

# **Asphalt pavements on bridge decks**

**EAPA Position paper**



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## **Summary**

In Europe most (if not all) steel and concrete bridges have an asphalt surfacing on top.

One of the main reasons for using asphalt is to protect the steel and concrete structures from water and de-icing salts.

This paper describes the systems that are mostly used for steel and concrete bridges.

In chapter 2 the layers used on the bridge decks are described. In general, the asphalt bridge pavement system can be split into four different layers: a sealing/bonding layer (primer), a waterproofing layer, a protecting layer and the asphalt surface layer. These four layers are described.

Chapter 3 describes the asphalt layers for steel bridge decks and concrete bridge decks and it explains the differences between steel and concrete bridge structures.

The bituminous mixtures used for asphalt layers on bridge decks are listed in chapter 4.

Maintenance and rehabilitation is addressed in chapter 5.

Chapter 6 gives the conclusions.

The appendix shows the experiences from different European countries.

# 1. General

There are many applications for asphalt. One of them is on bridges.

There are many types of bridges and these bridges can be constructed from different building materials such as concrete, stone, wood or steel [1.].

Bridges can be categorized in several different ways. Common categories include the type of structural elements used, their usage, whether they are fixed or movable, and by the materials used. According to structure type, bridges are classified as beam, truss, cantilever, arch, suspension, cable stayed and fixed and movable, double-decked and viaduct, made up of multiple bridges connected into one longer structure.

In terms of the materials used to build the structure, bridges are currently mostly built in concrete, steel, fibre reinforced polymers (FRP), stainless steel or combinations of those materials

This paper will concentrate on the use of asphalt on steel and concrete bridges, the most popular of modern types.

Many of the world's most magnificent modern steel bridge structures use the orthotropic steel plate systems.

*An orthotropic deck consists of a deck plate supported in mutually perpendicular directions by a system of transverse 'crossbeams' and longitudinal stiffeners. This results in a plate with dissimilar elastic properties in the two directions; in other words it is effectively an **ORTHO**gonal aniso**TROPIC** plate or, in short, an '**orthotropic** plate' [2.].*

The main reason for using asphaltic materials and asphalt layers on bridges is to protect the bridge system from some possible defects (intrusion of salts) and to give better properties for their durability, as described below.

## 2. Layers on the bridge decks

Bridge deck pavements must meet a large number of requirements, such as: Resistance to permanent deformation, texture depth, skid resistance, rigidity, evenness, ageing resistance, etc. It also must protect and seal the underlying supporting structure as this determines to a large extent the life of the structure under the heavy load of traffic and weather conditions [3.]. They must absorb traffic loads, transfer them to the supporting structures and remain even and resistant to deformation and provide good anti-skid conditions for vehicles. Besides, they must protect the bridge structure from surface water which in winter contains de-icing salt which promotes corrosion. Because of the different requirements for the pavement structure on a bridge deck, these functions are generally not fulfilled or only partially fulfilled by one material, a functional division can be made for the layers constructing the surfacing of the deck, often is a "system", consisting of several layers. This system is primarily composed of an asphalt pavement, but it can include primers and paving membranes, bond coats and paving fabrics [4.]. In general, the asphalt bridge pavement system can be split into four different layers: a sealing/bonding layer (primer), a waterproofing layer, a protecting layer and surface layer (asphalt).

Although different application techniques and materials can be used on steel and concrete bridge decks, the general construction steps on a bridge deck starts by surfacing of the deck, followed by sealing layer, a waterproofing layer, a protecting layer and the surface layer on top. The waterproofing layer + the protecting layer are often called "waterproofing system". The surface and subsurface drainage system should be applied on both steel and concrete decks. The sealing layer can be made from various materials, including bituminous materials.

### 2.1. Sealing layer (surface preparation, bonding)

Since asphalt layers cannot directly be bonded on a concrete or steel base, and nor is it 100% watertight, an intermediate sealing layer is necessary to establish a good bond to the waterproofing layer. On concrete bridges it also closes the voids in the concrete, thus minimising the risk of formation of blisters or bulges between the concrete and the waterproofing sheets.

*On steel bridge, bonding layer functions are;*

- Giving a reliable protection against corrosion
- Assuring a sufficiently strong adhesion between steel deck and the waterproofing layer
- Being resistant to shear forces
- Being resistant to fatigue

The most commonly used sealing method is applying a sealing layer with a kind of bituminous material as bitumen emulsion, PMB, epoxy resin, polyurethane, etc.

Before applying the sealing layer, the bridge deck surface has to be prepared properly to be clean, dry, sound, and free of all bond-inhibiting substances.

The concrete surface should have sufficient gradient in the longitudinal direction to ensure that drainage can occur in the drainage layer built-in and on the surface of the asphalt pavement. (The lack of this gradient has shown several incidents of damage on concrete bridges due to water penetration). When the concrete has cured sufficiently, the concrete surface is shot or sandblasted in order to remove excess cement laitance and to create a surface texture that will ensure good bonding when the waterproofing is executed. After the shot or sandblasting, sealing of the concrete surface with a sealing layer is applied on the clean concrete which must be surface-dry.

The steel bridge deck has to be stainless, no grease, oil, moisture or dust on the surface before application of primer.

## **2.2. Waterproofing system**

The waterproofing system generally consists of a waterproofing layer plus a protective layer.

### **2.2.1. Waterproofing layer**

The durability of bridges depends on the effectiveness of the bridge deck waterproofing system including the expansion joint. Salt water or de-icing fluids must be prevented from entering the structural parts of the bridge to avoid corrosion or freeze-thaw damage of the concrete and steel elements. Also migration of CO<sub>2</sub> can cause weakening of the concrete structures. In order to fully seal and waterproof a structure, a double layer system is imperative as local defects cannot be excluded. By applying a second layer, the system becomes robust against flaws achieving a guaranteed watertight system.

The main functional requirements for the waterproofing are [6.]:

- Water- & air-tightness under all conditions
- Adhesion between the bridge and the bituminous mixture
- Mechanical resistance (loads from the traffic, thermal expansion)
- Resistance to de-icing agents
- Compatibility with bituminous mixture
- Resistance to high temperatures during the application of the hot asphalt mixture.

The bridge deck waterproofing products can be divided into three main categories:

- a. **Sheet Systems:** They consist of pre-formed sheets mainly based on bituminous polymeric and elastomeric materials. They are bonded to the bridge deck, to form a continuous membrane, using bitumen adhesive.
- b. **Liquid (Sprayed) Systems:** These systems largely fall into three categories: acrylics, polyurethanes and bituminous materials.  
However, polyurethane and acrylic liquid membrane systems have the following limitations:

- low adhesion with asphalt surfacing that might lead to premature deformation of the surfacing
  - the waterproofing membrane could be damaged by construction equipment such as milling machines during pavement maintenance work.
- c. **Mastic layer:** The thickness of this Mastic layer (which does not contain aggregate like Mastic Asphalt) is normally between 8 and 10 mm. Sometimes rubber and polymers are combined with the mastic especially for steel bridges, due to the higher dynamic loads.

### 2.2.2. Protective layer

In most cases the protective layer is a Mastic Asphalt layer. This layer also serves as a second waterproofing layer. The non-porous mastic asphalt is usually used for the protective layer of the bridge pavement. For various reasons, in some countries preference is given to a traditional asphalt layer as protection layer on concrete deck. The protective layer on steel decks has to protect the steel from corrosion and to make a flexible transfer of load from the surface layer to the steel deck. This implies that the protective layer needs to be resistant against oil, water and minerals, less susceptible to weather conditions.

### 2.2.3. Drainage systems for sub-surface and surface

A successful and effective bridge deck drainage system has to address both surface and sub-surface drainage. Otherwise the water may collect in pools or run in sheets and its presence can slow traffic and cause hydroplaning.

Water may freeze or fall as ice or snow making roadways slick and plugging drains. Besides, its ability to disrupt the main traffic function of the bridge, rain may also pick up corrosive contaminants, which may cause deterioration. So, both surface and sub-surface drainage should be taken into account for a successful and efficient bridge drainage system.

If there is no sub-surface drainage, water absorbed into the asphalt layer sits on the waterproof membrane of the bridge deck. The impact of vehicles driving on the saturated asphalt can then cause weakening of the road surface and eventually the entire bridge structure.

Proper bridge deck drainage provides:

- Efficient removal of water from the bridge deck, enhancing public safety by decreasing the risk of hydroplaning.
- Long-term maintenance and the structural integrity.

## 2.3. Surface / Asphalt layer

Good skid resistance, flat surface and low sound levels are needed for surface layer for a safe and comfortable drive. To insure durability of the required characteristics of the surface layer, the surface layer needs to have:

- sufficient resistance against deterioration
- resistance against oil, water and minerals
- less susceptibility to weather conditions
- protection of the deck plate and the waterproofing layer
- high stability
- resistance to fatigue
- resistant to permanent deformation
- possibility to spread the loads

To assure sufficiently strong adhesion a tack coat is required. This tack coat has to provide the required strong adhesion. There are generally three types of tack coat layers, distinguished on the basis of bitumen (hot fluid bitumen), bitumen emulsion (cold fluid bitumen) and artificial resins. The resin tack coat layers consist of cold hardening epoxy resins scattered with grit.

The surface layer is made of asphalt. Generally the asphalt mixture types used on the bridges are Dense Asphalt Concrete, Mastic Asphalt and Stone Mastic Asphalt (SMA).

The examples of pavement thicknesses and types of the materials used in several countries are given in Appendix 1.

### **3. Asphalt layers**

#### **3.1 Asphalt layers for steel bridge decks**

Since a steel deck is more flexible than a concrete deck, the surfacing has to accommodate larger deflections without cracking, leading to a conflict with the requirement for high stiffness to give good wearing properties. In steel structures there are large deformations in the bridge-deck and therefore fatigue in the asphalt layer is more important for steel bridges than for concrete bridges (where it is no problem at all). So, it is necessary to find the optimum between the resistance against permanent deformation –rutting- and the resistance to fatigue – cracks. In some cases epoxy asphalt is used on steel bridge (e.g. the Humber Bridge in the UK).

In general, the steel plate thicknesses range from 10 to 14 mm and the asphalt layer from 35 to 80 mm.

To minimise dead loads, the weight of steel and pavement of the bridge deck needs to be kept to a minimum.

#### **3.2 Asphalt layers on concrete bridge decks**

Concrete bridge decks are the most common and they are also susceptible to cracking under live loading and shrinkage cracking. They can deteriorate as a result of concrete distress from freeze-thaw damage, abrasion damage, alkali-aggregate reactivity, corrosion of the reinforcement. Measures must be taken to prevent or minimize the ingress of potentially salt laden moisture. The estimated life for concrete bridges is 100 years. One condition to ensure this long lifetime is waterproofing of the bridge deck together with a high quality asphalt pavement.

The main functional requirements for asphalt pavement are watertightness under all conditions, mechanical stability/strength to resist traffic loads, including compression and shear forces in curves and during braking and acceleration, resistant to cracking and stratification under the influence of temperature variations and traffic loads, and the maintenance of mechanical and chemical resistance during normal loads, weathering and de-icing chemicals.

The asphalt layers normally consist of a protecting layer and a surface layer. The protecting layer is in most cases Mastic Asphalt or a modified asphalt concrete, as opposed to traditional asphalt concrete, with a high content of aggregate and with low air void content. The asphalt for the surface layers can be adjusted to be stiffer. The protecting layer should be designed to be a little bit softer than the surface layer. Due to the stability of the pavement and for the sake of heat influence on the waterproofing layer lying below, the protective layer should have enough thickness.

The protecting layer is a stable and dense layer, which also protects the waterproofing layer from mechanical damage and prevents penetration of surface water.

On smaller bridges generally the same surface layer is often as that used on the adjacent road. On larger bridges different types of asphalt concrete can be used as surface layer such as SMA, thin asphalt concrete, etc. The surface layer should also be made with a hard grade or polymer modified bitumen. The asphalt mix design for concrete bridge decks is easier because of its rigid behaviour.

## 4. Bituminous mixtures used for asphalt layers on bridge deck

Due to traffic loads, elastic deformations occur in the bridge deck system. These repeated deformations have to be followed by the asphalt layer and are not supposed to lead to fatigue cracking, because being impermeable is a major requirement of the construction.

On the decks, generally ‘rolled / compacted’ asphalt (asphalt concrete, hot rolled asphalt and SMA) and mastic asphalt are applied.

The mostly used mixes on the bridge deck applications are:

### 4.1 Mastic asphalt

Mastic asphalt is characterised by overfilling of the voids with bitumen. General characteristics of mastic asphalt are:

- The binder forms a continuous phase that is sufficiently liquid that it can be poured.
- Since Mastic Asphalt is very visco-elastic means that it does not crack easily. To make it resistant to permanent deformation, additives such as thermoplastic elastomers are often used to provide elasticity but also products that “harden” the binder are used such as waxes, polymers and natural asphalts.
- For production of mastic asphalt a normal asphalt plant with some modifications can be used.
- The voids are overfilled with mastic. It is a very thermo-plastic material which implies that it does not crack quickly, yet it is sensitive to deformation
- Due to the overfilled voids and the absence of a steady body, the mix does not need to be compacted.
- Because of the high percentage of fines and high binder content, mastic asphalt itself has a poor skid resistance due to its smoother surface. To improve the skid resistance fine aggregate is applied on the surface.
- The resistance to permanent deformation is not obtained from the aggregate but from the mastic binder, being a hard bitumen (45/60, 20/30 or a mix of 45/60 and Natural asphalt or modified bitumen) and a large percentage of filler
- The low voids content renders these types of mixes extremely impermeable
- Highly modified mastic asphalt layer systems are applied that combine the various system layers in one.
- Due to the high mortar stiffness, production and processing take place at relative high temperatures. It is possible to produce Mastic Asphalt at lower temperatures by using a warm mix technology
- For paving a special spreading machine is needed, unless only small areas are paved through hand laying.

Although it is more difficult to produce and apply Mastic Asphalt than “rolled asphalt”, Mastic Asphalt is able to follow the large deformations of the steel deck without fatigue cracking, mainly because of the flexibility of the mix. Next to that the bonding of the Mastic Asphalt with the underlying layers is better than that of “rolled asphalt”.

### 4.2 Modified asphalt concrete

Where an asphalt concrete is used for a concrete bridge as the protecting layer, it is in most cases a modified asphalt concrete with a high content of aggregate larger than 4 mm and with low air void content (generally lower than 4 % by volume). Modified asphalt concrete is made with a hard bitumen grade and is rich in binder content. The specifications for asphalt pavements on bridges are based on the specifications for pavements for roads but are made more rigorous in their requirements, a stronger material and performance control is demanded together with a more comprehensive inspection during the execution of the work.

### 4.3 Stone Mastic Asphalt

A Stone Mastic Asphalt (SMA) is a more robust mixture for bridge decks, with high resistance to fatigue and permanent deformation (i.e. sufficient rigidity) and which can be produced and processed with conventional asphalt plants and pavers. SMA is resistant to permanent deformation by the stone-to-stone contact of the stone skeleton. Sufficient voids in the compacted layer prevent the mixture from becoming over-filled with mortar.

#### 4.4 Highly modified asphalt mixtures

An appropriate mix design on steel bridge deck is challenging as the mix must be very low in voids, very flexible, and rut resistant all at the same time: a highly modified asphalt application is used as waterproofing material on bridge decks. Often modifiers are added to the bitumen to improve the characteristics of the mixture. In mixtures with high polymer content (approximately 7.5%) good rutting resistance is expected while the soft base is comparable to other materials. The flexibility of mixture allows the designer to use a wider range of base bitumens to accommodate the requirements of any specific application, harder base bitumen for extreme rut resistance, or softer base bitumen (as in steel bridge deck case) for extreme fatigue resistance.

#### 4.5 Porous asphalt/Open-graded asphalt concrete

In some countries (e.g. the Netherlands) Porous Asphalt is also used as a surface layer. It is generally laid on top of the waterproofing system. The open-graded asphalt concrete must retain a large content of air voids, approximately 20 to 25% by volume, when compacted and post-compacted by the traffic. Further, the stability of the layer must be sufficient for its function as a base layer for the pavement.

#### 4.6 Epoxy asphalt

Epoxy asphalt is a two phase binder in which a paving grade asphaltic binder serves as the initial phase, and in which a liquid di-epoxy resin serves as the continuous phase. The material is produced and installed generally in the same manner as hot mixed Asphalt Concrete, but results in an exceptionally durable and flexible surface which is ideal for orthotropic decks. It has been used in several parts of the world on bridges. It is a difficult product because it needs special organisation for manufacturing and laying due to the setting time (time for asphalt concrete hardening is short, sometime less than 1 hour).

### 5. Maintenance and Rehabilitation

Without timely maintenance, concrete bridge decks are susceptible to concrete deterioration and corrosion of the steel reinforcement in particular when exposed to de-icing fluids or salts. [7.] (Since the corrosion of reinforcing steel in highway bridge decks exposed to salt laden air or de-icing salts leads to on-going problems of maintenance, repair, and even deck replacement ) [8.]. Moisture saturation in the asphalt surfacing could cause premature deformation and serious distress, as well.

#### Types of distress that might occur in orthotropic steel bridges surfacings:

- **Permanent deformation:** Generally caused by exceptionally high and/or repeated stresses.
- **Cracking:** Fatigue cracking of pavements materials is caused by repeated stresses (shear or tensile) induced by traffic, environment and poor construction. When the cracks reach the steel deck, it rusts and may lead to debonding.
- **Blistering:** That is a local expansion/swell of a waterproof layer and occurs when a waterproof layer is laid on a layer that contains water. When asphalt is laid on such a layer, water evaporates forming bubbles and will be seen at the surface as “isolated lumps”.
- **Disintegration:** This includes ravelling (loss of stone particles from surface) and potholes. It is caused by cracking, loss of bonding and/or a combination of other distress mechanism. Ravelling can seriously reduce the skid resistance of the pavement and hence endangers the safety of road users.

Sometimes distress is characterised by means of the mechanisms causing the distress. These are facilitated by the action of mechanisms reducing the pavement strength, i.e. decrease of the bond strength between the plate and the surface layer, ageing of bitumen, weathering of aggregate materials (chemical decomposition caused by oxygen, water, heat and/or solar radiation) and strength reduction of bituminous materials because of low viscosity at high temperatures. Once the bond between the steel deck and surfacing is destroyed, the failure of

the pavement is merely a matter of time. There are several reasons behind the destruction/weakening of the bonding layer among which are:

- The high shear stresses between the pavement and the deck produced by accelerating or braking wheel loads which weaken and hence destroy the bond.
- The rather high application temperature of the mix. This can increase the temperature of the steel plate and may result in high strains at its topside.
- Vibrations set up in the deck by fast moving traffic also weaken the bond.
- The shear forces (both in the longitudinal and transverse directions) increase with the increase of the slope of the bridge deck. These shear forces may result in cracks at the elevated points of the structure.

Preventive maintenance is defined as a planned strategy of cost-effective treatments applied at the proper time to preserve and extend the useful life of a bridge. There are several rehabilitation methods for steel bridge pavements: replacement of the asphalt surface layer and/ or removing the whole pavement and reconstructing again.

### **Possible distresses in concrete bridge pavements**

For concrete bridge pavements, low adhesion between the waterproofing membrane and the asphalt surfacing and moisture saturation in the asphalt surfacing are the most significant factors that might cause the distress. This could cause premature deformation if the asphalt surfacing is not of sufficient thickness and the tack coat not properly applied.

To repair cracked bridge decks, determining whether the cracks are structural or non-structural is crucial: in addition establishing chemical and waterproofing requirements of the deck and the structure, as well as whether the repairs will affect the asphalt surface. Limited structural and non- structural cracking can be remedied using a low-pressure epoxy injection system, protecting the deck beyond its normal wear surface life cycle [9].

Mill and fill is the most used rehabilitation method.

Preferred is: A planned strategy of preserving and extending the useful life of a bridge before failures occur, encompassing:

- Cleaning, comprising an annual water flush of all decks, drains, bearings, joints, pier caps, abutment seats, concrete rails, and parapets.
- Preventative maintenance activities such as painting, coating and sealing, and routine, minor deck patching and railing repairs.
- Advanced repairs, including jacking up of structures, crack repairs, epoxy injection, repairing or adjusting bearing systems, repair and sealing of expansion joints, repair or reinforcement of main structural members including stringers, beams, piers, pier and pile caps, abutments and footings, underwater repairs, major deck repairs, and major applications of coatings and sealants.
- Stream channel maintenance including debris removal, bank stabilisation and correcting erosion problems.

## **6. Conclusions**

- The use of asphalt concrete ensures the best and safest ride quality and matches the expectations of drivers on most roads, as well as bridge surfaces.
- Modern asphalt concrete combined with well-designed waterproofing solutions and with appropriate maintenance are great solutions to match the current expected 120 year design life of bridges.
- The innate waterproofing qualities of asphalt can be used to double as waterproofing layer through the use of Mastic Asphalt.
- Various dedicated waterproofing materials and systems exist that can be used to ensure a low maintenance high performance concrete and or steel protection

- Asphalt pavements on bridge decks must absorb traffic loads, transfer them to the supporting structures and remain even and resistant to deformation and provide good anti-skid conditions for vehicles. At the same time they must protect the bridge structure from surface water, which in winter contains de-icing salt that promotes corrosion. These functions are generally not fulfilled or only partially fulfilled by one material and a functional division can be made for the layers forming the surface of the deck.
- Generally, the deck surface consists of sealing/bonding layer, protective layer, adhesion layer, and surface layer. The thickness of bridge pavement varies and depends on type of the deck.
- The sealing layer must cover the full surface of the bridge deck. The concrete deck is primed with bitumen emulsion, PMB, epoxy resin, polyurethane and similar materials.
- A successful and efficient bridge drainage system has to take into account both surface and sub-surface drainage. To ensure a long lifetime, waterproofing of the bridge deck together with a high quality asphalt pavement is essential.
- To assure a sufficiently strong adhesion between the asphaltic layer and the underlying layers, an adhesion layer is required. Bitumen (hot fluid bitumen), bitumen emulsion (cold fluid bitumen) or artificial resin could be used.
- Surface layers need to have good skid resistance, a flat surface, low sound levels, sufficient resistance against deterioration, resistance against oil, water and minerals, less susceptibility to weather conditions, providing a waterproofing layer, high stability, resistance against fatigue, resistant to permanent deformation, and the possibility to spread the loads for safe and comfortable drive. The surface layer is made of asphalt. Generally Dense Asphalt Concrete, Mastic Asphalt and SMA are used as asphalt mixture on the bridges.
- In steel structures there are large deformations in the bridge deck and therefore fatigue in the asphalt layer is more important for steel bridges than for concrete bridges. Different countries use different asphalt surfacing materials and different layers thicknesses.
- Mastic Asphalt is generally used on steel bridge decks and also as a waterproofing layer on both concrete and steel bridges. Mastic Asphalt is a very thermo-plastic material, which implies that it does not crack quickly, yet it is sensitive to deformation. A modified SMA is the alternative for Mastic Asphalt.
- Epoxy asphalt is a two phase binder which includes a paving grade asphaltic binder. The material is produced and installed generally in the same manner as hot mixed Asphalt Concrete.
- The asphalt mix design for concrete bridge decks is easier because of its rigid behaviour. The asphalt for the surface layers can be adjusted to be stiffer. The protection layer should be designed a little bit softer than the surface layer. Generally, on smaller bridges, the surface layer is often the same as that used on the adjacent road. On larger bridges, different surface layers can be used such as SMA, Thin asphalt concrete, etc.
- Proper and timely maintenance and rehabilitation is essential for good performance and good durability. For repairing cracked bridge decks, it is necessary to define the cracks, i.e. whether they are structural or non-structural. Major rehabilitation actions may range from installation of a protective surface system, to complete replacement of the bridge deck. Preventive maintenance is defined as a planned strategy of cost-effective treatments applied at the proper time to preserve and extend the useful life of a bridge.
- There is a French standard for fatigue resistance of asphalt concrete used on steel deck bridge.

## 7. References

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## **Appendix 1. Experiences from different countries**

### **1 - GERMANY**

In Germany the asphalt pavements on bridge decks are built in 2 layers. The first asphalt layer is a protection layer (it is built on the waterproofing system). Normally the protection layers are made with mastic asphalt. The second layer works as a surface layer and is not a part of the sealing system. For the surface layer mastic asphalt can be used as well as SMA, PA or AC. Normally MA is used. The thickness of each layer should be at least 35 mm and at the maximum 40 mm (depending on the maximum aggregate size).

The asphalt mix design for concrete bridge decks is easier because of its rigid behaviour. The asphalt for the surface layers can be adjusted to be stiffer. The protection layer should be designed a little bit softer than the surface layer.

The asphalt mix design for steel bridge decks is more complicated. The design depends on the behaviour of the steel construction. Often there is a choice between ruts or cracks. For the mix design ruts are the better choice because via cracks water can enter into the bridge sealing system.

In Germany for the waterproofing systems of concrete and steel bridge decks it is required to obtain a license for the building materials and the construction systems by the Bundesanstalt für Straßenwesen (BASt), a subsidiary of the Ministry of Communication.

#### **Concrete Bridge Decks**

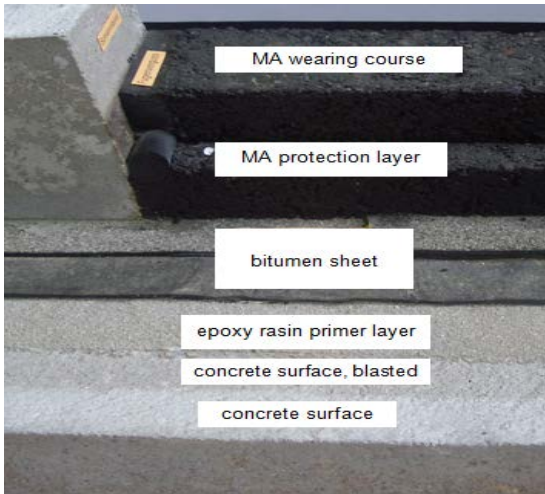
For concrete bridge decks 2 different construction types are possible:

**Type1: waterproofing layer with bitumen sheet** (Figure 1).

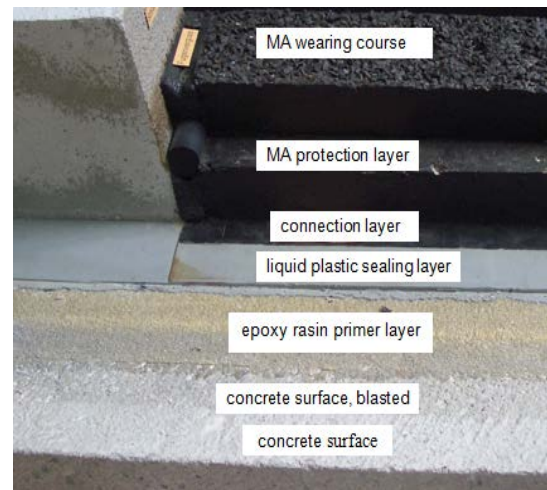
- Special priming: Primer layer; Solvent-less primer based on a epoxy resin system gritted with 300 - 500 g/m<sup>2</sup> quartz sand
- Bitumen sheet waterproofing layer thickness: 4,5 - 5,5 mm
- Mastic asphalt protection layer ( ZTV-ING Partl 7 )
- Surface layer (TL Asphalt-StB ;EN 13108 for MA, SMA, AC or PA)

**Type -2 waterproofing layer with liquid plastic Sealing** ( Figure 2).

- special priming: Primer layer; Solvent-less primer based on an epoxy resin system gritted with 300 - 500 g/m<sup>2</sup> quartz sand
- liquid plastic sealing thickness:  $\geq 2$  mm and  $\leq 6$  mm
- bitumen sheet waterproofing layer thickness: 4,5 - 5,5 mm
- mastic asphalt protection layer ( ZTV-ING Partl 7 )
- surface layer (TL Asphalt-StB ;EN 13108 for MA, SMA, AC or PA)



*Figure 1: Type1: Waterproofing layer with bitumen sheet*



*Figure 2: Type 2- Waterproofing layer with liquid plastic Sealing*

## Steel Bridge Decks

For steel bridge decks 3 different construction types are possible:

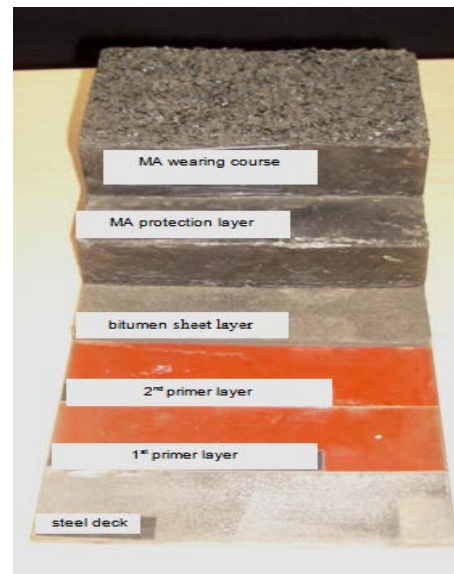
- Type 1: reaction resin waterproofing layer (divided in type 1a and 1b) ( Figure 3)
- Type 2: bitumen waterproofing layer (divided in Type 1a and 1b)
- Type 3: reaction resin/bitumen waterproofing layer (Figure 4)

### *Type 1a: reaction resin waterproofing layer*

- primer layer based on reaction resin , gritted adhesive layer based on reaction resin
- cushion layer based on polymer modified bitumen
- mastic asphalt protection layer (ZTV-ING Part 7-thickness: 35 mm)
- surface layer (TL Asphalt-StB :EN 13108 for MA, SMA)



*Figure 3: Type 1a: Reaction resin layer*



*Figure 4: Type- 3 Reaction waterproofing resin/bitumen waterproofing layer*

## 2 - TURKEY

### 1 - Pavement on Concrete Bridge Decks

The typical pavement structure on concrete bridge decks:

AC-50 mm or SMA-40 mm
Bituminous /PMB sheet membrane
Special bitumen based primer
Concrete surface

The thickness and the bituminous mixture types of surface layer on concrete bridge is the same as that used on the adjacent road.

Asphaltic concrete is normally used for the bridges of state roads, SMA or Asphaltic Concrete produced with Polymer Modified Bitumen are paved on the bridges and viaducts of motorways.

Expansion joints can be made mechanically or by use of a bituminous joint sealant filled with fine aggregate.

Main distresses of asphalt surface layer are cracking, rutting and raveling due to poor waterproofing system, poor quality of construction, insufficient joint sealing.

### 2- Pavement on Steel Bridge Decks

The typical pavement structure on steel bridge decks:

Mastic asphalt- 35mm
Special tack coat
Eliminator® membrane
Anti-corrosive metal primer
Zinc plating
Shot blasted steel deck

Eliminator® bridge deck waterproofing membrane system is used on steel bridge deck. The system is durable enough to withstand the traffic loads and to provide a sufficient bond to both the steel deck and the subsequent surfacing which should resist the high shear forces. The high bond of the membrane to deck and the membrane to surfacing combined with the stiffness of mastic asphalt surfacing helps to reduce stresses in the structure.

- **First Bosphorus Steel Suspension Bridge**

Bosporus Bridge in Istanbul/Turkey connecting Europe and Asia, spanning Bosporus strait	
Total length / Width / Height	1510m / 39m / 105m
Longest span / Vertical clearance	1074m / 64m



The Bosphorus Bridge was the 4th longest suspension bridge span in the world when it was completed in 1973. At present, it is the 16th longest suspension bridge span in the world.

The highway bridge has a total width of eight lanes. Each direction has three lanes for vehicular traffic plus one emergency lane and one sidewalk.

Nowadays, around 180,000 vehicles pass daily in both directions. Since 1980 heavy traffic is not allowed anymore. Fully loaded, the bridge sags about 900 mm in the middle of the span.

Mastic asphalt surface layer was completely renewed in 1991. After that, it hasn't been renewed due to high traffic volume. So local maintenance such as patching has been frequently carried out with mastic asphalt and sealed cracks on the surface. Main distresses are cracking, raveling and pot holes. The pavement is planned to be renewed in 2013.

- **Fatih Sultan Mehmet –Steel suspension bridge**

Fatih Sultan Mehmet Bridge in Istanbul/Turkey spanning Bosphorus strait	
Total length/ Width/ Height	1510m / 39,4m / 111m
Longest span / Vertical clearance	1090 / 64m

The highway bridge was completed in 1988 and has four lanes for vehicular traffic plus one emergency lane in each direction.



Nowadays, around 250,000 vehicles are passing daily in both directions, almost 15% being heavy vehicles.

The Mastic Asphalt surface layer was completely renewed in 2002. Since 2002 local maintenance was carried out. Patching with mastic asphalt has been frequently carried out and cracks in the surface were sealed.

The main distresses were cracking, rutting, and ravelling. The cracks seemed to be induced by fatigue and rutting. Poor bonding to the steel deck and insufficient high temperature stability appeared to be main reasons for the problems with the surface layer besides high traffic volume at low speed.

In 2012 the Mastic Asphalt surface layer was completely renewed .

### 3- SWEDEN

Mainly two types of waterproofing systems are used, waterproofing with mastic asphalt and waterproofing with polymer modified bitumen sheets. Bridge waterproofing and pavement are applied according to the Bridge norm (**TRVKB 10 Tätskikt på broar TRV 2011:089**). Liquids such as polyurethane or epoxy are not used for waterproofing concrete bridge decks.

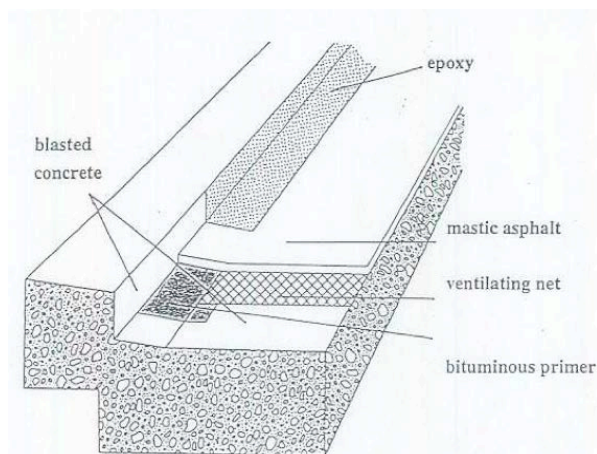
#### -Main waterproofing systems

Mastic asphalt on glass fibre net has been used in Sweden since 1970. The results have generally been good.

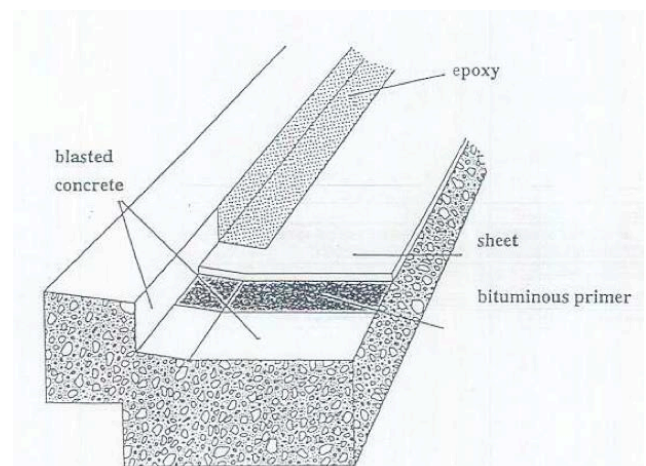
The waterproofing system consists of a 10 mm thick mastic asphalt layer on ventilating glass fibre net. Mastic asphalt is a mix of polymer modified bitumen, limestone filler and sand (max particle size 2 mm). The polymer modified bitumen shall consist of at least 4,0 % of SBS-polymer and the bitumen may not be oxidized. Along the inside edges of the concrete deck is treated with bituminous solvent primer. Edge sealing of the parapet is normally applied with coal tar epoxy.

The protective layer consists of dense asphalt concrete, mastic asphalt or concrete. Mastic asphalt must not be used on weak constructions (such as steel girder bridges in the northernmost parts of Sweden (with a mean daily temperature of -22°C)).

Waterproofing systems with polymer modified bitumen sheets are now taken its share of the market on bridges in Sweden. High quality SBS-modified bitumen sheet is used. The waterproofing sheet must be at least 5 mm thick, with a core placed high within the sheet, and is normally applied in a single layer. The bridge deck is pre-treated with a suitable primer (bituminous solvent primer that has been tested together with the waterproofing sheet). Today, edge sealing uses thixotropic epoxy (or waterproofing sheet). Normally, asphalt concrete or mastic asphalt is used as protective layer. (Figure: 1 and 2)



*Figure: 1*  
*Waterproofing system with mastic asphalt*



*Figure:2*  
*Waterproofing system with polymer modified bitumen sheet.*

## - Test methods and requirements for polymer modified bitumen sheets

In Sweden they have requirements for the polymer modified bitumen sheet, the polymer bitumen and primer, and the waterproofing system (concrete, primer, waterproofing sheet and protective layer). The requirements for the polymer modified bitumen sheet is summarised below as an example. Almost all test method are now in accordance with EN-standards. There are also specifications for weldable sheets including some functional testing.

### Requirements for polymer modified bitumen sheets:

	Testing	Requirements	Method SS-EN
1	Thickness	> 5.0 mm on concrete 3,5-5,0 mm on steel The individual values may deviate by $\pm 0,5$ mm from the nominal value. (Without granules)	1849-1
2	Mass per unit area	To be specified The average measured values may deviate from the nominal value by $\pm 10$ % (sheets without granules) $\pm 15$ % (sheets with granules)	1849-1
3	Tensile strength Elongation	> 800 N >40%	12311-1
4	Flexibility	-20°C -10°C After artificial ageing	1109 1296
5	Dimensional stability  Higher temperature	After 28 days at 70°C $\leq 0,40$ % shrinkage $\leq 0,25$ % permanent elongation Storage 1 h at 160°C $\leq 0,40$ % shrinkage $\leq 0,25$ % permanent elongation	1107-1
6	Drainage temperature	$\geq 115^\circ\text{C}$	1110
7	Water absorption	Max change in weight 1.0 % (without granules)	14223
8	Resistance to indentation and dynamic water pressure	No leakage	1110

## 4- CZECH REPUBLIC

The most frequent types of the concrete bridges in Czech Republic (CR) are beam type structure for short spans and segmental box-girder for medium spans. There are few concrete suspension bridges and no steel suspension bridge for long spans in the Czech Republic. Asphalt pavements on bridges in CR are similar as in other European countries.

Bituminous sheets or sprayed layers (polyurethane etc.) both with mastic asphalt as a protective layer are preferred by the Czech road administration, however other systems are allowed as well. The sprayed waterproofing membrane laid with the high speed has been used on a couple of job sites. The approval of any waterproofing system has to be obtained from the road administration in the Czech Republic before the contractor can propose it in a tender.

There is new Czech standard "Pavements on bridges" valid since 2011. The requirements are similar as in the German specifications. It contains specifications for asphalt and concrete pavements as well as for waterproofing systems. The norm is quite voluminous (about 60 pages). The 3 layer pavements for the concrete bridges are specified in the table 2 of the norm. *(The asphalt mixes in the CR are classified in the national annexes of EN in 3 quality classes. The best class is called S, the medium + and the lowest quality class is without any sign. For example the mix SMA 11 S is the mix of the best class, SMA 11 + is medium class and SMA is the lowest class).*

Layer	Types of asphalt mixes <sup>1)</sup> after national Annex of EN 13108 -1, 5, 6 and the layer thickness in (mm) for different classes of traffic <sup>2)</sup>			
	S, I	II, III <sup>3)</sup>	IV	V, VI
Surface layer	SMA 11 S 40, AC 16 S 50, AC 11 S 40	SMA 11 S (+) 40, AC 16 S (+) 50, AC 11 S (+) 40	SMA 11 + 40, AC 16 + 50, AC 11 + 40	SMA 11,8 40 (35) AC 11 40 (45) AC 8 40 (35) MA 11 II 40 (35) MA 8 II 40 (35,30)
Binder layer <sup>4)</sup>	AC 16 S 50 (60)	AC 16 S (+) 50 (60)	AC 16 + 50 (60)	AC 16 50 (60)
Protective layer	MA 11 IV 35, MA 16 IV 40	MA 11 IV 35, MA 16 IV 40 SMA 11 S (+) 40 <sup>5)</sup> AC 11 + 40 <sup>5)</sup>	SMA 11 + 40, AC 11 + 40, MA 8 IV 30, MA 11 IV 35	SMA 11,8 40(35) AC 11,8 40 (35) MA 11 IV 35 MA 8 IV 30 (35)

NOTE 1 Recommended protective layer is MA, especially due to the lower risk of the damage of the waterproofing layer.

NOTE 2 Classes of traffic are in the norm ČSN 73 6114

<sup>1)</sup> Types of bitumen binders corresponding to the specifications in National Annex of European norms are agreed by the contractor and investor (materials and Initial type tests must be approved)

<sup>2)</sup> Three layer pavements are not used on steel bridges and on concrete bridges for traffic classes V, VI

<sup>3)</sup> The quality class S or + is used for traffic class II. Quality class + is used for traffic class III. The protective layer AC 11, is used for both traffic classes in the quality class +.

<sup>4)</sup> Binder layer AC 22 with the thickness of 60 mm can be used for the repairs and reconstructions only if the level of the bridge permits it

AC 16 + can be used for surface layers for the traffic class IV and AC 16 for traffic class V-VI

<sup>5)</sup> It can be used in some cases, if the reasons are explained and accepted

Two layers pavements for concrete and steel bridges are in the table 3 of the norm.

Layer	Types of asphalt mixes <sup>1)</sup> after national Annex of EN 13108 -1, 5, 6 and the layer thickness in (mm) for different classes of traffic <sup>2)</sup>			
	S, I	II, III <sup>3)</sup>	IV	V, VI
Surface layer <sup>4)</sup>	SMA 11 S 40, AC 16 S 50, AC 11 S 50, MA 16 I 40 (45), MA 11 I 40,	SMA 11 S (+) 40, AC 16 S (+) 50, AC 11 S (+) 50, MA 16 I 40 (45), MA 11 I 40	SMA 11,8 + 40, AC 16 + 50, AC 11 + 40 (50), MA 11 II 40, MA 8 II 40	SMA 11,8 40 (35),  AC 11 40 (45), AC 8 40 (35), MA 11 II 40 (35), MA 8 II 40 (35,30)
Protective layer <sup>5)</sup>	MA 11 IV 40, MA 16 IV 45	MA 11 IV 40, MA 16 IV 45 SMA 11 S (+) 40 <sup>6)</sup>	SMA 11,8 + 40, AC 11 + 40, MA 16 IV 40, MA 11 IV 40 (35), MA 8 IV 30 (35,40)	SMA 11,8 40 (35), AC 11,8 40 (35),  MA 11 IV 35, MA 8 IV 30 (35)

<sup>1)</sup> Types of bitumen binders corresponding to the specifications in National Annex of European norms are agreed by the contractor and investor (materials and Initial type tests must be approved)

<sup>2)</sup> minimum thickness for the classes S, I, II is 80 mm; for classes III, IV – 75 mm; and for classes V, VI – 70 mm

<sup>3)</sup> Quality class S or + is used for traffic class II and quality class + for the traffic class III

<sup>4)</sup> Surface layers from MA can be used only if the protective layer is also form MA

<sup>5)</sup> Mixes AC, SMA 8 are not used for steel bridges.

<sup>6)</sup> It can be used in some cases, if the reasons are explained and accepted

The annex A “Recommended pavements on bridges” contains recommendations on waterproofing systems. The different tests of waterproofing systems are described in annex B to E of the norm.

## 5-DENMARK

(Summary of “Surfacing of concrete bridges” by Vibeke Wegan, Road Directorate, Danish Road Institute, Denmark [10.]

### Waterproofing sheets

Sealing of the concrete surface with two layers of sand dusted epoxy primers is used. Three primers are type approved. Two are based on synthetic materials in a solvent and one is a solvent free epoxy primer dusted with sand. When the waterproofing membranes are applied and hence they are protected by a second primer that consists of 50 % solution of polymer modified bitumen. When the primer or primers have been applied, the texture of the concrete surface has to be between 0.4 and 1.3 mm measured by the sand patch method all over the bridge deck. Priming of the concrete bridge deck, normally two polymer modified bitumen sheets are fully torch-welded on the surface. For bridges with low daily traffic (ADT <2000), without considerable importance for local and regional traffic, without heavy traffic or without braking or turning traffic, only one polymer modified bitumen sheet is specified. The lower sheet has 1 mm polymer modified bitumen on top of the reinforcement and 2.5 mm on the underside. In the upper sheet the reinforcement is placed at the top of the sheet, with only 0.1 - 0.2 mm polymer modified bitumen above the reinforcement and 3.3 - 3.4 mm under the reinforcement. The sheets are normally torch-welded.

### Flashing at the edge beam

The edge beam is a very important part of the waterproofing since experience has shown that many problems with the waterproofing start at this point

An example of the construction at the edge beam is illustrated in Figure 1.

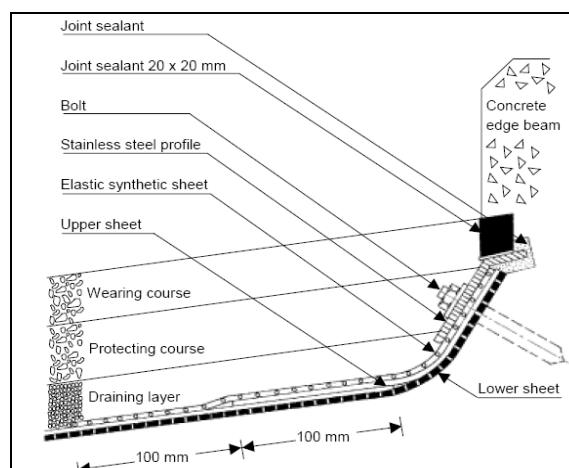


Figure 1: The edge beam where the sheets are fastened with a stainless steel profile to the concrete

### Draining

A drainage layer provides the drainage of the waterproofing. An open-graded asphalt concrete is laid on the surface of the waterproofing sheets in a thickness of 15-20 mm. The purpose of this layer is to permit sub-surface drainage of any seepage water through the above-lying pavement through drain channels to drip-pipes or drains. After the drainage layer is laid, it must be rolled immediately.

Drain channels are placed in deep lines parallel to the edge beams and directly above the waterproofing sheets. They are always placed outside the trafficked area. The drain channels are normally made of very open-graded epoxy concrete in a thickness more than 25 mm and with a width between 100 and 150 mm

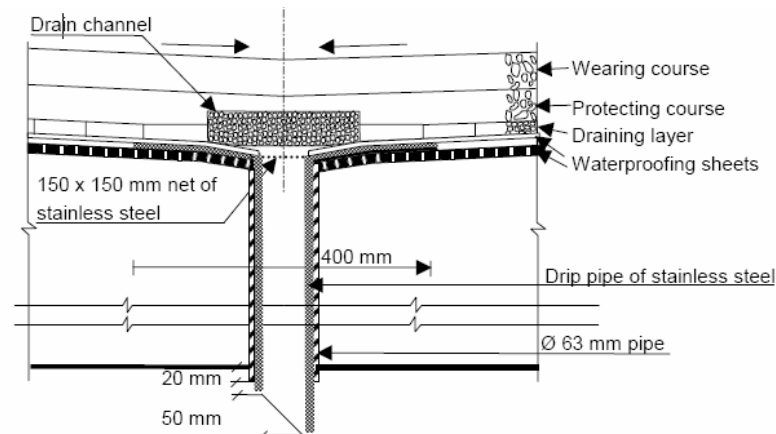


Figure 2: Drip-pipe placed lower than the surface of the waterproofing under a drain channel.

### Protecting and surface layer

Above the draining layer the asphalt pavement is laid with a thickness of 80 to 100 mm. It normally consists of a protecting and a surface layer. The protecting layer is in most cases asphalt concrete (ABM), modified compared to traditional asphalt concrete, with a high content of aggregate with low air void content. ABM is made with a hard bitumen grade and is rich in binder content. The protecting layer should not be thicker than 50 mm. On smaller bridges, the surface layer is often the same as used on the adjacent road. On larger bridges, Stone Mastic Asphalt (SMA) is normally used as surface layer.

The surface layer should also be made with a hard grade or polymer modified bitumen.

The concept described for surfacing of concrete bridge decks has been used many years in Denmark with a very good result. At the Great Belt Link, the concept has recently been used for the 6.6 km long concrete bridge. On this bridge, the surfacing consists of two layers of epoxy primer to get assurance against blistering, 15 mm open graded asphalt concrete, 40 mm protective layer (ABM) and 40 mm SMA as surface layer. The bridge surfacing was completed in 1995 and the lifetime of the surface layer is expected to be at least 25 years after heavy traffic.

### Joint sealing

In the longitudinal direction of the bridge, a joint filled with a hot poured joint sealant or a cold applied joint sealant after priming of the sides in the joint. To obtain large movements an asphaltic plug joint is made in both the protecting layer and the surface layer.

### Final remarks

The concept described for surfacing of concrete bridge decks has been used many years in Denmark with a very good result. At the Great Belt Link, the concept has recently been used for the 6.6 km long concrete bridge. On this bridge, the surfacing consists of two layers of epoxy primer to get assurance against blistering, 15 mm open graded asphalt concrete, 40 mm protective layer (ABM) and 40 mm SMA as surface layer. The bridge surfacing was completed in 1995 and the lifetime of the surface layer is expected to be at least 25 years after heavy traffic.

## 6- FRANCE

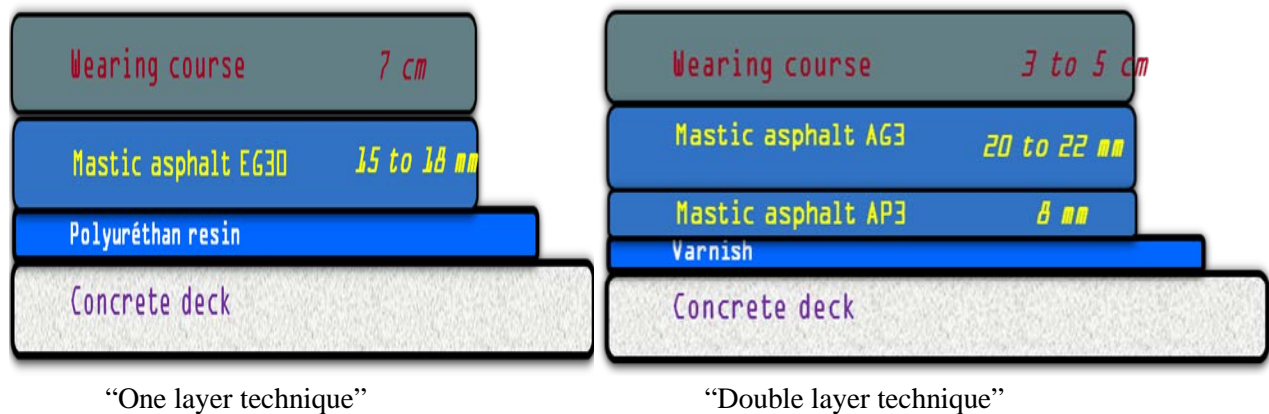
### Bridge deck waterproofing -The French techniques

#### 1. Concrete bridge deck :

On concrete deck, 4 main techniques are used and specified by the “Setra” which is the French State Department for Civil Engineering.

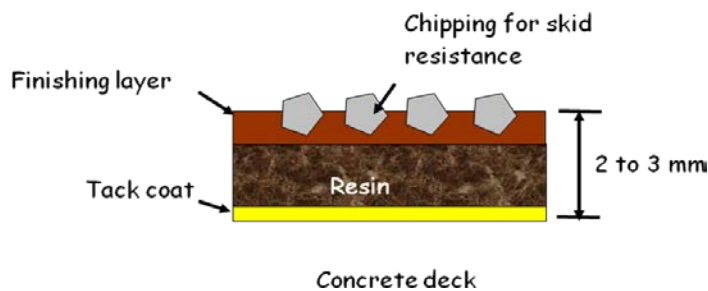
##### a. Mastic asphalt solutions

These solutions represent 26 to 30 % of the waterproofing solutions used (based upon the surface area). Concerning mastic asphalt solutions, there are 2 possible techniques that are the one layer ‘ technique’ and ‘double layer’ technique as described in the scheme below:



##### b. Resins Solutions

Solutions with resin are considered as ‘thin’ techniques, as described on the scheme below:



##### c. Bituminous sheets

This solution represents the most commonly used technique. These solutions represent 22 to 25 % of the waterproofing solutions used (based upon the surface area). There are 2 possible ways to cover the sheet:

- With conventional hot asphalt mixes:
  - Surface layer (70 mm minimum) on
  - a bituminous sheet (25 - 45 mm) on
  - cold tack varnish on

- the concrete deck.
- With mastic asphalt
  - Surface layer (50 - 70 mm) on
  - Mastic AsphaltAG3 (25 mm) on
  - a bituminous sheet (27 - 35 mm) on
  - cold tack varnish on
  - the concrete deck.

#### d. Bituminous complex

Those solutions appeared between 1980 and 1990.

They are very attractive for huge projects because of very high laying speed rates.

They consist of several layers laid by the mean of traditional road construction equipment, as shown on the scheme below.



## 2. Steel bridge deck

Waterproofing complexes for steel bridge deck used in France are mainly waterproofing solutions using:

- either a PmB membrane, or a bituminous sheet as waterproofing
- a surface layer made of bituminous concrete on 65 mm minimum

Those solutions are designed for flexion resistance which is the main parameter for durability.

As a result, the bituminous concrete contains a highly polymer modified bitumen as a binder.

## 7-HUNGARY

The bridge (slab) types are usually divided into two groups. These two groups are distinguished by the use of insulating and surface layers.

### Steel slab:

The steel slab supported by the girders is a relatively thin (typically 10-16 mm thick) slab, which carries the pavement loads and useful loads.

The insulation system is a multi-layer one, which is responsible for the steel slab water insulation and the long-term corrosion protection only. Sprayed insulations can be used.

The system consists of:

- anti-corrosion primer,
- insulating layer and bonding,
- protective asphalt layer.

The pavement consists of three asphalt layers. The asphalt layers assure the durability of the pavement (against the effect of the traffic) and work together with the layers of the insulation system.

Consists of:

- protective layer,
- a bonding layer
- asphalt surface layer.

The protective asphalt layer is mastic asphalt (MA): MA 11 (mF) (with modified bitumen), the design thickness is 35 mm,

Binder and surface layer: the binder and surface layer mixes (and the protective layers of asphalt) shall comply with the requirements of the Hungarian Technical Specifications and the European Asphalt Standards (Generally AC 11/SMA 11 for surface layer, AC 22 for binder layer). Type and thickness of the layers is generally the same as on the adjacent road section but there are exceptions to this rule (see under). The hot mix asphalt surface layer's thickness is generally 40 mm; the binder layer's thickness is generally 70 mm.

An exception to the above mentioned pavement: a large bridge in Hungary (Szebényi viaduct)

The bridge is an orthotropic deck structure. After surface preparation, a mastic polyamide bonded insulation was added (StoPox ZNP-TE 21 - 10 mm).

35 mm protective mastic asphalt layer MA 11 (with PmB modified bitumen) was laid.

As a binder layer not 70 mm AC 22 but 40 mm SMA 11 was laid. The surface layer was the generally used 40 mm SMA 11.

Along the roadway edges on both side, 250 mm (high side) and 400 mm (low side) wide mastic asphalt (MA 11) bands were made (layers' thickness: 35 mm + 40 mm + 40 mm). The joints between the MA and the SMA were filled up with flexible joint filling material.

### **Reinforced concrete slab:**

In the case of reinforced concrete bridges the following insulation types are used:

- Normal bitumen sheet (BL),
- Polymer enhanced, flexible, cement-based (PCC)
- Mastics (M),
- PmB-A based modified bitumen (PmB-A)
- Modified bitumen sheet (mBL),
- Flexible plastic-based (RMA).

On sprayed insulation only mastic asphalt, on sheet insulation also hot mix asphalt may be used.

The protective asphalt layer's type can be MA 11 (with normal, hard bitumen) or MA 11 (mF) (with modified bitumen).

Over the insulation, two or three asphalt layers can be used. These are: protective asphalt layer, binder layer (which may be missing in some cases) and surface layer.

The design of the type of insulation depends on:

- Bridge parameters (bridge structure, free span, etc.)
- Design life of the bridge (heavy traffic class and loads).
- Building conditions (construction technology, technical and economic reasons, etc.)
- other special circumstances.

The pavement design depends on the traffic load class as:

- normal (N),
- increased (F).

In case of normal load class an 80 mm overall thick pavement may be designed (insulating protective layer and asphalt surface layer)

In case of increased load class a 120 mm overall thick pavement may be designed (insulating protective layer, asphalt binder layer and asphalt surface layer).

## 8-THE NETHERLANDS

In the Netherlands the Ministry of Infrastructure and Environment published “Guideline for the design of asphalt pavements on concrete and steel bridge decks” (in Dutch); Rijkswaterstaat Technical Document RTD 1009:2012 in May 2012.

This guideline gives standard solutions for concrete and steel bridge decks but other solutions than the standard solutions are in principle acceptable if it is shown that the alternative meets all the requirements stated in the guideline.

### *Standard solution for a porous surface layer on a concrete bridge or structure*

The standard asphalt pavement with a porous surface layer on a concrete deck is as follows:

- a surface layer of (to be chosen)
  - 30-40 mm Porous Asphalt PA 11, or
  - 50 mm Porous Asphalt PA 16, or
  - 70 mm Double layered Porous asphalt;
- a tack coat;
- a (profile)layer of AC 16 (50-70 mm), which meets the required water tightness
- (local) fills with AC 11 if the unevenness of the concrete substrate is >20 mm, with a normal tack coat at the upper side
- a tack coat (0,6 kg/m<sup>2</sup> in two passes, with split on top)
- (line wise) sealing of joints, if applicable
- hydrophobic coating on the concrete (if the concrete is new)

### *Standard solution for dense surface layer on a concrete bridge or structure*

The standard asphalt pavement with a dense surface layer on a concrete deck is as follows:

- a layer AC 16 surf (50-70 mm), which meets the required water tightness
- (local) fills with AC 11 if the unevenness of the concrete substrate is >20 mm, with a normal tack coat at the upper side
- a tack coat (0,6 kg/m<sup>2</sup> in two passes, with split on top)
- (line wise) sealing of joints, if applicable
- hydrophobic coating on the concrete (if the concrete is new)

### *Standard solution for a porous surface layer on a steel bridge deck or structure*

The standard asphalt pavement with a porous surface layer on a steel bridge deck is as follows (starting at the top):

- Porous Asphalt PA 11, polymer modified (35 mm)
- membrane: Parafor Ponts or similar (5 mm)
- mastic asphalt (MA), polymer modified (25 mm)
- membrane: Parafor Mistral C or similar (4 mm)
- primer
- steel bridge deck

### *Standard solution for a dense surface layer on a steel bridge deck or structure*

The standard asphalt pavement with a dense surface layer on a steel bridge deck is as follows (starting at the top):

- Surface layer: Mastic Asphalt (MA), polymer modified (25 mm)
- Mastic Asphalt (MA), polymer modified (25 mm)

- membrane: Parafor Mistral C or similar (4 mm)
- primer
- steel bridge deck

The total minimal layer thickness is 50 mm (in case of deviation from the above mentioned nominal thicknesses).

*The expected life time is 7to 10 years if the application is done in the right way under good circumstances.*

## Appendix-2. Examples of bridges with an asphalt pavement



Bridge over the lake Jordan in Czech Republic near Tabor



Bridge in motorway D 47 in Czech Republic on the river Odra (the length of the main span is 105 m)



Millau Bridge in France



Bosphorus Bridge- Turkey



The 6.6 km West bridge on the Great Belt Link (Denmark)



Oresund steel bridge between Sweden to Denmark



Reinforced concrete bridge: M6/M60 motorway, Hungary



Steel bridge at Marcaltő, Hungary