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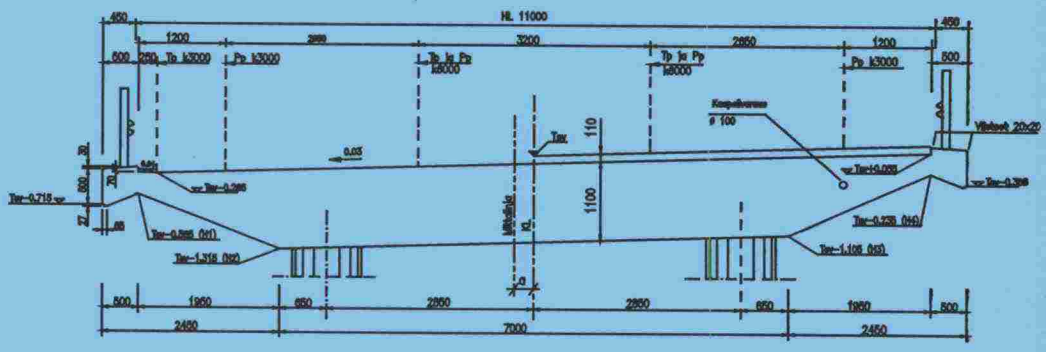
GENERAL QUALITY REQUIREMENTS

FOR BRIDGE CONSTRUCTION

Deck Surface Structures - SYL 6

Finnish National Road Administration



Specifications and quality requirements

Helsinki 1996

Bridge Engineering Unit

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PREFACE

The general quality specifications for the construction of bridge deck surface structures were previously laid down in the sixth edition of SYL 6, published in April 1992.

This document has been amended and revised on the basis of practical experience. The new working group comprises: Jouko Lämsä MSc. (Eng.) of the Bridge Engineering Unit (Chairman), Olavi Holma, Project Manager, of Finnish National Road Administration Oulu Region, Jaakko Holopainen, Engineer, of Uusimaa Region, Pekka Lehto, Construction Engineer, of Turku Region, Pekka Merivirta, Construction Engineer, of Kaakkois-Suomi Region (the southeastern road region), Martti Alhainen, Managing Director of Eristys-Mara Oy and Kyösti Laukkanen, Senior Research Officer, of the Road and Geotechnical Survey Unit/Technical Research Centre of Finland (VTT). The technical aspects of the revised draft text have been prepared by Kalevi Falck MSc. (Eng.) of Laatukonsultit Oy.

Opinions and advice have been sought from all the regional Road Administration Boards, Finnish State Railways, Helsinki City Public Works Office and various contractors and manufacturers of waterproofing materials, among others.

This document has been checked and revised by the Bridge Engineering Unit.

Helsinki, August 1996

Bridge Engineering Unit

This English translation has also incorporated changes and addendum prepared in 1998. The changes and addendum are originated from the experience and findings from a research project, implemented as a joint venture together with VTT. The research concerned the problem of having blisters in the waterproofing.

Helsinki, June 1998

Torsten Lunabba
Bridge Engineering Unit

Contents

6 DECK SURFACE STRUCTURES

6.0 A PRODUCT MANUFACTURED IN ANOTHER EUROPEAN COUNTRY

A product which has been manufactured in another Member State of the European Union or in another country in the European Economic Area shall be deemed upon application to be in conformity with the quality requirements presented in this publication on the following preconditions:

1. The tests and inspections have been performed in the country of manufacture in accordance with the methods and requirements employed in Finland or ones yielding a corresponding standard of quality and safety, and the results show that the product meets the requirements laid down for it.
2. The body which performed the test and inspections is approved for these tasks by the country of manufacture.

The Finnish National Road Administration is keeping abreast of European standardization in the sector and will amend the guidelines to conform with European standards once they are ready.

6.1 GENERAL

6.1.1 Area of application

This section of the General Quality Specifications for Bridge Construction shall be complied with when constructing deck surface structures of bridges by the 'LVR' method or by the traditional construction method.

SYL 1 lays down the general quality requirements and instructions. These requirements also apply to the work having the quality defined hereinafter.

The binding quality requirements and instructions are laid down as text in wide columns and useful information, guidelines and details of working practices for contractors as text in narrow columns. Deviation from the latter is permissible with the approval of the supervisor.

The applicable sections of the 'General Quality Requirements and Work Specifications for Road Construction, Paving Works' by the Finnish National Road Administration /2/ shall be complied with when executing deck surface works. Concrete casting work shall be carried out according to the processes and definitions in SYL 3.

6.1.2 Definitions

The following terms are defined below in addition to those laid down in Section 1.1.3 of SYL 1.

Deck surface structure as used in these quality requirements means the waterproofing, the protective layers and the pavements on the upper surfaces of the bridge deck superstructure.

Substrate refers to the deck upper surfaces, surfaces of the edge beams which shall be insulated and other surfaces to be insulated.

Polymer bitumen is bitumen with added polymers to change its properties so that the bitumen has elastic characteristics.

Polymer bitumen sheet membrane is a product which is impermeable to water and used for waterproofing purposes. The sealing material is polymer bitumen and the base material for bridge surfacing structures is generally polyester felt.

Sheet membrane waterproofing structure is a two-layer waterproofing structure formed by a base membrane attached to the surface to be insulated and a upper membrane attached to the base membrane.

Mastic asphalt waterproofing is a waterproofing mastic asphalt used as water insulation.

Liquid applied membrane waterproofing compounds are generally polyurethane, acrylic or epoxy base waterproofing materials suitable for spreading in liquid form

Liquid applied membrane waterproofing is sprayed or brushed waterproofing compounds used as insulation.

Gluing bitumen is polymer bitumen KB 100 or a gluing bitumen otherwise approved by the Finnish National Roads Administration (TIEL).

Thin-layer pavements are thin coating layers (5-20 mm thick) spread on bridge deck, which function both as waterproofing agents and as pavement.

Epoxy sealing compounds are double treatments used to seal a concrete surface and to prevent blistering.

6.1.3 Works management

A person in charge of the surfacing work shall have sufficient knowledge of the field and shall have a minimum of two years' experience. The

requirements for the foreman of concrete casting work are laid down in SYL 3 of this manual.

6.1.4 Technical work plans

The contractor shall submit the work plans to the supervisor at least one week before the start of each work stage. This shall clarified in detail at least items recited in Section 1.3.3.3 of SYL 1.

> The most common types of bridge deck surface structures are shown in Appendix 1.

Waterproofing work plans shall include inter alia:

- drying of the substrate and of the condensed humidity before beginning waterproofing
- any necessary correction of unevenness or flaws in the concrete surface
- preparation / bonding treatment of the surface
- waterproofing layers for each work stage, plus overlap scheme
- method of waterproofing installation
- equipment, including the type of the melting pot
- measuring thickness of layers and monitoring consumption of compounds
- the protection of the waterproofing
- sealing of abuttals and ducts
- providing for changes in weather conditions

6.1.5 Quality plans

The quality plans for surface construction work shall be drawn up in the appropriate manner as laid down in SYL 1, 1.3.3.

6.1.6 Documentation and proof of acceptability

Documentation and proof of acceptability laid down in SYL 1, Section 1.3.4 shall be complied with as appropriate.

6.2 WATERPROOFING

6.2.1 General quality requirements

Bridge deck waterproofing shall be watertight. This means that, irrespective of the location, the insulation and it's junctures shall withstand without any leaking the stress from the prevailing weather conditions, from the water pressure and from traffic as well as form deformations due to temperature changes and shrinkage of concrete. The waterproofing material has to be approved by the Finnish National Road Administration (TIEL). The requirements for approval are laid down in Appendices 3 to 11.

> The waterproofing materials approved by the Finnish National Road Administration are listed in SILKO Directives (folder 3) /1/ and in letters supplementing those Directives.
>
> The requirements laid down in Appendices 3 to 11 are acceptability requirements only where specifically stated in Section 6.2.6.

The insulation layers shall be attached to the substrate and to each other in such a way that they do not move in relation to each other after the bridge is opened for traffic.

The finished waterproofing shall be protected according to the requirements in Section 6.3, unless the customer has otherwise approved another course of action. The methods of protection and materials for this purpose shall be laid down in the design documents.

Protection of the waterproofing shall be undertaken as soon as possible, and at the latest within one week of the insulation work.

> The lowermost layer of the pavement shall be done as soon as possible after protecting the waterproofing, this to reduce the risk of damaging the insulation.

Approval of the material is valid for five years unless the client agrees otherwise.

6.2.2 Quality requirements for materials

6.2.2.1 Polymer bitumen primer

Polymer bitumen primer KBL 20/ 100 manufactured from polymer bitumen KB100 and a solvent shall comply with the requirements shown in Table 1 of Appendix 3. Polymer bitumen primers shall contain a minimum of 0.5% by weight of diamine-type bonding primer.

6.2.2.2 Polymer bitumen

The polymer bitumen shall contain styrene butadiene styrene polymer (SBS polymer) or another type of polymer approved by the Bridge Engineering Unit. Polymer bitumen shall comply with the requirements laid down in Table 2, Appendix 3.

Approved melting pots are listed in SILKO Directive 4.831 /1/.

6.2.2.3 Tar epoxy

Tar epoxy shall be non-drip and shall comply with the requirements laid down in Table 1, Appendix 4.

Tar epoxy and its constituent ingredients shall be compatible with polymer bitumen and bitumen contained in asphalt, as approved by the Technical Research Centre of Finland (VTT-2653).

6.2.2.4 Epoxy sealant

Epoxy sealant shall comply with the quality requirements laid down in Appendix 5.

6.2.2.5 Mastic asphalt waterproofing

Mastic asphalt waterproofing is made of sand, filling agents and binding agents.

Binder content in mastic asphalt waterproofing shall be a minimum of 15% by weight. The binder shall contain bitumen and SBS polymer. Limestone powder is used as a filler, which shall be in sufficient quantity that the grain size distribution of the mastic asphalt is 25% to 40% through a 0.074 mm sieve. Sand shall pass through a 2 mm sieve.

The binder (KB 85) in mastic asphalt waterproofing shall comply with the quality requirements laid down in Table 2, Appendix 3. Mastic asphalt waterproofing shall comply with the requirements in accordance with Table 2, Appendix 4. Mastic asphalt shall, in addition, comply with requirements for type approval tests /9/.

The mastic asphalt waterproofing compound shall be tested beforehand using exactly the same mix and the same aggregate. The results of the testing shall comply with the quality requirements laid down for such mastic asphalt waterproofing. However, preliminary testing is not required, where quality control tests from the same compound are available and not more than three months old.

6.2.2.6 Venting net

The venting net shall be polyester or glass-fibre type with a mesh size of not less than 4 to 8 mm and a thickness of at least 0.7 mm. Glass fibre net shall have a plastic treated surface.

Net types approved by the Finnish National Road Administration are listed in SILKO Directives /1/.

6.2.2.7 Polymer bitumen sheet membranes and sheet membrane waterproofing

Sheet membrane quality requirements

Individual sheet membrane types shall be approved by the client and these have to comply with the quality requirements for these types of sheet membranes, as stated in the general quality requirements for sheet membranes in Appendix 6.

For sheet membranes, deviations from the required quality properties are allowed to the extent acceptable in the SFS Standard.

The properties of individual sheet membranes are examined in the manner laid down in Standard SFS 5011 /6/ or an equivalent EN Standard.

Sheet membrane rolls shall be stored in such a way that their properties will not change during storage periods.

> Rolls shall be stored at the site in a dry place before installation, in a temperature of not less than +0 °C. The plastic sheeting around the membrane shall be opened to allow potential condensed moisture to evaporate before installation.

Polymer bitumen sheet membranes shall be attached to the substrate, depending on the product, by gluing with polymer bitumen, with a bonding

agent suitable for the product, with a self-adhesive glue layer on the bottom of the membrane or by heating (torching) the gluing bitumen on the bottom layer of the sheet membrane.

Sheet membranes are classified depending on purpose of use as base sheet membranes or as upper sheet membranes. Base sheet membranes are of the K-MS type or of ventilating K-TMS type, and sheet upper membranes are of the K-PS type. A sheet membrane can also be a single layer type, K-PS.

Quality requirements for sheet membrane waterproofing structures

The substrate of waterproofing shall be sealed with epoxy on main road bridges (that is on significant highways, semi-motorways, motorways) and on their ramp bridges as well as on bridges having the amount of traffic (KVL) is > 3000 vehicles/day, being close to traffic lights or having a slope of > 4%. On other bridges, where the construction depth of the deck is > 400 mm (that is massive slab and girder bridges) a venting sheet membrane may also be used. In that case there will be no epoxy sealing, instead bonding primer is spread on the substrate according to Section 6.2.2.3.

The classification of sheet membranes according to their service state is presented in Appendix 7. On frame bridges having an embankment fill on the superstructure and being on busy roads (KVL > 3000 vehicles/day) a sheet membrane combination of service class grade 2 may be used.

The client shall approve permitted sheet membrane waterproofing structures on the basis of VTT testing /8/. Test results for sheet membrane structures shall meet the quality requirements laid down in Appendix 7.

Approved sheet membrane waterproofing structures are laid down in the SILKO Directives /1/.

6.2.2.8 Liquid applied membrane waterproofing and other waterproofing materials

Brushed and sprayed liquid applied membrane waterproofing compounds shall be products approved by the client and these compounds shall meet the quality requirements laid down in Appendix 8.

Approved products are epoxy resin or polyurethane compounds: these are listed in the SILKO Directives /1/.

Where a bonding primer is used it shall be a product recommended by the manufacturer.

The use of other waterproofing materials for bridge deck shall be approved by the client and those materials shall meet the quality requirements laid

down in the design.

6.2.2.9 Compatibility of materials

If different materials are used as waterproofing structures, the manufacturer of these materials shall be able to demonstrate in advance, with the aid of tests carried out by an independent material testing centre, that the materials will not damage each other and that they will bond together reliably. If a pavement is in direct contact with a waterproofing material, the waterproofing material shall be chosen so that it will not suffer damage from heat when overlaying the pavement.

Bituminous and synthetic resin products shall be compatible and shall always be tested by an independent material testing centre.

6.2.3 Waterproofing concrete decks

6.2.3.1 Waterproofing plan

Work and quality plans for waterproofing shall be drawn up as laid down in Sections 6.1.4 and 6.1.5.

6.2.3.2 Requirements for substrate

The surface to be waterproofed shall meet the requirements laid down in Section 3.2.3.4 of SYL 3. Where necessary the surface shall be levelled before waterproofing. This work shall be done in a manner approved by the client.

> The instructions for the requirements applying to levelling of different waterproofing materials are laid down in Appendix 2. The evenness is measured using a 2 metre straight edge. Particular caves, having a size exceeding aforesaid limits, are levelled with heat-resistant epoxy-based patching mix with good bond to the substrate or, on permission of the supervisor, with a 1:2 mix of polymer bitumen and sand. Epoxy-based patching mix has the advantage of quick hardening and drying. If the area to be levelled is uniform and fairly large,
> it will be fraised and the final levelling is done as said before or by synthetic resin based patching mortar or compound. Fine quartz sand is spread on the newly patched surface for guaranteeing good bond for the insulating layer.

The surface to be waterproofed shall be clean and dry before waterproofing work is carried out. To ensure good bond, cement paste, oil, grease and other

undesirable substances shall be removed by shot blasting or sand blasting and the surface vacuum cleaned before waterproofing work is carried out. Cleaning shall be carried out to 'middle depth' as classified in the Publication By 40, 'Concrete Surfaces, Classification Directives', by the Finnish Concrete Association /11/. After cleaning, cracks in the upper surface of the deck are sealed off (by saturating, or where necessary by injecting) with an appropriate epoxy sealant which is approved for this purpose and accepted by the client. The epoxy sealant shall withstand heat and polymer bitumen.

Approved epoxy sealants are listed in SILKO Directives /1/.

When curing is completed, the surface shall be left to dry for at least a three weeks period. This period is considered to start when sand or shot blasting is finished and end when the epoxy sealing and surface waterproofing work is going to start. Curing is regarded as finished when wet curing (water spraying) is finished or when curing materials have been removed by shot blasting or by sand blasting.

Surface moisture is measured either in terms of absolute humidity, which may not at the commence of waterproofing works exceed the levels shown in Table 1, except where the surface area of the deck is under 100 m² and the construction depth is <= 400 mm. In these cases the surface moisture content is not usually determined from a measurement but the concrete is instead allowed to dry out for at least a three weeks period starting from the date of finishing curing and ending at the beginning the waterproofing work.

Methods for measuring the absolute humidity is in more detail presented in the Section 6.2.3.2 of the 'Directives for the Supervision of Bridge Works' (SVO) published by the Finnish National Road Administration's Bridge Engineering Unit.

During surface waterproofing work the relative humidity in the air may not exceed 85 %. The surface temperature of the deck to be waterproofed shall be at least + 3 °C above the dew point, and the exact temperature in case of sheet membrane and polyurethane waterproofing always at least + 5 °C and in case of mastic asphalt waterproofing at least + 0 °C.

Table 1. Maximum moisture content on the substrate when waterproofing work is commenced.

	Absolute humidity(VTT 2650) % by weight
Sheet membrane waterproofing	4,5
Liquid applied membrane waterproofing	4,5
Mastic asphalt waterproofing	5,5
Venting membrane	5,5

When the moisture content is measured, it shall be specified for a minimum

of three positions on the deck. If the surface area of the deck is over 500 m², a testing point shall be added for each 500 m² area, to a maximum of 6 testing points.

The above requirements also apply to patched deck surfaces.

6.2.3.3 Sheet membrane waterproofing

If the surface is not to be sealed with an epoxy resin, a bonding primer shall be spread on the surface to be waterproofed at a rate of application of 0.1 to 0.3 kg per m². Epoxy sealing is applied in two layers: the 1st layer 300-500 g/m² + topping sand, 2nd layer >600 g/m² and according to the manufacturer's instructions. The polymer bitumen primer must always be carefully agitated in it's container before spreading on the deck.

The melting pots for polymer bitumen shall be of a type approved by the Finnish National Road Administration. On the site, the temperature regulator of the melting pot shall always be aright and the pot shall be cleaned before the work is commenced. The melting pot shall also have a functioning agitating device.

The structure of the sheet membrane waterproofing shall be chosen as it is indicated in the bridge specific quality requirements. If a venting sheet membrane (K-TMS) is used as a base membrane, a strip of conventional base sheet membranes (K-MS) shall be installed at the both sides of the bridge deck and first thereafter venting sheet membranes shall be used. The bond of the membrane to the base is measured according to the applicable section of the tensile test laid down in procedure VTT- 2651 (Technical Research Centre of Finland). The bond of a venting sheet membrane shall be measured at glued sections, where the bond shall fulfil general requirements for that sheet membrane. The bond strength covering different temperatures is laid down in Figure 1. A value of 0,1 N/m² may be subtracted from the values of the curve in case the fracture in the tensile bonding test is an internal cohesion fracture of the gluing bitumen and in case after the waterproofing work is finished, the values of the gluing bitumen fulfil the requirements in Table 2 in Appendix 3.

In structures with venting membranes, the bridge deck is equipped with venting pipes having the material of plastic instead of that in SYL 7 of Section 7.7.5.

> The positioning of venting pipes is shown in Appendix 12a for bridges with venting membranes. Attachment of the membrane to the substrate shall be carried out in such a way that the venting pipes are always kept open and are not in the area of the gluing bitumen. Where necessary a piece of geotextile, for example, is installed on the top of the pipe to prevent the flow of melted bitumen into the venting pipe.

The sheet membrane shall be properly overlapped and flat, without any creases. There shall be no blisters between the substrate and the membrane. Joints shall be sealed watertight.

The sheet membranes shall be installed in longitudinal direction. Overlapping of membranes shall be at least 100 mm longitudinally (side seams) and 150 mm crosswise (end seams). Adjacent sheet membranes shall have their joints staggered by a minimum of 500 mm in longitudinal direction. In a sheet membrane laid on the top of an other, the seams shall be overlapped by a minimum of 100 mm in relation to the seams of the lower sheet membranes.

A double layer of tar epoxy or polymer bitumen (KB 100) at layers of 2 × 1 kg/m² is always applied to the inner face of an edge beam and on a 250 mm wide strip of the waterproofing structure next to the edge beam, irrespective of the gluing technique employed for the waterproofing. Polymer bitumen and tar epoxy for this purpose shall comply with the quality requirements laid down in Table 2, Appendix 3, and with Table 1, Appendix 4 respectively.

Sheet membrane waterproofing is protected by a protective layer according to the design as shown in Section 6.3.

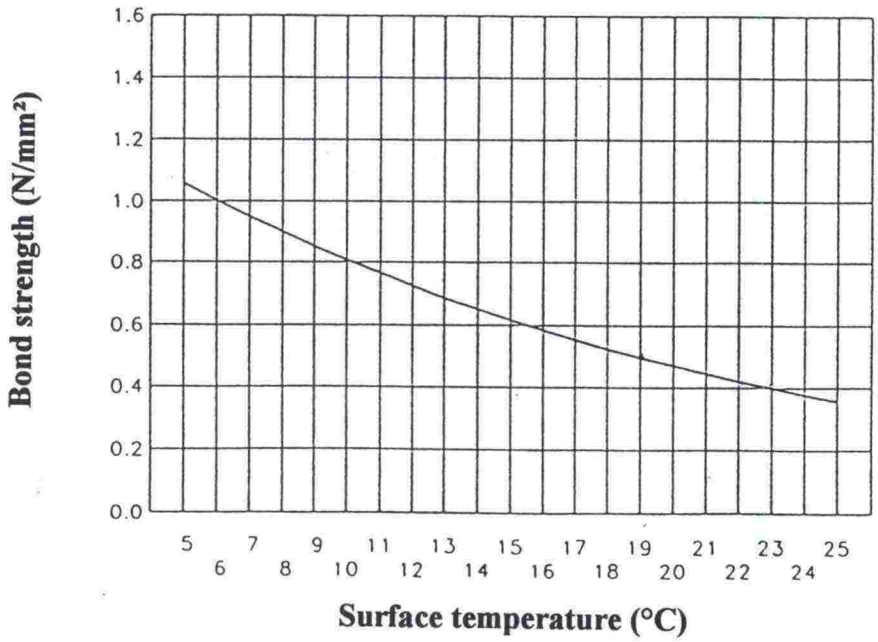


Figure 1. Requirements for pull-off bond strength of sheet membrane.

It is not permitted to drive by a car over the membrane before the membrane has been protected. On occasions where this is unavoidable, the membrane shall be covered with plywood (minimum 5 mm thick) where the wheels go over the membrane. In these circumstances the car shall not be allowed to stop on top of the membrane surface. When the first layer of asphalt concrete (AB 6 or AB 12) shall be rolled, a roller having the both rollers driving shall be used.

6.2.3.4 Mastic asphalt waterproofing

Venting pipes

While using mastic asphalt waterproofing, a bridge deck shall be equipped with venting pipes as laid down in Section 7.7.5 of SYL 7.

The positioning of venting pipes on the bridge deck is shown in Appendix 12b, while using mastic asphalt waterproofing.

Venting net

The net is fastened by spot gluing with polymer bitumen in such a way that the net does not get folded or creased while spreading the mastic asphalt. Polymer bitumen used for this purpose shall be KB 100 grade and comply with the quality requirements laid down in Table 2, Appendix 3.

Spreading mastic asphalt waterproofing

The mean distribution of mastic asphalt over the whole bridge deck shall be a minimum of 55 kg/m^2. The mastic asphalt is spread in two layers.

The mastic asphalt shall be on the average 20 mm thick and a minimum of 15 mm thick overall. The slope of the mastic asphalt surface shall be such that there will be no water puddles in it. The finished surface shall have a uniform lustre, with no blisters or cracks visible on it.

The mastic asphalt is spread by hand, with a rake, no later than 32 hours after applying the polymer bitumen. Clogging of drain pipes shall be prevented while applying the mastic asphalt.

The inner face of edge beams and the mastic asphalt on an >= 250 mm wide strip next to the edge beams shall be coated with tar epoxy or polymer bitumen according to the requirements in Section 6.2.3.3.

It is not permitted to drive by a motor vehicle over the top of the mastic asphalt waterproofing before it has been protected in the manner described in Section 6.3.

6.2.3.5 Brushed and sprayed liquid applied membrane waterproofing

Where the upper surface of the deck is not sealed with an epoxy compound, an appropriate quantity of bonding agent shall be spread on the surface, in accordance with directions for the product.

The density of the layer of waterproofing shall not be less than 3% of the optimum, or if the optimum is not specified, the void volume shall not exceed 15% for liquid applied membrane waterproofing.

The optimum thickness shall be specified before work commences, according to the directions for that product. A test area of waterproofing shall be spread at the start of each working shift. An area of approximately 1 m² shall be tested on plastic sheeting to check the thickness of the layer and the density of the mix. This test area is separated from the plastic when it has hardened enough and then cut into three 10 cm × 10 cm samples for measurement with a slide calliper. The test pieces are then immersed in a test solution with a density less than 3% of the optimum for the waterproofing compound. If the samples do not sink into the solution, the density of the waterproofing layer does not meet the quality requirements. If this is the case the spray application equipment has to be adjusted and new test samples taken. The procedure has to be carried out in this way until the required density is achieved.

> By measuring the optimum density, it is checked that the allowable pore volume is not exceeded due to foaming caused by moisture or excess of air.

Two 250 mm × 400 mm samples of the waterproofing compound having an acceptable density, shall be cut for possible later examination and testing.

Samples of the constituent ingredients of the waterproofing compound and the bonding primer shall be taken at the construction site in separate containers for possible examination later on. The amount shall be sufficient to produce 2.5 kg sample of the ready mix.

The compound is usually sprayed in a criss-cross fashion, in two layers. If the upper of the two coatings shall be added the following day, the bonding between the two layers shall be ensured by applying a bonding primer treatment. Sprayed strips are overlapped by a minimum of 50 mm. Product requirements for the use of sprayed compounds shall be carefully followed.

Waterproofing work shall not be undertaken in rain and the surface temperature of the area to be coated shall be in line with the manufacturer's instructions, generally not below + 5 °C.

The thickness of the layer shall be an average of 2.5 mm and overall not less than 1.5 mm.

During the spraying process the thickness of the not yet hardened layer shall be measured by a combing gauge. Each individual test result shall fulfil the thickness requirement. Where a single result does not meet the requirements, the thickness from three additional places less than 30 cm from the area failing to fulfil the requirements shall be checked. If each of the three additional measurement samples fulfils the thickness requirement, the above-

mentioned single measurement is considered to be a measuring error and ignored. Where one of the additional measurements reveals a thickness below the required, then extent of the area having thickness failing to fulfil the requirement shall be identified. That are shall be corrected immediately by spraying an additional amount of the appropriate compound to build up the surface to the sufficient level. The thickness requirement is also checked by monitoring the compound consumption .

Bonding of the waterproofing to the substrate shall be:

- on average ≥ 1.2 N/mm²
- minimum ≥ 1.0 N/mm².

The colour of the waterproofing surface shall be of uniform quality. There shall be no pores, blisters or needle-like cracks due to blisters dispersing. Defective areas shall be removed and the surfacing renewed for those sections where correction by simple brushing or spraying is not successful.

> Noticeable differences in the thickness are usually visible through colour variations on the surface.

Visible surfaces shall be protected with a UV resistant skim coat with a wet film density ≥ 80 µm where the surfacing is not of a type resistant to ultraviolet light. The surface shall be dry and clean before application of the skim coat.

6.2.3.6 Other waterproofing structures

To be carried out according to the quality requirements laid down in the design.

6.2.4 Waterproofing of steel decks

6.2.4.1 General

Plans for waterproofing work shall be drawn up according to Sections 6.1.4 and 6.1.5.

6.2.4.2 Requirements for the substrate

Preliminary cleaning of the steel deck shall comply with the directions and requirements of Standard SFS 4957.

The cleaned and dry steel deck is sand blasted to a cleanliness grade of Sa 2.5 (SIS 055900) /7/. Cleaning shall be carried out in dry conditions, if necessary under protective cover.

After shot blasting the steel deck shall be protected immediately with polymer bitumen at a rate of 0.1 to 0.3 kg/m². Fixing steel components shall be protected as well as other steel surfaces. The polymer bitumen primer used for this purpose shall comply with the quality requirements in Table 1, Appendix 3.

6.2.4.3 Mastic asphalt waterproofing

Polymer bitumen (KB 100) shall be spread at a rate of 3 kg/m² on the substrate. The polymer bitumen used shall comply with the quality requirements laid down in Table 2, Appendix 3. The spreading operation is carried out in dry weather conditions where the air temperature is at least +5°C. The temperature of the compound when applying shall be in the range 180 °C to 210 °C. Also potential fixing steel components shall also be thoroughly treated with polymer bitumen.

Mastic asphalt waterproofing is spread on top of the polymer bitumen, the mastic asphalt shall comply with the quality requirements in Table 2, Appendix 4. The spreading is carried out by hand raking in one or two layers according to the design. The average consumption of the mastic asphalt, not including that for the fixing steel components on the bridge deck, shall be a minimum of 55 kg/m², and the thickness of the mastic asphalt shall be a minimum of 15 mm. For a bridge deck fitted with fixing steel components the corresponding amount of mix is 35 kg/m² and the thickness requirement is 12 mm.

Bonding chipping (with a grain size of 6 to 12 mm) is spread on top of the mastic asphalt, to the quantity of 10 kg/m² in average. The chipping is not rolled.

The finished mastic asphalt surface shall fulfil the requirements in Section 6.2.3.4.3. The seams on the bridge sides and ends are sealed with a double layer of polymer bitumen coating KB 100 (at a rate of 2 × 1.0 kg/m²).

6.2.4.4 Brushed and sprayed liquid applied membrane waterproofing

The waterproofing compound shall fulfil the requirements in Appendix 8 and comply with the quality requirements for finished work, see Section 6.2.3.5.

> Examples of liquid applied membrane waterproofing are polyurethane, acrylic, epoxy resin and tar epoxy compounds.

6.2.5 Waterproofing of timber decks

6.2.5.1 General

Work and quality plans shall be drawn up for waterproofing work according to Sections 6.1.4 and 6.1.5 .

6.2.5.2 Requirements for substrate

Where a preservative is used for a timber deck, compatibility of this timber treatment with the waterproofing compound shall always be ensured.

There shall not be any local indentation more than 2 mm on the substrate. The substrate shall be clean and dry, and waterproofing work may not be carried out in rain. When using brushed or sprayed waterproofing compounds, the surface to be waterproofed shall be shot blasted and when using mastic asphalt waterproofing, the surface shall be cleaned by compressed air.

6.2.5.3 Sheet membrane waterproofing

Waterproofing work is carried out in accordance with the requirements in Section 6.2.3.3. The bottom layer sheet membrane shall not be of a type which is bonded by heating (torching).

6.2.5.4 Mastic asphalt waterproofing

Mastic asphalt waterproofing is spread directly on to the cleaned surface in a single application, at a rate of 30 kg/m², according to the requirements in Section 6.2.3.4. However, the venting net is left out.

6.2.5.5 Sprayed and brushed liquid applied membrane waterproofing

The waterproofing compounds shall comply with the requirements for materials, in Appendix 8, and with the requirements for finished structures, in Section 6.2.3.5.

6.2.5.6 Thin-layer pavements

The thin-layer pavement mixture containing polymer bitumen is spread directly on to the cleaned substrate with a rate of 50 kg/m² on bridges with low traffic volume in the manner described in Section 6.4.4.

6.2.6 Proof of acceptability

6.2.6.1 General

A summary of tests for the acceptability of waterproofing work laid down in Table 2. Measurements and samples shall be taken by the contractor in the presence of the client's supervisor. Samples of polymer bitumen primer, polymer bitumen and mastic asphalt shall be sent from the bridge construction site to a laboratory approved by the client. Samples sent shall comply with the 'General Quality Requirements and Work Specifications for Road Construction, Paving Works' /2/.

In addition to the samples mentioned in Table 2, further samples of additional materials shall be taken, where necessary, if there is reason to suspect any deviation from the quality requirements. Additional samples may also be taken for possible future testing.

Samples which are taken for possible future testing purposes shall be kept by the client until the end of the guarantee period. At the end of this period the samples are either disposed of or returned to the contractor. Disposal of hazardous waste shall be dealt with by taking statutory regulations into consideration.

The diameter of pull-off disc for the bond strength test is chosen according to the surfacing material. For sheet membrane waterproofing the largest possible disc is used (Ø >= 50 mm), for brushed and sprayed compounds a smaller disc is used (Ø from 28 mm to 50 mm).

6.2.6.2 Sheet membrane waterproofing

The acceptability of polymer bitumen and polymer bitumen primer are proved by tests on taken from the binder at the bridge site. Samples are taken from the melting pot (a minimum of one sample per bridge) immediately before spreading the compound. Samples of polymer bitumen primer are tested for the properties shown in Table 1, Appendix 3. Polymer bitumen samples are tested for the properties as shown in Table 2, Appendix 3.

The watertightness of waterproofing epoxy sealant is measured by the electric resistance test (VTT 2654-1995): three measurements shall be taken for each bridge. The bond of waterproofing epoxy sealant to concrete is measured by a tensile test (VTT 2651) at the rate of three tests per bridge.

Where the surface of the deck is greater than 100 m², the bond of the sheet membrane to the substrate is tested, by means of the bond strength test, at three separate places for each commenced 1000 m² stretch. If an individual test measurement is below the corresponding temperature requirement in the above-mentioned series of tests, an additional series of bond strength tests is carried out at a place approximately 1 metre from the first testing point. If poor results are still achieved in the additional tests, the extent of the area having poor bond is then identified, for example by tapping with a hammer or with a cross-sectional test, and corrected.

Where the deck area is less than 100 m², bond strength is tested by cutting with a carpet knife an area of approximately 100 m² ×100 m² through to the substrate. By lifting the cut edges by hand it will be evident whether the membrane is firmly attached to the substrate or not. If the membrane does not come loose by pulling, the bond strength is acceptable. In cases where the bond is not acceptable, the section concerned shall be removed and the waterproofing reapplied. The incision test shall be carried out at three places on the bridge deck.

Sections of the surfacing where blistering has occurred shall always be corrected. Sheet membranes which have become crumpled or damaged due to over-heating shall be removed immediately and replaced with correct ones.

6.2.6.3 Mastic asphalt waterproofing

The acceptability of asphalt waterproofing is proved by examining a sample of the substance, by measuring the thickness, (>= 10 measures per bridge), by visual examination and by the water test (1 sample per bridge).

Samples for testing the mastic asphalt binder and the mastic asphalt are taken during the waterproofing works. One 2.5 kg sample is taken of the polymer bitumen binder, plus a 5 kg sample of the mixed mastic asphalt compound for each commenced 1500 m² area, with a minimum of 2 samples to be taken. The properties of the samples are tested according to the properties specified in Table 2, Appendix 4.

The acceptability of the ready mastic asphalt waterproofing is proved by a visual check. The surface shall have a uniform lustre, there shall be no air voids or cracking.

The watertightness of the mastic asphalt is checked by a water test. The membrane shall not leak under the static pressure (=3 kPa) of a 300 mm column of water and withstand two hours of sprinkling without leaking.

The water column test is carried out with a 200 mm diameter plastic pipe. The joint at the pipe and the mastic asphalt shall be sealed watertight before testing. The test shall be carried out on top of a venting pipe, where any potential leaking is immediately visible under the deck.

6.2.6.4 Sprayed and brushed liquid applied membrane waterproofing

The waterproofing shall be wholly bonded to the substrate. Bond is tested at three separate places on the deck by the bond strength test for each of the first (commenced) 1000 m² areas to be waterproofed.

If a single reading of the bond strength test is below the required value, an additional series of tests is carried out at a distance of approximately 1 m from the initial testing place. Where poor results are achieved in the further set of tests which are carried out, the extent of the area having poor bond is identified and the waterproofing on that section corrected.

If the waterproofing compound or the gluing agent in it contains bitumen or tar, the temperature at the concrete deck surface under the surfacing layer shall be between + 5 °C and +25° C when performing the bond strength test.

The thickness of the finished surface shall be measured for each commenced 250 m² of the survey area. The surface thickness is measured in ten places for each of these 250 m² areas. Measurements are taken with the measuring instruments specified for this test. Where holes are created for these tests, these shall be patched after each measurement is taken.

It is recommended that measurements are taken immediately after the sealing compound has cured, in order that the patching work may be done straight away.

Before a hole is created for a thickness test, these areas shall be clearly marked off, with for example liquid ink, to clarify them. The hole to be patched shall be filled with a compatible patching mix compatible with the waterproofing immediately after testing as not all individual holes will be found later on the deck of a wide bridge.

6.2.6.5 Other types of waterproofing

The acceptability of other types of waterproofing is proved by methods stated in the design or in another approved manner.

Table 2. Acceptability tests and checks for sealant

Structural part	Property	Action	No of samples
Substrate	Evenness	Measurement	≥ 3 samples per bridge
(of the waterproofing)	Moisture content	-"-	3-6 samples per bridge
	Compactness and bond of sealing epoxy	-"-	≥ 3 samples per bridge
Concrete surface	Puddle forming	Water test	≥ 1 samples per bridge
Sheet membrane waterproofing	Bonding	Measurement	3x2 samples per each commenced 1000 m^2
-polymer bitumen	Properties	Rating	1 sample per work shift, 0.3 kg
-polymer bitumen primer	-"-	-"-	1 sample per bridge, 2.5 kg
-sheet membrane	-"-	-"- if needed	1 sample per bridge, a piece of 2 m^2
Mastic asphalt waterproofing	Binder content	Rating	1 sample per 1500 m^2, min. 2 samples per bridge
-sample of the mix	Particle size distribution	-"-	2.5 kg (per binder)
	Sag	-"-	5 kg (per mix)
	Return	-"-	
-waterproofing	Thickness	Rating	≥ 10 per bridge
	Water content	Water test	≥1 per bridge, watering 2 h
		-"-	≥1 per bridge, water column test
Liquid applied membrane waterproofing	Density	Rating	1 per working shift
	Bonding	-"-	3x2 per each commenced 1000 m^2
	Thickness	-"-	10 per each commenced 250 m^2
-constituents		Determination if needed	1 per bridge for mix of 2.5 kg
-completed waterproofing		-"-	2 per bridge, a piece of 250 mm x 400 mm

6.3 PROTECTION OF WATERPROOFING STRUCTURES

6.3.1 General quality requirements

The protection of the waterproofing shall be bonded to the substrate and to the pavement in such a way that there is not any movement between the layers after the bridge is taken into use. The evenness and the slope on the upper surface of the protective layer shall be such that there will be no water puddles in it. The surface shall follow the fall of the drainage installations.

Recommended methods for protecting the waterproofing are shown in Table 3. Different methods may be chosen if these are approved by the client.

Table 3 Methods of protecting waterproofing

Type of waterproofing	Protection
Sheet membrane waterproofing with upper membrane of type K-PS 220/4000	With a protective layer AB protective layer as said in the design
Sheet membrane waterproofing with upper membrane of type K-PS 170/4000 or other approved membrane	Asphalt concrete AB 6/50
Sheet membrane waterproofing with upper membrane of type K-PS 170/4000 or one-layer membrane structure	Protective layer
Sheet membrane waterproofing on a bridge having an embankment fill on the superstructure, upper membrane of type K-PS 170/4000.	Geotextile and sand or protective concrete
Sheet membrane waterproofing on a bridge having an embankment fill on the superstructure, one-layer membrane structure	Protective layer
Mastic asphalt waterproofing	Asphalt concrete AB 12/50
Polyurethane waterproofing	No separate protection, but first pavement layer of type VA/KBVA
EPDM polymer	Asphalt concrete AB 6/50
Other waterproofing	According to separate and approved design.

6.3.2 Asphalt concrete (AB 6/50)

Asphalt concrete which is used as the protective layer for the waterproofing shall be a minimum of 20 mm thick and shall comply with the 'General Quality Requirements and Work Specifications for Road Construction, Paving Works' /2/. An exception to the requirements is that for the evenness, which longitudinally of the bridge shall be within 10 mm over a 5 m length, crosswise the bridge shall be within 5 mm over a 2 m length. The grain size for stone aggregates in the asphalt concrete shall be according to Figure 2.

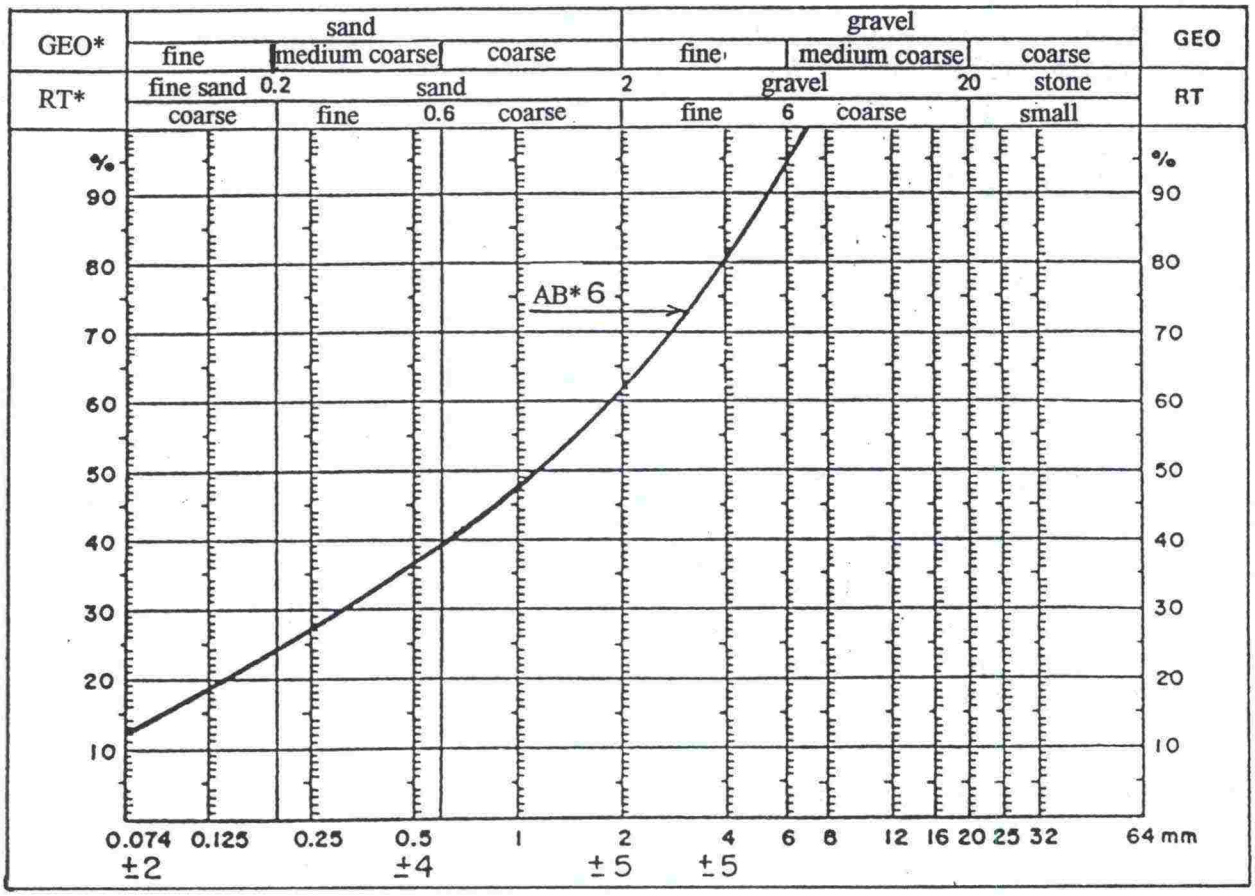
> The maximum grain size of aggregate may also be 4 mm, where this is with the permission of the client's supervisor.

The acceptability of the compound mix is indicated in the 'General Quality Requirements and Work Specifications for Road Construction, Paving Works' /2/.

In spreading the mix the use of roller-bottomed distributor is not permitted. Compacting is carried out by a non-vibrating smooth roller having a maximum weight or 4 tonnes. The temperature while spreading shall be between 130 °C to 150 °C.

ASPHALT CONCRETE AB 6

Aggregate mix:	filler, minimum	4 % by weight
	sand, maximum	35 % by weight
	crushed aggregate	55% by weight
Binder:	bitumen **B-160/220**	



Permitted deviations from specified grade curve.

Asphalt concrete AB 6	Inspection method
Amount of mix 50 (kg/m²)	
Permitted void content under 10 % by volume	PANK[1] 4114
Binder content 7.3 (% by weight, permitted deviation 0.4%)	PANK 4102

Figure 2. Grain size distribution in asphalt concrete AB 6/50

AB* = asphalt concrete
GEO* = geotechnical classification
RT* = structural classification
PANK refers to Päällystealan neuvottelukunta, Finnish Pavement Technology Advisory Council.

6.3.3 Protective concrete

Protective concrete is made to a thickness of 50 mm, as a steel fibre reinforced slab: the amount of steel fibres is 50 kg/m³. Concrete shall be frost resistant (grade P 50) and with a strength grade K45-1.

The directions for the mixing, quality control and proof of acceptability for protective concrete are found in SYL 3.

The strength of the concrete shall be at least 70% of the design strength before carrying out the paving.

6.3.4 Geotextile and sand

When protecting the sheet membrane waterproofing with a geotextile and a 20 mm layer of sand, the geotextile shall fulfil the class 3 of quality requirements (VTT-GEO) of the Technical Research Centre of Finland (VTT)/Geotechnical Engineering Laboratory. The geotextile which is used for this purpose shall have an approved test report.

The geotextile is attached to the sheet membrane layer beneath by spot gluing. The geotextile may not be allowed to cockle. The gluing bitumen shall meet the quality requirements for polymer bitumen KB 100, see Table 2, Appendix 3. The maximum grain size for sand is 2 mm.

6.3.5 Asphalt concrete AB 12/50

Asphalt concrete AB 12 is used to protect the mastic asphalt waterproofing. It shall fulfil the 'General Quality Requirements and Work Specifications for Road Construction, Paving Works' /2/. Aggregate used in this mix shall comply with the grain size specified in Figure 3.

The thickness of the asphalt concrete for use in the protective layer shall have an overall cover of 20 mm (minimum thickness).

In spreading the mix the use of roller-bottomed distributor is not permitted. The mix shall be spread by hand raking always when the temperature of the mix at the time of spreading is above +20°C.

Compacting of the mix is carried out by a non-vibrating smooth roller having a maximum weight of 4 tonnes.

Acceptability of the mix shall be proved in accordance with the 'General Quality Requirements and Work Specifications for Road Construction, Paving Works' /2/.

6.3.6 Protection of sprayed and brushed applied liquid membrane waterproofing

Polyurethane waterproofing does not require a special protective layer. Asphalt mastic (VA) is spread directly on to the surface in accordance with Section 6.4, at a temperature of 230° C to 240° C. Where the client has otherwise approved the use of polymer bitumen asphalt mastic (KBVA), the temperature at the time of spreading is between + 200° C to 210° C

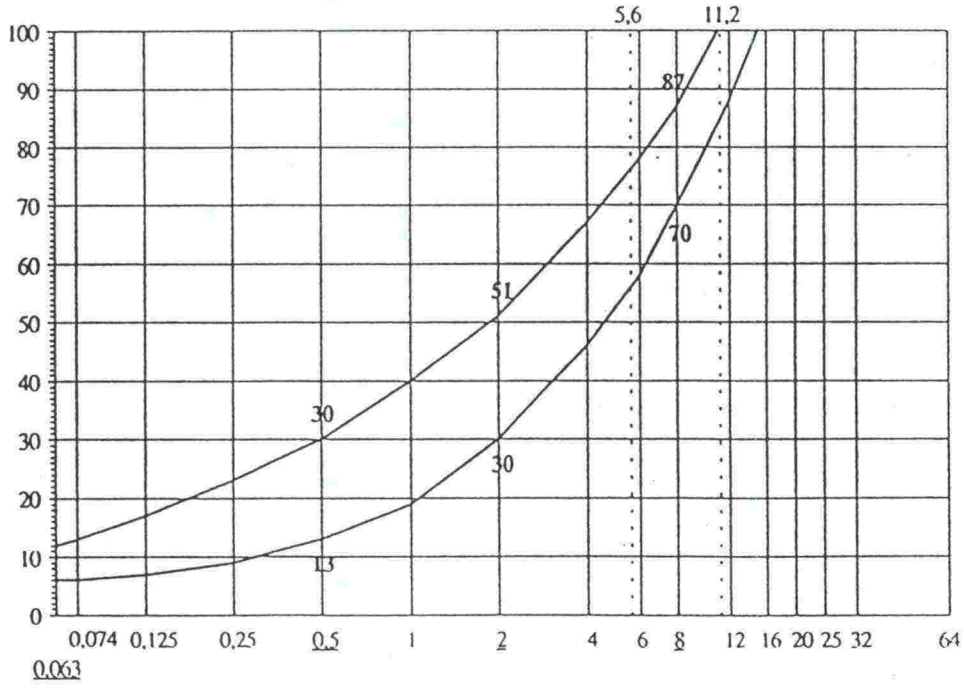
ASPHALT CONCRETE AB 12

AGGREGATE
Aggregate in sizing classes medium and coarse shall contain the following proportions of wholly or partially fractured grains by class:
at least 60% in class B
at least 50% in classes C and D.

BINDER

Bitumen	**B50/70-B160/220**
Binder content	**5.2-6.2% by weight**

PENETRATION - %



RANGE (mm, specified grid sizes underlined)

Void space in different graded batches shown in Table 18 in 'Asphalt Standards' /13/.	B,C	1.0 to 6.0 % by volume
	D	1.0 to 7.0 % by volume

Figure 3. Bituminous concrete AB 12 particle size distribution

6.3.7 Protection of other waterproofing structures

Other waterproofing materials are protected according to separate and approved work plans.

6.4 PAVEMENT

6.4.1 General quality requirements

Pavements are divided into the following types: asphalt, concrete and thin-layer pavements. Asphalt pavements are laid according to the requirements indicated in the design of the bridge, according to the directives mentioned hereinafter, according to the 'General Quality Requirements and Work Specifications for Road Construction, Paving Works' /2/ as well as according to the 'Asphalt Standards' which are currently in force /13/. The most commonly used pavement types for bridges are shown in Figures 1 to 15, Appendix 1. Asphalt pavements are proportioned according to the 'Asphalt Standards', Section 4.1.2, and practical experience unless the design states otherwise.

Neither equipment for heating surfaces nor multi-purpose spreaders with heating facilities (e.g. recycling vehicle) may be used for spreading asphalt on bridges. When compacting and fraising, attention shall be taken to avoid causing damage to the expansion joints.

The pavement shall be bonded to the base in such a way that there is no movement between the two layers after the bridge is opened for traffic.

All visibly damaged sections of bridge pavements, as stone pockets and jigged sections, shall be corrected while the work is still in progress.

The greatest permitted jog on roughened concrete pavements is 3 mm more than the corresponding figure for asphalt concrete.

The surface shall not have any recurring unevenness, which is likely to cause harmful vibration to vehicles, any harmful undulations or impressions left by rollers.

For examples the deflections and the creep of concrete are adjusted by the pavement.

The pavement shall be smooth and the slope steep enough so that there will be no water puddles in the carriage way.

Products which are manufactured outside the construction site and which are used while paving shall be manufactured by producers which are duly inspected.

6.4.2 Asphalt pavements

6.4.2.1 Quality requirements for materials

Asphalt pavements such as asphalt concrete, asphalt mastic, polymer asphalt concrete and polymer bitumen asphalt mastic shall fulfil the 'General Quality Requirements and Work Specifications for Road Construction, Paving Works' /2/.

The binder for polymer bitumen asphalt concrete (KBAB) is polymer bitumen KB 75 and for polymer bitumen asphalt mastic (KBVA) polymer bitumen KB 85. Binders shall comply with the quality requirements according to Appendix 9.

The highest mixing temperature for asphalt mixtures containing polymer is + 210 °C. While spreading the first pavement layer on top of the sheet membrane, it's temperature shall be between 130° C and 150° C.

The asphalt pavement is underdrained according to Section 7.7.6 of SYL 7.

> More detailed instructions for carrying out underdraining work are laid down in SILKO Directives /1/.

6.4.2.2 Execution of work

The pavement mix is prepared, transported, spread and compacted according to the 'General Quality Requirements and Work Specifications for Road Construction, Paving Works' /2/, but with the exception of the before mentioned exclusions.

6.4.2.3 Quality control and proof of acceptability

> Paving a bridge may be a part of more extensive road paving work. When this is the case and the type of pavement on the bridge is the same as on the road section, supervision of the work is regarded as a whole and proof of acceptability will be confirmed by mutual samples, checks and measurements.
>
> Bridge paving work can also be an independent work and pavement material may differ from that used on the roadway section.

The quality of materials used in the pavement mixture and its acceptability is monitored and proved according to the 'General Quality Requirements and Work Specifications for Road Construction, Paving Works' /2/ and the

'Asphalt Standards' /13/. In addition to these requirements the following specific definitions and exceptions apply:

- Evenness and slope are measured by means of a straight edge and by the water test.

- One sample of 2.5 kg is taken of the mix of compounds containing polymer bitumen: this shall test for return of the binder. One 10 kg sample of the mix is taken to test for the properties stated in Appendix 9.

- One sample is taken for each commenced 250 tonnes of asphalt concrete mix and for each commenced 100 tonnes of asphalt mastic. A minimum of one sample shall be taken for each layer. The mix samples are examined for the binder content and for grade curve. Asphalt mastic samples are also examined for sag.

- Samples taken by drilling are not done for paved areas less than 500 m², unless there are justifiable grounds for assuming that the properties of the paving mix is below the required standard. Two series of strip samples of asphalt concrete are taken where the paved area is between 500 m² and 5000 m². If the area is over 5000 m² four series are taken. The protecting layer or the waterproofing layer shall not be perforated during drilling, samples shall only be taken from the wearing course. Holes shall be patched after sampling. Drilled samples are examined for the thickness of the mix, void content and binder content. Void content may alternatively be determined by radiometric measuring. When this is done the equipment shall be calibrated for the mix to be examined.

- Drilled samples are not taken of asphalt mastic.

The results of laboratory tests, logs stating surface area measurements and measurements of evenness, records of errors in work and reports of working shifts as well as report of the completion shall be passed on to the supervisor.

6.4.3 Concrete pavement

6.4.3.1 Quality requirements for materials

Where concrete pavement on a bridge is conjoined to the road pavement of concrete, the pavement quality requirements indicated in the road design shall be complied with. Otherwise, the requirements in this section shall be complied with.

Materials used for concrete pavement shall fulfil the requirements laid down in SYL 3. The fibres to be used shall be approved by the client.

The gravel in aggregate used for this purpose shall fulfil Class 1 in the Publication By 20, 'Classification of Concrete Aggregates' /12/ and Class 2 of pavement classification instructions in the 'Asphalt Standards' /13/.

6.4.3.2 Quality requirements for pavement

Before roughening, a concrete pavement shall meet the requirement of grade 1 for timber float finished surfaces according to the Publication By 40, 'Concrete Surfaces, Classification Directives', by the Finnish Concrete Association /11/. However, the degree of evenness and the slope shall meet the requirements shown in Section 6.4.1. The depth of the crosswise roughening shall be 2 to 3 mm.

The concrete used in pavements shall be of strength grade K50-1 and of frost resistance grade P50.

Figures 13a and 13b in Appendix 1 show two types of structure for concrete pavements.

6.4.3.3 Work

General

Work and quality plans shall be drawn up in accordance with SYL 1 for concrete paving works .

Reinforcement

The largest permitted deviation of the vertical positioning of reinforcement is ± 5 mm.

Where necessary a separate plan shall be drawn up for reinforcement work in accordance with SYL 3.

Mixing, casting and curing of concrete

A concrete works plan shall be drawn up for concrete paving works following applicable parts of SYL 3. The plan encompasses the mixing, transportation, spreading and compacting, as well as the curing and joint manufacturing.

The directions in SYL 3 for mixing, casting and concrete curing of concrete shall be followed.

Sawing shrinkage joints in concrete pavements shall be done according to the design as soon as possible, at an appropriate stage of work.

Paving joints are sealed according to Section 6.4.5, when concrete has cured and dried.

6.4.3.4 Proof of acceptability

Proof of acceptability of concrete and concrete surface is as shown in the applicable directives of SYL 3.

The evenness and slope of concrete surface are measured where necessary with the aid of a water test.

The acceptability of joint sealing compounds is proved in the manner described in Section 6.4.5.3.

6.4.4 Thin-layer pavements

6.4.4.1 Quality requirements for coatings

Thin-layer pavements shall comply with the requirements shown in Appendix 10. Thin-layer pavements shall be watertight in accordance with Section 6.2.1.

The upper surface of the pavement shall comply with the relevant requirements for evenness of asphalt concrete in Section 6.4.1.

6.4.4.2 Work

The substrate under a thin-layer pavement shall comply with the requirements for moisture and temperature in Section 6.2.3.2.

The pavement material shall be accompanied by a direction for application and product declaration in Finnish, showing the type and amounts of the constituent parts, time of mixing, plus the temperatures at the mixing stage and stage of application as well as the time of use for the mixed material.

A technical work plan shall be made for the paving work. This is sent to the supervisor for approval at least a week before work begins. Thin-layer pavements shall always be roughened with wear resistant crushed aggregate.

6.4.4.3 Proof of acceptability

The acceptability of thin-layer pavements is proved in the same way as that of liquid applied (sprayed and brushed) membrane waterproofing materials (see Section 6.2.6). However, the acceptability of polymer bitumen compounds is regarded in the same way as for mastic asphalt waterproofing compounds.

The thickness of the thin-layer pavement is measured before spreading the roughening aggregate material.

The acceptability of the evenness and slope shall be proved, if necessary with the aid of a straight edge and a water test.

6.4.5 Pavement joints

6.4.5.1 General quality requirements

Pavement joints are made with bonding primers, joint sealing compounds and joint strips which are approved for this purpose by the client. Direction for application, health and safety information and a product declaration shall be available for the compound in Finnish. The stated requirements for joint filling compounds are shown in Appendix 11.

> Approved joint sealing compounds and bonding primers for different types of pavement joint structures are listed in SILKO Directives /1/.

Materials used for joints shall make the joint watertight. The watertightness is checked by a static water test. The joint shall be able to withstand the pressure of a 300 mm column of water (= 3 kPa) for two hours without leaking off.

The joint sealing compound shall have good bond with the surface it is bonded to and it shall sustain and maintain its quality properties for long time. The joint sealing compound shall preserve its properties as a sealant at temperatures of between - 40° C and + 70° C. It shall be able to withstand de-icing salt, oil, petrol, dilute acids and alkalis as well as the effects of ozone and ultraviolet light.

> The specified quality requirements for joint sealing compounds do not apply to joint strips. The client approves each product separately.

6.4.5.2 Jointing

Jointing with joint sealing compound

The surfaces to be bonded shall be clean, dry and solid. Concrete surfaces to be jointed shall comply with the relevant moisture and temperature requirements in Section 6.2.3.2.

Gaps shall be cleaned immediately before jointing.

If a base filling or webbing is installed in the joint, the correct depth and position of this shall be checked by measuring.

The surfaces to be jointed are treated with a bonding primer approved by the client unless this is specifically forbidden.

Joint gaps are filled with a joint sealing compound within two weeks of after paving, in practice this means as soon as possible after the joint faces are dry.

Pavements are jointed according to the manufacturer's instructions. Compounds containing polymer bitumen may not be melted above the highest permitted temperatures. The temperature when working with joint sealing compounds and hardening shall be >= + 5° C. Heating shall be used where necessary.

> Detailed instructions for the stages of jointing work are provided in SILKO Directives /1/.

The upper surface of the jointing compound shall be on a level with the upper surface of the pavement, except where there are expansion joints, in this case the jointing shall be 3 to 5 mm under the top surface of the pavement.

Sealing with joint strips

Joint strips may be used for asphalt mastic and polymer bitumen asphalt mastic pavements.

The bonding surfaces of joints shall be clean, dry and firm.

To improve bonding surfaces are brushed by bonding primer before fixing of joint strips according to the manufacturer's directions.

At the installation stage the joint strip this shall be left 3 to 5 mm higher than the pavement surface at the joint to the edge beam, elsewhere it is on the surface level.

6.4.5.3 Proof of acceptability

A satisfactory standard of workmanship in jointing is demonstrated by a visual examination with the exception of the watertightness, which is verified by the water test. Where there is any justified reason to suspect the standard of the material used, this is checked in a laboratory.

Samples of the constituent ingredients of the joint sealing compound and the bonding primers shall be taken in separate containers. The amount of material shall be sufficient to produce 2 kg sample amount of a ready mix. Where required the sample is tested at a later date for the properties shown in Appendix 11.

The freshness of joint sealing compounds and bonding primers is checked with the aid of packaging information and delivery notes.

A two metre piece of joint strip and 1 litre of the bonding primer are stored for possible future examination.

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Sealing a Crack in Pavement

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3.234 Muovipohjaiset juotosmassat
Polymer-modified Grouting Mortars
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3.252 Pinnoitus- ja tiivistysaineet
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6.6 APPENDICES

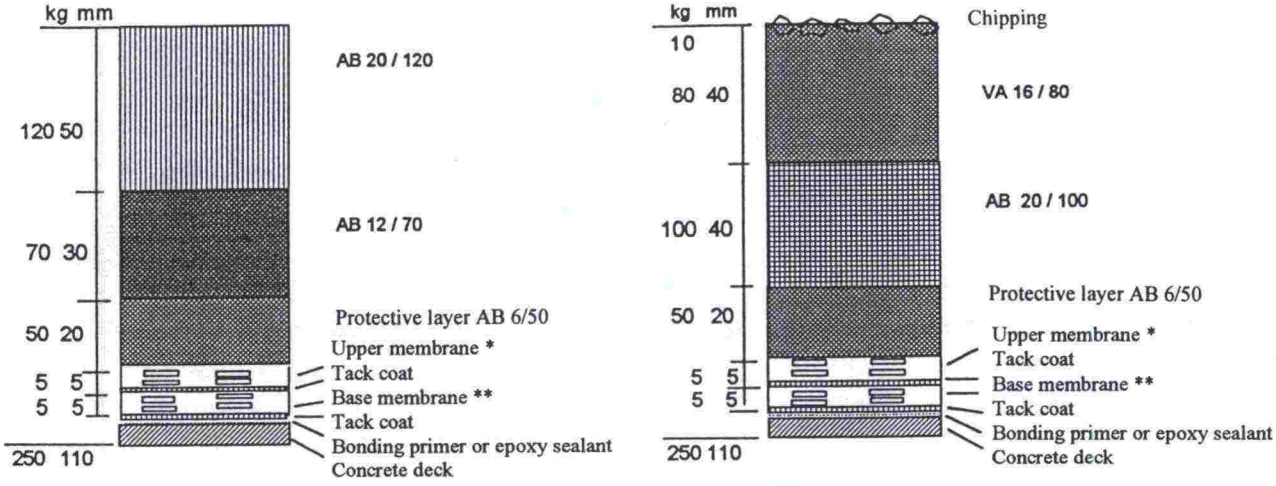
1. Bridge deck surface structures
2. Guidelines and corrective procedures for levelling substrate on bridges with concrete deck
3. Quality requirements for polymer bitumen primer KBL 20/100 and polymer bitumen KB 85 and KB 100
4. Quality requirements for tar epoxy and mastic asphalt waterproofing
5. Quality requirements for epoxy sealing compounds
6. Sheet membrane quality requirements
7. Quality requirements for sheet membrane waterproofing
8. Quality requirements for brushed and sprayed liquid applied membrane waterproofing
9. Quality requirements for polymer asphalt concrete and polymer bitumen asphalt mastic
10. Quality requirements for thin-layer pavements
11. Quality requirements for joint sealing compounds

12a Positioning of venting and drain pipes in venting membrane structures

12b Positioning of venting and drain pipes in structures with mastic asphalt waterproofing

BRIDGE SURFACE STRUCTURES

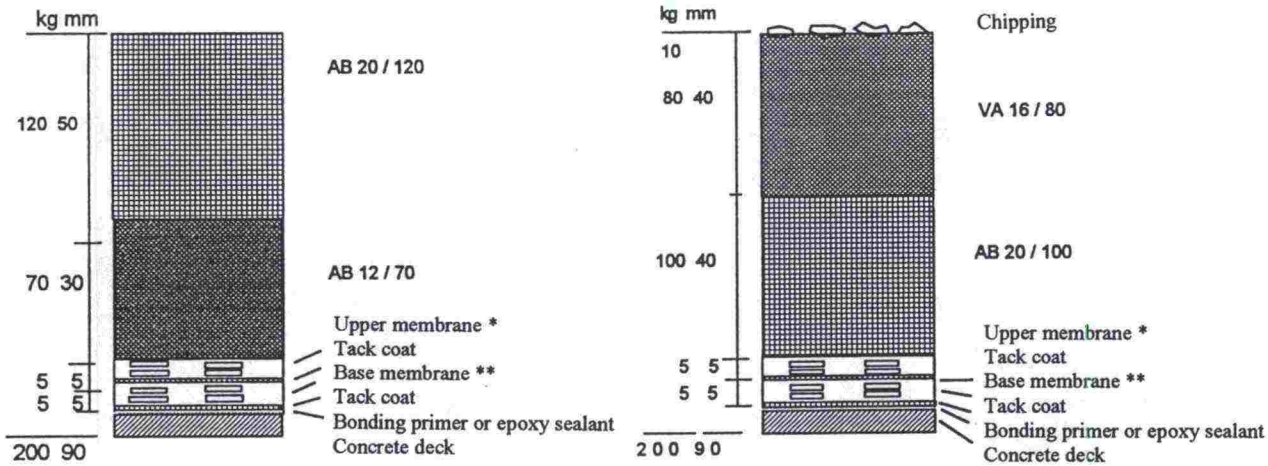
KBAB Polymer bitumen asphalt concrete
KBVA Polymer bitumen asphalt mastic
VA Asphalt mastic



1a. Asphalt concrete pavement **1b. Asphalt mastic pavement**

* or heat adhesive or self-adhesive sheet membrane
** or heat adhesive or self-adhesive sheet membrane or venting membrane (where shown in the design)

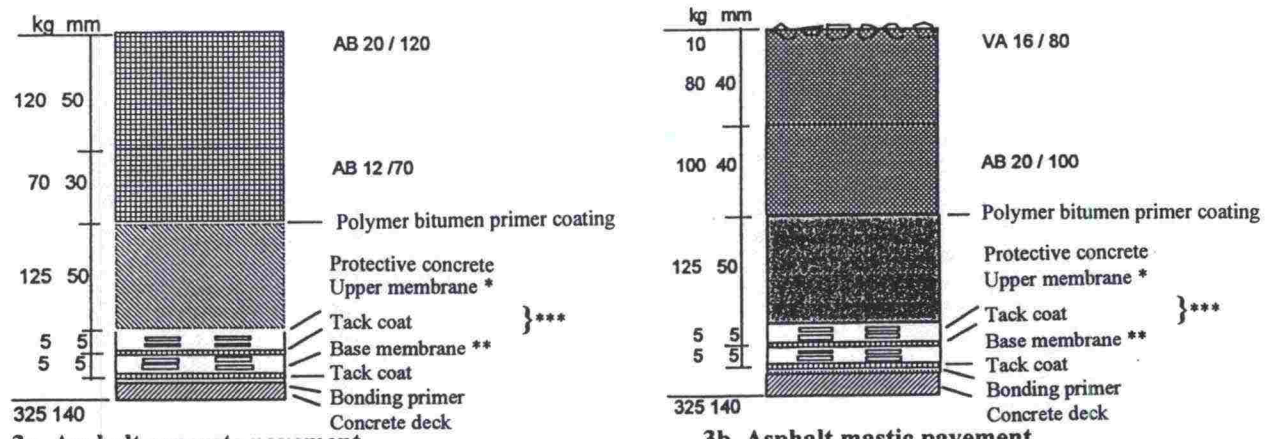
Figure 1. Roadway on a bridge with concrete deck. Surface structure with sheet membrane waterproofing



2a. Asphalt concrete pavement **2b. Asphalt mastic pavement**

* or heat adhesive or self-adhesive membrane
** or heat adhesive or self-adhesive membrane or venting membrane (where shown in the design)

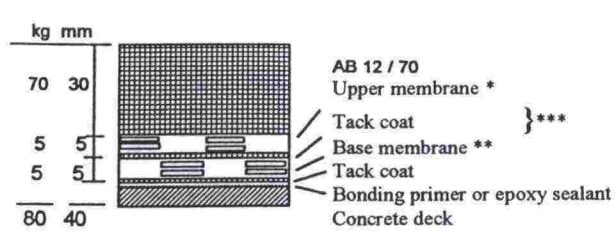
Figure 2. Roadway on a bridge with concrete deck. Surface structure with sheet membrane waterproofing



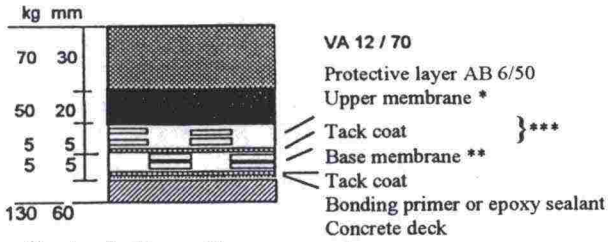
3a. Asphalt concrete pavement **3b. Asphalt mastic pavement**

* or heat adhesive or self-adhesive membrane
** or heat adhesive or self-adhesive membrane
*** or one-layer membrane waterproofing (where shown in the design)

Figure 3. Roadway on a bridge with concrete deck. Surface structure with sheet membrane waterproofing



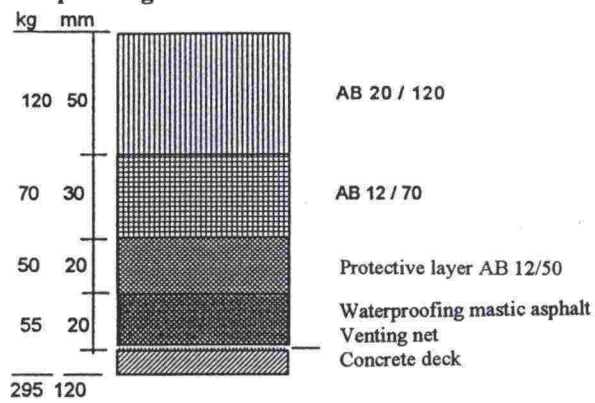
4a. Asphalt concrete pavement



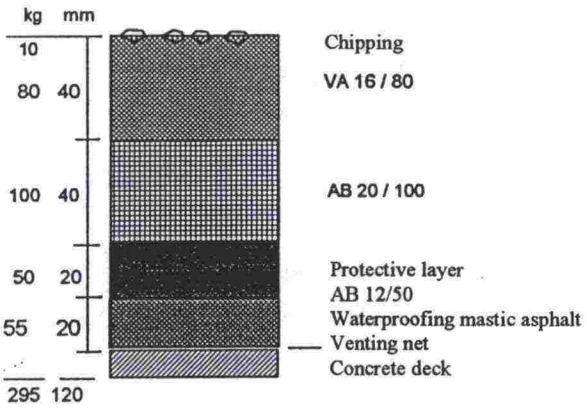
4b. Asphalt mastic pavement

* or heat adhesive or self-adhesive membrane
** or heat adhesive or self-adhesive membrane
*** or one-layer membrane waterproofing (where shown in the design)

Figure 4. Pedestrian and bicycle bridge with concrete deck. Surface structure with sheet membrane waterproofing

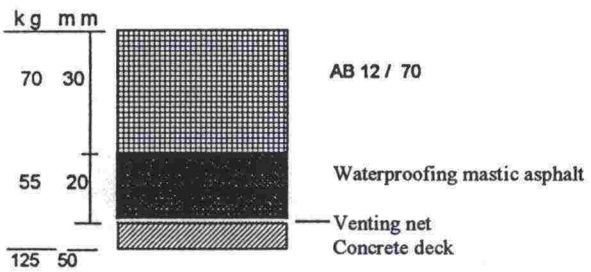


5a. Asphalt concrete pavement

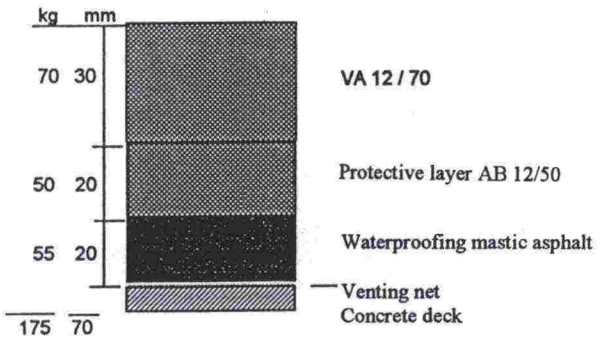


5b. Asphalt mastic pavement

Figure 5. Roadway on a bridge with concrete deck. Surface structure with mastic asphalt waterproofing

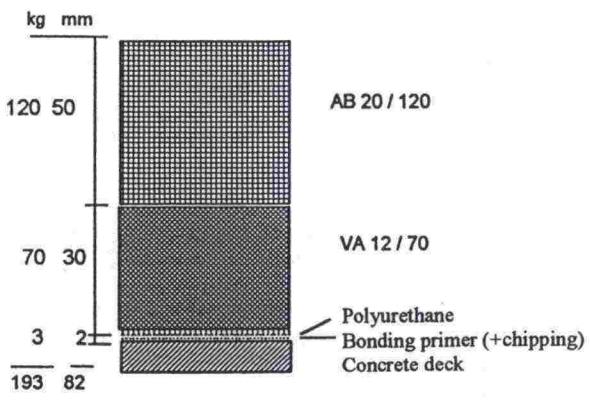


6a. Asphalt concrete pavement

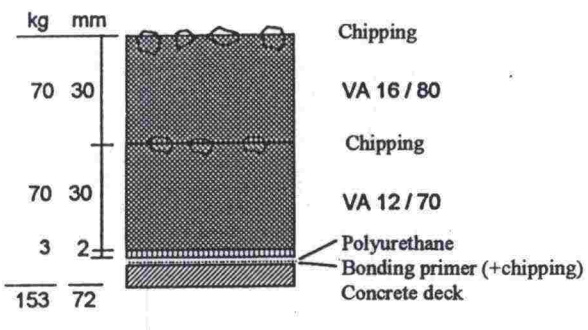


6a. Asphalt mastic pavement

Figure 6. Pedestrian and bicycle bridge with concrete deck. Surface structure with mastic asphalt waterproofing

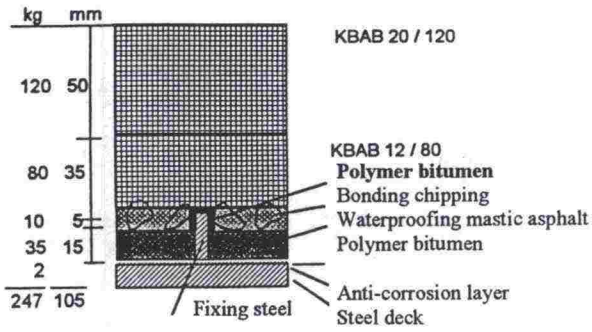


7a. Asphalt concrete pavement

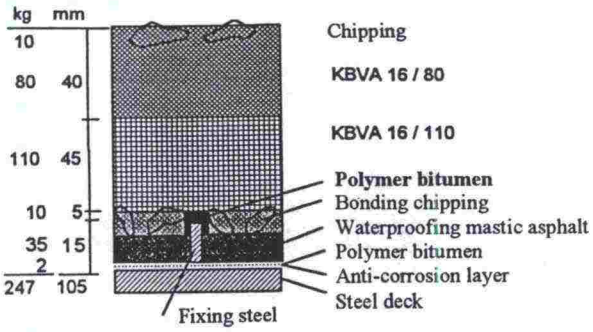


7b. Asphalt mastic pavement

Figure 7. Roadway on a bridge with concrete deck. Surface structure with polyurethane waterproofing

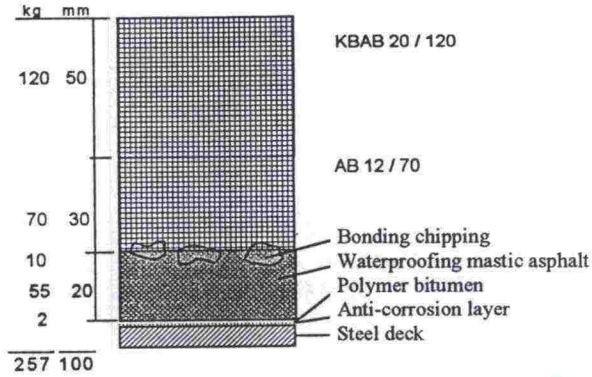


8a. Asphalt concrete pavement

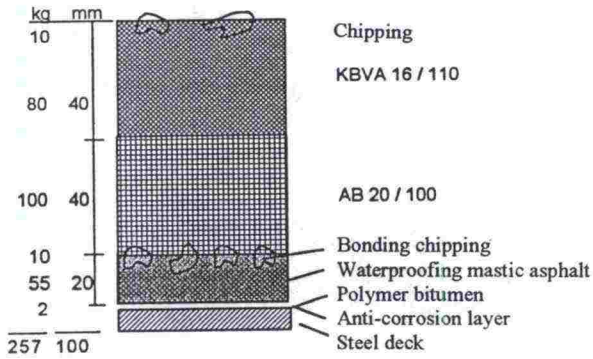


8b. Asphalt mastic pavement

Figure 8. Surface structure of a roadway on a bridge with steel deck with fixing steel components

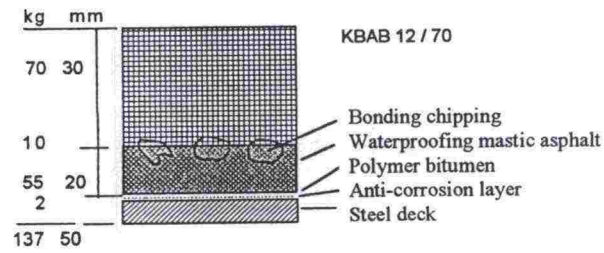


9a. Asphalt concrete pavement

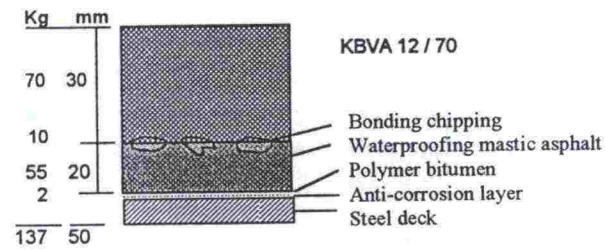


9d. Asphalt mastic pavement

Figure 9. Surface structure of a roadway on a bridge with steel deck without fixing steel components

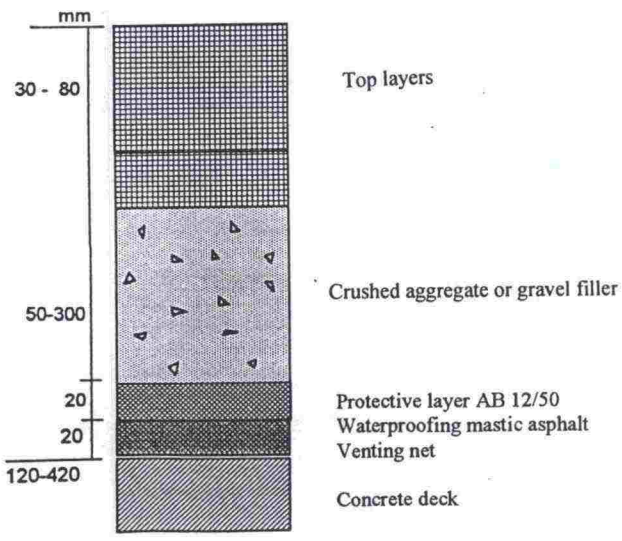


10a. Asphalt concrete pavement



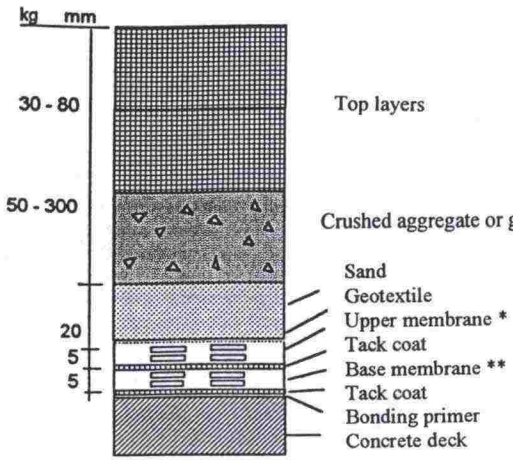
10b. Asphalt mastic pavement

Figure 10. Surface structure of a roadway on a bicycle and pedestrian bridge with steel deck without fixing steel components



Surface structures generally the same as on other sections of roadway.

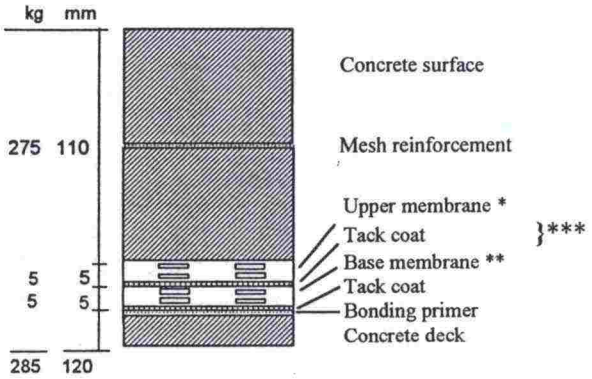
Figure 11. Surface structure of a bridge with mastic asphalt waterproofing and aggregate or gravel filling on the deck



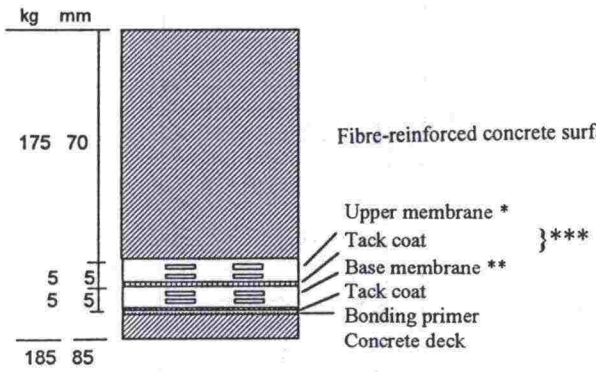
Surface structures generally the same as on other sections of roadway.

* or heat adhesive or self-adhesive membrane
** or heat adhesive or self-adhesive membrane, or ventilating membrane (where shown in the design)

Figure 12. Surface structure of a bridge with sheet membrane waterproofing and aggregate or gravel filling on the deck



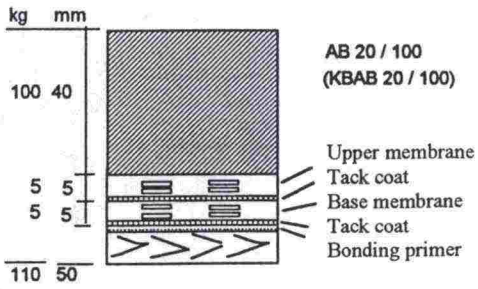
13a. Concrete pavement



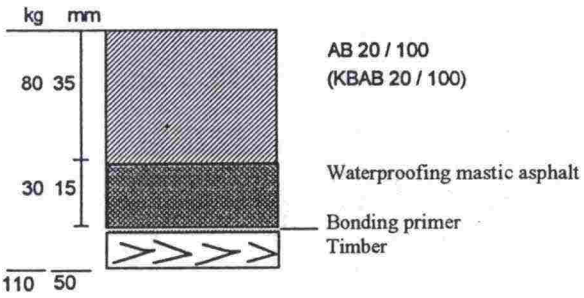
13b. Fibre-reinforced concrete pavement

* or heat adhesive or self-adhesive membrane
** or heat adhesive or self-adhesive membrane, or ventilating membrane (where shown in the design)
*** or one-layer membrane sealant (where shown in the design)

Figure 13. Surface structure of a bridge with concrete deck and sheet membrane waterproofing.



14a. Surface structure with sheet membrane waterproofing



14b. Surface structure with mastic asphalt waterproofing

Figure 14. Roadway on a bridge with a timber deck

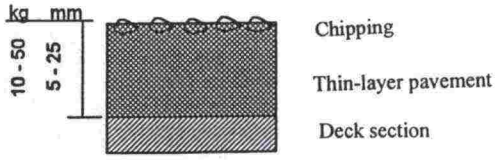
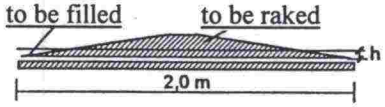


Figure 15. Thin-layer pavement on a bridge with concrete, steel or timber deck

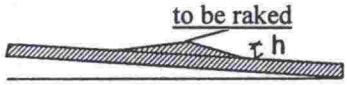
Mastic asphalt waterproofing:

1) round bossage — h ≤4 mm /2.0 m



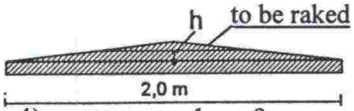
-mastic asphalt layer may remain too thin when the surface of waterproofing is raked directly

2) sharp edge bossage — h ≤3 mm



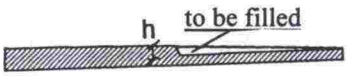
-mastic asphalt layer may fracture on top of the sharp edge (notch effect)

3) pointed change of gradient — h ≤4 mm /2.0 m



-mastic asphalt layer may remain too thin when the surface of waterproofing is raked directly

4) staggered surface — h≤ 4 mm



-mastic asphalt layer may remain too thinly spread or rupture at an elevated point

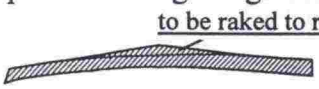
5) splashes of concrete, stones etc.
-to be raked or scraped off with a barking spud

h ≤ 3 mm

6) pot holes
-pot holes are patched so that there will be no water puddles in the surface

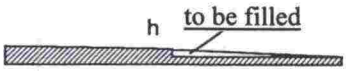
Sheet membrane waterproofing:

1) sharp edge bossage or pointed change of gradient — height of the bossage is not limited



-pointed ridge may rupture the membrane

2) staggered surface — h ≤ 4 mm



-membrane may remain loose from the substrate at side of dent
-high dent may rupture the membrane

3) splashes of concrete, stones etc.
-to be raked or scraped away with a barking spud — h ≤ 2 mm

-the membrane may get ruptured

4) pot holes
-pot holes shall always be patched so that there will be no water puddles in the surface

Polyurethane waterproofing:

As for mastic asphalt waterproofing in 2, 4 and 5 above.

Table 1. Quality requirements for polymer bitumen primer KBL 20/100

Property		Unit	Requirement	Procedure
Viscosity	min-max	mm²/s	12…25	PANK 1103
Rotavapor distilling [1]				
Residue of distillation	min	% by volume	20	-
Properties of the residue of distillation				
Softening point				
Ring and ball	min	°C	70	PANK 1112
Solubility in toluene	min	% by weight	97	PANK 1104
Return 0°C	min	%	50	PANK 1502
Flash point				
ABEL-PENSKY	min	°C	21	PANK 1105
Drying time	max	h	3	PANK nnnn
Class of inflammable fluids	min		II	-

[1] Separation of polymer bitumen as unbroken chains of polymer, temperature not exceeding 220°C

Table 2. Quality requirements of polymer bitumen KB 85 and KB 100.

Property		Unit	Requirement		Procedure
			KB 85	KB 100	
Penetration, 25°C		0.1mm	50…120	30…70	PANK 1101
Softening point	min	°C	77	94	PANK 1112
Viscosity, 180°C	max	mm²/s	1500	20000	PANK 1103
Return +5°C					
-streched-out 100%	min	%	50	60	PANK 1502
Stability					
-change of softening point					
upper-lower	max	°C	25	15	PANK 1501
Flash point	min	°C	210	210	PANK 1105

Table 1. Quality requirements for tar epoxy

Property	Unit	Requirement	Procedure
Bonding, 23°C			
-to the concrete	N/mm²	1,5	VTT 2633-1992
-to the polymer bitumen	N/mm²	0,4	VTT 2633-1992
-to the asphalt concrete	N/mm²	0,4	VTT 2633-1992
Fluidness	mm	≤ 1,5	VTT 2635-1992
Time to apply			
- 25 °C	min	80 - 120	DIN 16945
- 5 °C	min	20 - 40	DIN 16945
Hardening			
- + 23 °C, 1 day	%	≥ 75	ASTM D 2240
- + 5 °C, 2 days	%	≥ 50	
Heat endurance			
- + 240 °C, 3 min	mm	≤ 1,5	VTT 2636-1992
Cold brittleness	mm	h = 60 mm/-20 °C	VTT 2631-1992
Compatibility with polymer bitumen	-	Compatible	VTT 2633-1992
Resistance against alkali	-	No damage	Water 28 days
Consistency			
-epoxy	% by weight	Same as in the	Approval test
-tar	% by weight	approval test of Finnra	
Loss in weight 105 °C/3h	% by weight	< 2	SFS 3638

Table 2. Quality requirements for waterproofing mastic asphalt

Property	Unit	Requirement	Procedure
Binder content	% by weight	≥ 15	PANK 4102
Grade curve			
- 0,074 mm	% of passed	25…40	
- 2 mm	-"-	≥ 90	
Sag, +20°C	mm	4…12	PANK 4401
Return, +5°C	%	≥ 50	PANK 1502

Quality requirements for sealing epoxy

Property	Unit	Requirement	State	Procedure
Viscosity, max -mixed	mm^2/s	500		DIN 53214 or equivalent
Loss in weight	% by weight	≤ 2	24 h, +23 °C 3 h, 100 °C	DIN 53216/ SFS 3638
Heat endurance		No changes in appearance (blisters, cracks etc.)	+250°C/60min	ZTV-PT-BEL-EP
	N/mm^2	No severe damage Bonding $\geq 1,5$	+420°C/1 min	
Final strength	MPa	≥ 60	+23 °C, 7 days	DIN 53153 or equivalent
Hardening	% of the final strength	≥ 50	18 h, +23°C, RH 50%	DIN 53153 or equivalent
	% of the final strength	≥ 50	2 h, +40°C, RH 50%	
	% of the final strength	≥ 50	40 h, +12°C, RH 75%	
Moisture penetration during hardening		No change in colour due to moisture	+12°C, RH 75%	ZTV-TP-BEL-EP
Absorbancy of water	% by weight	$\leq 2,5$		DIN 53495
Watertightness	MΩ	≥ 500		VTT 2654
Bonding to concrete	N/mm^2	Average $\geq 1,5$ N/mm^2 Min $\geq 1,0$ N/mm^2	+ 23 °C	VTT 2633
Compatibility with polymer bitumen		Compatible		VTT 2653

QUALITY REQUIREMENTS FOR SHEET MEMBRANES

Table 1. Quality requirements for sheet membranes bonded by gluing or self-adhesive sheet membranes

Property	Unit	K-PS 170/4000	K-MS 170/3000	K-PS 220/4000	K-TMS 170/3000	One-layer membrane
Consistency	g/m²					
-weight of the fabric		170	170	220	170	220
-amount of polymer		1500	1500	1500	1500	2300
bitumen		4000	3000	4000	3000	4500
-weight of the product						
Tensile strength +23°C	kN/m					
-longitudinal (min.)		10	10	10	10	15
-transversal (min.)		8	8	8	8	10
Elongation +23°C and -20°C (min.)	%	30	30	30	30	15
Endurance against hydraulic pressure	kPa	300	300	300	300	500
Resistance to tearing (min.)	N	40	40	40	40	80
Heat endurance (min.)	°C	+80	+80	+80	+80	+80
Creasability, °C/mm	°C/dia.	-25/30	-25/30	-25/30	-25/30	-20/30
Effect of heat to linear measures	%	± 0,6	± 0,6	± 0,6	± 0,6	± 0,3
Temporary heat endurance (VTT-2637)	°C	+ 200		+ 200		
Tensile strength of joints	kN/m					10

Table 2. Quality requirements for sheet membranes bonded by heating (torching)

Property	Unit	K-PS 170/4000 torched	K-MS 170/3000 torched	K-PS 220/4000 torched	K-TMS 170/3000 torched	One-layer membrane
Consistency	g/m²					
-weight of the fabric		170	170	220	170	220
-amount of polymer		2650	2650	2650	2650	3450
bitumen		5150	4150	5150	4150	5500
-weight of the product						
Tensile strength +23°C	kN/m					
-longitudinal (min.)		10	10	10	10	15
-transversal (min.)		8	8	8	8	10
Elongation +23°C and -20°C (min.)	%	30	30	30	30	15
Endurance against hydraulic pressure	kPa	300	300	300	300	500
Resistance to tearing (min.)	N	40	40	40	40	80
Heat endurance (min.)	°C	+80	+80	+80	+80	+80
Creasability, °C/mm	°C/dia.	-20/30	-20/30	-20/30	-20/30	-20/30
Effect of heat to linear measures	%	± 0,6	± 0,6	± 0,6	± 0,6	± 0,3
Temporary heat endurance (VTT-2637)0	°C	+ 200		+ 200		
Tensile strength of joints	kN/m					10

Classification of sheet membranes according to the class of service conditions:

Designs shall show:

- class of service conditions (1, 2 or 3)
- substrate cleaning (shot or sand blasting)
- polymer bitumen primer coating or epoxy sealant, where applicable (depth of the deck > 400 mm)
- venting membrane structure, if any (depth of the deck > 400 mm), not however used as a one-layer membrane structure (class of use 3)
- material used to protect the sheet membrane layers, if any

CLASS 1: (complying with quality requirements for class 1 sheet membrane waterproofing structures)

Bridges having the amount of traffic (KVL) is > 6000 vehicles/day:
Two-layer sheet membrane waterproofing with protective layer. Protective layer is of asphalt concrete AC 6/50.
Bridges having the amount of traffic (KVL) is between 3000 and 6000 vehicles/day:
Two-layer sheet membrane waterproofing without protective layer or with protective layer of asphalt concrete AC 6/50.

CLASS 2: (complying with the quality requirements for Class 2, sheet membrane waterproofing structures)

Bridges having the amount of traffic (KVL) is < 3000 vehicles/day:
Two-layer sheet membrane waterproofing with protective layer of asphalt concrete ac 6/50 or the protective concrete.
Pedestrian and bicycle bridges:
Two-layer sheet membrane waterproofing without protective layer

CLASS 3: (complying with the requirements for Class 3 of sheet membrane waterproofing construction)

Bridges having the amount of traffic (KVL) is < 500 vehicles/day:
One-layer sheet membrane waterproofing layer with protective layer. Protective layer is the protective concrete.
Pedestrian and bicycle bridges:
One-layer sheet membrane waterproofing without protective layer.

Quality requirements for sheet membrane waterproofing structures in approval tests:

Criteria	Requirement			Procedure
	Class 1	Class 2	Class 3	
Weight of the fabric of the upper membrane *) [g/m²]	≥ 220	≥ 170	≥ 220	SFS-5010
Temporary heat endurance of the upper membrane	200	200	200	VTT-2637
Thickness of the waterproofing structure [mm]	≥ 7	≥ 6	≥ 5	
Durability against cracking in -20°C	No damage	The base membrane is not cracked down to the fabric	No damage	VTT-2645
Bursting strength [N] (upper membrane)	≥ 220	≥ 150	≥ 220	VTT-2646
Shear strength **) [N/mm²]	≥ 0,15	≥ 0,10	≥ 0,10	VTT-2647
Bonding to concrete and epoxy [N/mm²] +23°C + 8°C	≥ 0,50 ≥ 1,00	≥ 0,40 ≥ 0,90	≥ 0,40 ≥ 0,90	VTT-2633
Water absorbing capacity [%]	≤ 0,5	≤ 0,5	≤ 0,5	VTT-2648

*) The weight of the fabric is used as a test to identify the membrane.
**) Shear resistance is not measured for structures with venting membranes.

Quality requirements for liquid applied (sprayed and brushed) membrane waterproofing.

Properties	Unit	Requirement	State	Procedure
Thickness	mm	min. ≥1,5 Average ≥2,5		Section. 6.2.6.4
Deviation of the density from standard value	%	≤-3	+20°C	Section 6.2.3.5
Hydraulic pressure	kPa	≥ 300		SFS-5011
Bonding to the substrate and to the pavement	N/mm²	average ≥1,2 min. ≥ 1,0	+23°C	VTT-2633
Durability against cracking	mm	≥1,2	5 min -30°C	VTT-2632
Creasability			r=10mm	VTT-2634
- not aged	°C	≤ -40		
- aged with UV (if the waterproofing will be exposed to sunlight during it's service life and will not be protected e.g. with paint)	°C	≤ -40 No significant change in colour		
Fluidness	mm	≤ 1,5 24 h	+70°C	VTT-2635
Heat endurance	mm	≤ 1,5	+240°C 3 min	VTT-2636
Compatibility with bitumen and polymer bitumen		Compatible		VTT-2653

Quality requirements of binders in polymer asphalt concrete and polymer bitumen asphalt mastic

Property	Unit	Requirement		Procedure
		KB 85	KB 100	
Penetration, 25°C	0,1 mm	70-150	50-120	PANK 1101
Softening point, min.	°C	≥ 70	≥ 77	PANK 1112
Kinematic viscosity 180°C, max.	mm^2/s	≤ 800	≤ 1500	PANK 1103
Return +5°C, min.	%	≥ 35	≥ 50	PANK 1502
Stability - change of softening point upper-lower max.	°C	≤ 25	≤ 25	PANK 1501
Flash point, min.	°C	≥ 210	≥ 210	PANK 1105

Quality requirements for thin-layer pavements

Property	Unit	Requirement	State	Procedure
ALL BRIDGES				
Thickness	mm	≥ 5		Section 6.2.6.4
Deviation of the density from the standard value	%	≤ -3	+20°C	Section 6.2.3.5
Watertightness / hydraulic pressure	kPa	≥ 300		SFS 5011
Bonding to the substrate	N/mm²	average ≥ 1,5 min. ≥ 1,0		VTT-2633
Wearing durability	cm³	≤ 6 for carriageways ≤16 for pedestrian and bicycle ways		PANK 4209
BRIDGES WITH CONCRETE DECK, SUPPLEMENTARY REQUIREMENTS				
Durability against cracking	mm	≥ =,4	-30°C	VTT-2632
Static bending (only composite girder bridges) -not aged -aged	°C	 no cracking no change in colour	-20°C radius h=10 mm	VTT-2631
BRIDGES WITH STEEL AND TIMBER DECK, SUPPLEMENTARY REQUIREMENTS				
Dynamic bending*)	cycle	> $2x10^5$ no cracking	-20°C	VTT
Static bending -not aged -aged	°C	 no cracking no change in colour	-20°C radius h=10 mm	VTT-2631

* also suspension bridges

Quality requirements for joint sealing compounds

Property	Unit	Type of joint** 1	2	3-4	5	Temperature	Procedure
		Requirement				°C	
Elasticity	%	160	160	-	160	+23	VTT-2639
(min.)	%	160	125	-	125	-20	(ISO 8340)
Elongation at bond	%	200	100	15	100	+23	VTT-2638
test* (min.)	%	150	60	15	60	-25	(ISO 8339)
Shrinkage (max.)	%	10	-	10	10		VTT-2640 (NT BUILD 015)
Creasability (min.)	°C	-40	-30	-	-30		VTT-2641 (ASTM D 1737-79)
Softening point (min.) (polymer bitumen)	°C	-	-	≥70	≥70		VTT-2644 TIE 104
Fluidness (max.)	mm	1,5	-	-	-	+50	VTT-2643 (ISO 7390)

*The largest permitted variation in the bond test and tensile test is 50% separation
**Joint types are shown in Figure 1.

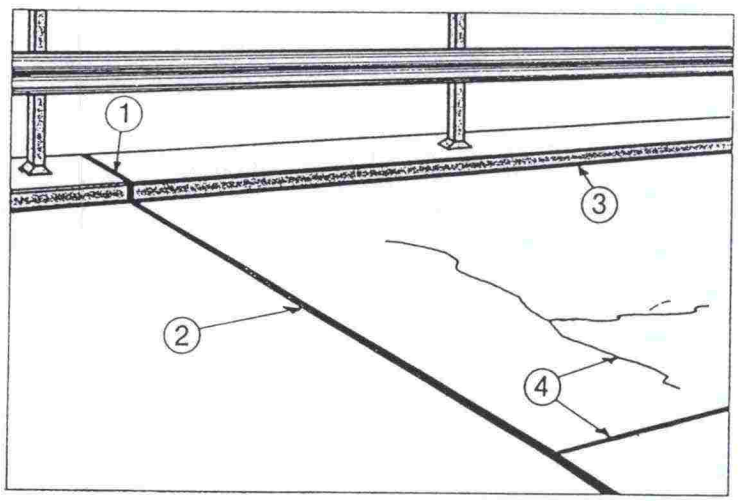


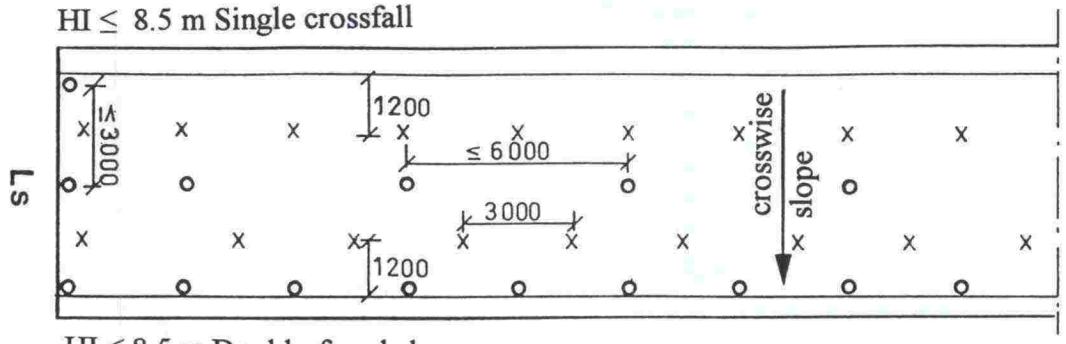
Figure 1, Joint types on bridge deck

1 Joints on edge beam (play ≤ ± 20% of the width of the joint)
2 Pavement expansion joints with limited play (play ≤ ± 10% of the width of the joint)
3 Joints between the edge beam, the nosing (asphalt mastic or concrete pavement in the
4 Contraction joints and when closing the cracks in the pavement
5 Joints between prefabricated reinforced concrete deck units

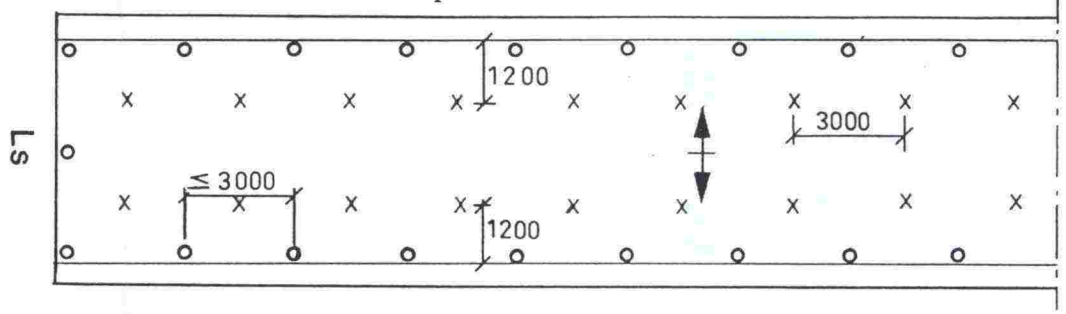
Positioning of venting and drain pipes

Waterproofing with venting membranes

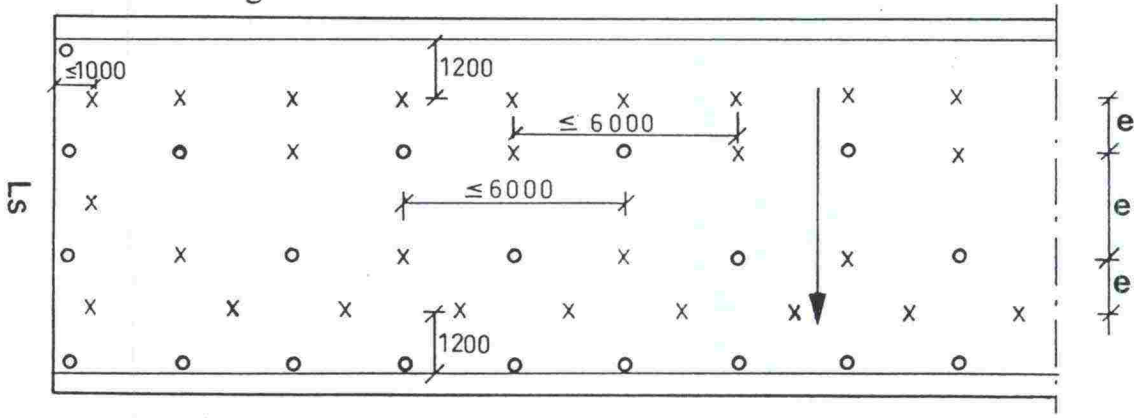
HI ≤ 8.5 m Single crossfall



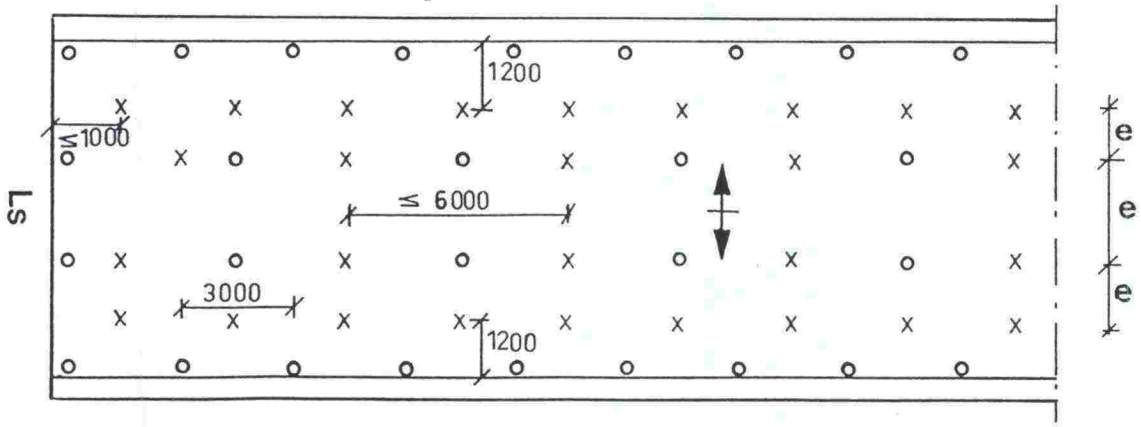
HI ≤ 8.5 m Double-faced slope



HI > 8.5 m Single crossfall



HI > 8.5 m Double-faced slope

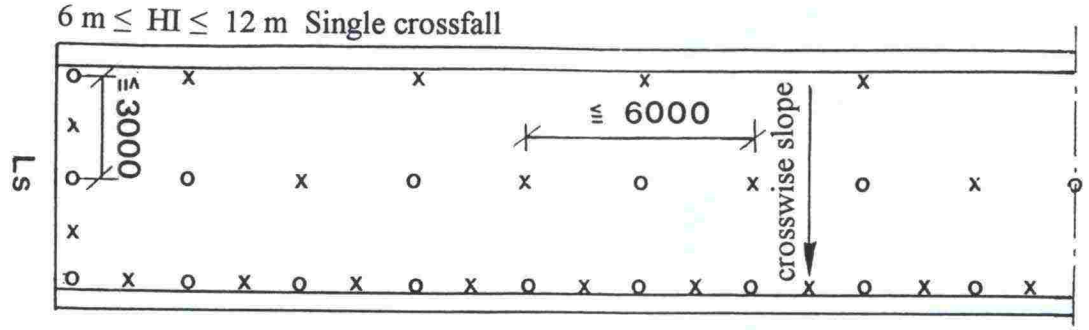


x= venting pipe
o= drain pipe
Ls= expansion joint
e= distance e.g.3000-6000 mm

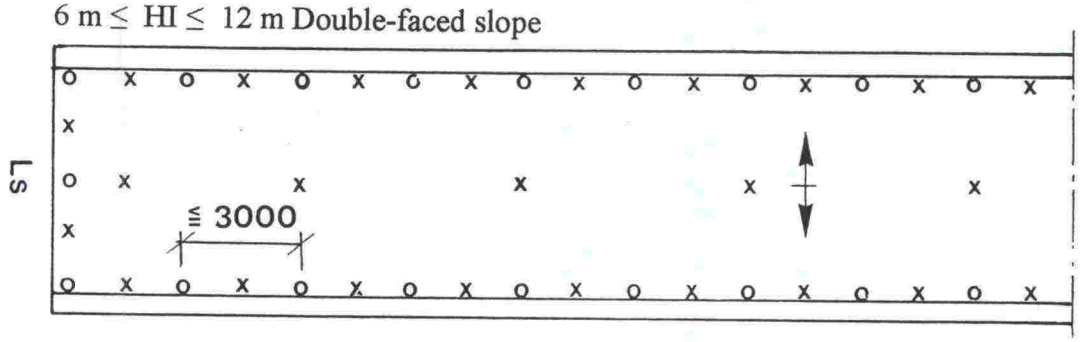
Positioning of venting and drain pipes

Mastic asphalt waterproofing structures

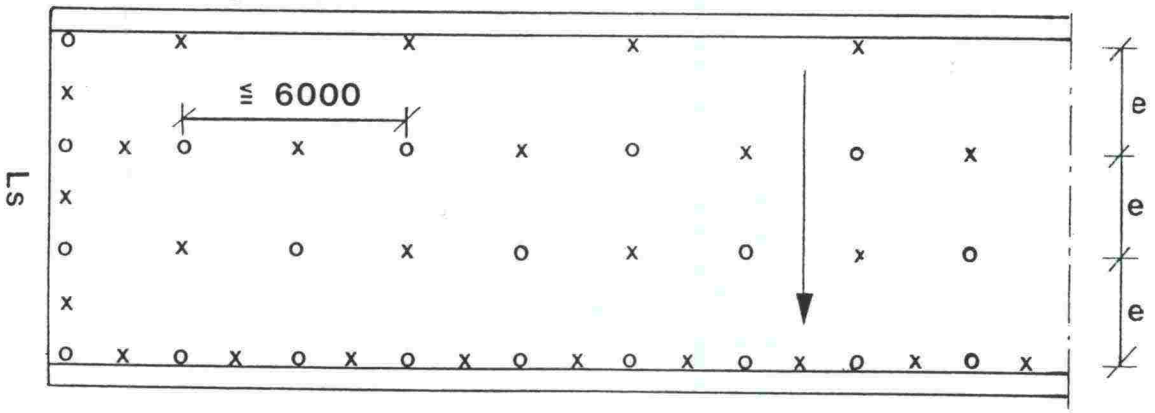
6 m ≤ HI ≤ 12 m Single crossfall



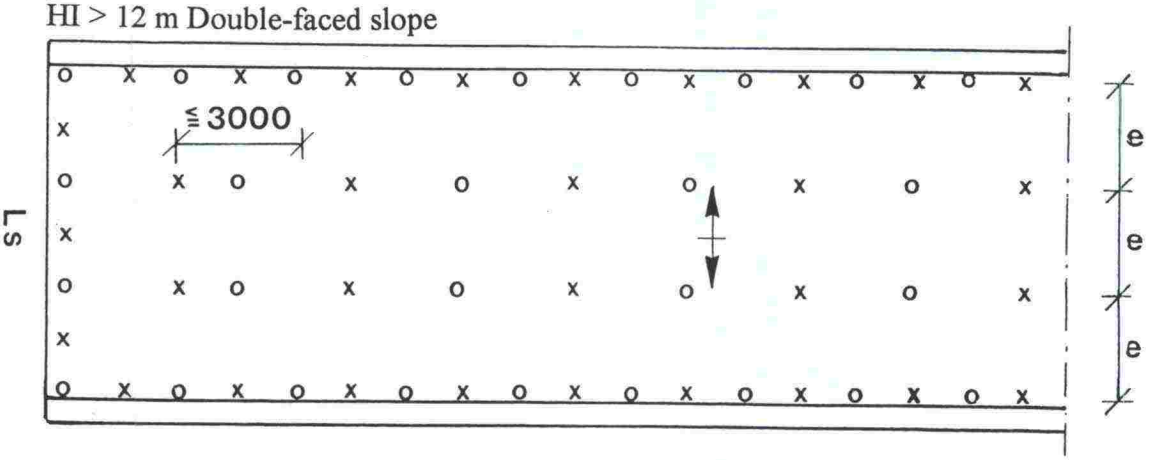
6 m ≤ HI ≤ 12 m Double-faced slope



HI > 12 m Single crossfall



HI > 12 m Double-faced slope



x = venting pipe
0 = drain pipe
Ls= expansion joint
e max. = 6 m