded in many applications and will continue to rise, particularly as better records and control of RA feedstock from clients is achieved and mixing technology develops.

The EN 13108 family of Standards include specific procedures for calculation of the amount and grade of fresh binder required for a new asphalt mixture of the correct binder content and grade when RA from known feedstocks is added. The resultant required aggregate additions can also be calculated by simple blending programmes. Properties of mixtures containing RA should also be Type Tested to EN 13108-20, and additional requirements for factory production control of mixtures and feedstock are found in EN 13108-21.

There are a number of practical asphalt recycling issues, often related to binders in RA:

- *Variability of binder in reclaimed asphalt* - which can generally be addressed by homogenising the RA feedstocks (either in screened sizes or as “all-in” RA feedstock).
- *Hardness and level of ‘recovered binder activation’*, in other words how much of the old binder is participating in the new binder instead of just acting as black rock. For lower temperature systems there is generally little to no participation of the old binder, but particularly in hot asphalt a large percentage of the binder will be re-activated during mixing and available as binder, depending on the level of binder ageing. Binder activation is particularly relevant in ensuring workability of new mixtures, but the volumetric contribution also needs to be carefully considered for performance.
- *Compensation for the ageing process in the design of the added virgin binder*. If all the aged binder is considered to be active, then the target binder content and grade can often be achieved simply by blending with softer virgin bitumens. In some cases, the aged binder in RA may be ‘rejuvenated’ with other oils and additives to ensure they have

appropriate viscosity for blending, mixing and compaction as well as delivering appropriate performance of the asphalt.

- *Recyclability of any polymer modifiers.* The most commonly used modifiers like non-crosslinked SBS and EVA can be easily recycled as being thermoplastic they melt upon heating, even after ageing. Although the polymer might have degraded, this can still have a substantial beneficial effect on the asphalt performance. The presence of polymers in RA therefore needs to be carefully considered in the overall mixture design.
- *Recyclability of asphalt with legacy materials,* such as asphalt with Coal Tar or asbestos. While such products are no longer applied, they can still be found in old road pavements and recycling them requires particularly special attention from start to finish from identification and assessment, to planing, transport, storage and mixing. In many cases it is better recommended to leave such products in the ground as disturbing them is likely to lead to more practical issues in trying to reuse them. If they are to be recycled then typically only cold recycling (in-situ and/or ex-situ) should be considered, to minimise any exposure or emissions. Asphalt containing crumb rubber also needs special attention as there may be a tendency to add excess heat to overcome high viscosities during mixing, which could result in potentially dangerous fumes. Road owners have a fundamental Duty of Care in identifying the presence of potential contaminants in roads which they need to maintain, and therefore a key role to play in ensuring that such wastes do not enter the recycling stream.

There may often be additional environmental permitting requirements for asphalt plant operations where recycling operations take place. Responsible producers will be in possession of these and operate to their requirements.

## **8. Asphalt should never be waste to landfill**

As can be seen already, recycled asphalt has an intrinsic value in asphalt operations and where possible this value should be maximised. If, however, all else fails and no reasonable opportunity exists to recycle asphalt back into asphalt, all is not lost! It is also possible to use recovered asphalt in other engineering applications, and this is sometimes known as “Downcycling” as the recycled material does not go back to its original use, but into an alternative less demanding application. [Some people would consider the recycling of surface course asphalt, particularly where it employs high specification aggregates, into a binder or base course application to be downcycling.]

Because recycled asphalt is an aggregate-based product and is classified by EN 13108-8, it can be considered for use as recycled aggregate in other construction products (with or without further processing). These include



Aggregates for Railway Ballast (EN 13450), and Armourstone (EN 13383), but more usually as Aggregates for Unbound Mixtures (EN 13242) such as sub-base and fill materials for civil engineering works or as unbound mixtures themselves (EN 13285). When recycled asphalt is used in other materials, there will naturally be quality limits and requirements in the specifications for the destination material, particularly relating to the retained binder content. Recycled asphalt can even be used as aggregate for concrete (EN 12620) but clearly this does not exploit the inherent value of the bitumen content.

Asphalt planings have been used as a granular aggregate for pathways which will coalesce and bind together in warm weather and while this may be considered as a paved area, it may also be seen as downcycling whereby the full potential of the aggregates and binder are not being realised.

## **9. Make it last as long as possible (lifecycle and durability)**

The best strategy for asphalt roads is simply to prolong their life, preserving the asphalt as long as possible in the road, thereby reducing the need to remove or recycle at all. A pavement preservation or asset management strategy involving simple, timely and cost effective surface treatments to retain the asphalt integrity before later more costly repairs or rebuilds makes economic sense. If a road is properly designed, constructed and maintained and lasts for twice as long, then 100% of the virgin materials which would have been used to reconstruct it have been preserved - this supports the “reduce” element in the recycling hierarchy.

There are various preventative (non-structural) maintenance treatments for asphalt roads, some of which are outlined below.

### *Preservative sprays*

Surface oxidation of bitumen is a key factor in asphalt degradation - oxidised bitumen is more brittle and susceptible to fatigue damage, and particularly so when it is heavily trafficked. Asphalt preservative sprays claim to ‘reseal’ asphalt surfaces by absorption into the top few millimetres of asphalt to prevent and reduce ongoing oxidation of volatiles from the bitumen and provide a membrane to protect from further environmental attack. To be fully effective frequent re-applications are often recommended, typically as soon as possible after initial asphalt installation (and at least when the material is still in good condition) and every 5 to 7 years thereafter. Some sprays also require the application of very fine aggregate in order to retain skid resistance properties.

### *Surface dressing*

Surface Dressing is a long established highway maintenance technique. In simple terms it involves the spray application of a bituminous emulsion binder

onto the existing road surface followed immediately by the even application of aggregate chippings to 'dress' the binder. Surface dressing seeks to seal the road surface against ingress of water, arrest the deterioration of the road surface and underlying road pavement structure and restore the necessary level of skid resistance to the road surface.

#### *Micro & slurry surfacings*

These materials are cold-applied, thin bituminous surface courses incorporating bitumen emulsion and fine graded aggregate with fillers.

Slurry Surfacing is normally a single coat application laid mechanically or manually up to a dried film thickness of 6mm. Slurry surfacings are usually only appropriate for very lightly trafficked areas such as footways and cycleways and micro-surfacings for urban roads and those with relatively low volumes of commercial traffic (< 250 cv/d).

Micro-surfacing incorporates a polymer modified bitumen emulsion and is often a two-coat application and can be laid mechanically or manually to a maximum dried film thickness of 15mm. These materials are usually referred to as Micro-Asphalts. Some Microasphalts have been designed for significantly higher traffic volumes than would be appropriate for slurry surfacings.

#### *Thin surfacing*

Thin asphalt surfacing overlays can also be considered as a preventative treatment, in addition to being a 'generic' construction option. If overlaid at less than 40mm there is not generally considered to be any significant additional structural contribution, but it does give increased scope for re-profiling larger areas of a road and improving road surface evenness.

Preservative treatments are generally applied in the thinnest layer possible in order to enhance cost effectiveness and reduce the need to adjust levels of, for example, gulleys, drainage and utility inspection covers, kerbs, crash barriers and other street furniture and not impinging on the headroom of over-bridges, cables etc.

Regardless of the effectiveness of preventative treatments and planned maintenance, all asphalt pavements have a finite life and a programme of progressive structural renewal will also need to be considered alongside to prolong the lifespan of the road in the long term. This may encapsulate widening or drainage works, partial reconstruction and thickening as necessary for increasing traffic and/or climatic demands. It is also possible to adapt and improve performance of existing upper layers through careful mixture design in order to meet changing pavement requirements, and for which the range of asphalt recycling processes can also make a contribution.

However, in some cases thick asphalt pavements can reach a state of structural equilibrium beyond which they are no longer observed to deteriorate - these are known as “perpetual” or “long-life” pavements. In this case, the only maintenance or performance improvement required will be in the upper layers of surfacing (binder and surface courses) to protect the indeterminate life base and foundation, presuming that adequate drainage etc. are already in place.

## **10. There are big Carbon savings from recycling**

In addition to the reduction of waste argument in favour of asphalt recycling, the contribution of reducing emissions (or “Carbon Footprint”) also needs to be considered. These can be achieved from optimising various parts of the production and installation processes and technologies.

Direct emissions - there is potential to reduce direct burner emissions in comparison to hot mix processes by employing reduced temperature techniques when incorporating recycled asphalt. Estimates and experience to date suggest that these are in the region of 30 to 50% of direct emissions.

Embodied in raw materials - the potential to ‘save’ all of the embodied carbon in the raw materials (aggregate and binder) when they are recycled. This is approximately 40% of the cradle to gate carbon of new asphalt, so 10% inclusion of RA would recover 4%, but 50% RA content would recover 20% of embodied carbon.

Transport - recycling of locally planned asphalt will reduce emissions from imported raw material transport.

Transport - in situ recycling saves even more significant transport carbon emissions.

In use - an even and smooth resurfaced road can reduce the rolling resistance of vehicles, thereby improving vehicle fuel economy and reducing traffic carbon emissions. As little as a 2% improvement in rolling resistance and hence fuel economy could account for all the embodied carbon in an asphalt road construction.

## **11. Asphalt and asphalt recycling does not harm the environment**

Several countries in Europe have Regulations dealing with the potential for release of dangerous substances into groundwater or the atmosphere. Bound asphalt mixtures have been tested as monolithic structures and identified not to leach substances from within its structure. Asphalts are in fact used as linings for landfill facilities to prohibit leaching and bitumen waterproofing

sealants and membranes are used for reservoir liners and dams as well piping in direct contact with drinking water.

The industrial production processes involved in asphalt production are also closely regulated across Europe to prevent excessive emissions to the environment through the burning of fuels and fumes from hot materials. Similarly, occupational exposure limits are in place to protect the health of the workforce and others in close proximity to production facilities and installation operations.

Recycling of asphalt by whatever means is clearly a sustainable approach to 'waste' management, however it must be carried out responsibly with particular respect to the environment in which it is to be applied. Of particular concern is the legacy of tar binders in existing road pavements. Until the mid/late 1980's tar from the coal production process was used as a binder in asphalt mixtures. It was subsequently established that coal tar contains potential carcinogens in the form of Polycyclic Aromatic Hydrocarbons (PAH). In their cold and solid state in pavements they do not represent a threat to human health or the environment. When heated, those PAHs can be reactivated and released with subsequent risk to health and the environment. Materials containing tar must therefore be carefully managed to ensure it does not enter the "hot recycling" stream.

However, asphalt also has a role to play in dealing with the legacy of tar in roads. Asphalt can effectively be used to encapsulate tar-contaminated materials reclaimed from old roads during their maintenance. It is vital that such encapsulation is carried out using cold asphalt recycling techniques, typically employing foamed bitumen or bitumen emulsion technologies, either in-situ or ex-situ at asphalt production facilities. As noted above, when bound into an asphalt mixture, the potential risk of leaching is minimal.

## **12. Make the best use of what we already have. The long term strategy for preserving the asset**

Governments and Road Authorities across Europe have invested in the construction of highways networks and continue to invest in their maintenance. They are often the most valuable asset of a nation and return many times more in economic activity than their construction and maintenance costs. Every tonne of asphalt therefore has not just a financial cost, but an economic value in providing the efficient door to door delivery of goods and services that modern society demands. That investment cost and intrinsic value of road materials needs to be protected and if possible enhanced. Recycling of asphalt provides one opportunity to best recover that historic investment.

Planned progressive structural renewal - based on a 40 year design life a structural renewal/recycling policy of just 3% of the network asset per annum would lead to long term sustainability. Some nations invest less than 1% of the road network asset value in its maintenance, which can only ultimately devalue the asset itself in the long run and result in higher future reconstruction costs.

Asphalt production processes have traditionally involved high temperature combustion of fuels with subsequent 'carbon' emissions. New and improving production technologies can make the combustion process more efficient, thereby reducing emissions. At the same time, material technologies and design can reduce the need for as much heat in the production process generally, also reducing emissions.

Existing asphalt products in the road can be considered to have embodied carbon already in them, and in order to reduce the demand for future emissions, recycling of asphalt preserves the carbon already burnt.

### **13. Conclusion**

The well-appreciated benefits of asphalt and asphalt roads can be replicated time and time again by recycling and re-using this essential construction material. It is uniquely 100% recyclable as itself and with continually developing and innovative technologies the scope for re-use will continue to increase.

Due to its recyclability the asphalt road is a valuable asset and a sound investment for future generations. Recycling of asphalt is proven successful technology, environmentally sound, economical and contributes to conservation of natural resources.

Optimising and maximising the use of recycled asphalt clearly makes sustainable sense in delivering the roads of the 21<sup>st</sup> century and beyond.