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Asphalt in Landfill Construction

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Abstract*— *The sealing systems of landfills have the primary task of preventing damage to the groundwater by pollutants from the landfill body and withstanding general mechanical stresses during the construction and operation of the facility. In the course of increased environmental awareness, the technical requirements in landfill construction, especially for sealing systems, are becoming more stringent. Asphalt sealing systems have proven their worth for companies with experience in hydraulic engineering with sealing areas of more than 25 million m2 in various designs, both as surface sealing and as core sealing of dams. The feasibility of slope inclinations of up to 1:1.2 means an additional gain in landfill volume compared to the standard sealing system [1].

Keywords*— *Sealing system, asphalt, bitumen, landfill sealing, landfill construction.

I. INTRODUCTION

Especially in landfill construction, it is essential that the sealing layer is absolutely impermeable to liquids. In addition to water, other liquids or dissolved substances occur here that are harmful to the environment and can contaminate the groundwater. Bituminous waterproofing is insensitive, resistant and suitable for particularly contaminated material. Consequently, no further measures are necessary to protect the bituminous sealing layer. In addition, they are extremely resistant to ageing and flexibly absorb subsidence and deformation of the substrate [2].

II. BASICS

According to DIBt - Deutsches Institut für Bautechnik [3], a general building authority approval for landfill asphalt for use in landfill base sealing systems of landfill class DK II has been issued by German Institute for Structural Engineering (Deutsches Institut für Bautechnik). This specifies the requirements for a landfill asphalt for landfill base sealing systems of landfill class DK II. The sealing consists of an asphalt base layer and an asphalt sealing layer and may be applied under the conditions of the approval in the area of the base and slope of the landfill base up to a slope of 1:2.5 [4].

The requirements for landfill classes DK 0, I, II and III are shown in Table 1 [5].

III. RESISTANCE OF ASPHALT SEALING IN LANDFILL CONSTRUCTION

Landfill base seals must be resistant during the construction, operation and aftercare phases to:

- Mechanical,
- Biological and
- Chemical stresses [6].

TABLE I. The requirements for landfill classes [5]

Nr.	System components	DK 0	DK I	DK II	DK III
1	Levelling layer	not required	required	required	required
2	Gas drainage layer	not required	not required	If necessary	If necessary
3	First sealing component	not required	required	required	required
4	Second sealing component	not required	not required	required	required
5	Seal control system (newly included!)	not required	not required	not required	required
6	Drainage layer d ≥ 0,30 m, k ≤ 1 x 10^{-3} m/s , Slope > 5 %	If necessary	required	required	required
7	Recultivation layer	required	required	required	required

Mechanical stresses

The high resistance of asphalts to mechanical stresses is a great advantage for the operation of landfills, as the asphalt sealing can be directly driven over with large equipment in all weather conditions, even without a protective layer. In the event of mechanically induced damage, exposed asphalt seals can be repaired without difficulty. Asphalts react plasto-viscously to deformations caused by uneven settling of the base up to a ratio of trough depth to trough diameter of 1:10, without their sealing function being in the least endangered [6].

Biological stresses

In connection with the resistance of landfill base seals made of asphalt to biological stresses, the question arises whether the binder bitumen in the asphalt is possibly attackable by microorganisms [6]. From the comparable field of hydraulic engineering, no damage to asphalt seals due to biological effects is known. No facts could be found in the technical literature that could indicate a lack of resistance of asphalt seals and their binder bitumen to biological (bacterial) attacks [1].

Chemical-physical resistance

When discussing the resistance of asphalt sealants to physical/chemical effects, the ageing of the binder bitumen must also be addressed. Systematic studies on this topic [7] have shown that the softening point ring and ball (EPRK) as the characteristic value decisive for the viscosity of a bitumen increases by 5 K during the production of asphalt and the subsequent recovery and testing of the bitumen.

Extensive studies [8] have shown that the hardening of the binder in asphalt wearing courses of roads is strongly determined by their void content during the service life. Under unfavourable conditions, the EPRK of a bitumen B 80 in an asphalt concrete 0/11 with a void content of 7 % by volume can increase by about 25 K within a period of about 10 to 12 years. In the investigations [9] it was found that on bitumen B 80 recovered after 5 to 10 years from a landfill base seal of asphalt with void contents between 1.1 and 2.6 vol.%, softening points are between 51.5 and 53.0 °C. This may be interpreted as meaning that the softening point of bitumen B 80 in a landfill base seal of asphalt with void contents between 1.1 and 2.6 vol. This may be interpreted to mean that no ageing process at all took place under the landfill material during the service life indicated above, since the determined softening point ring and ball, taking into account the hardening due to processing, should already have been present immediately after production. In the case of properly executed asphalt sealing of landfills with void contents of up to 3.0% by volume, ageing is therefore practically not to be expected [6].

Hydrodynamic/chemical resistance

Even in orderly landfills, it will not be possible to completely exclude the possibility of solvents escaping from smaller containers and hitting the surface of the asphalt sealing in the future. The impact of each solvent droplet is associated with a hydrodynamic attack on the asphalt surface directed towards erosion, which can be followed by a dissolving process and finally a removal of the dissolved components. The effects caused by the solvent attack depend on the type and amount of solvent acting per unit of time and the inclination of the asphalt surface relative to the horizontal. The test set-up for addressing the resistance of compacted asphalts to droplet solvent action is shown in Fig.1 [6].

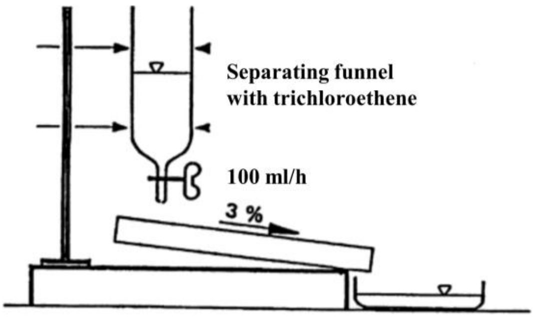

Fig. 1. Test set-up to address the resistance of compacted asphalts to droplet solvent exposure [6]

Resistance of landfill asphalt to mineral oil products

On the area of a mineral oil company for planned asphalt sealing of retention basins, the resistance to mineral oil products, in particular to super gasoline with the strongest dissolving power, was investigated. As a result of these tests, the resistance and impermeability to super gasoline could be clearly proven with the appropriate thickness of the asphalt layer and the required proof could be provided [10].

IV. Technical requirements for sealing asphalt

The following main requirements are generally imposed on seals [11].

1. The gasket must be practically impermeable to water under the maximum expected water pressure.
2: The gasket must be able to withstand all stresses that occur. The gasket must be able to withstand all occurring stresses.
3. The gasket must be filter-stable, i.e. it must not be possible for it to be pressed into the neighbouring zone under the prevailing water pressure; even its fine-grained parts must not be pressed out. The sealing asphalt must be practically impermeable to water under the maximum water pressure to be expected.
4. The sealing asphalt mixture must be capable of being placed and sufficiently compacted under the given conditions.

Water impermeability

The waterproofing asphalt with a voids content of < 3 % by volume is to be considered impermeable.

Stability and shear strength of the pavement

With regard to stability, construction-specific mix formulations must be prepared, as slope gradients differ for individual structures.

Durability

The durability of an asphalt pavement depends on the mortar content, the binder and the quality of the aggregates.

Deformability

Asphalt seals must be deformable, they must withstand certain settlements of the base without damage to the surface.

Frost and weather resistance

Dense asphalt is frost resistant provided the aggregates used are frost resistant.

Resistance to ageing

Dense asphalt is more resistant to ageing than conventional asphalt for road construction due to the high bitumen content and due to the particularly dense structure.

V. Nomenclature/layer designation of the landfill asphalt sealing component

The previously used designations DAD, DAT and DATD are also adapted with regard to the European designations of asphalts as follows [12]:

AC 16 T-DA Asphalt concrete with maximum grain size 16 mm for asphalt base courses in sealing component made of landfill asphalt (formerly landfill asphalt base course - DAT).

AC 11 D-DA asphalt concrete with maximum grain size 11 mm for asphalt sealing layers in sealing components made of landfill asphalt (formerly landfill asphalt sealing layer - DAD)

AC 16 TD-DA Asphalt concrete with maximum grain size 16 mm for base sealing layers in sealing components made of landfill asphalt (formerly landfill asphalt base sealing layer - DATD).

AC = Asphalt concrete (asphalt concrete)
D = Surface courses; for landfill asphalt: sealing layers
DA = Landfill asphalt
T = Base courses
TD = Base courses; for landfill asphalt: base sealing layers

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VI. REQUIREMENTS FOR LANDFILL ASPHALT

The composition requirements for the landfill asphalts AC 16 T-DA, AC 11 D-DA and AC 16 TD-DA are given in Table 2. The asphalt mix composition is to be selected in such a way that a void content of maximum 3.0 % by volume for AC 11 D-DA and AC 16 TD-DA or maximum 4.0 % by volume for AC 16 T-DA is maintained in the finished layer.

In the initial test, a void content for AC 11 D-DA and AC 16 TD-DA of maximum 2.0 vol.% and for AC 16 T-DA of maximum 3.0 vol.% must be verified on the Marshall specimen at 2 x 20 blows [12]. An asphalt concrete with a residual pore content of ≤ 3 vol. % is considered convection-tight and ageing-stable.

TABLE III. Requirements for base layers (AC 16 T-DA), sealing layers (AC 11 D-DA) and load-bearing sealing layers (AC 16 TD-DA) in sealing components made of landfill asphalt [12]

	Designation /Unit	AC 16 T-DA	AC 11 D-DA	AC 16 TD-DA
Binder grade		70/100	70/100	70/100
Binder content	M.-%	5,2-6,5	6,5-7,5	6,0-7,0
Cavity content of the finished layer	Vol.-%	≤ 4	≤ 3	≤ 3
Sieve passage 22.4 mm	M.-%	100		100
Sieve passage 16.0 mm	M.-%	90-100	100	90 -100
Sieve passage 11.2 mm	M.-%	-	90-100	-
Sieve passage 2.0 mm	M.-%	40-60	45-60	40-60
Sieve passage 0.063 mm	M.-%	9-14	11-16	9-14

The composition of landfill asphalt according to literature [13] is shown in Table 3.

TABLE IIII. Landfill asphalt composition [13]

		Landfill base course asphalt 0/16	Landfill sealing asphalt 0/11
Layer thickness		Single layer, 8 cm	Two-layer, each 6 cm
Mineral substances	M.-%	9 – 14	12 – 16
Particle size distribution			
< 0,09 mm			
> 2,0 mm	M.-%	35 – 50	45 – 60
Oversized grain	M.-%	max. 8	max. 8
Crushed sand/natural sand	-	≥ 1 : 1	≥ 1 : 1
Fictitious void content	Vol.-%	≤ 20	≤ 20
Binding agent	M.-%	B 65, B 80	B 65, B 80
Binder type		≥ 5,2	6,5 – 7,5
Binder content			
Cavity content	Vol.-%	≤ 3	≤ 2
In the Marshall specimen			
of the installed layer	Vol.-%	≤ 5	≤ 3

Only natural materials are permitted as mineral materials according to the Technical Terms of Delivery for Minerals in Road Construction TL Min-StB 2000 [14]. Only dense limestones are used for the sealing layers (in the mixture > 0.09 mm, the CaCO3 content should be less than 40 wt.%) [13].

The stiff modulus (measured at a frequency of 4 Hz) of the landfill asphalt at the rock temperature of 30 °C is approx. 800 MPa and thus lies in its stiffness between the road construction asphalt concrete 0/11 (2500 MPa) and the hydraulic engineering asphalt mastic (approx. 340 MPa). In addition, a combination of an asphalt and a mineral seal was also proposed for above-ground landfill seals. The structure of such a combination seal is shown in Figure 2 [13].

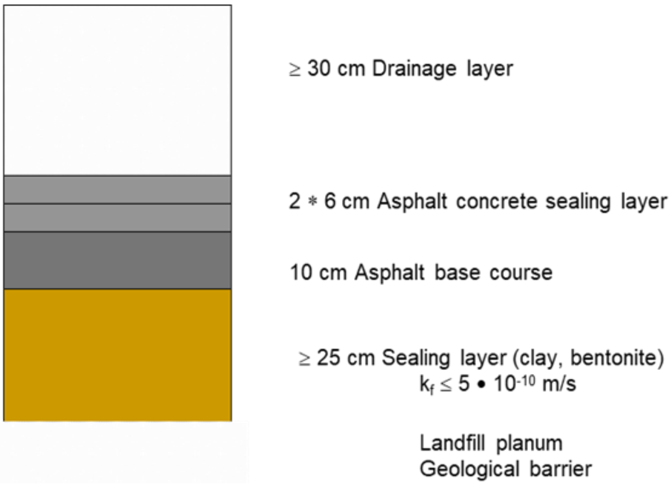

Fig. 2. Combined sealing system for above-ground landfills [13]

VII. CONSTRUCTION METHODS

According to [13], there are two construction methods as sealing components for both base and surface sealing of Class DK I to DK III landfills.

Variant A

Variant A (Fig.3) consists of a 6 cm thick landfill asphalt base layer (AC 16 T-DA) and a 4 cm thick landfill asphalt sealing layer (AC 11 D-DA) placed on top. For the purposes of this quality guideline, the sealing function is only assigned to the sealing layer. This construction method is recommended if the support is sufficiently resistant to deformation ($Ev_2 \geq 45$ MN/m^2) and load-bearing. The seams of the base layer and sealing layer must be offset from each other by at least 0.5 m [13].

Fig. 3. Landfill asphalt sealing component consisting of a landfill asphalt base layer and a landfill asphalt sealing layer [13]

Variant B

Is the resistance to deformation and load-bearing capacity high ($Ev_2 \geq 80$ MN/m^2), an 8 cm thick combined landfill asphalt base sealing layer (AC 16 TD-DA) can be used.

Fig. 4. Tire forces acting according to the Coloumb friction model [3, 10]

VIII. PLANNING AND CONSTRUCTION

Drill core removal and plugging of boreholes

The void contents determined on the cores are the decisive acceptance criterion for the finished layer. The tests on the cores are to be carried out in accordance with TP Asphalt-StB [15]. The drill core sampling points are to be determined by the third-party inspector - asphalt (FP) in agreement with the competent authority.

The drilling core removal and the sealing of the boreholes shall be carried out by the construction company in the presence of the FP at the specified locations. After the removal of the drilling water or the removal of the masking, the borehole is to be mechanically cleaned on the walls and all around the surface, dried with hot air, then the borehole wall and the area shown in Fig. 5 on the surface are to be painted with hot bitumen [13].

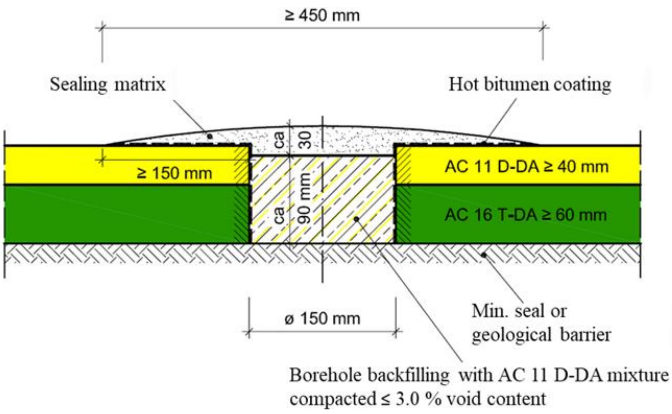

Fig. 5. Sketch of drill core removal and plugging of borehole for variant A [13]

Pipe support

The pipe bedding and sheathing must be carried out according to planning and structural specifications. Rigid pipe supports are not permitted for plastic pipes. In order to direct the seepage water to the drainage pipe, sufficiently load-bearing and dense support mixtures must be used, e.g. the support mixture "Mixture No. 9" of the Technical University of Munich (1996), a mixture of approx. 70% sand, 27% clay powder and 3% blast furnace cement HOZ 35 L [13].

Particular attention must be paid to maintaining the slopes. Below the pipe support, the requirements for the thickness of an underlying sealing component and the geological barrier must be observed in particular (Fig.6). In addition, no seams may be placed under the pipe support. Of particular importance for quality assurance in the area of the pipe support is the creation of a good layer bond (possibly cleaning and spraying of the layer surfaces) and the monitoring on the survey side. With proper execution, a homogeneous block of AC 11 D-DA is created. This rules out the possibility of horizontal seepage water transport to the outside via the layer boundaries. By means of several levellings along the pipe axis on the asphalt layers, the remaining thickness of the AC 11 D-DA under the pipe bed after the milling operations must be verified. To prevent erosion at the pipe bedding (e.g. during flushing), a geotextile or a plastic sealing sheet must be laid on the surface of the pipe bedding [13].

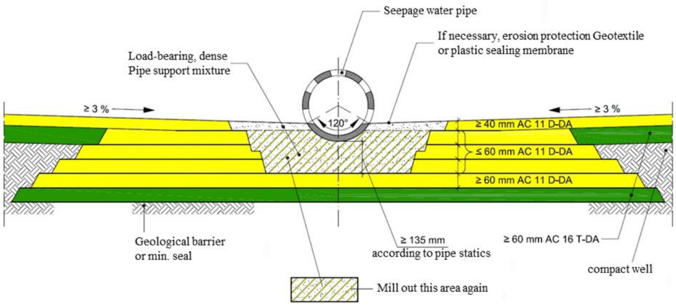

Fig. 6. Pipe support for variant A (exemplary principle sketch in milled construction, adapted to a standard paver with a minimum pave width of 2.5 m) [13]

Figs. 7 and 9 show what this looks like in practice.

Fig. 7. Pipe support a landfill with PE-HD seepage pipe [5]

The principle sketch of the pipe support according to DVWK bulletin 237 [16] with the pipe casing made of gravel 16/32 mm, is shown in Fig.8.

Legend on figure 8:

1. Landfill asphalt sealing layers, 2. Landfill asphalt base layers, 3. PE-HD seepage pipe, 4. Pipe support, 5. Drainage layer (gravel 16/32 mm), 6. Erosion protection (if necessary).

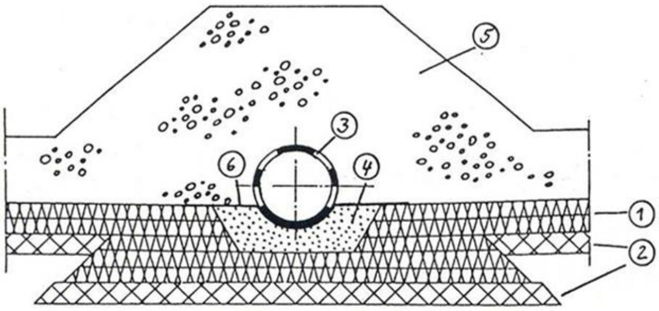

Fig. 8. Principle sketch pipe support [5]

Fig. 9. Pipe support a landfill with PE-HD seepage pipe and drainage layer of gravel 16/32 mm [5]

Transitions from the bottom to the slope

From the positional sketch Fig.10, the assignments according to Fig.11 and 12 can be explained.

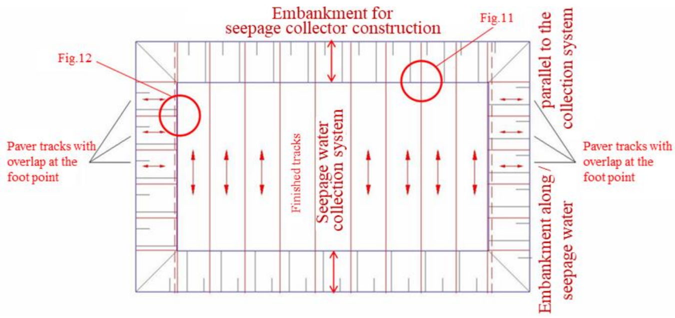

Fig. 10. Principle sketch of the position of the transition from the bottom to the slope longitudinally or parallel (Fig.11) and transversely (Fig.12) to the direction of production in the bottom [13]

The transition of the invert to the slope transverse to the direction of the leachate collector is shown in Fig.11, the transition of the invert to the slope along the direction of the leachate collector is shown in Fig.12 as an example. The order of manufacture is defined in the figures by the circled numbers.

Legend on Fig.11: ① to ④ – Sequence of manufacture,

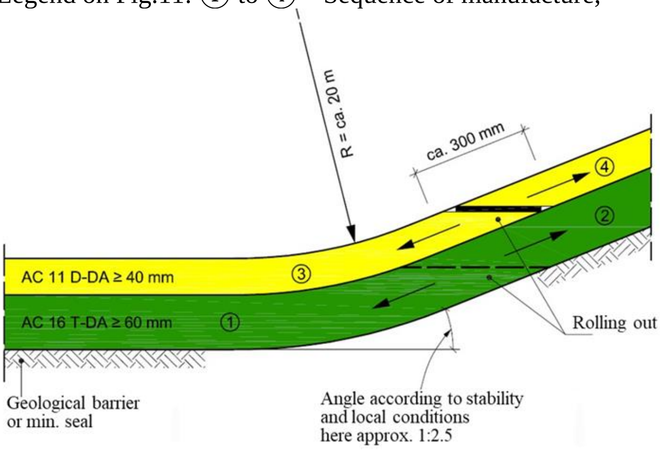

Fig. 11. Transition from the invert to the slope (transverse to the direction of the seepage collector) [13]

In practice, the transition from the base to the embankment shown in Fig. 11 has proven to be particularly effective on embankments running transverse to the direction of the leachate collector.

Notes on execution: When constructing the solution shown for variant A (landfill asphalt base layer and sealing layer), the following must be observed [13]:

1. First, the transition at the toe of the embankment is "rounded out" with a radius of approximately 20 m using earthworks technology.
2. The AC 16 T-DA sheeting is then laid on the invert, starting in the rounded section in the landfill field ① and the track approach "rolled out" to the embankment.
3. Starting at this approach, the AC 16 T-DA track is manufactured towards the embankment ②.
4. This is followed by the installation of the AC 11 D-DA tracks ② und ④ analogous.
5. The transition (seam) from track ③ to track ④is formed. For this purpose, the rolled-out surface of the track is ③ treated with hot bitumen and the track ④set on and made upwards.
6. After cooling down, this area is heated again by means of infrared radiation (internal temperature +70 °C) and recompacted. For this purpose, the following is required when applying the track ④to work with some "surplus material".
7. The tracks transitions ① to ② and ③ to ④must always be positioned above the level of the invert.
8. To check the tightness of the transition ③ to ④Vacuum tests can be carried out at random.

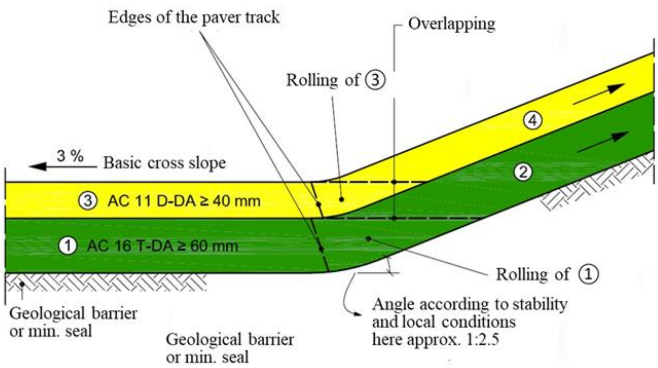

Fig. 12. Transition from the bottom to the slope (along or parallel to the direction of the seepage collector)[13]

Legend on Fig.12: ① to ④ Sequence of manufacture; Manufacturing direction ② and ④; Manufacturing direction for ① and ③ is perpendicular to the cutting line; ① and ③ Make thicker at the base of the embankment and roll into the gussets.

Top of embankment - transition plateau - embankment

The top of the asphalt seal at the top of embankment should be designed in such a way that water is prevented from entering between the asphalt seal and the geological barrier or mineral seal (seal as asphalt spur or connection to concrete edge stone, form edge road with cross slope). When designing

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the top of embankment, the subsequent connection of a surface seal should already be taken into account [13].

Figure 13 shows the situation in which the surface sealing on the embankment is first completely finished and then the plateau area is constructed. If the slopes and the plateau area are to be built in one operation, it is possible to work without transverse joints at the transition given the specified rounding. The transverse seam in the upper sealing layer at the transition from the slope to the plateau is still to be placed in the slope area (Fig.13). The transverse seam in the base course is advantageously located in the plateau area (clean work when positioning the upper track) ④.

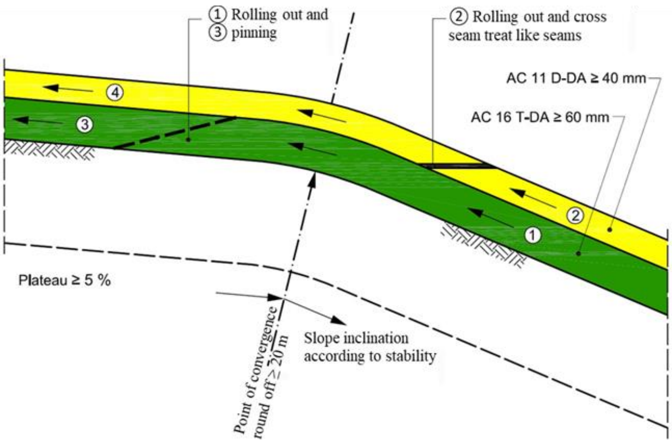

Fig. 13. Exemplary sketch for the design of a surface sealing made of landfill asphalt according to variant A (base and sealing layer) at the transition from the plateau to the slope. Surface sealing with attached intermediate berm and seepage water drainage [13]

Legend on the Fig.13**:** ① to ④Sequence of manufacture

Figure 14 shows a berm design with intermediate surface seepage drainage over a single-layer paved membrane ("drainage membrane") as sealing layer D-DA- 0/11 applied to the continuous seal made of landfill asphalt (variant A) [13].

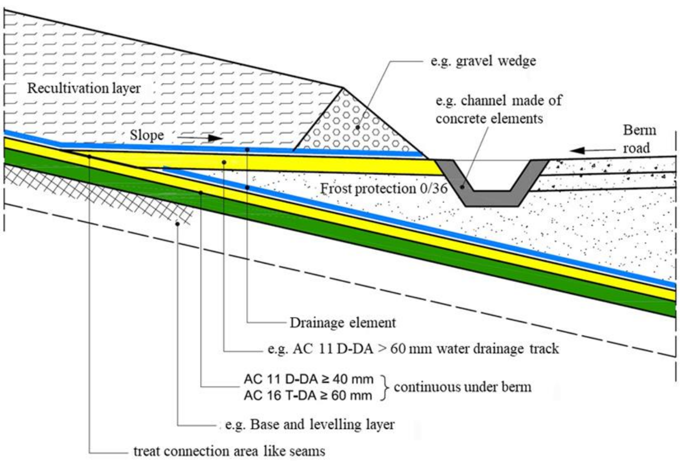

Fig. 14. Exemplary sketch for the design of a surface sealing component made of landfill asphalt with arrangement of a berm and intermediate surface water drainage [13]

IX. Paving and Compaction

Installation at Cholwald landfill, Germany

On its function as a reactor landfill, Cholwald Landfill stores sewage sludge ash, construction waste and contaminated soils. Landfill 4 was planned as an extension of the first three landfill sections. The execution of the works took place in two stages between 2012 - 2013. For WALO, the task was to build a "channel" of sealing asphalt so that the drainage pipes of the soldrainage could be connected to a manhole building.

This "channel" serves as a safety measure for the overlying pipes in the event of any leaks in the lines and "disappeared" into the embankment when the shaft building was built. A particular challenge lay in the extreme geometry around a manhole building. The solution: The entire paving operation was carried out by means of a silo paver and multifunction winch truck. The asphalt work at the Cholwald landfill site is shown in Figs. 15 and 16 [2].

Fig. 15. Asphalt work at the Cholwald landfill site [2]

Fig. 16. Asphalt work at the Cholwald landfill site [2]

Installation and compaction at the Wetro "Puschwitzer Feld" industrial waste landfill, Germany

Fig.17 shows the asphalting work at the Wetro "Puschwitzer Feld" industrial waste landfill of P-D Industriegesellschaft mbH, Puschwitz in Germany [5].

Fig. 17. Asphalting work at the Wetro "Puschwitzer Feld" industrial waste disposal site of P-D Industriegesellschaft mbH, Puschwitz, Germany [5]

Installation at Vogelsang landfill, Heilbronn, Germany

New construction of slag storage at Vogelsang landfill, Heilbronn, asphalt paving in night shifts to meet the required short construction time:
16,500 m^2 paving of asphalt base course d = 14cm and asphalt surface course d = 4cm
16,500 m^2 installation of gravel base layer d = 60cm
Client: City of Heilbronn, waste disposal companies, construction time: 3 months Year of construction: 2015 [17]. See Fig.18.19 and 20.

Fig. 18. Asphalt paving at Vogelsang landfill, Heilbronn, Germany [17]

Fig. 19. Asphalt paving at Vogelsang landfill, Heilbronn, Germany [17]

Fig. 20. Aerial view of Vogelsang landfill, Heilbronn, Germany [18]

Installation at the "Abfallentsorgung Kreis Kassel" landfill, Germany

The company "Abfallentsorgung Kreis Kassel" has expanded its landfill by two new sectors. On an area of 26,400 m^2, building rubble and contaminated soils will be stored in the future. The construction of a so-called bottom sealing with a length of 330 m and a width of 80 m was entrusted to Joh. Wachenfeld GmbH & Co. KG was commissioned.

Thus, the construction site was divided into 13 sections. In each of these sections, a layer of crushed lime gravel had to be placed, followed by four layers of 25 cm clay each. Due to the special importance of a functioning waterproofing system, each of these layers was individually checked with regard to its impermeability - both by an engineering firm and by Wachenfeld itself. Two layers of special landfill asphalt form the final layer (Fig. 21) [19].

Fig. 21. Paving and compaction at the landfill "Abfallentsorgung Kreis Kassel", Germany [19]

Installation at the Ramsklinge landfill in the Esslingen district, Germany

The surface sealing system according to DepV [20] has a minimum thickness of 2.30 m (Fig.22 a), while the alternative surface sealing system has a total thickness of 3.02 m (Fig.22 b). This is mainly due to the 1.0 m thicker recultivation layer. Since a recultivation layer is required by the forestry authorities anyway to allow tree planting (also in the case of the standard sealing system) and this requirement is regularly taken into account, the low thickness of the sealing layer even results in a reduction of the layer package [21].

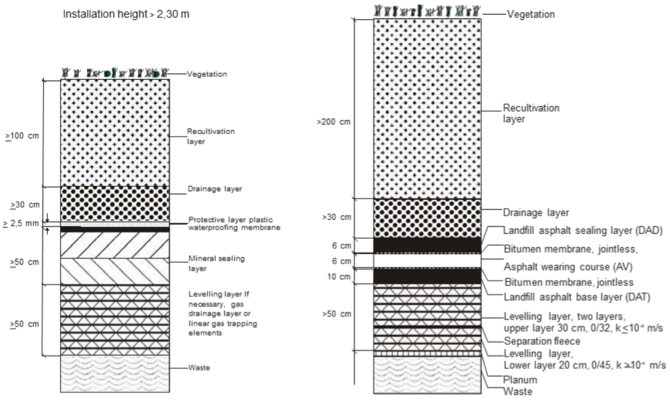

Fig. 22. Comparison of alternative surface sealing system / surface sealing a) according to TASi and structure height > 2.30 m; b) Alternative structure of the surface sealing system with the structure height 3.02 m [21]

Fig. 23. DAD – installation in the leveling area of the Ramsklinge landfill site [21]

Fig. 24. Asphalt trough installation of the Ramsklinge landfill site [21]

Installation at the Reesen landfill in Saxony-Anhalt, Germany

The approved Class I landfill in Reesen was constructed in three stages in a progressive open-cast sand mining operation. It has a final storage area of about 20 ha and a storage volume of about 4.5 million m³. During the preliminary planning stage, it was decided to use a more cost-intensive asphalt liner for the base seal than a KDB (plastic liner). In addition to greater mechanical robustness, which is reflected among other things by the fact that the cooled asphalt sheeting can be driven over, the advantages of asphalt over a KDB are greater stability of the embankments due to higher frictional resistance and lower sensitivity to weathering [22].

Fig. 25 shows an overview of the Reesen landfill site.

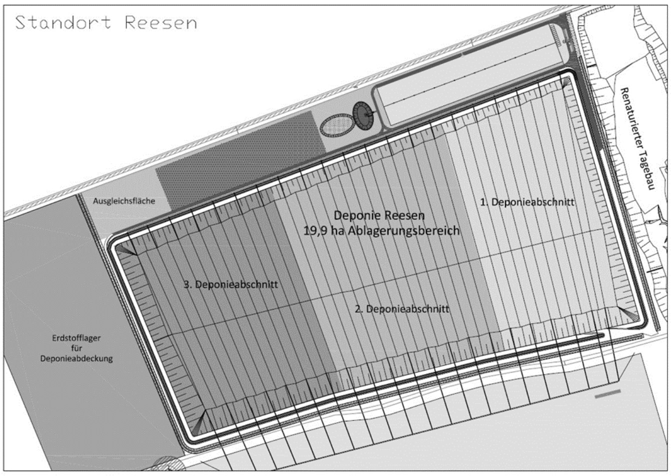

Fig. 25. Overview landfill Reesen [22]

According to the planning approval decision and the requirements of the quality assurance plan, the specifications listed in Table 4 had to be met for the landfill asphalts of the base sealing system. These are based on the characteristic data of the DIBt [3].

TABLE IVV. Features asphalt barrier [22]

	Landfill asphalt base layer (DAT)	Landfill asphalt surface layer (DAD)
Thickness	0,12 m	0,8 m
Grain size	0/16	0/11
Grain size < 0.09 mm (filler)	9 - 14 %	12 - 16 %
Grain size > 2.00 mm (chippings)	50 - 65 %	40 - 55 %
Binder type	50/70 or 70/100	50/70 or 70/100
Binder content	5,2 - 6,5 Mass-%	6,5 – 7,5 Mass-%
Cavity content of mix	≤ 3 %	≤ 2 %
Cavity content drill core	≤ 5 %	≤ 3 %

Figures 26, 27, 28, 29, 30, 31, 32, 33 show the photos of asphalt paving at the Ressen landfill.

Fig. 26. Construction 1st test field [22]

Fig. 27. "Hot to hot" asphalt base courses on geological barrier with inclined seam flank [22]

Fig. 28. Installation DAT with "hot to hot" sheets in the area of the low points of the roof profiles [22]

Fig. 29. Finished DAT in the plane [22]

Fig. 30. Installation DAT in the slope area [22]

Fig. 31. Installation DAT in the embankment area, detail [22]

Fig. 32. Installation of DAD in the embankment area [22]

Fig. 33. DAD completion level [22]

X. Conclusion

Asphalt liners have been used in hydraulic engineering for many decades and have also been used sporadically in landfill construction within the last 40 years. Landfill base seals must be resistant to mechanical, biological and hydrodynamic/chemical stresses during the construction, operation and aftercare phases. According to the principles for the proof of suitability of sealing elements in landfill sealing systems of the German Institute for Construction Technique (Deutsches Institut für Bautechnik) DIBt [3], the impermeability of the base sealing to aggressive liquid media must be proven when exposed to a quantity of permeant of 10 l/m2 at a temperature of + 40 °C.

The strength of an asphalt seal in relation to mechanical stresses is influenced by the substrate and the mix composition. Bitumen alone is relatively easy to deform, but landfill asphalt usually only has a bitumen content of 5 to 7 wt.%, so that it is easy to deform over large radii.

In the area of base seals, the asphalt seal can be attacked by both aerobic and anaerobic microorganisms, whereby the temperature, humidity and atmospheric oxygen content are of great importance. Aerobically, about 20 - 50 g of bitumen per year and m2 can be degraded, anaerobically about 0.2 - 0.6 g of bitumen per year and m2. Rooting and attack by animals (e.g. rodents) are of great importance for surface sealing.

The impact of each drop of solvent is associated with a hydrodynamic/chemical attack on the asphalt surface directed towards erosion, which may be followed by a dissolving process and eventual removal of the dissolved components. In view of the problem-free producibility of asphalt sealing on beds and embankments, which has been proven in decades of practice, and the resistance and effectiveness against the most severe stresses, which has been proven by test results, nothing should stand in the way of the use of asphalt as a construction material for the basic sealing of landfills.

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