Asphalt Surfacing for high stress areas
## Contents

1. Introduction .............................................................................................................................. 4
2. General considerations ...................................................................................................... ....... 4
3. Construction points ......................................................................................................... ............. 5
4. Typical examples............................................................................................................ .......... 5
5. Publications ................................................................................................................ .............. 5

**Annex**

- Czech Republic ................................................................................................................. .................... 6
- France ................................................................................................................................................ 8
- Germany ................................................................................................................................................ 9
- Italy.................................................................................................................................................... 10
- United Kingdom .................................................................................................................. 11
1. Introduction

Asphalt surfacings are used worldwide for roads and other paved areas. However, where excessive indenting loadings are envisaged, special types of surfacing may be necessary and strong foundations will need to be provided. Similar measures are likely to be necessary where channelised trafficking arises or where for any other reason unduly high stress is placed on the surfacing.

Examples of such situations are:
- where solid metal support feet or dolly-wheels of heavy trailers are in contact with the surfacing;
- where goods are to be stored on the surfacing, particularly if there is heavy point contact with the surfacing, e.g. through rims of drums, corner feet of containers, etc;
- where tight manoeuvring by heavy vehicles gives rise to abnormally high stress wheel scuffing;
- where there is use of the surfacing by forklift trucks;
- where heavy objects are likely to be dropped on the surfacing;
- where heavy vehicles are travelling in tightly defined wheel-tracks, e.g. bus lanes.

2. General considerations

Fork lift trucks are of particular concern, for although the load carried by them may not be particularly heavy, they are slow moving, make sharp turns, often travel along fairly well-defined paths and produce high contact pressures; all of which can result in indentation or scuffing of the normal asphalt surfacing. The problem is greater for forklifts with solid metal or rubber wheels than for those with pneumatic tyres.

For heavy static loads the greatest problems are the risk of settlement of the construction and indentation of the surface. The greatest care must therefore be taken regarding not only the stability of the surfacing but also the strength of the formation, base etc.

Paved areas where high stress usage most commonly arises are often sited on weak soils, for instance on poorly consolidated estuarine silts or on made-up ground in the vicinity of docks and harbours. In such circumstances it is particularly desirable to enlist the aid of a specialist in structural design of pavements to make sure that the pavement is adequate in strength and stiffness to carry the expected loads. It is also important to ensure that there is adequate provision for the drainage of the formation as well as good falls for the rapid removal of surface water.

Even after taking all appropriate steps with regard to the strength of the lower layers of the construction, it is still necessary to reduce to a minimum the risk of indentation within the surfacing. This involves taking into account not only the maximum loads likely to be involved, but also the bearing areas. Something frequently overlooked with respect to indentation is that the important factor is the load per unit area rather than the total load; with small bearing areas the deformation or indentation risk is likely to be disproportionately great. Metal wheels will be more damaging than rubber tyres as the area of contact is likely to be less.

It is not often appreciated that indentation of asphalt surfacings is related not only to load but also to loading time and temperature, with the same load causing greater damage the longer it is applied and the higher the surfacing temperature. Thus, the disposition of the site in relation to prevailing sun and weather can be significant.
3. Construction points

Except in the case of very weak formations such as soft or made-up ground, the construction of the lower layers of paved areas for these high stress situations can generally follow that suggested by national bodies for heavy vehicle parking, but particular attention should be paid to the strength and compaction of the sub-base and base. The binder course should be one of the stiffer and denser mixes, for example asphalt concrete with 30/45 or 40/60 grade bitumen, depending on the severity of site usage.

Where the risk of indentation/deformation is general to the whole paved area, but of a relatively low risk nature, some improvement in the resistance of traditional asphalts can be obtained by adopting the principles of increasing coarse aggregate content and binder hardness and reducing binder content (but only to a level consistent with achieving satisfactory durability). These stiffer mixes will inevitably be more difficult to lay and achievement of full compaction in all layers of the construction is essential to satisfactory performance. Therefore, only experienced specialist surfacing contractors should be employed for this type of work.

Where heavy indenting loads are likely to be concentrated in a relatively limited section of a paved area, one compromise is to provide a normal asphalt surfacing, as indicated above, for the majority of the area but to provide some means of load spreading over the critical area, (e.g. steel plates), or an indentation-resistant inset, (e.g. concrete or concrete block construction).

Where very high risk of indentation and stress are anticipated, alternative types of construction will be necessary. These may involve the use of proprietary surfacings of the cement/polymer grouted or epoxy asphalt types, or alternative types of construction, such as concrete or concrete block paving. Such alternative surfacings or types of construction and/or the use of special oil-resisting binders in the asphalt will also need to be considered where there is a risk of undue spillage of hydraulic or petroleum oils, in view of the possible adverse effects of these oils on the normal bitumen-bound asphalt surfacings. Where concrete block paving is adopted, the use of an asphalt concrete base may provide a suitable high-strength, stable foundation.

4. Typical examples

In the annexes typical examples of uses of asphalt in high stress areas from different EAPA members can be found.

- Czech Republic – Container storage area
- France – Container terminal
- Germany - Industrial road in Berlin
- Italy – Airport track
- UK – Steel manufacturers internal access roads

These demonstrate that asphalt can be one of the right solutions for pavements for heavy loaded sites.

5. Publications

Other publications dealing with uses of asphalt are available from EAPA. A full list of these publications may be obtained from the EAPA website: www.eapa.org.

Ref. (3)2-03-00.006
Annex

Typical examples of uses of asphalt in high stress areas from various EAPA members.

This annex contains the following examples of heavy loaded sites constructed with asphalt pavements:

- Czech Republic – Container storage area
- France – Container terminal
- Germany – Industrial road in Berlin
- Italy - Airport track
- UK – Steel manufacturers internal access roads

Czech Republic – Container storage area

Construction of a new storage area (surface area of about 8 000 m²) with railway access in a large factory was required. The designer proposed a concrete structure. However, the client wished to finish the construction works without the constraint of curing times of concrete. Hence the project was changed just at the beginning, when the earthworks had started. The proposed concrete slab design was replaced by a pavement structure using a high modulus mix in the binder layer and semi-flexible concrete asphalt composite in the wearing course. This structure could receive loading one week after the end of construction.

The following structure was constructed according to the contractor’s own design proposal: (compared with concrete design)

<table>
<thead>
<tr>
<th>Asphalt design</th>
<th>Initial concrete design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concrete asphalt composite</td>
<td>50 mm</td>
</tr>
<tr>
<td>High modulus mix</td>
<td>70 mm</td>
</tr>
<tr>
<td>Cement treated gravel</td>
<td>230 mm</td>
</tr>
<tr>
<td>Cement treated gravel</td>
<td>300 mm</td>
</tr>
<tr>
<td>Total thickness:</td>
<td>650 mm</td>
</tr>
<tr>
<td></td>
<td>600 mm</td>
</tr>
<tr>
<td>Lime treated clay</td>
<td>500 mm</td>
</tr>
</tbody>
</table>

In-situ lime stabilisation treatment of the subsoil to a depth of 500 mm was proposed in both solutions as the soil was of poor quality.

Ref. (3)2-03-00.006
Asphalt surfacings for high stress areas

Heavy loading arose for two reasons:

- **A special truck-crane** that moves the containers (max weight of one container 25 tons) from the railway wagons to their position in the storage area. The maximum load on the front axle of this truck was 110 tons. The contact stress under the special wheels of the vehicle was more than 1 MPa. (A stress of 1.27 MPa was used for an equivalent circular loading of diameter 0.46 m in design computations).

- The client wanted to stack containers up to 5 high in any one column due to the limited space. This would result in a static stress under the foot of the bottom container of 10.7 MPa. Due to the restricted space between individual columns of containers the influence of “near-neighbours” had to be considered in the design of the structure, which could effectively result in about four times this static stress.

- It was recommended to the client that if more than 3 containers were to be placed in one column, then steel plates should be placed under the feet of the lowest container to decrease the contact stress.

Due to the very short time for the construction and the fact that it was the first time that such a heavily loaded structure had been constructed, some organisational problems arose during the construction and design. Some type testing had to be carried out during the construction period, in order to keep to the very tight time schedule demanded by the client. Thus, assumed performance values based on experience from similar projects had to be chosen for the contractor’s design computation. The mix composition of the second layer of cement treated gravel (bought from a local supplier) was improved, based on initial testing results. These factors might still have some influence on the long-term behaviour of the structure.

The structure was finished in June 2000. Monitoring of the behaviour of the structure during its first period of utilization was proposed but due to various reasons this monitoring was not fully realised.

In spite of these shortcomings no significant signs of problems with the use of the structure have been experienced, apart from some minor traces of distress under the feet of containers. It is anticipated that the experience from this site will allow similar structures to be constructed in the future in such a way that the long-term behaviour will be fully assured and the benefits of asphalt over a concrete structure can be demonstrated.

Ref. (3)2-03-00.006
France – Container terminal

The French example is a railway container terminal with a connection to road traffic. This terminal consists of a stocking area, a handling area and also traffic and parking areas with channelised lanes. It is located in Rennes (in the west of France).

In the handling areas, there are about 35,000 container movements per year and the life span is only 10 years. The handling vehicle has a front axle load of 110 tonnes on 4 wheels and the contact pressure is 1 MPa.

The pavement is composed mainly with high modulus asphalt concrete produced in France. From top to bottom, there are:

1. Handling area:
   - 60 mm BBME (High modulus asphalt concrete for surface course)
   - 350 mm EME (High modulus asphalt concrete for base course)
   - soil (modulus of 50 MPa)

2. Stocking area:
   - 60 mm of cement mortar grouted porous asphalt
   - 340 mm EME
   - soil (modulus 50 MPa)
   For this area, a shear failure for the surface is allowed.

3. Traffic area:
   - 50 mm BBME
   - 100 mm EME
   - soil (modulus 50 MPa)

The design is based on the French method by using “Alize” software and the main characteristics for the materials (stiffness, modulus, fatigue law, etc). This software computes the stresses and deformations in a semi-infinite homogeneous isotropic block under a circular load. Computation ceases with the comparison between computed and allowable values (stresses or deformations) for a given material.

The construction was carried out in summer 2001 and the performance is very good. Since this work, high modulus asphalt concretes are often used for industrial areas are one of the solutions.
Germany - Industrial road „Freiheit“ in Berlin

The road called „Freiheit“ is a very high trafficked part of a road in the industrial area of Berlin-Spandau. In fall 2001 until spring 2003 the old concrete pavement was taken out and special designed asphalt was brought in with traffic still rolling the whole time. The problem is a very slow moving heavy duty traffic and a high part of parking vehicles including trailers which put their legs directly onto the asphalt.

The construction is as follows:
- 4 cm stone mastic asphalt 0/11 with a special binder
- 8 cm asphalt binder 0/22 with a special binder
- 10 cm asphalt base 0/22 with paving grade bitumen penetration 30/45

The stone mastic asphalt and the asphalt binder are made with a polymer modified bitumen PmB 25 plus an additive which allows to lower the production and laying temperatures on a paraffin bases. This binder combination which has been tested before showed a very high resistance against deformation in laboratory tests.

Using the additive the laying temperatures could be 30 to 40° C lower than normal. No blue smoke could be seen at any time. The combination of the high viscose polymer modified binder and an additive on paraffin bases allows not only the reduction of the temperature but gives a higher viscosity in the asphalt which gives an additional reserve in the performance of the heavy duty asphalt. The performance in practise during the hot and long summer of 2003 has proven the laboratory experiences right, no indentations have been found.

Laying of the asphalt binder-layer
Asphalt surfacings for high stress areas

**Italy – Airport track**

At the Bologna Airport "G. Marconi" in Italy an airport track was built.

The maximum landing gear loads for aircraft are respectively: Airbus A300-B4 730 KN (so 4 wheels, each 158.5 kN) and Boeing 767-200 634 KN (4 wheels, each 182.5 kN) and the maximum contact stress under aeroplanes wheels is approximately 1,38 MPa (for the B767-200)

The pavement structure consists of:

- 50 mm High modulus asphalt surface course with modified bitumen
- 300 mm binder course with modified bitumen
- 500 mm existing asphalt base layer (on a tout venant foundation)

The mix design for the 50 mm asphalt surface course layer, with a bitumen percentage: 4.31 %, is:

<table>
<thead>
<tr>
<th>Sieve n°</th>
<th>passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>100-100</td>
</tr>
<tr>
<td>25</td>
<td>88-100</td>
</tr>
<tr>
<td>15</td>
<td>55-80</td>
</tr>
<tr>
<td>10</td>
<td>45-70</td>
</tr>
<tr>
<td>5</td>
<td>30-55</td>
</tr>
<tr>
<td>2</td>
<td>20-45</td>
</tr>
<tr>
<td>0.4</td>
<td>7 - 25</td>
</tr>
<tr>
<td>0.18</td>
<td>5 - 15</td>
</tr>
<tr>
<td>0.075</td>
<td>4 - 8</td>
</tr>
</tbody>
</table>

The mix design for the 300 mm asphalt binder course layer, with a bitumen percentage: 4.31 %, is:

<table>
<thead>
<tr>
<th>Sieve n°</th>
<th>passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
<td>100-100</td>
</tr>
<tr>
<td>30</td>
<td>80-100</td>
</tr>
<tr>
<td>25</td>
<td>70-100</td>
</tr>
<tr>
<td>15</td>
<td>45-85</td>
</tr>
<tr>
<td>10</td>
<td>35-70</td>
</tr>
<tr>
<td>5</td>
<td>25-55</td>
</tr>
<tr>
<td>2</td>
<td>17-40</td>
</tr>
<tr>
<td>0.4</td>
<td>6 - 20</td>
</tr>
<tr>
<td>0.18</td>
<td>4 - 14</td>
</tr>
<tr>
<td>0.075</td>
<td>3 - 8</td>
</tr>
</tbody>
</table>

A special polyethylene grid, wet by bitumen, was inserted between the old cracked pavement and the two new asphalt layers with the purpose of avoiding the reflective cracking. All the work phases were under a constant monitoring of asphalt materials characteristics and execution techniques.

The design of pavement was analysed with special software that simulates the linear elastic behaviour of multi-layer section, considering the complex behaviour of asphalt layers on an indefinite surface. An asphalt pavement with modified bitumen was chosen because this guarantees better mechanical characteristics than a concrete pavement. The pavement was constructed in 1996.

Normally high modulus pavements, as referred to above, are used in container terminals, for industrial floors and in all similar situations that require improved mechanical characteristics.

Ref. (3)2-03-00.006
UK – Steel manufacturer’s internal/access roads

One asphalt producer in the North of England has developed a series of proprietary materials incorporating steel slag, a by-product of the steel making process. This was notably beneficial to the company as they are a service provider to the metallurgical industries. The material is similar in nature to Asphalt Concrete (AC), and the nature of the aggregates give it improved strength, durability and resistance to polishing where skid resistance is a concern. It is available in a variety of nominal sizes, typically employing 40/60 penetration grade bitumen but can also be supplied with a polymer-modified bitumen to give further improvement in deformation resistance, dependent on the required application. Versions of the material are employed in a number of highway applications, including major local roads, container facilities, and motor sports tracks.

One significant application of this material is within the steel manufacturing facility, in the steel mill, on surfaces used for internal transportation of finished steel products. The steel in this area is moved on transfer ‘carts’ with solid rubber tyres, the total mass of the vehicle and load being between 100 and 120 tonnes. These roads also take normal road and heavy goods vehicles, and the main road to the weighbridge takes the entire year’s production of steel, currently standing at 1 million tonnes per annum. Additionally, all other raw material movements are carried out on these surfaces. Experience has shown that the material in this application has a typical lifespan of 12 years.

An extreme use of the material is as a sacrificial layer over a concrete roadway, on which the steel ladle transporter moves (see picture). The road is constructed from approximately 2.5m of type 1 sub-base reinforced with a geogrid, 600mm of concrete slabs and 40mm of steel slag asphalt. The asphalt is expected to rut under this loading and acts as a sacrificial layer to protect the concrete, should there be a spillage. If this were to occur on the concrete alone, the damage would be very difficult and time-consuming to repair, whereas with the asphalt, repairs can be made overnight and trafficking recommenced much more rapidly. Additionally, the impervious nature of the asphalt ensures that there is no ponding of water which would cause an explosion, should molten steel spill on to it.

The vehicle weighs 360 tonnes and moves on 3 axles. The back two axles take about 149 tonnes, each having four wheels. The front axle has two wheels and takes the remaining 62 tonnes. There is one fully laden movement across the asphalt every 40 minutes. The life of the asphalt in this application is around 4 years and the main (designed) failure arises due to the lack of restraining edges to the road on the bend which are also designed in order to promote run-off, further minimizing the risk of explosion.