# COMPACT ASPHALT
# – ADVANTAGES AND DISADVANTAGES OF A NEW TECHNOLOGY –

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## INTRODUCTION

The structure of an asphalt construction in conventional highway engineering consists of several layers, which are respectively laid and compacted in succession on the sub-base course that has cooled down already. However, compact asphalt pavements comprise two rolled layers of asphalt with different compositions: the lower layer's thermal capacity is used during the laying so that the thinner upper layer can be compacted better. A reliable bond between the layers is created without additional spraying while doing so, which results in a compact asphalt laminate [1].

The objectives of using compact asphalt pavements are:

- to improve the prerequisites for compaction;
- to achieve a reliable bond between the layers as the result of interlocking both layers; which results in better dissipation of shearing forces arising from the surfacing course;
- to save particularly high-quality building materials on account of the surfacing course's reduced thickness and thus
- to reduce the costs of construction and maintenance.

The customer and contractor both have to note the conditions of compatibility when constructing roadways with compact asphalt. These conditions have an affect on the use of machines and personnel among other things, as well as on the costs and the chosen laying process.

This study's objective comprises the fundamentals of compact asphalt technology, the laying of compact asphalt by the 'hot on hot' process, the quality assurance measures that have been proven in practice during laying and the consideration of economic efficiency with definitive prospects.

## 1. FUNDAMENTALS

### 1.1 Compact asphalt technology

Compact asphalt pavements are asphalts with which the upper and lower layers can be laid directly after one another: this enables an optimal bond to be achieved between the upper and lower layers.

The binder course is prevented from cooling down prematurely by means of laying the surfacing course directly onto the hot or warm binder course. The entire thermal capacity of both courses can then be better exploited for the compact asphalt's compaction. A longer time is available for the compaction, so that a higher degree of compaction and a lower content of voids can be achieved. The compaction is done with conventional rollers.

The thickness of the surfacing course with a construction of compact asphalt can be reduced to between 15 mm and 25 mm compared with a roadway's conventional structure, depending on the largest size of grain that is utilized in the bituminous mixture. The dimensioning is orientated to the guidelines of RStO 01 [2], depending on the overall road construction. The surfacing course either consists of mastic asphalt blinded with chippings or asphaltic concrete.

Compact asphalt pavements can only be laid over a bound sub-base course that has an adequate load-bearing capacity. The bond between the surfacing course of asphalt laminate and the sub-base course has to be ensured by spraying an adhesive agent (i.e., bituminous emulsion) onto the sub-base course [5]. It is inapplicable to apply the spray between the two layers of compact asphalt which are going to be laid.

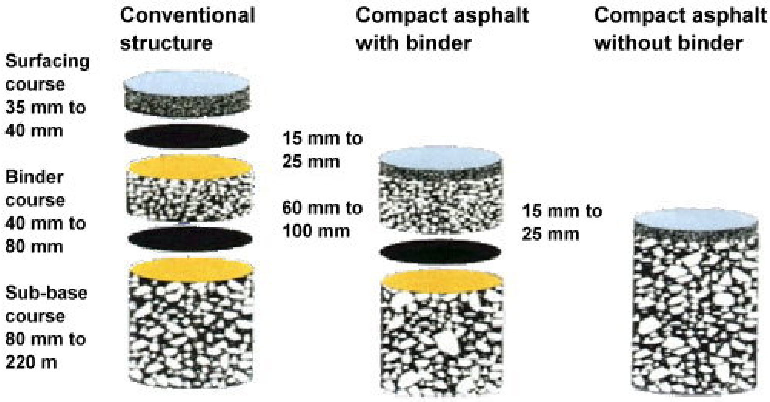

Figure 1 – Structure of the courses

Care must be taken to ensure that there is a steady laying speed and that the mixing plant has an adequate capacity when constructing compact asphalt pavements, in order to obviate the ocurrence of segregation and unevenness. The laying speed should be between 2 m per minute and 5 m per minute.

## 1.2 The laying process

One has to distinguish between the 'hot on warm' and 'hot on hot' laying processes as compact asphalt pavements. The term of 'compact asphalt' is certainly utilized only in connection with the 'hot on hot' laying process.

Two layers of rolled asphalt are laid shortly after each other chronologically by two conventional laying trains (the finisher plus a set of rollers) with the 'hot on warm' laying process. The lower layer is quickly compacted with a set of rollers before laying the upper layer, so that the following vehicles carrying the bituminous mixture and the second finisher do not leave any appreciable impressions in the layer. The lower layer certainly cools down for a long time while it is being compacted. The compaction's properties can therefore only be improved under certain conditions.

Moreover, a traffic lane for deliveries of the bituminous mixture is required next to the laying way for laying the upper layer: this prevents the roadway from being laid across the full width or it requires an additional construction road to be laid out. This process was not able to gain acceptance because of that. Only the 'hot on hot' process will be considered as this study progresses.

The 'hot on hot' laying process is characterized by the upper and lower layers being laid directly after one another.

So-called chargers are stipulated so that the compact asphalt can be constructed at a steady laying speed. The matter concerns feeding units for filling the individual finisher hoppers. The finisher hoppers have appropriately large capacities, so that the bituminous mixture can be permanently drawn off from the hoppers during the laying without having to stop the laying operation.

Both asphalt layers are finally compacted with rollers in one working cycle. It is absolutely essential to begin the rolling process on the entire laminated with three or four static rolling passes.

The 'hot on hot' laying process can be basically separated into two processes.

- Process 1: laying with a special finisher.
- Process 2: laying with conventional finishers.

### *1.2.1 Process 1 (laying with a special finisher)*

The compact asphalt is laid with the so-called compact modular finisher in this process. This special finisher consists of two laying boards for laying the upper and lower layers.

Vehicles deliver sequentially determined amounts of bituminous mixture, binder or surfacing to the laying point and they feed them into the charger's receiving hopper. The charger feeds the respective bituminous mixture on a conveyor belt to the appropriate finisher hopper (fig. 2: the flows of material are shown in green and orange). The finisher hoppers are alternately filled with charges in this way. Measures must also be taken to ensure that the hoppers are charged without making mistakes.

The bituminous mixtures inside the finisher are continuously drawn off from the hoppers – depending on the demand for material from the finisher's boards – and they are laid as the lower layer or upper layer. The asphalt laminate is then compacted with rollers.

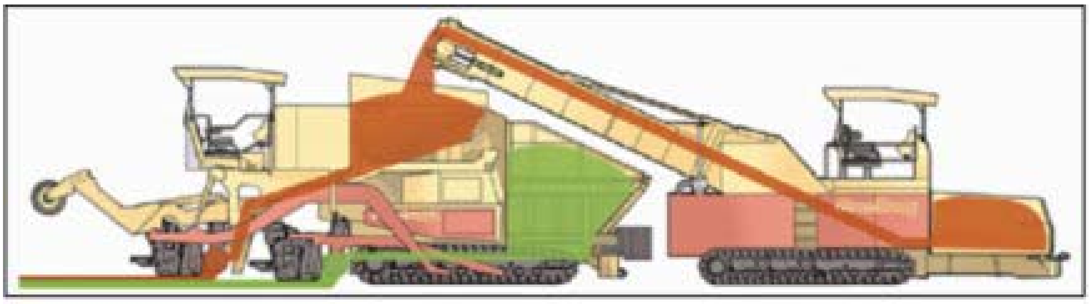

Figure 2 The laying operation with Process 1

It is possible with Process 1 to lay the compact asphalt over a maximum laying width of 13.25 m at present.

### *1.2.2 Process 2 (laying with conventional finishers)*

Process 2 enables the use of conventional finishers. The upper layer is laid by means of the second or third finisher passing over the lower layer, which is still highly pre-compacted. One can differentiate between two laying methods according to the number of finishers that are used.

### 1.2.2.1 *Method 1 (use of two finishers)*

With this method, the bituminous mixture is fed by means of the charger into either the bituminous mixture hopper of the finisher that lays the first layer, or onto a transfer conveyor belt which feeds the bituminous mixture to the hopper of the surfacing finisher that follows directly afterwards.

The bituminous mixture that has been laid in the lower layer is adequately pre-compacted by utilizing the first finisher's higher compacting laying board, so that the following finisher only makes initial impressions in the fresh asphalt layer by its own weight.

Figure 3 The laying operation with Process 2 using two finishers

### 1.2.2.2 *Method 2 (use of three finishers)*

The lower layer is also laid with two asphalt finishers running in tandem, which are equipped with higher compacting laying boards as well. The first finisher's boards are fastened eccentrically in order to charge the following surfacing finisher, which lays over the full laying width. It is thus possible to arrange that one charger for the surfacing finisher runs along in the intermediate space too.

## 1.3 Differences in the laying processes, which are related to the process

Differences in the laying process, which are related to the process, have to be noted: depending on special traffic lanes, geometrical constraints (curved radii, inclines, etc.), batch sizes and laying widths.

| **Laying process** | **Process 1** | **Process 2** |
|---|---|---|
| Finisher | 1 special finisher | conventional finisher |
| Laying width | 3 m to 13.25 m | 3 m to 12.5 m |
| Longitudinal seam | For laying widths of:<br>less than 13.25 m: none<br>more than 13.25 m: required | less than 12.5 m: none<br>more than 12.5 m: required |
| Running over the lower layer: | no | with a surfacing layer finisher |
| Use of the lower layer's thermal capacity: | complete | almost complete |
| Higher proportion on inclined sections: | must be dealt with first | - |
| Small-radius curves | must be dealt with first | - |

Table 1 Differences in the laying processes, which are related to the process [1]

## 1.4 Compaction of the compact asphalt

The entire laminate is compacted with rollers after laying the compact asphalt pavement. The asphalt surfacing course cools down with considerable delay compared with conventional laying methods: this enables an optimum degree of compaction and content of voids to be achieved in both asphalt layers because a longer period is available for the compaction overall.

Further investigations have proved that an increase in the degree of compaction by 1% improves the mechanical properties by about 15%. Longer durability with better properties of resistance to deformation can be expected [11].

An individual compaction concept – in which the meteorological conditions, the expected thermal capacity during laying and the thicknesses of layers to be laid are taken into consideration – should be drawn up before implementing any building operation, so that the optimal compaction can be achieved for both asphalt layers.

### *1.4.1 Example of a compaction concept (Laying Process 1 with a special finisher) [9]*

The surfacing course is compacted statically with light-weight rollers (1.8 metric tons) which are located directly behind the finisher during the construction by a compact modular finisher in order to prevent the following rolling operations from causing displacements in the surfacing course and producing an inappropriate evenness in this way. The main vibrating compaction is then done by medium-heavy rollers (6 to 8 metric tons). The requisite initial grip is produced by a grit spreader, directly after the main compaction.

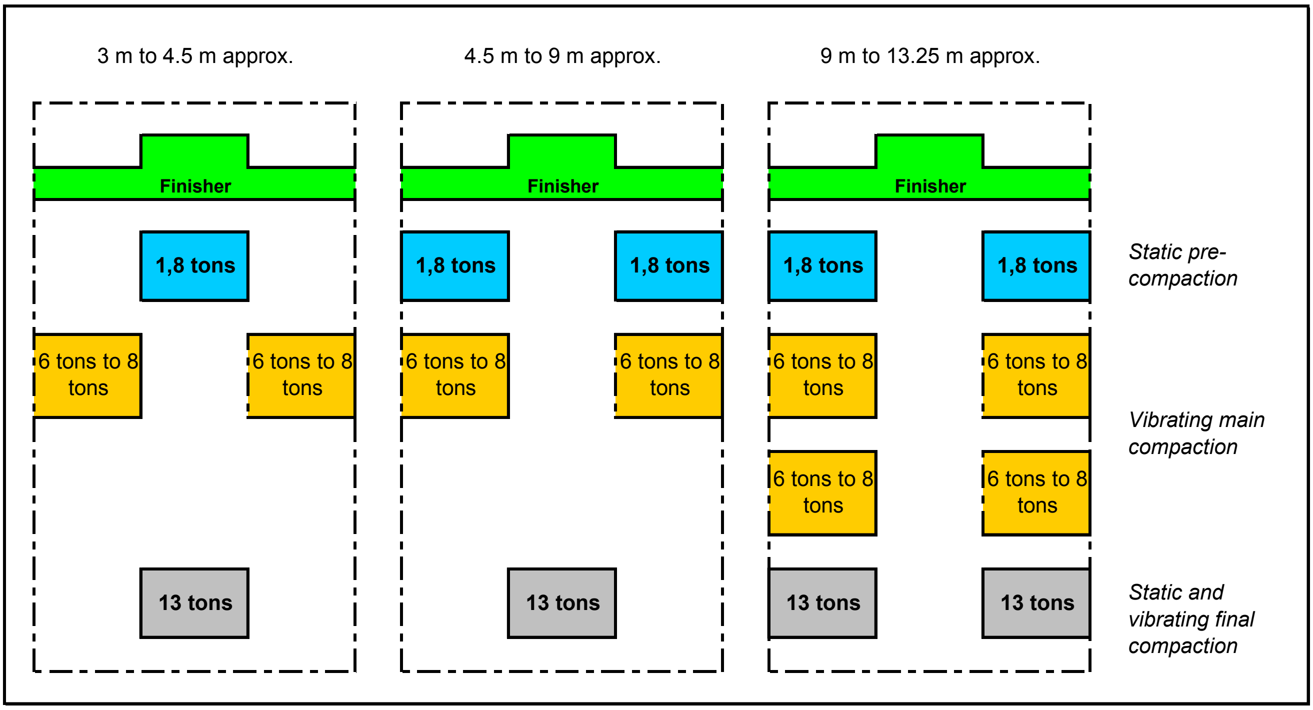


Figure 4 Use of rollers in Utterodt [12]

The heaviest rollers (13 metric tons) then finish off the final compaction, which is specified as being more than or equal to 99% for the binder and more than or equal to 99% for the surfacing. The requirement for compaction is stipulated as being more than or equal to 100%, insofar as it is intended to lay the binder with a thickness of more than or equal to 80 mm.

The surfacing is then compacted by passing a static roller weighing 13 metric tons over it in order to achieve an optimal final compaction of the surfacing course, which is only 15 mm to 25 mm thick.

#### *1.4.2 Example of a compaction concept (Laying Process 2 with 2 finishers)*

The binder course is pre-compacted directly at the finisher with Process 2. Higher compacting laying boards are so effective already that it is not required to compact the surfacing course or the binder course gradually any more by means of using light and heavy rollers intermittently. Nevertheless, the main compaction and the final compaction are then done with the aforementioned rollers in this case too [10].

### 1.5 Requirements for the compact asphalt

The following requirements and limiting values – among other things – are stipulated in the German national standards like ZTV Asphalt-StB 01 [3] and ZTV T-StB [4] for example.

- Requirements for the building materials and building mixtures.
- Limiting values for the laying thicknesses and laying weights.
- Limiting values for achieving adequate initial grip.
- Requirement for the degree of compaction and content of voids.

The M KA [1] code of practice for constructing compact asphalt pavements stipulates modifications which diverge from these requirements and limiting values; it also gives technical recommendations.

Minimum conditions for ancillary quotations according to ARS no. 13/2005 [6] apply in Germany to ancillary quotations that offer construction of the roadway as a compact asphalt pavement. Ancillary quotations for compact asphalt pavements laid with other methods of construction using mastic asphalt blinded with grit according to RStO 01 [2] and ZTV Asphalt-StB 01 [3] are equivalent, provided that they comply with these minimum conditions.

Seams and joints should be avoided, on account of the greater height of a seam's flanks compared with conventional laying. If a longitudinal seam is required, then the seam's flank must be formed and compacted in the warm state [5]. The supplements to the M KA [1] code of practice must also be noted for this purpose.

## 2. TECHNICAL ADVANTAGES AND DISADVANTAGES

### 2.1 The technology's advantages and disadvantages

It is an essential prerequisite for the overall construction's long service life that all asphalt layers are bonded permanently.

The surfacing course's grains of grit can be pressed into the binder course because the lower course has still not been compacted completely when the surfacing course is being laid and the hot mastic is still really soft in the binder course's superficial area. This interlocking ensures that substantially higher horizontal forces – especially those caused by horizontal thrust – can be better adsorbed than is the case with conventionally laid asphalt [16].

Moreover, optimal adhesion enables the maximum vertical forces to be absorbed in the separation layer. The adhesion results from bonding the binder's bitumen film with the surfacing course at the contact surface under high pressure [16]. One cannot expect the formation of track grooves in the roadway, despite the surfacing course's thin coating.

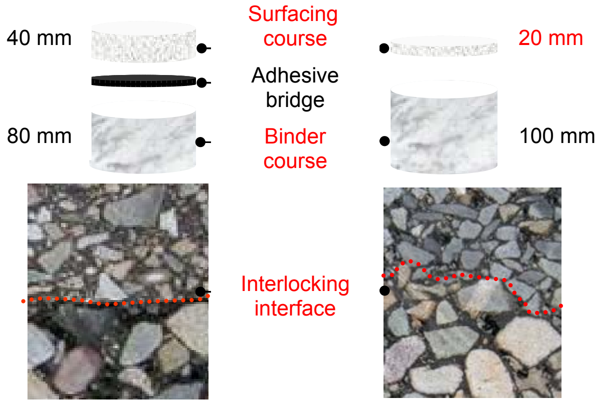


Figure 5 Bond between the layers, Vögele (2006) [10]

Higher resistances to deformation are achieved by better compaction and a lower content of voids because a longer period is available for the compaction. Compact asphalt can be laid down to a temperature of 0°C and almost 'insensitively to meteorological conditions', so that prolonged construction periods are feasible.

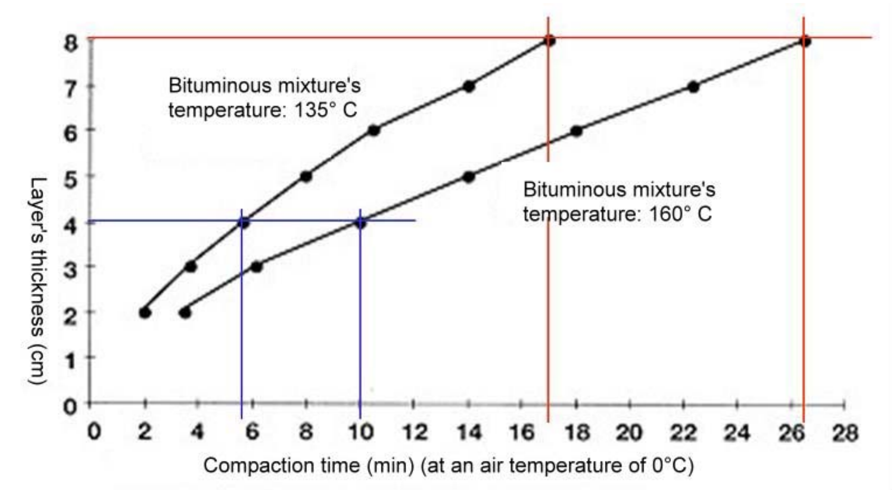


Figure 6 – Compaction time depending on the layer's thickness [16]

The improved resistance to deformation and the optimum bond between the layers allow one to expect that the asphalt surfacing course's service life will be extended to over 15 years.

One must not forget that the underlying layer of coarse grains is protected from meteorological influences or soiling by the construction site operation because both layers [of asphalt] are laid directly after one another.

The method of construction using compact asphalt certainly does not involve only advantages. For example, large divergences from the surfacing course's specified thickness have to be avoided upwards when producing the compact asphalt, in order to prevent the risk of excessive lubrication [7].

The lower content of binding agents in the lower layer [of asphalt] strongly affects the adhesive bond to a moist sub-base course adversely. Moreover, the sedimentation tendency in the transverse direction or over the layer's height is increased by the lesser content of binding agents in the asphalt binder course [7].

The sub-base course (which is the asphalt sub-base course as a rule) should not have any unevenness greater than or equal to 6 mm over a measured length of 4 m: this therefore requires that appropriate care is taken already during the laying, in order to construct this course.

A high degree of pre-compaction is required in the lower layer of compact asphalt, in order to thus avoid the bituminous mixture yielding laterally in the form of roller tracks and rucks. A steady laying speed is also stipulated (from 2 m/min. to 5 m/min. for the 'V' finisher), so that the required evenness can be achieved. All guidelines can only be followed and complied with by taking separate technical measures and by employing qualified and experienced personnel.

Furthermore, it must be ensured that the mixing plants have appropriate capacities, in order to avoid standstills during the laying. The individual capacity of mixing plants – besides the number of mixing plants – has to be checked in particular before constructing the roadway, in order to enable the charger to be supplied permanently.

The asphalt surfacing is not allowed to be delivered from several mixing plants. On the other hand, the asphalt binders can come from several plants as a bituminous mixture – provided that the bituminous mixture has the same composition (type of mineral aggregate and binding agent) – and be transported to the construction site.

Figure 7 The binder finisher is being charged: binder on the left and surfacing on the right.

Measures have to be taken on site to prevent mistakes being made when charging the finisher hopper or the charger. Possible measures are described in Section 3 of this study. Furthermore, technical measures also have to be planned for preventing segregation of the bituminous mixture in the feed unit.

A roadway that has been constructed with compact asphalt can only be released to traffic after 36 hours of cooling-down time, compared with conventional construction.

Careful planning and preparation of a building operation that uses compact asphalt, combined with the stipulation of an appropriate laying process, enables the compact asphalt to be constructed professionally, durably and economically.

Contractors must invest in the appropriate machines and know-how (i.e., expertise) at first as a rule, insofar as they decide in favour of a construction using compact asphalt. The existing personnel have to be appropriately trained and further personnel might have to be employed, so that the higher number of machines (rollers and finishers) can be operated.

The quality of the machines, the bituminous mixture and the constructed compact asphalt must be supervised constantly as well as corrected appropriately while the asphalt is being constructed, in order to typically prevent the removal of what are now 2 layers of asphalt [instead of 1] subsequently because of existing defects or damage in the worst case.

## 2.2 Advantages and disadvantages of the laying process

### *2.2.1 Process 1 (special finisher)*

Process 1 has been able to establish itself already as a fully recognized laying procedure on several building sites in Germany within recent years.

The complete exploitation of the lower layer's thermal capacity has a favourable effect on the compaction and thus on the compact asphalt's subsequent properties too. Moreover, the lower layer is neither run over by the transport vehicles nor by the rollers or finishers after the laying. Other running gears are therefore prevented from leaving impressions in the lower layer.

It is certainly required that the appropriate board creates a high degree of pre-compaction in the lower asphalt layer: this can only be achieved by taking the appropriate technical measures with the machines. Otherwise, it is possible that the bituminous mixture could yield laterally in the form of roller tracks and rucks, on account of an excessively heavy roller [8]. Furthermore, an inadequately high degree of pre-compaction in the lower layer can lead to both of the asphalt layers being mixed together. The roadway would therefore be damaged overall in terms of its resistance to deformation, durability and evenness.

The quality of individual asphalt layers cannot be assessed in detail while the laying is being done with the special finisher, on account of the short spacing between the binder board and the surfacing board.

### *2.2.2 Process 2 (2 finishers)*

The second process was only developed a few years after producing compact asphalt according to Process 1 and it has therefore only been used for about 2 years on various building sites in Germany and the Netherlands. Nevertheless, the results achieved and the experience gained while doing so allow one to expect that this laying process will also establish itself in the near future.

The lower layer's thermal capacity is almost completely exploited with this laying process, so that a high degree of resistance to deformation can also be achieved with this process.

The lower layer will certainly be run over by the surfacing finisher after it has been laid. It is possible in principle that the second finisher's running gear will leave impressions in the lower layer as a result. It is therefore recommended not to choose Process 2 in Germany generally speaking, insofar as impressions in the lower layer would be rejected [1]. This principle also applies especially to traffic surfaces with a high proportion of inclined sections and with small-radius curves because these areas are particularly subjected to stress and strains by the surfacing finisher's chain running gear.

It is certainly true nowadays that the current state of technological development with mechanical engineering already permits the first finisher to be equipped with a higher compacting board. Pre-compaction values of up to 98% in the asphalt binder will also be achieved – depending on the bituminous mixture – by using this higher compacting board, even without rollers. Impressions left by the second finisher in the binder course are hardly detectable.

Moreover, the high degree of pre-compaction in the binder course prevents the material in the binder course and the surfacing course from being mixed together, which ensures that the technically improved properties are not destroyed. It is possible that rolling faults will cause unevenness – as described for Process 1 in sub-section 2.2.1 – with this process too, whenever there is an inadequately high degree of pre-compaction by the first finisher

Moreover, the entire laying train's geometry in the second process requires that technical measures are taken for regulating the spacing between the individual machines, in order to ensure a steady laying speed.

Figure 8 Process 2 using Method 2.

The entire laying operation and its dependent, individual elements can only be supervised by means of effective communication between the individual employees without any problems. These circumstances are particularly clear and important whenever the compact asphalt is being laid according to the second laying method.

Both boards can be controlled as usual because the laying of binder and surfacing decouples them from one another when using Process 2. The levelling during the laying is also done via the external control units, as with conventional laying. The laying results for the upper and lower layers can be checked and appraised separately.

This laying process enables the machines to be re-equipped quickly for use on conventional building operations at short notice. For example, only the large receptacle (refer to Fig. 9) on the surfacing finisher has to be lifted up for this purpose.

## 3. MEASURES FOR QUALITY ASSURANCE ON BUILDING SITES WHEN USING CONSTRUCTION PROCESS 2

Measures concerning quality assurance for the second laying process (conventional finishers) will be demonstrated in the section. The described measures have proven themselves in practice already and they ensure professional and high-quality laying of the compact asphalt.

Optimal logistics on the building site are a very important prerequisite for choosing this laying process. For example, it can only be avoided in this way that the surfacing's bituminous mixture will be laid on the lower course or the binder's bituminous mixture will be laid on the upper course.

It is highly significant that the operator of the mixing plant and the supplier of the bituminous mixture coordinate well with each other in advance of the actual laying and that a consistent quality of the correct material will be delivered on time. The vehicles with different grades of bituminous mixtures should be identified, in order to prevent mistakes being made.

The operator of the charger takes over organization on the building site and he marshals the respective lorry carrying the bituminous material by means of switching traffic signals. He can choose between 'green' for the binder material and 'red' for the surfacing material with the aid of a switch: he signals this command to the identified vehicles carrying the bituminous material. The charger must be emptied completely before the charger hopper is refilled with another grade of bituminous mixture.

Figure 9 Material flow of the surfacing material

If the operator typically changes from the binder's bituminous mixture to the surfacing's bituminous mixture, then the conveyor belt will be adjusted in height and spacing automatically, so that the different hoppers can be served at the binder finisher correctly in this way.

Particular care must be taken to ensure that there is a steady laying speed when constructing compact asphalt pavements, in order to achieve the required evenness of 4 mm along a length of 4 m. It was established during the initial phase of developing the 'hot on hot' method of construction in particular, that the average level of evenness with conventionally constructed asphalt surfacing courses was mainly higher than that. However, it has been proved for several years that evenness will be achieved according to the contract [17]. Achieving the requirement of 4 mm depends on the laying team's experience primarily.

In addition, technical devices have been developed and used most recently. The spacing between the charger and the binder finisher with some laying vehicles is typically measured contactlessly and it is kept constant by means of three laser sensors. The spacing is adjusted automatically when changing the grades of bituminous mixture. If the spacing is reduced unintentionally, then the following machines will stop automatically. The speed of the entire train is set by the binder finisher.

Radio communication between the participants serves to protect against collisions, in addition to the technical measures like laser electronics. The employees at the start of the laying train can typically coordinate with the employees at the end of the laying train uncomplicatedly and unmistakably by using wireless phones. It has been proven that the entire laying personnel should be equipped with wireless phones, in order to make it possible for high-quality laying to be done.

The asphalt binder course is eventually run over by the second finisher with this process, so that impressions in the binder course could have a negative effect on the compact asphalt's properties: this applies particularly to traffic areas with a high proportion of incline sections and small radius curves, as mentioned above already.

The crawler gear's bottom boards can be widened to 400 mm, in order to counteract this problem. The bottom boards are made from steel in order to prevent bitumen from sticking to them. The crawler gear is sprayed with water, in addition.

## 4. ECONOMIC EFFICIENCY

The technological costs and their comparative benefits are eventually decisive for implementing and using new technologies.

An economic benefit for the public customer can result already from possible cost savings on the construction costs. These costs savings are made possible in the form of quotations and construction contracts for lower sums whenever individual operations are implemented by the contractor.

On the other hand, the commercial benefits for the contractor can only appear on account of a positive profit from the individual operations, after deducting all of the production costs and investment costs. The initial investment costs for additional finishers, rollers, special equipment, personnel training courses, etc. must not be underestimated in this case.

Nevertheless, both benefits depend decisively on the size of a construction job. The rule of 'the larger the construction job, the larger the commercial benefits' applies in this case.

The conventional method of construction is indeed more time-consuming than the method of construction using compact asphalt but it is less intensive in terms of equipment and personnel. Substantially higher fixed costs thus arise with the compact method of construction (e.g., from the transport of equipment on low loaders, setting-up costs, etc.), which can have a strong effect on the costs per square metre of asphalt roadway according to the size of a construction job.

Nevertheless, it is possible that the contractor will be able to increase the use of employees and equipment effectively; even at times of the year when the weather is bad (e.g., during the winter). The use of Process 1 with special finishers is practical for a laying area of at least 12,400 sq.m. [15], according to an initial study that was carried out by the Technical University of Darmstadt in 2001.

## 4.1 Reduced construction costs for a roadway

The costs of expensive mineral aggregate can be reduced lastingly because the compact asphalt enables the surfacing course's thickness to be reduced compared with the conventional method of construction. Moreover, the surfacing course can be optimized economically regarding its surface properties (grip, brightness, etc.).

Furthermore, it is inapplicable to make an adhesive bridge with the bituminous binding agent between the surfacing course and the binder course. Laying across the full width also obviates having to make a longitudinal seam.

**Example** — **Major road with a width of 11.5 m; SV construction class. Construction length of 5 km; area of 57,500 sq.m.**

**1. Saving on materials for the surfacing course**

Surfacing material (SMA 0/8 S): € 68 / ton
Binder material (Abi 0/22 S): € 53 / ton

| Construction | | | Quantity | Costs |
|---|---|---|---|---|
| | RSTO | | | |
| | Surfacing | 40 mm | 5,520 tons | € 375,360 |
| | Binder | 80 mm | 11,040 tons | € 585,120 |
| | | | | € **960,480** |
| | COMPACT | | | |
| | Surfacing | 20 mm | 2,760 tons | € 187,680 |
| | Binder | 100 mm | 13,800 tons | € 731,400 |
| | | | | **€ 919,080** |

**2. Saving on the adhesive bridge and longitudinal seam**

Making the adhesive bridge: € 0.10 / sq.m.
Making the longitudinal seam: € 4.50 / m.

| Construction | | RSTO | COMPACT |
|---|---|---|---|
| | Bonding emulsion | € 5,750 | € 0 |
| | Longitudinal seam | € 22,500 | € 0 |
| | | **€ 28,250** | **€ 0** |

**3. Saving on construction time**

| For measures according to RSTO | |
|---|---|
| Prolonged temporary provision of a steel sliding wall | € 740 / d |
| Prolonged temporary provision of traffic signs | € 60 / d |
| | **€ 800 / d** |

Figure 10 Potential saving arising from the method of construction

Moreover, the method of construction using compact asphalt enables shortened construction times for the individual building operations compared with the conventional method of construction. The shorter construction time again results in reduced costs for securing the building site and lesser hindrance of traffic for the respective regions.

It is even conceivable to reduce the bituminous mixture's temperature during manufacture in the mixing plant whenever the weather is appropriately warm, so that the costs of heating oil for the mixing plant will be reduced too. The bituminous mixture can also be processed extremely well at a lower characteristic temperature on the building site in this case.

**Continuation of the example** **Major road with a width of 11.5 m; SV construction class. Construction length of 5 km; area of 57,500 sq.m.**

**Energy saving at the mixing plant** (information according to AMMANN)

Cost of heating oil: approx. € 0.40 / l.
Energy cost at 180°C: approx. 7.5 l of heating oil per 1 ton of asphalt bituminous mixture.

- Temperature reduced to 100°C: up to 25% less heating oil.
- A saving of 0.23 l / ton of bituminous mixture – equal to € 0.09 / ton of bituminous mixture – results by reducing the bituminous mixture's temperature by 10°C.

A **potential saving of € 1,490** results from a laying quantity of 16,560 tons of bituminous mixture.

Figure 11 Energy saving at the mixing plant [12].

### 4.2 Reduced maintenance costs

It is undisputed that the roadway's surfacing will fail after a certain period and it will have to be renewed, even with the method of construction using compact asphalt.

Nevertheless, the costs for renovating the roadway's surfacing in the case of compact asphalt are up to 50% less than the costs for renovating a roadway made with the conventional method of construction, on account of the thinner surfacing course.

The improved resistance to deformation and the optimal bond between the layers allows one to expect that the service life of asphalt surfacing courses can be prolonged to over 15 years. Such a roadway only needs to be renovated at a substantially later point in time compared with the conventional method of construction, on account of the prolonged period in service.

## 5. PROSPECTS

The European asphalt standard known as DIN EN 13108 [14] shall come into force throughout Europe from 2008 onwards. The national legislation of the EU states has to be adapted in this connection. During the course of this adaptation, the aforementioned Laying Process 1 will be included and regulated in the ZTV asphalt StB 2007 as a recognized laying process, which will then apply in Germany.

Although Laying Process 2 will also be permissible in future, it will certainly not be included in the ZTV asphalt StB 2007 because the experience and results concerning this process are still inadequate at present. It must also be assumed in the case of this process that it will be implemented and become established, on account the building projects that have been completed in Germany and the Netherlands already.

Compact asphalt is a pioneering type of construction for the customer, on account of the aforementioned advantages in terms of costs and benefits: it should therefore be included in the planning processes and checked for applicability over the long term.

The contractor will indeed have to reflect on making a greater investment in equipment and personnel initiallly but he will obtain better planning reliability and exploitation of personnel and equipment with the method of construction using compact asphalt and its 'insensitivity to meteorological conditions', especially during the winter months, so that compact asphalt can represent a more economical solution than conventional laying.

The technology of compact asphalt has a future on account of its durability and economic efficiency but provided that the planning and laying are done carefully; irrespective of which laying process is chosen.

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