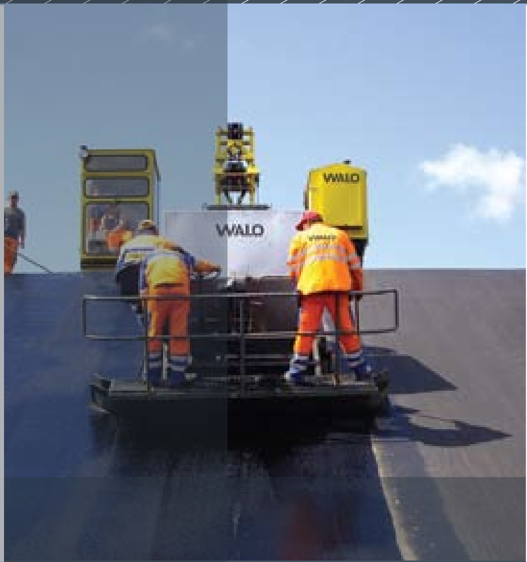


A well established solution to landfill engineering

WALO

WALO UK LIMITED

Contents

WALO UK LIMITED

The main benefits of using a Dense Asphaltic Concrete lining system is that it is strong and very robust, quick to lay yet extensively quality assured, flexible yet extremely impermeable and cost effective when the following points are taken into account:-

- Much less time taken for construction.
- Allowing positive target dates for completion.
- Proven consistency of all materials.
- Extensive Construction Quality Assurance.
- No protective measures required prior to laying the leachate drainage blanket.
- Reduced construction thickness on base and slopes, providing large savings in void space to be used for the waste product.
- Confidence that the surface is completely sealed.
- Environment Agency and Planning Authority approval.
- Completed areas can be left unprotected until required.
- Completed areas can be used by traffic immediately upon completion of the works.

Introduction

Dense Asphaltic Concrete Landfill lining technology at it’s best

Key Points

It is generally accepted that landfills, which receive potentially hazardous wastes in locations where the release of contaminants may have environmentally unacceptable consequences, must be contained.

In selecting and designing a containment system a realistic and pragmatic approach must be adopted which accepts the limitations of current knowledge but reduces the risks to the environment to what is perceived to be an acceptable level.

Landfill operators and designers have to consider ever-changing environmental issues and policies when it comes to designing the type of liner required for a fully contained landfill area.

There are generally four classes of containment or lining systems; Single Liner, Composite Liner, Double Liner and Multiple Liner. The decision as to which system is appropriate must be made on the basis of a risk assessment which considers the nature of the waste to be disposed, the leachability ability of the contaminants within the waste, the vulnerability of ground and surface waters and the ability of the liner itself to minimise risk.

Landfills must be designed to meet the necessary conditions for preventing pollution of soil, groundwater and surface water and this is to be achieved by the combination of a geological barrier and a bottom liner during the operational/active phase. Where the geological barrier does not meet the above conditions it can be completed artificially and reinforced by other means giving equivalent protection.

A Dense Asphaltic Concrete (DAC) lining system is engineered to provide complete containment rather than controlled. Seepage the containment provided by a DAC lining system is engineered to be more effective than any other type of liner, be it Single, Composite or a Multiple System.

A well astablished solution to landfill engineering called Dense Aspualtic Concrete.

Landfill cells of any shape and size can be accommodated using DAC. The tying-in joint to an existing cell is very straight forward and made completely watertight.

FACTORS AFFECTING THE CHOICE OF LINING MATERIALS

The choice of containment system must be based on a risk assessment, one element of which is the ability of the liner itself to minimise the risk of leakage of dangerous contaminants into ground or surface water. It is however, equally important to take into account any physical or logistical constraints which may render a technically acceptable liner impractical. The principal considerations, which should be identified, are listed below:

- Minimal hydraulic conductivity possible*
- Stability on steep slopes
- Sufficient flexibility
- Robustness
- Resistance to chemical attack
- Proven longevity
- Acceptance by regulatory authorities
- Acceptable installation techniques
- Realistic cost

****Note:* The term hydraulic conductivity is used in this brochure as a measure of the rate of flow of water based liquid through substrate assuming a hydraulic head of 3 metres.*

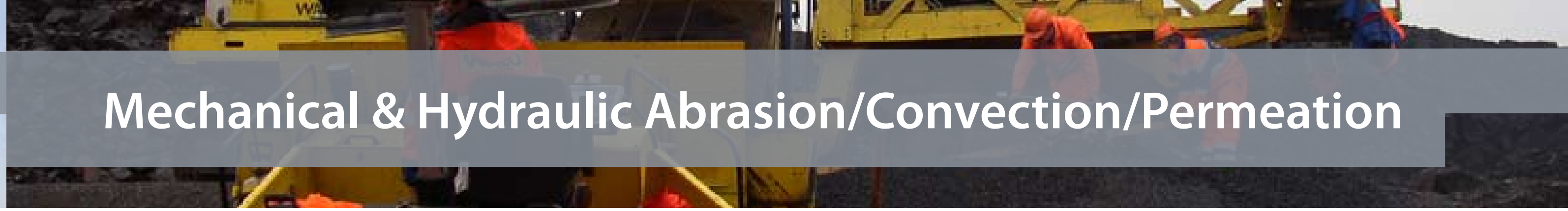
Properties of Dense Asphaltic Concrete

A dense asphaltic concrete lining system comprises of three layers, each of which fulfils specific functions to ensure the integrity of the liner system.

The stabilising/drainage layer (**SL**) is analogous to the subbase of a road. It is constructed from clean compacted, graded aggregate and serves two functions; it prevents the build up of water pressure beneath the liner caused by springs, seepage or the ingress of water around the edge of the liner whilst providing a firm, stable surface on which the equipment required for the construction of subsequent layers can be used. The (SL) is generally placed on a granular sub-grade layer or clay layer which has been compacted up to a stiffness of < 50MN/m² or a CBR of ≥20% (this deformation modulus is required to ensure satisfactory compaction of the subsequent asphaltic materials). When compacted, the stabilising layer is sprayed with a bituminous emulsion, which helps bind together the fines in the upper layers of the material whilst at the same time creating adhesion for the next layer. The asphaltic binder layer (**AB**) is an open textured asphaltic layer specifically designed to have a high permeability factor. This layer provides a strong stable base against which the dense asphaltic layer can be compacted and, by virtue of its permeability, allows any steam generated during the construction of the dense asphaltic layer to escape and so assist in preventing the formation of bubbles forming in the DAC layer. The AB layer is designed to be strong enough to support the DAC layer, the depth of the landfill, the daily cover material and any capping/restoration material without thinning and/or deforming or being forced into the voids of the underlying stabilising layer.

The dense asphaltic concrete layer (**DAC**) is not simply an artificial barrier system, it is a (**Fully Engineered, Specifically Designed Containment Lining System**) which is comprised of an asphaltic mixture with a continuously graded aggregate matrix, laboratory designed for each individual contract so that the quantity and grading of each aggregate fraction fills the gaps left in the matrix formed by larger sizes. The cementitious binding agent is bitumen, which plays an important part in the overall design and construction of the dense asphaltic concrete layer, being the agent that binds the minerals together and adds to the impermeability of the mixed material. Once laid and compacted, the material forms a completely impermeable layer that is resistant to deformation, yet retaining ample flexibility, having a bulk density of approximately 2500 kg/m².

Finally, a fine coat of mastic asphalt is applied to the top surface of the DAC layer. This mastic seal coat provides no additional strength to the liner but is an additional finish layer, providing additional protection against UV exposure and weathering during the period the DAC layer is left open to the elements.



Mechanical & Hydraulic Abrasion/Convection/Permeation

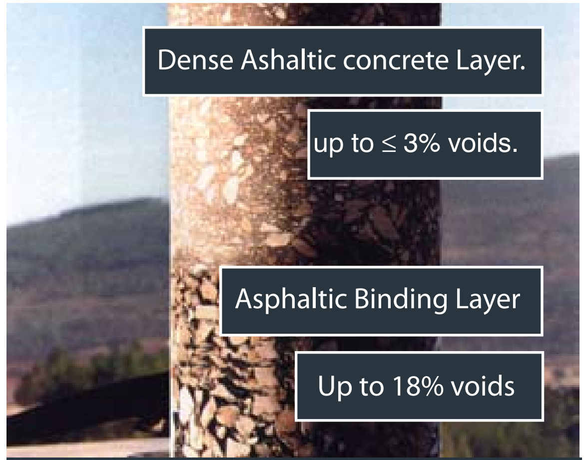
WALO have been lining landfill sites throughout continental Europe since the late 1970's, principally in Switzerland and Germany and more recently in Italy, Spain, Poland and the UK. WALO have laid DAC impermeable linings on more than 100 landfill sites to date with many having very steep side slopes. In the UK, thirteen landfill cells have been lined with DAC, two at a privately owned industrial waste landfill site and eleven at commercially owned municipal solid waste landfill sites. Many more sites are now going through the conditioning, planning and licensing stages to be engineered with DAC in the future.

Long term tests have been carried out on the hydraulic abrasion and resistance to permeability by convection and permeation using hydrocarbon solvents.

The results have proven that solvents such as trichloroethylene and a nine-component-mixture of different hydrocarbons were not able to penetrate into the mortar films of well designed dense asphaltic concrete lining systems used in the construction of landfill sites and it is proven and therefore safe to assume that DAC is durable against chemo-abrasive attacks from aggressive solvents.

Although there is no direct correlation between effective porosity and hydraulic conductivity, hundreds of tests on samples with voids of between 1.5% and 3% have regularly produced hydraulic conductivity initial inflow values of ≤K 1 x 10^{-13} m/s, tested under a 1.0 MPa, ((i.e. 10 bar - equivalent to 100m head of water) or (56lbs/inch²) or (1000kg/m²), with the outflow values showing a K factor of zero, indicating complete impermeability; (this is many orders of magnitude less than the commonly accepted k 1 x 10^{-9}m/s for landfill liners.

Laboratory tests are frequently carried out to determine the density/permeability of the DAC lining system insitu.



Picture of a core showing the difference in grading between the binding layer and the DAC layer.

The example shown in Table 1 (See page 9) are the results on four core samples taken from a DAC lining system constructed at a UK landfill site. The sample tests were undertaken by a UKAS Accredited Laboratory solely for the purposes of verifying the permeability results of the finished product and as part of the CQA requirement under the contract.

Four (DAC) cores of approximately 95mm diameter x 50mm depth were tested. Each core was given a unique laboratory sample number for identification purposes. The material testing laboratory were requested to undertake water permeability testing of the four DAC cores.

Test Method

The samples were tested in accordance with the method given in EN 12697-8; Methods of test for the determination of density and compaction.

Sample Preparation

Each core was cleaned with a dry, soft nylon brush. The test specimen was then sealed at the edges by placing in a circular stainless steel mould and filling the annular space with cold curing epoxy resin. When the resin had cured, the specimens were demoulded and conditioned at 23 ± 2°C in ambient laboratory humidity for approximately 24 hours. The water permeability determination was then commenced using the test apparatus as shown in Figure 1on page 10.

Water Permeability Coefficient Determination

A water pressure regime was applied to the test surface (top rolled surface) as outlined in Table 2. During the pressure regime, observations for water on the exposed surface were made. These observations are also shown in Table 2. Within this pressure regime, if water appeared on the exposure face, the flow was measured. If no water was observed on the exposed surface by the end of the pressure regime period each specimen was removed from the test apparatus, weighed and split longitudinally to measure the depth of water penetration.

Water Permeability Results - Table 1

* Due to no flow of water recorded through the specimens, the water permeability was calculated using Valenta's modified calculation

Client Ref	Units	05-4034	05-4034	05-4034	05-4034
Lab Ref		142891	142891	142891	142891
Date Test Started		21.07.05	21.07.05	27.07.05	27.07.05
Date Test Finished		28.07.05	01.08.05	04.08.05	04.08.05
Diameter of Core	(mm)	100	100	94	94
Depth of Core	(cm)	4.98	5.00	4.83	4.83
As Received Density	(Mg/m*)	2.2382	2.382	2.387	2.387
Maximum Pressure	(Bar)	5	10	5	5
Surface Area	(cm*)	68.96	69.40	69.99	69.84
Penetration Depth	(cm)	<0.01	<0.01	<0.01	<0.01
Void Content	(%)	2.15	1.83	2.86	2.86
Test Period	(hours)	120	96	120	120
Water Permeability					
Based on penetration	Valenta's (m/s)	9.98E-18	2.65E-18	1.65E-18	1.66E-18
Based on flow *	Darcy's (m/s)	-	-	-	-

The water permeability coefficient based on the measured flow rate, (or in this testing procedure - depth of penetration), was then calculated. Due to the impermeable nature of the material, (i.e. no water was seen to flow through the samples); Darcy's method of water permeability calculation can not be used. Therefore the water permeability calculation using Valenta's modified formula method based upon water penetration, is used - (i.e. no water penetration shown indicating complete impermeability). Seepage through most types of landfill liners is normally calculated using Darcy's Law which states *"Flow rate through porous media is proportional to the head loss and inversely proportional to the length of the flow path"*. Darcy's work was however carried out in the 1850's. The structure of a DAC lining system is such that it is designed to have apparent negligible total porosity and no effective porosity. The design grading of the aggregate and filler alone, without the binding agent, can reduce effective porosity and hydraulic conductivity to very low levels (≤1 x 10^{-8} m/s), and the covering of the aggregate with bitumen (which is a material effectively impermeable) and the filling by the same material of the interstitial voids creates a very flexible and an effectively nonporous material. Total air voids are normally specified in DAC at ≤ 3%, and in practice figures well below 3% are commonly achieved.

Permeability Test Apparatus - Figure 1

Observations made during pressure regime - Table 2

Pressure (bar)	Time (hours)	05-4015 142866	05-4016 142867	05-4033 142890	05-4034 142891
1	12	No water penetration	No water penetration	No water penetration	No water penetration
2	12	No water penetration	No water penetration	No water penetration	No water penetration
3	12	No water penetration	No water penetration	No water penetration	No water penetration
4	24	No water penetration	No water penetration	No water penetration	No water penetration
5	120	No water penetration	No water penetration	No water penetration	No water penetration
10	96	N/A	No water penetration	N/A	N/A

Darcy's Law cannot apply in terms of substances as impermeable as Dense Asphaltic Concrete.

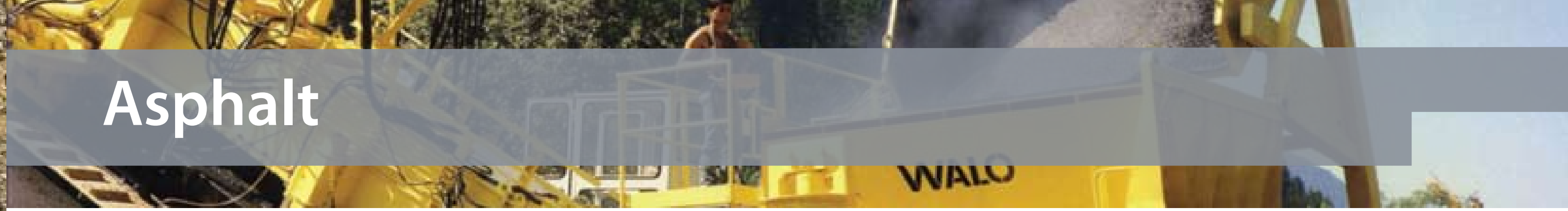
In reality, most materials contain interstitial spaces on a molecular level through which smaller molecules of certain chemical species could diffuse. The permeant migrates through the material on a molecular basis by activated diffusion and not as a liquid which can flow through the pores of soils and carry dissolved chemical species.

However the voids in a compacted DAC mix are not interconnected. This therefore makes laminar flow through the material virtually impossible and any results obtained on impervious asphaltic elements using Darcy's Law are inappropriate.

A number of conditions are required for the diffusions process to take place, the most basic of which is the "chemical potential" of the permeant and the solubility of the permeating species in the membrane. The next stage depends upon the size and shape of the molecules involved. In DAC the use of fillers inhibits diffusion rates by interfering with molecular movement, especially the polymer chains. DAC is advantageous in this respect because of its greater thickness and its asphalt and heterogeneous composition.

It should be noted that diffusion could, depending upon the circumstances (which is a landfill environment is constantly changing), operate in the reverse direction, depending upon relative concentrations on either side of the membrane. It is extremely unlikely that a condition of steady-state diffusive flow of constituents across a DAC liner will develop and thus analysis is outside the scope of Fick's first law of diffusion.

In essence therefore, the measure of escape across a DAC barrier membrane either by diffusion or by advection is virtually impossible.



Asphalt

Key Points

Chemically defined, asphalt is "a complex combination of high molecular weight organic compounds containing a relatively high proportion of hydrocarbons with high carbon-to-hydrogen ratios" whilst composed primarily of complex hydrocarbon molecules, asphalt also contains such atoms as oxygen, nitrogen and sulphur.

The principal source of asphalt used in modern construction is from the refining of crude petroleum. Crude petroleum is composed of a variety of compounds and a refinery is used to separate the crude petroleum into its various constituents. Briefly described, the refining process involves heating the crude petroleum to approximately 400°F to vaporize the lighter, more volatile fractions.

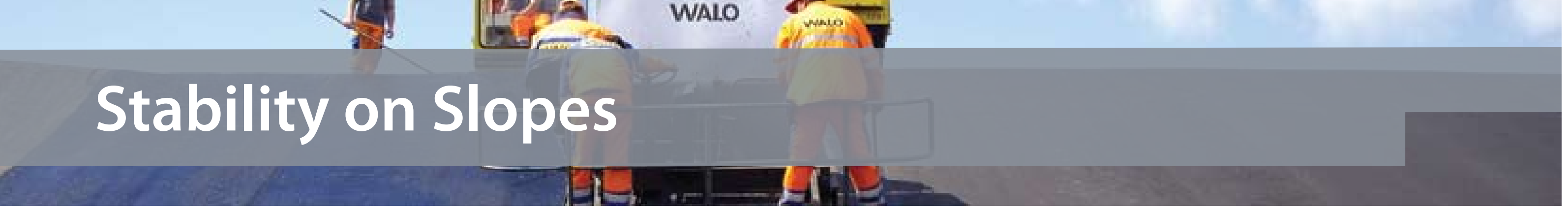
These lighter fractions are removed and the petroleum is further refined into such products as naphtha, petrol, kerosene, fuel oils and lubricants.

After one or more additional refining processes have removed the lighter petroleum compounds, the non-volatile portion which remains is the vacuum residuum or asphalt.

Any additional refining and manufacturing procedures are aimed at making products that meet various grades of asphalt for varying specifications.

This complexity of asphalt composition combined with the aggregate and fillers in a DAC mixture makes for an overall resistance to all forms of permeation, including gas.

The only conclusion which can be gained from the above information and from our experience of conducting many hundreds of CQA and comprehensive in-situ and laboratory tests on DAC samples over 70 years is, that providing the specification, the composition and the construction is controlled in terms of void content, DAC is vastly superior to the basic standards for lining systems required for landfills in the U.K.



Stability on Slopes

Long-term experience by WALO in the use of DAC for lining dams, reservoirs, canals and landfill sites, which have been subject to prolonged exposure to sunlight, extremes of temperature and repeated wetting and drying, indicates that these conditions do not adversely affect the performance of a DAC membrane in-situ.

The slope inclination is determined by the soil mechanics, the stability of the bituminous layers and the installation procedure employed. At present the limit of inclination for asphalt hydraulic engineering structures is 1:1.5 (34°).

Many sites throughout Mainland Europe and the UK have been lined by WALO, with slopes up to 1:1.5. WALO have extensive experience in laying DAC to steep slopes thereby providing considerable confidence in the stability of the product we provide.

Key Points

A landfill cell being lined with our impermeable DAC system, even the ramps into the cell can be completely sealed with our DAC and then trafficked.

WALO have designed the technology to be able to lay DAC at 70° - parallel to a quarry face, now making redundant quarries a viable option for landfilling.

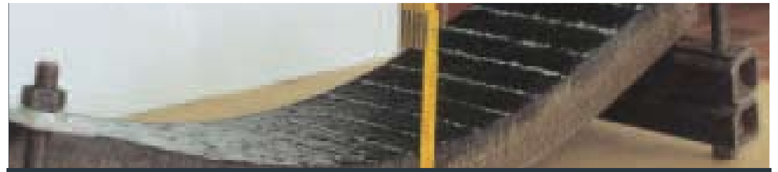
Flexiblilty

The known flexibility of asphaltic materials is reflected in its many uses at critical locations in civil engineering.

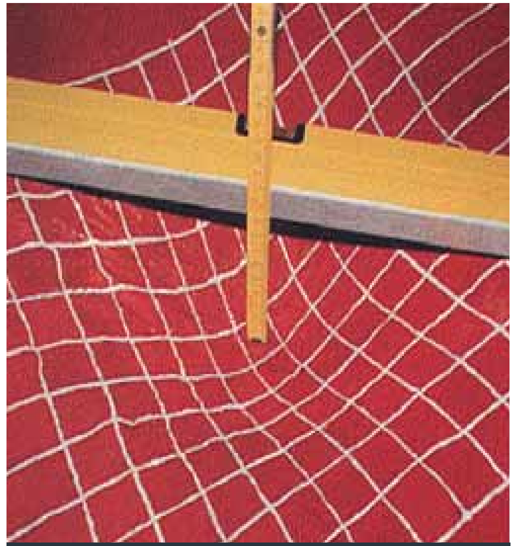
Flexibility in power station pump storage reservoirs for example, which are designed to accept extreme changes in pressure on the DAC lining system when large volumes of water is pumped from one reservoir into a lower reservoir and then back again on a daily cycle.

Another example is the use of short stretches of asphaltic surfacing on concrete surfaced highways where the road surface crosses over concrete bridge structures where flexibility is critical, (although it must be emphasised that material used for road surfacing is not designed in the same way as dense asphaltic concrete). Extensive experience and testing of dense asphaltic concrete in recent years has been more than convincing in terms of proving its ability to flex without showing signs of stress cracking. Thus accomodating any differential settlement that might be present.

Van Asbeck flexibility and bending tests performed on full thickness “beams” of asphaltic concrete cut from trial panels confirms the ability of the material to deform at ratios greater than 1:10 without stress cracking.



A laboratory test showing DAC flexing up to 50mm without showing signs of cracking and still retaining its impermeability



A laboratory sample showing DAC flexing more than 10% without cracking.

Key Points

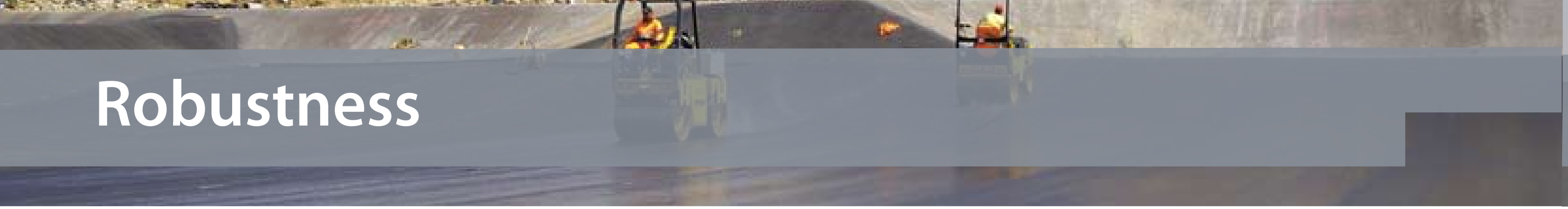
Physiological Compatibility

The successful use of DAC in hydraulic applications such as in domestic drinking water reservoirs, fish rearing ponds and canal liners is well documented. Physiological compatibility of bitumen with drinking water has been proven many times.

DAC is durable, flexible and can be designed to be either impermeable or porous. As an inert material, it is resistant to the actions of almost all acids, alkalis and salts.
The use of Dense Asphaltic Concrete linings in reservoirs is fully compatible with all water authority drinking water hygiene regulations. The DAC material is mixed and laid at very high temperatures and during the mixing process the lighter oils contained within the bitumen are completely burnt off, leaving a material that is very stable and non-toxic.

Weathering

Whilst the stone stabilising layer and asphaltic binder layer can be laid in most climatic conditions, construction of the DAC layer is restricted during heavy rain or when the temperature and/or wind chill causes rapid cooling of the surface of the asphalt, normally at or about 5° Centigrade. Once the DAC layer has cooled however, no adverse weathering will affect its ability to function and remain completely stable.



Robustness

In terms of relative robustness, it is sufficient merely to point to the performance of dense asphaltic concrete in comparison to other lining materials. No other lining system allows traffic or waste to be placed upon it without firstly requiring extensive protective measures. DAC does not require any additional protective layers prior to placing the stone leachate drainage blanket.

Taking into account that a DAC lining system is specifically designed for each and every site, its robustness is completely assured.

Depending upon the type of lining system used, the phasing of landfill construction and its operation generally limits the extent to which additional cells are lined ahead of tipping. To ensure continuity of cell readiness, landfill cells using DAC can be lined much earlier than needed because the lining system cannot be damaged by inclement weather or by vehicles using it or by vandals.

The inherent flexibility such an approach provides allows the use of these additional cell areas for the temporary storage of solid waste for pre-treatment or for composting of green wastes which can provide additional cost benefits for the operator.

A DAC barrier is robust enough to withstand exposure to the weather for time spans running into decades and yet still give confidence that it will perform its primary function when required.

Resistance to Chemical Attack

When assessing the ability to withstand chemical attack, the significance of the DAC layer thickness (80mm) and the influence of the hardstone aggregate content and the small amount of binding agent in the DAC material should not be ignored.

When testing and evaluating chemical resistance it is necessary to take bitumen's thermoplastic characteristics into consideration, since the action of acids with a pH value of <4, (the pH of most municipal solid waste landfill leachate is usually in the range of 4.8 to 5.2) or high volumes of solvents may increase the temperature of the bitumen slightly and this could be linked to a slight softening of the bitumen's structure.

Experiments have shown however that any softening of a DAC barrier through such an attack would only affect a few millimeters in the top surface. The binder film i.e. the bitumen, between the mineral components is only a few microns in thickness and therefore the flow of fluid between these components is extremely prohibitive. In effect any loosening of the binder would increase the tightening of the aggregate interlock, thereby increasing the barriers impermeability. Once the acidity or solvent has been dissipated the bitumen reverts back to its normal state.

The DAC concept is one of using clean graded hardstone aggregates that do not swell and which are mix-designed in such a way that even without the bitumen, the composition gives a hydraulic conductivity of 1×10^{-8} m/s.

The hydrocarbon content in a DAC barrier comprises less than 8% of its composition of weight compared to other lining materials HDPE whose composition is nearer 100% by weight of hydrocarbon derivative.

Acceptance by Regulatory Authorities

The 'Landfill Directive 1999/31/EC' and the 'Landfill Regulatory Guidance note (RGN6)' states that the geological barrier in a landfill is to be determined by geological and hydrological conditions below and in the vicinity of a landfill site providing sufficient attenuation capacity to prevent a potential risk to groundwater. In addition, where the geological barrier does not provide sufficient environmental protection it can be artificially enhanced and reinforced by other means giving equivalent protection.

If this is not possible with the existing subgrade materials it can be made suitable with an initial capping layer of DAC placed on top of a stone drainage layer followed by the subsequent normal layers of DAC. This initial capping layer of DAC would save on the expensive cost of extraction and removal from site of any unsuitable materials and the subsequent cost of replacement, whilst providing additional attenuation and, once the normal DAC layer is placed on top of this initial capping layer, it would in effect provide a double liner system.

The Directive and Guidance also state that - *"The landfill base and sides shall consist of a mineral layer which satisfies permeability and thickness requirements. With a combined effect in terms of protection of at least equivalent to $K < 1 \times 10^{-9}$ m/s; thickness > 0.5m, for landfills taking nonhazardous waste.*

The DAC lining system is not simply another artificially established geological liner but is a *"Fully Engineered Specifically Designed Lining System"* which does not have to rely on being laid 500mm thick to make it impermeable and strong enough to withstand decades of service.

The Environment Agency: (EA) Landfill Regulatory Guidance Note 6.0 (version 2, July 2004, section 5) the guidance note is headed *"Artificial Sealing Liner"*, it states that *"the requirements for an artificial sealing liner would be met by a liner system such as a dense asphaltic concrete (DAC)"*.

In Mainland Europe, where DAC has been the preferred barrier system for decades, the 'EA's' have such confidence in the material that it is the only system specified to be used in those landfill facilities which take only highly contaminated incineration fly ash.

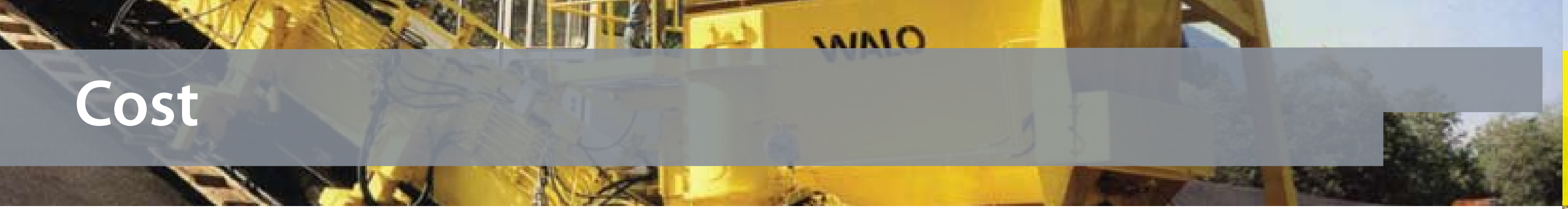
Key Points

Acceptable Installation Techniques

One of the most important elements of installation of any lining system is the supervision and construction quality assurance procedure (CQA). An intensive level of construction quality assurance testing is provided by WALO during the construction phase of its DAC lining system. In particular, the joints between adjacent lanes are rigorously tested to ensure the full effectiveness of the seal. Raw materials and mixed asphalt are thoroughly tested to ensure their compliance with the mix design, and density tests are carried out to ensure that the compacted material has a void content below 3%, thereby providing a hydraulic conductivity $\leq 1 \times 10^{-13}$ m/s.

Whether the asphaltic material (which is mixed daily for each location) is produced on site or produced at an offsite quarry, extensive CQA procedures are carried out at every stage of the production. WALO always have a laboratory on the contract site to ensure thorough monitoring and suitability of all asphalt supplies. It is our regular practice to lay sample test areas of DAC at the beginning of a contract and subject these sample areas to intensive in-situ and core tests to ensure the design specification is achieved. Measurement of temperature and compaction is regularly carried out during all laying operations and particular attention is paid to jointed areas.

A completed landfill cell ready to recieve the stone lachate blanket. This cell of 20.000m² was completed in six weeks.



Cost

DAC has been used as an impermeable barrier system for landfills sites throughout Europe for many years. In the UK Environment Agency has approved its use for sites which have problems meeting the groundwater directive, on or near by aquifers and generally where there is a likelihood of potential settlement or where a site is close to a drinking water source.

The actual cost of a barrier system is a function of many variables in addition to the unit cost per square metre of any particular system. The overwhelming factor in deciding the cost-effectiveness of a containment system is the amount of void space the lining system itself occupies. Any additional space taken up by the containment lining system is space that cannot be occupied by waste.

There is also a difference between the real cost of installation of a barrier system and the theoretical cost. If a barrier system is susceptible to physical damage then other protection layers are necessary. Then apart from the obvious additional cost of the protection material there is also the cost involved with slower and more onerous construction practices and the inevitable delays when damage occurs which has to be repaired. Such costs can be of the order of several times the initial design cost, if the damage results in the need for extensive remedial measures.

As with all barrier systems, the cost of lining a cell with DAC depends upon its overall size, base and slope areas, the length and angle of the slope, its overall height and the general topography of the site. Prices can be readily worked out once these factors are known. Taking everything into account, such as the increased void space created by using a much thinner lining system, the speed of laying, the increased steepness of side slope and the alternative uses that a cell having a DAC lining system can be put to the price is very comparable with other lining products.

Key Points

Advantage to the Dense Asphaltic Concrete over other Lining system

The following is a summary of the benefits of using Dense Asphaltic Concrete as the impermeable lining system for landfill sites.

It is much quicker to construct, taking weeks instead of months to complete. It is not affected by inclement weather whilst being laid or afterwards, giving the landfill operator a quicker response time for starting his landfill operations.

It is a much thinner lining system to construct, with the total thickness generally averaging approximately 340cm. (including drainage layer, binder layer, and the DAC layer) a saving of a metre or more of void space against most other lining systems.

It is strong and constructed to provide hydraulic permeability results of ≤ 1 x 10^{-13} m/s, tested up to 10 bar (100m) head of water pressure.

It is constructed using an extensive construction quality assurance procedure, and all results can be re-tested throughout the construction period and afterwards without destroying the integrity of the lining material.

It is extremely flexible, allowing sufficient flexibility to accommodate a differential settlement of the underlying formation amounting up to 1 in 10 without showing any signs of stress fracture or cracking.

It does not contain mobile toxic compounds that may pollute the ground or surface water.

It has complete stability when placed on slopes of up to 1:1:5 (34°) under all conditions of waste and leachate cover. The increased steepness of slopes provides extra void space for the waste product.

It can be laid parallel to a quarry face of 70°

It is unaffected by vandalism, frost action and all natural weather conditions that may be experienced before covering with waste. Rubber tyred construction plant and vehicles may run on the surface without fear of damaging the lining system.

It is strong enough to support landfill material, daily cover material and capping material without thinning or deforming.

It cannot be punctured and is resistant to mechanical forces resulting from the impact of drainage materials and landfill materials.

It is unaffected by leachate and gases normally found in MSW landfills.

Conclusion and Summary

Lining systems have developed from simple layers of compacted clay to complex composite and multi layer systems of engineered clay, plastic membranes (usually HDPE) and/or Bentonite treated soils or Bentonite geocomposites.

The cost of lining any reasonable size waste cell is now significant and must of course be borne by the operator well before any payback in the form of waste through the gate can be achieved.

The true cost of many barrier systems is seldom calculated, because many of the aforementioned lining materials have specific installation problems that lead to delays (often due to poor weather conditions or construction methods).

There are often difficulties in supply, damage and deterioration over time, sometimes requiring repair and/or replacement. In addition, there is a general acknowledgement that it is difficult to install some lining materials without causing punctures and tears and this is leading to the specification of ever more complex multilayer systems. The cost effectiveness of laying varying thickness of lining materials with their subsequent protective layers is also open to question and, by taking up evermore valuable void space, does not lend itself to the overall concept of sustainable waste management.

The Dense Asphaltic Concrete impermeable lining system has been used for sealing landfill sites and waste treatment facilities throughout Continental Europe since the late 1970's, longer than some of the materials commonly accepted here in the UK as being tried and tested.

Walo UK Limited was the specialist company involved in the construction of the UK's first DAC lining system at a commercial municipal solid waste landfill site in Derbyshire. Since then eleven more cells have been constructed in the UK using DAC as the lining system and many more sites are already being programmed for lining with DAC in the foreseeable future.

Walo lined a 40,000m² landfill cell in the UK in less than nine weeks and have gone on to complete additional cells for the same client, with several new sites now coming on stream.

Due to its flexible nature, its superior impermeable properties and its much reduced overall thickness compared to alternative systems, DAC is also suitable for capping completed landfill sites and brownfield sites.

A DAC installation generally consists of three main layers; a granular stabilising layer, an asphaltic binder layer and a dense asphaltic layer. Finally a seal coat of hot mastic is applied to the top coat to give additional protection from exposure to ultra violet-rays.

Slopes up to a gradient of 1 in 1.5 and heights up to 150m can be constructed using our specially designed slope laying equipment. This method of construction, using established engineering techniques combined with our unique laying and testing methodology, provides proven confidence in the quality of the final product we produce.

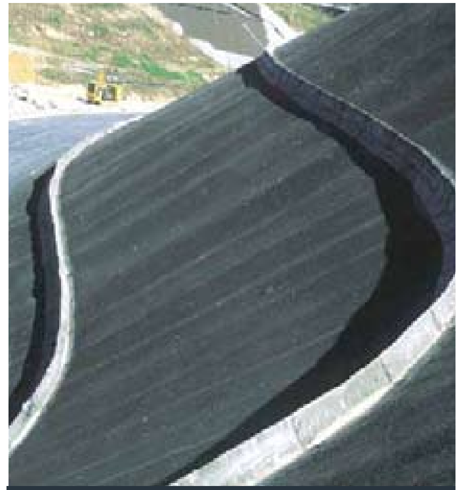
The Dense Asphaltic Concrete lining system is engineered using a very thorough CQA procedure throughout the whole construction period in which temperature; thicknesses and density are regularly measured. External laboratory tests are carried out on cores taken from the compacted materials to examine porosity and hydraulic conductivity.

Detailed written and computerised information is made available to the client, the Environment Agency and associated regulatory authority risk assessment programmes. The speed of completion of the works is a significant element in the saving of costs.

The capacity to lay a considerable area of high quality lining system in a short time period, even during inclement weather conditions, and to know that it will not be subject to subsequent deterioration or loss in performance is seen by most clients as being extremely advantageous.

The indirect and practical advantages of a DAC lining system go towards making the overall installation of the lining system very comparable when compared to other lining materials. Other benefits include the fact that our DAC system is relatively thin, yet strong enough to be robust under all conditions, so void space is maximised without compromising containment standards.

The strength of the lining system is such that it can be trafficked by rubber tyred equipment almost immediately after completion without fear of damage or puncture. The final surface is one on which surface water run-off can be easily controlled, even on steep slopes, thus preventing excessive leachate generation. As an engineering material, DAC certainly adds to the range of engineered options that are available in the quest to minimise risk associated with landfill operations.



Rain water divert channels stuck onto the barrier. These channels prevent excessive rainwater entering the cell. They can be removed or simply left in place without fear of damaging the barrier

Key Points

Walo UK Limited is a division of the Walo Bertschinger Group of companies whose headquarters are situated in Zurich, Switzerland.

The Walo Bertschinger Group was established in 1917 as a civil engineering company and over the past 91 years has expanded its activities in the civil engineering and construction industry to include rail construction, general building construction, tunnelling, road surfacing for indoor and outdoor sports grounds and hydraulic engineering.

Hydraulic engineering has become a very important aspect in the companies' development whereby WALO are now regarded as one of the leading specialists in the world in the construction of hydraulic asphaltic linings for dams, reservoirs, canals, pump storage basins and for the past 29 years, for waste disposal sites and waste treatment facilities.

The Bertschinger Family wholly owns the Group which has over 2,200 employees in departments operating throughout Europe. In 1955 the Walo Group engineered the first of many reservoirs with dense asphaltic concrete and in 1979 successfully completed the first Dense Asphaltic Concrete landfill lining contract in Switzerland. Since then the company has lined more than 100 separate landfill sites throughout Continental-Europe and the United Kingdom.

In 1999 the Walo Group established an operating division in the UK, which is now based in Stafford (Walo UK Limited), to provide a local service of construction of dense asphaltic concrete lining systems throughout the United Kingdom and Ireland. From our base at Stafford we can quickly respond to any request for information on our system and are able to organise and carry out projects with minimal notice.

We have at our disposal the technical support of our ISO/IEC accredited independent laboratory, together with our own operational expertise and specialist equipment necessary to carry out landfill lining systems of any size and anywhere.

If you would like to receive more information on our DAC lining system, or would like to discuss a project, then please contact: David Wilson – Managing Director at Walo UK Ltd. Or visit us at:
www.walo.co.uk

Dense Asphaltic Concrete

Landfill lining technology at its' best

The Dense Asphaltic Concrete (DAC) lining system is a well proven solution to landfill engineering technology. Its strengths and remarkable impermeable properties provide the Landfill Engineer with a lining system which gives confidence that it will withstand many decades of use without risk of leakage or degradation.

The DAC system can also be adapted to increase the attenuation of the existing geological sub-grade if required and all with the benefit of saving valuable void space for the waste product, whilst ensuring the complete protection to the environment.

WALO
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