REPUBLIC OF SLOVENIA

MINISTRY OF INFRASTRUCTURE

TECHNICAL SPECIFICATION TSG-211-XXX: 2025

TSG-211-XXX: 2025

Pursuant to Article 13 of the Roads Act (Official Gazette of the Republic of Slovenia, Nos 132/2022, 140/22 – ZSDH-1A, 29/23, and 78/23 – ZUNPEOVE) and Article 50(6) of the Railway Safety Act (Official Gazette of the Republic of Slovenia, Nos 30/18 and 54/21), the Minister of Infrastructure issues the following technical specification:

BRIDGE STRUCTURES

EXECUTION OF WATERPROOFING ON CONCRETE BRIDGE STRUCTURES

(Evidence for waterproofing systems and for individual components)

TSPI - PG.07.451: 2025

Minister of Infrastructure

M.Sc. Alenka Bratušek

Number:

Ljubljana,

This Technical Specification PG.07.451 and PG.07.452: 2025 is issued having regard to the information procedure in accordance with Directive (EU) 2015/1535 of the European Parliament and of the Council of 9 September 2015 laying down a procedure for the provision of information in the field of technical regulations and of rules on Information Society services (OJ L 241, 17. 9. 2015, p. 1).

Table of contents

1 Subject of the technical specification

Technical guidelines TSPI PG.07.451 and PG.07.452 specify the technical conditions for construction products and the installation of horizontal sealing layers on concrete bridge structures and other concrete traffic surfaces on public roads and railways in the Republic of Slovenia. The Guidelines do not apply to white box systems and to road and railway tunnels.

The quality requirements set out in this technical specification represent the minimum values that must be met for individual groups and classes of traffic loads, in accordance with the requirements of other applicable technical specifications for roads and traffic areas.

The content of this TSPI cannot be interpreted and implemented in such a way as to prevent or condition the proper use of construction products placed on the market in accordance with the requirements of the Construction Products Act.

The TSPI for the execution of waterproofing on bridge structures is divided into two volumes:

PG.07.451 Evidence for waterproofing systems and individual components (chapters 1 to 5) (hereinafter also referred to as Volume 1)

PG.07.452 Execution of waterproofing systems (chapters 6 to 15)

(hereinafter also referred to as Volume 2)

The first volume is intended for the manufacturers and users of the waterproofing systems and contains the requirements for placing the waterproofing system on the market in the Republic of Slovenia.

The second volume is intended for operators of waterproofing systems and contains requirements for the execution of waterproofing layers and their protective layers.

The following abbreviations are used in this TSPI:

AC	motorway
BHT	bitumen waterproofing sheet
FPC	factory production control
HC	expressway
HI	waterproofing
HTN	waterproofing with liquid application
DOP	Declaration of Performance
IQC	Internal quality control
PMMA	polymethyl methacrylate
RS	THE REPUBLIC OF SLOVENIA
TEDR	Technological Expert's Detailed Report
ZHI	protective layer of waterproofing (asphalt, concrete)
EQC	External quality control
ZTP	initial type test

2 Definition of terms

Slovenian	Description	English	German
Asphalt leveling course	The asphalt layer of the road surface, which is intended to achieve the required level indicator before the wearing course is laid (in this TSPI, it refers to bridges).	Asphalt leveling course	Asphalt Ausgleichsschicht
Asphalt wearing course	The asphalt layer of the carriageway on which traffic travels.	Asphalt wearing course	Asphaltdeckschicht
Asphalt binder layer	An asphalt layer that is installed between the base course and the wearing course. In TSPI, it refers to the layer that is installed between the protective layer (ZHI) and below the wearing course in a three-layer road structure.	Asphalt binder layer	Asphaltzwischenschicht (Binderschicht)
Asphalt or concrete protective layer of waterproofing	see Protective layer of waterproofing		
Concrete substrate	Clean, roughened and level concrete surface ready for the application of a waterproofing system (renovation work may already have been carried out on it).	Concrete substrate	Betonuntergrund, Untergrund für die Abdichtung
Bituminious covering material	Bitumen containing mineral fillers, which is applied to the upper and lower sides of the bitumen sheet carrier.	Bituminious covering material	Bithuminus Deckmasse
Bitumen solution	Bitumen solution based on petroleum, intended to reduce viscosity (used for pre-coating)	Bitumen solution	Bitumenlösung
Bitumen joint tape	Bitumen sheet for sealing vertical joints	Bitumen joint tape	Bitumenfugenband
Test piece	Part of the sample from which the test specimen was prepared	Test piece	Teststück
Day joint	Contact between two layers of waterproofing carried out in a short period of time (up to a maximum of one week)	Day joint	Tagesgelenk
Elastomeric bitumen	Bitumen obtained from crude oil and/or oxidised bitumen modified with the addition of a thermoplastic elastomer (Styrene Butadiene Styrene)	Elastomeric bitumen	Elastomeres Bitumen
Epoxy mortar	A liquid-tight mixture of reaction resins with flame-dried quartz sand to compensate for individual	Epoxy mortar	Reaktionsharzmörtel

Slovenian	Description	English	German
	local reinforcements.		
Epoxy resin, Epoxy	A mixture of resin and hardener raw materials. The term reaction resin is also used.	Epoxy resin, Epoxy	Reaktionsharz
Epoxy impregnation coating	Epoxy material that is applied directly to the prepared concrete surface to saturate the fresh concrete.	Epoxy impregnation coating	Epoxid-Imprägnierbeschichtung
Epoxy primer	An epoxy material that is applied directly to the prepared concrete surface to ensure good adhesion between the concrete surface and the waterproofing layer, as well as to bind dust and close pores in the concrete. It is usually the first layer of epoxy coating. The term “primer” is also used.	Primer	Grundierungsharz
Epoxy sealing coating	Epoxy coating for sealing (last epoxy coating before laying bitumen sheets)	Epoksy seal coat (Sealing coating?)	Versiegelungsharz Schicht
Waterproofing	A measure that prevents water from passing between or through different layers to the surface to be protected. The composition of individual layers is specified, which as a whole ensure sealing. It includes all kinds of sealing (bitumen waterproofing, waterproofing with liquid application...).	Waterproofing	Abdichtung
Bitumen Waterproofing course	Bitumen sheets with a sealing layer from bitumen or bituminous mixture, having a function of preventing the passage of water or water vapour to the surface to be protected. Bitumen is a sealing component in sheets.	Bitumen Waterproofing course	Abdichtungsschicht aus Bitumen
Waterproofing sheet	Factory-made flexible sheet made of a carrier and a sealing layer. The sealing layer may be surface-treated and may also have a surface course protection. The holders are made of various materials (glass voiles, polyester fabric, glass fabric, etc.).	Waterproofing sheet	Abdichtungsbahn
Liquid applied waterproofing system	Sealing systems in which the sealing layer consists of one or more layers of liquid components that must be applied one after the other by	Liquid applied Waterproofing System	Flüssig aufzubringenden Abdichtungssysteme

Slovenian	Description	English	German
	spraying or pouring and spreading.		
Seal coat	A liquid-tight layer made of a levelling compound consisting of epoxy resin and flame-dried quartz sand.	Seal coat	Kratzspachtelung
Component	One of the materials that make up the “system components”.	Component	Komponente
Liquid applied waterproofing kit	Components of a waterproofing system with liquid coating.	Liquid applied waterproofing kit	flüssig afzubringende Abdichtunssysteme
Components of a waterproofing system	For liquid waterproofing, this means a specific form of the product consisting of at least two components which are combined into the entire system on a site during the implementation of the system. The product components react with each other to form an “assembled waterproofing system” when installed.	Kit	Komponenten der Abdichtungssystem
Adhesive	In this TSPI, it refers to a polymer-modified bituminous mixture for hot bonding of bituminous hydro insulation strips.	Adhesive	Klebemasse
Wet sandblasting	Surface treatment by wet sandblasting.	Wett sandblasting	Nass- oder Feuchtstrahlen
Supervision of waterproofing works	Assessment of conformity by observation and judgement, accompanied by measurements or tests where appropriate (in this TSPI, this refers to waterproofing works).	Supervision of waterproofing works	Überwachung of Abdichtungsystemen
Internal Layer (of liquid applied waterproofing kit)	A layer of non-woven geosynthetic material, glass mesh, etc., which is installed on site to reinforce the liquid applied waterproofing.	Internal Layer	Einlagen
Carrier (in bituminous waterproofing sheet)	The material is embedded in a factory-made bitumen waterproofing sheet which ensures its dimensional stability and resistance to mechanical influences.	Carrier	Träger
Support	Supporting base. In this TSPI, it refers exclusively to concrete substrates.	Support	Rohtragwerk
Reinforced bitumen sheet	Factory-made flexible bitumen sheet with at least one reinforcement support.	Reinforced bitumen sheet	Bitumenbahn mit Trägereinlage
Oxidised bitumen	Vacuum or fluxed bitumen obtained from crude oil, which	Oxidied bitumen	oxidiertes Bitumen

Slovenian	Description	English	German
	has been subjected to hardening by a process of oxidation with hot air at high temperature, with or without the use of a catalyst.		
Sandblasting under pressure	Sandblasting under pressure.	Sandblasting under pressure	Druckluftstrahlen
Plastomeric bitumen	Bitumen obtained from crude oil and/or oxidised bitumen modified with the addition of polyolefins or polyolefin copolymers (APP).	Plastomeric bitumen	Plastomeres bitumen
Asphalt strenghtening ribs	Asphalt strenghtening ribs (at expansion joints)	Asphalt strenghtening ribs	Asphalt Stützrippen
Finish Layer	Only for exposed systems of liquid applied waterproofing (no protection). Coating for protection against UV rays and/or coating for aesthetic purposes. The coating is applied to the entire waterproofing system.	Finish Layer	Schutzlage
Polymethyl methacrylate (PMMA)	PMMA-based reactive resin - a polymer of methylmethacrylate units	Polymethyl methacrylate	Polymethylmethacrylat
Test report	A report on the determined test results (in the case of the HI system, it refers to the initial type test and evaluation issued by an accredited testing body in accordance with the SIST EN ISO 17025 standard).	Report	Prüfbericht
Broadcasting	Flame-dried quartz sand of a specific grain size, which is spread onto a fresh layer of reaction resin.	Broadcasting	Abstreung
Bonding coat	Coating to improve adhesion between two layers.	Bonding coat	Haftvermittler
Connection layer	A course to improve adhesion applied to the top layer of a waterproofing system to improve contact between the waterproofing system and the superstructure (e.g. asphalt).	Connection layer	Verbindungschicht
Surface treatment	In this TSPI, it refers to the application of a coating that is applied to the top layer of waterproofing to improve the contact between the sealing system and the protective layers (e.g. asphalt) or to increase sliding friction or as protection against	Surface treatment	Oberflächen-behandlung

Slovenian	Description	English	German
	deterioration (UV rays).		
Surface protection	Material applied to the surface to protect the waterproofing sheet and prevent it from sticking to one or both surfaces of the sealing layer.	Surface protection	Oberflächen-schutzschicht
Tack coat	Adhesion improving coating applied to the substrate or to the top layer of a waterproofing system to improve contact with the waterproofing system.	Tack coat	Haftvermittler (Haftschicht)
Test specimen	A section of sheet extracted from the test section, which must be of precisely specified dimensions.	Test specimen	Probe, Probestück (Prüfstück?)
Surface preparation	Procedure for preparing the supporting concrete surface for the application of sealant (after the concrete surface has already been repaired – e.g. reinforcement protection).	Surface preparation	Oberflächenvorbereitung, Untergrundvorbereitung für die Abdichtung
Manufacturer's declared value (MDV)	The value stated by the manufacturer on the Declaration of Performance in accordance with the product standard.	manufacturer's declared value (MDV)	vom Hersteller angegebener Wert
Free film	A layer (in this case, waterproofing) that is not bonded to the substrate (a test specimen is prepared from a free film).	Free film	freier Film
Section joint	Contact of two layers of waterproofing performed within a time period of one week to 6 months	Section joint	Abschnittsgelenk
Assembled system	System components that are already installed on the building.	Assembled system	Zusammengebautes Abdichtungssystem)
Waterproofing system (with bitumen sheets)	The system consists of one or more layers of bituminous waterproofing sheets, which are laid and interconnected to form a complete system. The system as a whole is suitable for sealing, the characteristics depend on the entire system. The system can be single-layer or multi-layer. Note: There are several different sealing systems.	Waterproofing system	Abdichtungssystem
Sealing system for bridges	Waterproofing system with bituminous sheets or liquid applied waterproofing, between the superstructure of	Sealing system for bridges	Abdichtungssystem für Brücken

Slovenian	Description	English	German
	the bridge structure and the carriageway structure (or the upper structure of the railway track)		
Dry sandblasting	Dry surface treatment with steel balls and dust particle extraction	Dry sandblasting	Kugelstrahlen
Surface bush hammering	Treatment of concrete surfaces, whereby the surface is treated in such a way that, at the end of the process, it becomes rough and robust in both appearance and functionality.	Surface bush hammering	Stocken von Betonoberflächen
Liquid sealing layer	A layer that prevents the passage of water and moisture. In liquid applied waterproofing, it consists of one or more layers of liquid components that must be applied one after the other.	Liquid sealing layer	Flüssig aufzubringenden Dichtungsschicht
Liquid material	A material that usually consists of several components, which can be poured, applied with roller or sprayed on site.	Liquid material	Flüssig afzubringendes Material
Priming coat (primer)	Coating applied directly to the prepared concrete substrate to ensure good adhesion between the concrete surface and the waterproofing layer and to close pores in concrete (e.g. “epoxy coating” or “pre-coat with bitumen emulsion”).	Priming coat (primer)	Grundierung
Sealing layer	A layer that prevents the passage of water and moisture.	Sealing layer	Abdichtungsschicht
High pressure washing with water	High pressure water jet surface treatment.	High pressure washing with water	Hochdruckwasserstrahlen
Pavement structure	Asphalt and/or concrete layers lying above the waterproofing.	Pavement structure	Fahrbahnaufbau
Intermediate layer of asphalt	Asphalt layers that lie above the protective asphalt layer and below the wearing asphalt layer. These are levelling and/or binding asphalt layers	Intermediate layer of asphalt	Zwischenschicht aus Asphalt
Sampling	Procedure used to collect and prepare a sample.	Sampling	Probenahme
Sample	Test material – for example, bitumen sheet from which the testing part was taken.	Sample	Probe, Probestück
Initial Type Testing (ITT)	Standard determined preliminary tests to determine the properties of materials and	Initial Type Testing (ITT)	Erstprüfung

Slovenian	Description	English	German
	systems.		
Protective layer	The first layer that protects the waterproofing. This is usually an asphalt (road structures) or concrete (railway structures) layer.	Protective layer	Schutzschicht
Test protocol	A record of the test results, the content of which complies with the requirements of the test standards and does not have the validity of a test report.	Test protocol	Prüfprotokoll
“Renovation of the bridge waterproofing”	The road surface is being renovated and the waterproofing system and pavement structure of similar thickness are being replaced.	»Renovation of the bridge waterproofing«	»Sanierung der Brückenabdichtung«
“Reconstruction of the bridge waterproofing”	The scope of work is larger and also includes other work that enables an increase in the thickness of the asphalt layers.	»Reconstruction of the bridge waterproofing«	»Sanierung der Brückenabdichtung«

3 General

3.1 Tests and control of materials

This technical specification defines tests for a construction product represented by an individual material for waterproofing and a product as a waterproofing system. For each individual waterproofing material, the prescribed tests defined in the harmonised EN (hEN) standards must be carried out as part of factory quality control, and this serves as proof of the product type (Initial type testing) and forms the basis for the CE marking and the Declaration of Performance (DoP). In the case of the production of a material not defined in hEN, the remaining possibilities of other technical specifications (referred to in Article 6 of the Construction Products Act ZGPro-1) must be used. The test procedures and criteria are listed in this TSPI.

This TSPI specifies additional procedures and tests that must be performed in order for the waterproofing system to be used on bridge structures of public roads and other public traffic areas (e.g. parking decks) and on railways in the Republic of Slovenia.

This TSPI also lists the field inspections that must be carried out by the contractor or internal quality control (IQC), as well as the client's control as external quality control (EQC).

3.2 Certification of the waterproofing system and the competence of the waterproofing contractor

For bridge structures on motorways, expressways, main roads, regional roads marked R1 and all railway structures, the implementation of a waterproofing system made of similar materials must be demonstrated in advance. As proof, a reference object or test field on a cement concrete surface covering at least 100 m^2 is required. For the implementation of a waterproofing system on regional roads (designated R2, R3 and RT), local roads (designated LC) and other traffic areas, the contractor may first demonstrate implementation with similar or equivalent materials. As proof, a reference object or test field on a cement concrete surface covering at least 50 m^2 is required.

The preliminary procedure includes the preparation and approval of the TEDR with all supporting documents submitted by the contractor in order to confirm their approach to the implementation of a test field for the implementation of a specific waterproofing system. Evidence for materials, equipment and internal training of operational staff in the field of waterproofing works, as well as a description of the technological procedures that are the subject of the TEDR, must be reviewed and approved by an Engineer (Adviser or Supervisor). "Adviser", "Engineer" or "Supervisor" is a contractor providing engineering and supervision services who, in accordance with the general and specific terms and conditions of the construction contract, performs engineering services in accordance with the FIDIC contractual provisions and supervision services in accordance with the Construction Act (an economic operator or group of such operators undertaking the work).

To check the quality of the work done in each phase of implementation, control tests are carried out by internal and external quality control. The procedures for conducting control tests and the requirements for evaluation are specified in the thematic chapters of this TSPI.

On the basis of the evidence field carried out, an independent institution that demonstrates competence by accreditation (SIST EN 17025 General requirements for the competence of testing and calibration laboratories (ISO/IEC 17025)) shall issue a Final Report on the execution of waterproofing works containing internal and external quality controls. The basis for issuing the Final Report are harmonised product standards for individual products, or technical approvals and guidelines of this TSPI. The final report with a positive evaluation of the works carried out is the basis for the Engineer to confirm the competence of the waterproofing contractor for the individual waterproofing system.

The final report on the execution of waterproofing works must contain at least the information from the previously approved Technological Expert's Detailed Report and from point 10.2 Minimum scope of internal and external quality control of this TSPI.

3.3 Procedure for executing the waterproofing system

The execution of the waterproofing system for bridge structures comprises the following steps:

- designing the waterproofing system,
- production and confirmation of the TEDR,
- preparation of cement concrete surfaces to a healthy base,
- checking the actual condition of the surface to be sealed and, if necessary, supplementing the TEDR,
- application of base coats (usually epoxy or bitumen coating),
- sealing with special bituminous waterproofing sheets or sealing with materials applied in liquid form,
- implementation of waterproofing protection or implementation of pavement structure.

All phases of implementation, design, control of input materials, acceptance of the building area, compliance with the required installation conditions, control of correct installation and verification of completed works must be carried out and documented in writing.

3.4 Acceptance tests for quality control of the work carried out

Control or acceptance tests shall be carried out for the quality control of the works carried out at each execution stage. The requirements for acceptance tests are specified in the relevant sections of this TSPI.

4 Waterproofing systems with bitumen waterproofing sheets (BHT)

Horizontal waterproofing systems with bituminous waterproofing sheets (BHT) for cement concrete bridge structures on roads and railways and other traffic areas made of cement concrete consist of several different products.

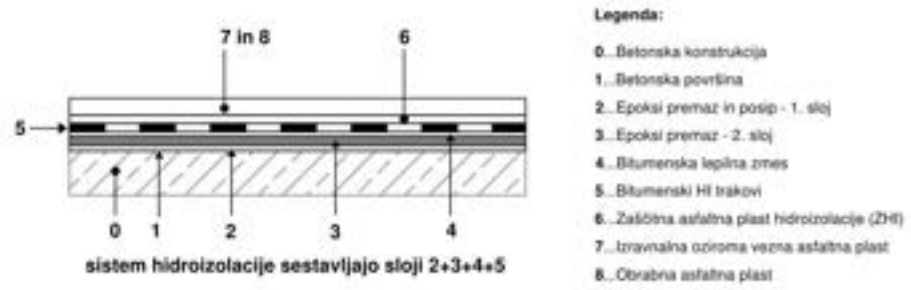


Figure 4-1: Example of waterproofing system for road bridge structures

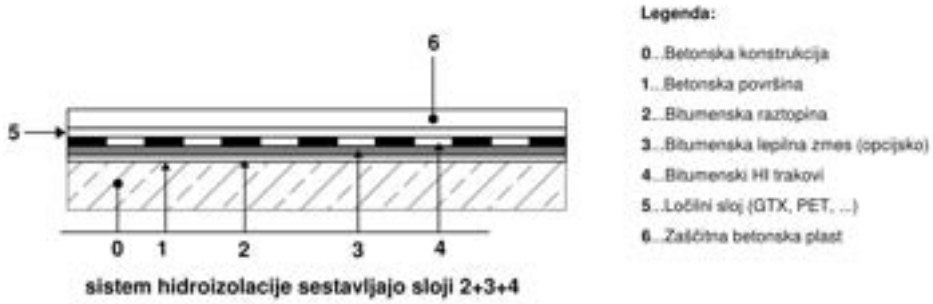


Figure 4-2: Example of a waterproofing system for buried road bridge structures

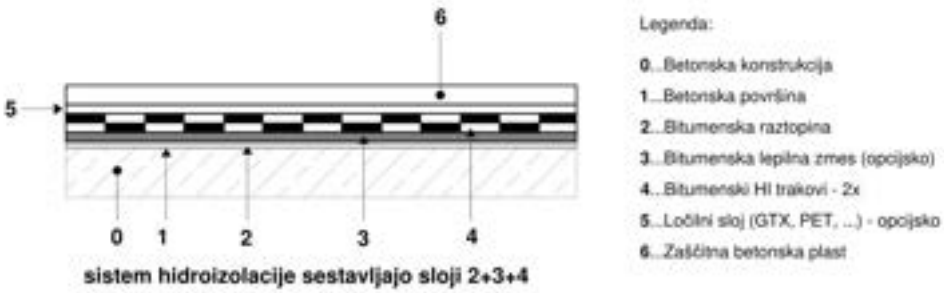


Figure 4-3: Example of waterproofing system for railway bridge structures

sistem hidroizolacije sestavljajo sloji	the waterproofing system consists of layers
Legenda	Key
0 Betonska konstrukcija	0 Concrete construction
1 Betonska površina	1 Concrete surface
2 Bitumenska raztopina	2 Bitumen solution
3 Bitumenska lepilna zmes (opcijsko)	3 Bituminous adhesive (optional)
4 Bitumenski HI trakovi – 2x	4 Bitumen HI sheets - 2x
5 Ločilni sloj (GTX, PET, …) - opcijsko	5 Separating layer (GTX, PET, etc.) – optional
6 Zaščitna betonska plast	6 Protective concrete layer
7 Izravnalna oziroma vezna asfaltna plast	7 Regulating or binder asphalt course
8 Obrabna asfaltna plast	8 Asphalt wearing course

4.1 Products and systems

In this TSPI, they are considered in terms of:

- the material and amount of the base coatings required,
- type of sealing layers, method of installation of bitumen waterproofing sheets (BHT) or liquid applied waterproofing (HTN),
- the type of waterproofing protection.

For all systems, the adhesion of waterproofing with the prepared substrate must be ensured. The waterproofing shall be adapted to all movements of the structure without damage.

Epoxy coatings or a dedicated bituminous solution shall be used as base coatings.

For the adhesive, a bituminous mixture that meets the quality characteristics specified in this TSPI is used in the hot process. When testing the entire waterproofing system, the compatibility of the adhesive with the base coatings and with BHT must be demonstrated.

For the waterproofing of cement concrete road bridge structures and other traffic surfaces made of concrete (e.g. car parks), it is necessary to use BHT, which are CE marked in accordance with SIST EN 14695 and meet the requirements of Slovenian standard SIST 1031, Table 5, “Minimum quality requirements for waterproofing sheets according to standard SIST EN 14695” and the additional requirement in point 4.2.5 of this TSPI. For double-layer waterproofing of cement concrete railway bridge structures, it is necessary to use BHT, which are CE marked in accordance with SIST EN 13969 and meet the requirements of Slovenian standard SIST 1031, Table 2b, “Minimum quality requirements for waterproofing sheets according to standard SIST EN 13969”.

Asphalt mixtures are commonly used as a protective layer for horizontal waterproofing on road bridges and other traffic surfaces; in certain cases, cement concrete may also be used. On railway bridge structures, as a rule, cement concrete is used to protect waterproofing. Requirements and recommendations for the various protective layers of waterproofing are described in Chapter 8.5 of this TSPI.

4.2 Material requirements

The minimum required tests for individual products that make up the BHT waterproofing system are listed in this chapter. Tests must be carried out in accordance with the instructions of the product and analytical EN standards. Tests for which EN analytical standards are not available must be carried out according to the instructions in Chapter 9 of this TSPI.

The requirements for the implementation of the entire waterproofing system with BHT and the necessary measures are given in Volume 2 of this TSPI.

4.2.1 Requirements for materials – epoxy or PMMA primer

Requirements for epoxy or PMMA primer for cement concrete bridge structures are specified in SIST EN 1504-2. The mandatory information to be provided by the manufacturer is given in Table 4-1 below. If stricter or additional requirements are specified

in the instructions of the manufacturer of the waterproofing system for epoxy coating, the requirements of the manufacturer of the waterproofing system must be observed.

Table 4-1: Requirements for epoxy or PMMA coatings for concrete structures

Property	Test method	Unit of measure	Requirement
Liquid components			
Minimum and maximum ambient temperature during use	-	°C	8 to 35
Density	SIST EN ISO 2811-1	kg/m^3	specify
Viscosity of components A and B	SIST EN ISO 3219	mPa.s	specify
Infrared analysis	SIST EN 1767	-	specify
Fresh composite			
Viscosity at 12 °C	SIST EN ISO 3219	mPa.s	< 4000
Open time of use	SIST EN ISO 9514	min	> 10
Hardness according to Buchholz	SIST EN ISO 2815	- - -	Final hardness according to Buchholz after 7 days for NK 23 / 50-2:> 60 h solidification time NK 23/50-2: <18 h Solidification time at 12 °C and 85% relative humidity < 40 h

Composite properties			
Ash residue after incineration (550 °C)	SIST EN ISO 3451-1	m.-%	< 1
Moisture sensitivity	TSPI point 9.4.3	-	must not be bleached
Non-volatile substances	SIST EN ISO 3251	m.-%	≥ 98.0
Capillary absorption of water and water permeability	SIST EN 1062-3	$kg/(m^{-2} \times h^{-0.5})$	w < 0.1
Permeability to CO_2	SIST EN 1062-6	m	S_D > 50
Water vapour permeability	SIST EN ISO 7783-1	-	Class III
Initial pull-off (adhesion) strength	SIST EN 1542	MPa	≥ 2.0 (1.5)*
Appearance and pull-off strength after temperature shock silicone oil, temperature ≥ 230 °C	SIST EN 13687-5 and SIST EN 1542	MPa	without damage ≥ 2.0 (1.5)*
Appearance and pull-off strength after ageing for 7 days at 70 °C	SIST EN 1062-11 and SIST EN 1542	MPa	without damage ≥ 2.0 (1.5)*
Appearance and pull-off strength after cyclic freezing and thawing without the influence of salt	SIST EN 13687-3 and SIST EN 1542	MPa	without damage ≥ 2.0 (1.5)*

4.2.2 Requirements for quartz sand

Quartz sand must be hot-dried, and the moisture content of the sand must not exceed 0.2 m.-% (determined by drying to a constant mass at 110 °C+/-5 °C). The grain distribution shall meet the limits given in Figures 4.3. and 4.4. Quartz granulation A is used for epoxy

mortar, quartz granulation B is used for broadcasting after the first layer of epoxy coating and in combination with quartz granulation A for the composition of epoxy mortar.

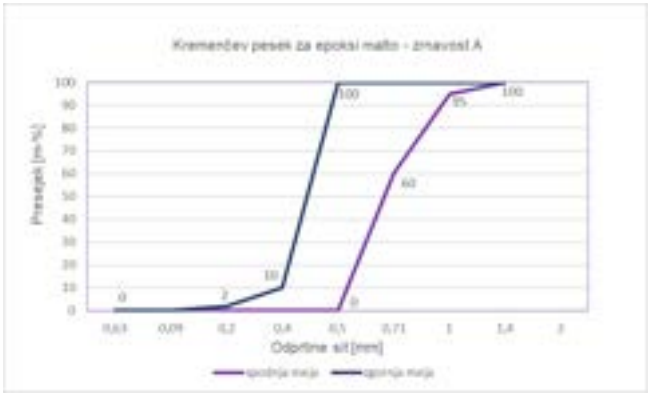


Figure 4.3: Grain size distribution of quartz sand A

(for epoxy mortar in combination with quartz sand with grain size distribution B)

Kremenčev pesek za epoksi malto – zrnavost A	Quartz sand for epoxy mortar – grain size A
Presejek [m-%]	Screening [m-%]
Odprtine sit [mm]	Sieve opening [mm]
spodnja meja	lower limit
zgornja meja	upper limit

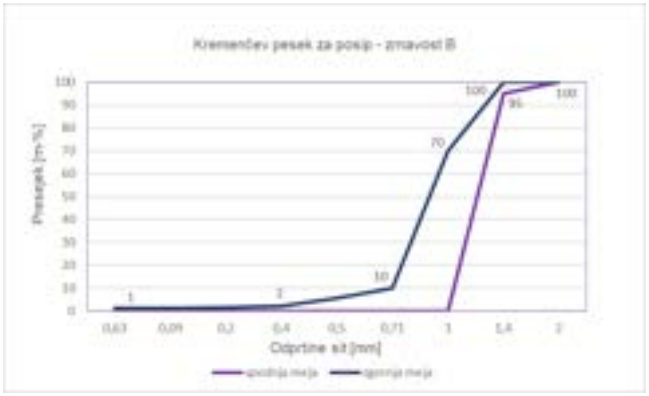


Figure 4.4: Granularity distribution of quartz sand B (for broadcasting)

Kremenčev pesek za posip – zrnavost B	Quartz sand for broadcasting – grain size B
Presejek [m-%]	Screening [m-%]
Odprtine sit [mm]	Sieve opening [mm]
spodnja meja	lower limit
zgornja meja	upper limit

4.2.3 Requirements for bituminous solution for primer

The manufacturer must provide a Declaration of Performance for the product containing the information required in SIST 1037 and in Table 4-2 below.

Table 4-2: Requirements for bituminous solution for primer

Property	**Test method**	**Unit of measure**	**Requirement**
Content of bituminous binder	SIST EN 13358	m. %	30 - 50
Flow time by efflux viscometer (d=4mm, T=25 °C, 100 ml)	SIST EN ISO 2431	s	15 – 20
Softening temperature of the recovered bitumen	SIST EN 13074-1 and SIST EN 1427	°C	≥ 54
Penetration of recovered bitumen	SIST EN 13074-1 and SIST EN 1426	1/10 mm	≤ 30
Flash point - closed cup method	SIST EN ISO 13736	°C	≥ 21
Drying time (dust dry)	SIST EN ISO 9117-3	h	≤ 3

4.2.4 Requirements for bituminous adhesive

The manufacturer must provide a Declaration of Performance for the product containing the information required in Table 4-3 below.

Table 4-3: Requirements for bituminous adhesive

Property	**Test method**	**Unit of measure**	**Requirement**
Ash content	SIST EN ISO 6245	m.-%	≤ 5
Softening point	SIST EN 1427	°C	≥ 150
Bitumen penetration	SIST EN 1426	mm/10	20 – 30
Flexibility at low temperature (-5 °C)	TSPI, Chapter 9.4.1	/	suitable
Shear strength at 50 °C τ_{max}	TSPI, Chapter 9.4.2	MPa	≥ 0.080
Shear deformation upon pushing at 50 °C (displacement at τ=0.08 MPa)	TSPI, Chapter 9.4.2	mm	specify

4.2.5 Requirements for bituminous waterproofing sheets (BHT)

The requirements are specified in SIST 1031 “Waterproofing sheets - Bitumen sheets for waterproofing - Requirements”. All tests specified in SIST 1031, Table 5, must be performed: “Minimum quality requirements for waterproofing sheets according to standard SIST EN 14695 - Bridges”. For two-layer waterproofing systems on railway concrete bridge structures, the requirements are given in SIST 1031 “Waterproofing sheets - Bitumen sheets for waterproofing - Requirements”. All tests specified in SIST 1031, Table 2b, must be performed: “Minimum quality requirements for waterproofing sheets according to standard SIST EN 13969”.

Additional requirements for BHT intended for installation on road bridges or other traffic surfaces where a protective asphalt layer will be installed on the waterproofing system are given in Table 4-4.

Table 4-4: Additional requirements for bituminous waterproofing sheets

Property	Test method	Unit of measure	Requirement
Shear strength at 50 °C τ_{max}	TSPI, Chapter 9.4.2	MPa	≥ 0.080
Shear deformation at 50 °C (displacement at τ=0.08 MPa)	TSPI, Chapter 9.4.2	mm	specify

4.2.6 Requirements for bitumen joint sealing materials

On bridge structures, a joint shall be implemented between the vertical elements (e.g. kerbs) and the wearing barrier layer (asphalt or concrete), which shall be sealed when or after the wearing barrier layer is implemented. The joint must be watertight. Bitumen joint tape or bitumen sealing compound for filling joints can be used.

The manufacturer must provide a Declaration of Performance for the bitumen tape containing the information required in Table 4-5 below. If stricter or additional requirements are specified in the instructions of the manufacturer, the requirements of the manufacturer must be observed.

Table 4-5: Requirements for bitumen joint sealing tape

Property	Test method	Unit of measure	Requirement
Ash content	SIST EN ISO 6245	m.-%	≤ 5
Softening point	SIST EN 1427	°C	≥ 85
Cone penetration of bitumen	SIST EN 13880-2	mm/10	40 – 100
Ability to return to original position	SIST EN 13880-3	%	≤ 60
Low-temperature flexibility	TSPI, Chapter 9.4.1	/	≤-5

Bituminous sealing compound for filling joints must comply with SIST EN 14188-1 Joint fillers and sealants – Part 1: Specifications for hot applied sealants (Type N2) and with the minimum requirements in Table 4-6.

Table 4-6: Requirements for sealing compound for filling joints

Property	Test method	Unit of measure	Requirement
Watering temperature	-	°C	specify
Softening point	SIST EN 1427	°C	≥ 85
Cone penetration (25 °C, 150 g)	SIST EN 13880-2	mm/10	40 – 100
Penetration and return (25 °C, 75 g ball, 5 s)	SIST EN 13880-3	%	≤ 60
Resistance to flow (60 °C, 5h, 75°)	SIST EN 13880-5	mm	≤ 3
Cone penetration after heating (70 °C, 168h)	SIST EN 13880-4	°C	40 – 100
Penetration and return after heating (70 °C, 168h)	SIST EN 13880-4	%	≤ 60
Compatibility with asphalt pavements (60 °C, 72h)	SIST EN 13880-9	-	no excretion and no damage

4.3 Waterproofing system – material testing

For the implementation of the waterproofing system on concrete bridge structures and other traffic surfaces made of cement concrete on public roads and railways in the Republic of Slovenia, the contractor shall prove the implementation with the same or equivalent materials as given in Chapter 3.2 of this TSPI. All the parameters referred to in Chapter 4.2 of this TSPI, which demonstrate the compatibility of individual components of the system, must be demonstrated in advance for individual materials. In the case of replacement of an individual component of the system, the compatibility of the individual materials must be demonstrated once more on all the parameters referred to in Chapter 4.2 of this TSPI.

5 Liquid applied waterproofing (HTN) systems

5.1 Materials, systems and labelling

This chapter deals with liquid applied waterproofing (HTN) systems for cement concrete bridge structures on roads and railways and other traffic surfaces made of cement concrete. Waterproofing systems must be approved on the basis of EAD 030675-00-0107:2020 “Liquid applied bridge deck waterproofing kits” (EAD - European Assessment Document) and must be suitable for the following applications:

- for upgrading with a protective asphalt layer or cement concrete in accordance with Chapter 8 of this TSPI,
- without upgrading with a protective layer and specified anti-slip and UV protection by the system manufacturer (e.g. bridge structures intended for cyclists and pedestrians),
- without upgrading with a protective layer (example of a railway bridge structure without a track bed or direct rail fastening into a cement concrete structure).

5.1.1 Materials

The HTN system is most commonly made from materials (see EAD 030675-00-0107, Tab. 3.2.1),:

- sealing layer,
- components for the primer coat, finishing coat and bonding coat,
- mineral aggregates,
- materials for the reinforcement of the layers.

5.1.2 Composition of the waterproofing system

The manufacturer of a liquid applied waterproofing system (HTN) must clearly specify in the Technical Data Sheet how the system is composed, the possible methods of application of the layers, the sequence of application of the layers, and which materials (components) must be used for each layer.

5.1.2.1 Primers

In accordance with EAD 030675-00-0107, the primer is used to ensure adhesion between the cement concrete surface and the sealing layer and also has the additional function of penetrating the cement concrete substrate and partially hardening it. In order to improve adhesion to the sealing layer, a coating may also be applied to the primer to improve adhesion.

5.1.2.2 Waterproofing layer

The waterproofing layer consists of one or more layers of liquid components that must be applied one after the other. A reinforcement bracket can be installed in the waterproofing layer in accordance with EAD 030675-00-0107. A connection layer can be applied to the waterproofing layer or the surface of the waterproofing layer can be treated.

The connection layer may consist of one or more layers of coating or broadcasting. The connection layer has the task of ensuring a good connection between the waterproofing layer and the protective layers.

For systems that are not protected by an asphalt or concrete layer, a “finish layer” with characteristics that ensure adequate protection against environmental and traffic influences can be applied to the surface of the waterproofing layer.

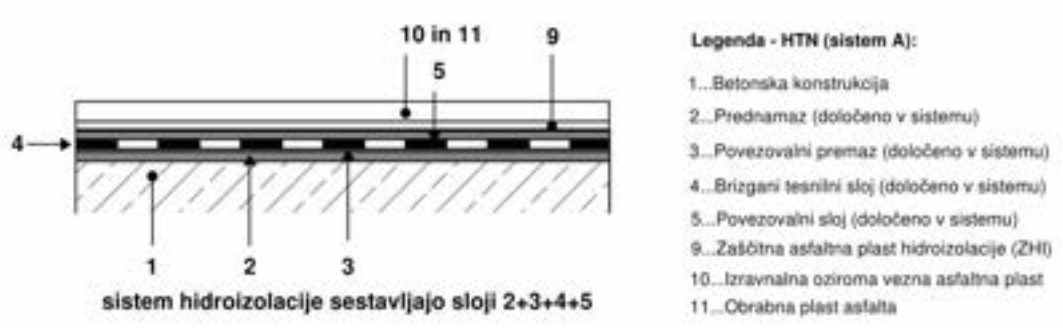


Figure 5.1: HTN implementation – with asphalt protective layer (system A)

sistem hidroizolacije sestavljajo sloji	the waterproofing system consists of layers
Legenda – HTN (sistem A)	Legend – HTN (system A)
1. Betonska konstrukcija	1. Concrete structure
2. Prednamaz (določeno v sistemu)	2. Pre-coating (specified in the system)
3. Povezovalni premaz (določeno v sistemu)	3. Bonding coat (specified in the system)
4. Brizgani tesnilni sloj (določeno v sistemu)	4. Sprayed sealing layer (specified in the system)
5. Povezovalni sloj (določeno v sistemu)	5. Connection layer (specified in the system)
9. Zaščitna asfaltna plast hidroizolacije (ZHI)	9. Protective asphalt layer of waterproofing (ZHI)
10 Izravnalna oziroma vezna asfaltna plast	10 Regulating or binder asphalt course
11. Obrabna plast asfalta	11. Wear course of the asphalt

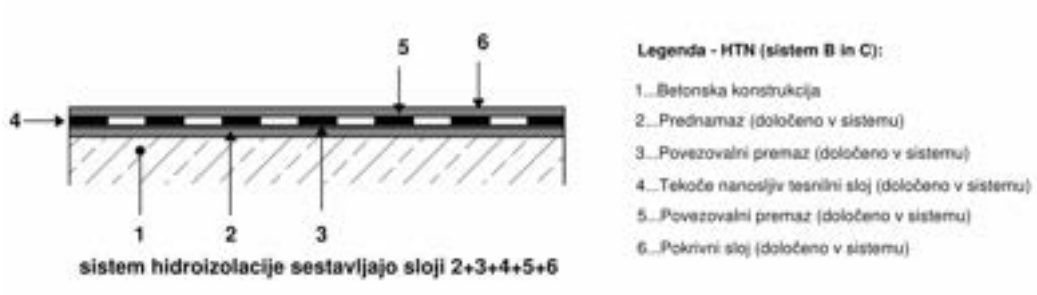


Figure 5.2: HTN implementation – without superstructure (system B or C)

sistem hidroizolacije sestavljajo sloji	the waterproofing system consists of layers
Legenda – HTN (sistem B in C)	Legend – HTN (system B and C)
1. Betonska konstrukcija	1. Concrete structure
2. Prednamaz (določeno v sistemu)	2. Pre-coating (specified in the system)
3. Povezovalni premaz (določeno v sistemu)	3. Bonding coat (specified in the system)
4. Brizgani tesnilni sloj (določeno v sistemu)	4. Sprayed sealing layer (specified in the system)
5. Povezovalni sloj (določeno v sistemu)	5. Connection layer (specified in the system)
6. Pokrivni sloj (določeno v sistemu)	6. Finish layer (specified in the system)

Systems B and C differ in that system B must provide both weather protection (UV radiation resistance) and pedestrian and cyclist safety (anti-slip and wear resistance, such as the requirements of the OS11 system according to DIN V 18026). System C does not require anti-slip and wear resistance (in Figure 5.2, layers 5 and 6), (e.g. exposed non-walkable edge surfaces of bridge structures).

5.1.3 Labelling

The manufacturer of the HTN system must provide a Declaration of Performance for the entire system. Product data sheets, technical data sheets, safety data sheets for all components of the system shall be available for the materials of which the waterproofing system is made.

Mandatory information on all components of the pre-coating and sealing system:

- manufacturer, address,
- product name/designation,
- product description, intended use,
- label in accordance with the Chemicals Regulation,
- date of manufacture and expiry date,
- requirements for transport and storage,
- description of components and mixing ratios,
- infrared analysis,
- density,
- non-volatile substances,
- viscosity,
- mixing – the method and duration of mixing,
- open time of use of the product in the packaging in minutes at 10 / 23 / 30 °C,
- drying/hardening process,
- maximum permissible relative humidity in the surroundings,
- the minimum and maximum processing time at a temperature of 10 / 23 / 30 °C of the building elements,
- waiting times until the layer is ready for use and performing the pull-off strength test,
- tensile strength and elongation of composite.

Mineral aggregate data:

- manufacturer,
- product name/designation,

- granularity,
- moisture content.

Information about materials for system reinforcement:

- manufacturer,
- product name/designation,
- area-related mass,
- tensile properties.

5.2 Tests of materials and liquid applied waterproofing systems

Material tests shall be carried out in accordance with the standards specified in EAD 030675-00-0107 for each system.

To facilitate the assessment process, the areas of application are classified as follows:

(A) HTN system with superstructure suitable for different traffic loads

- A.1 bituminous mixtures of type AC and SMA (160±10 °C)
- A.2 bituminous mixtures of type MA, (220 °C to 250 °C)
- A.3 for concrete superstructure (no friction tests required)

(B) The HTN system without superstructure (exposed) and intended only for pedestrian or cyclist traffic.

(C) HTN system without superstructure (exposed) and with no traffic (including the specific case of rail without ballast).

5.3 Test categories for liquid applied waterproofing systems

The test categories are detailed in EAD 030675-00-0107 Annex C “Test categories”. This point of the TSPI provides a summary. The test categories cover various conditions of use that may occur in EU countries or in countries where the product is marketed.

In order to place a construction product on the market in a particular EU Member State, an authorised assessment body must carry out an assessment based on the EAD and issue an ETA document. It is up to the manufacturer to choose in which Member State(s) the product or system is to be marketed and to take due account of the specific requirements of that or those Member States.

The complex testing system provides for the following testing methods or combinations thereof:

- four test categories related to the conditions for preparing test specimens (P),
- five test categories related to loading conditions prior to testing (S),
- six test categories related to temperature conditions during testing (T).

We select individual test combinations from the tables. In this way, we prepare a testing programme for specific properties that are important in a particular country, depending on climatic conditions and methods of use, and which must be demonstrated.

The methods for preparing specimens for testing are described in detail in (EAD 030675-00-0107 Annex A “Specimen preparation”). Test specimens shall be prepared in accordance with SIST EN 13375 with some deviations:

For the purposes of testing liquid applied waterproofing, we distinguish between two groups of samples:

- for samples Type 1, Type 3, and Type 4, HTN is applied to the concrete slab,
- for Type 2 samples, this is only the HTN membrane (without substrate) from which the test piece is made.

The preparation of samples shall be carried out in one of the following ways:

- Type 1: HTN bonded with concrete slab (without protective layer)
- Type 2: the HTN membrane (without substrate) from which the specimen is made.
- Type 3: HTN bonded with concrete slab with a protective layer of asphalt concrete or crushed stone with bituminous mastic applied at 160 +/- 10 °C
- Type 4: HTN bonded with concrete slab with a protective layer of mastic asphalt applied at 220 °C to 250 +/- 10 °C. If the temperature according to the manufacturer's instructions is lower than 250 °C, the protective layer of mastic asphalt is applied at the temperature specified by the manufacturer of the asphalt mixture.

The temperature of the asphalt mixture shall be measured in accordance with SIST EN 12697-13.

5.4 Conditions for the preparation of samples for testing – categories (Pi)

These categories depend on the conditions in which we prepare the specimens (different climatic conditions and specific substrate conditions).

- Normal conditions in preparation of specimens (NC) – P1

In order to simulate normal weather conditions during application, the test specimens (applied to a concrete slab) must be prepared under normal climatic conditions P1 (23 +/- 2) °C and (50 +/- 10)% relative air humidity.

- Extreme climatic conditions (SC) - P2

Extreme climatic conditions are conditions with very low or very high temperatures combined with high relative air humidity. The test specimens are prepared at the minimum and/or maximum temperatures specified by the manufacturer for the application of their product (when applied to a concrete slab), P2 (see EAD 030675-00-0107 in section 2.2.12).

- High moisture content in the substrate (MC) - P3

Special climatic conditions apply when the system is applied to concrete with high moisture content (e.g. concrete that is only 7 days old) (see EAD 030675-00-0107 in section 2.2.13.1).

- Overlap areas (OA) – P4

Sometimes waterproofing systems are implemented in such a way that the new waterproofing layer is connected to the other (old) waterproofing surface by means of overlapping. It is assumed that, in this case, the overlap area may be exposed to weather conditions and/or UV radiation for up to 7 days for construction joints (day joints) and up to 6 months for expansion joints (section joints). The tests shall confirm that this overlap area achieves the same pull-off strengths to the substrate as the surrounding waterproofing area (see EAD 030675-00-0107 in Part 2.2.13.2-3).

5.5 Pre-test loading conditions - categories (Si)

These categories cover loads that may affect the characteristics and sealing of the waterproofing system. The following load conditions are anticipated:

- No previous loads - S0

Initial samples; in order to be able to evaluate the effects of various loads, the initial samples must be tested without special loading conditions.

- Heat impact – S1

In order to determine the heat impact of the implementation of hot protective layers on the sealing layer, the following categories are envisaged (see EAD 030675-00-0107 in Part 2.2.5):

  - S1.1 Performance of cast asphalt at a minimum temperature greater than 220 °C up to a maximum temperature of 250 °C – (specified by the producer of the cast asphalt)
  - S1.2 Production of asphalt concrete or crushed aggregate with bituminous mastic at 160 °C

- Heat ageing (HA) - S2

Ageing of the material at high temperatures (see EAD 030675-00-0107 in Part 2.2.18).

- Freezing/thawing (FT) - S3

Alternating freezing/thawing of the sealing system (see EAD 030675-00-0107 in section 2.2.25).

- UV radiation (UV) - S4

Effects of climatic conditions on unprotected sealing systems due to UV radiation and precipitation (see EAD 030675-00-0107 in section 2.2.19).

- Mutual chemical influence of materials with which the sealing layer comes into contact - S5

Effects on specific product characteristics (see EAD 030675-00-0107 in section 2.2.14/15/17):

  - S5.1 Water – Wa
  - S5.2 Alkalis - Al
  - S5.3 Bitumen - Bi

5.6 Temperature conditions during testing - categories (Ti)

These categories refer to temperature conditions that may affect test results. This covers a wide range from very high to extremely low temperatures at which the waterproofing properties must be demonstrated (see EAD 030675-00-0107 in section 2.2.8).
The test temperatures and categories are as follows:

- extremely low temperatures (-30 °C) - T1
  For systems used in areas with extremely low temperatures, testing shall be carried out at -30 °C.
- very low temperatures (-20 °C) - T2
  For systems used in areas with very low temperatures, testing shall be carried out at -20 °C.
- low temperatures (-10 °C) - T3
  For systems used in areas with normal low temperatures, testing shall be carried out at -10 °C.
- moderate temperatures (0 °C) - T4
  For systems used in areas with moderate temperatures, testing shall be carried out at 0 °C.
- normal temperatures (+23 °C) - T5
  The tests shall be carried out at normal temperatures of +23 °C.
- high temperatures (+40 °C) – T6
  For systems used at high temperatures, testing shall be carried out at +40 °C.

5.7 Requirements for the Republic of Slovenia for liquid applied waterproofing systems - Requirements for systems A.1 and A.2

Property	**Point EAD 030675-00-0107**	**Type of test specimen**	**Test conditions***	**Requirement**
Adhesion to a cement concrete surface	2.2.1	Type 1	P1, T5	≥ 1.5 (1.0) MPa
Crack-bridging ability:				
- test after exposure to temperatures of 160 °C and ageing for 12 weeks @ 70 °C (AC or SMA)	2.2.2	Type 1	P1, S1.2/S2	suitable
- test after exposure to temperatures of 220 °C to 250 °C and ageing for 12 weeks @ 70 °C (MA)	2.2.2	Type 1	P1, S1.1/S2	suitable
Resistance to chloride ion penetration	2.2.3	Type 1	P1, T5	<0.04%
Resistance to dynamic perforation	2.2.4.1	Type 1	P1, T5	suitable
Resistance to dynamic influences - installation of asphalt layer	2.2.4.2	Type 2	P1, S1.2, T5	suitable
Temperature resistance of the installed asphalt layer AC or SMA	2.2.5 / 2.2.1	Type 1	P1, S1.2, T5	≥ 1.5 (1.0) MPa
Temperature resistance of the installed asphalt layer MA	2.2.5 / 2.2.1	Type 1	P1,S1.1,T5	≥ 1.5 (1.0) MPa
Shear resistance with asphalt protective layer				
- protective asphalt layer AC or SMA	2.2.5 / 2.2.6	Type 3	P1,S1.2,T5	≥ 0.5 MPa
- protective asphalt layer MA	2.2.5 / 2.2.6	Type 3	P1,S1.1,T5	≥ 1.0 MPa
Watertightness	2.2.7	Type 2	P1, T5	suitable
The influence of the substrate				
- adhesion to substrate influence – moisture	2.2.13.1	Type 1	P3, T5	≥ 1.5 (1.0) MPa
- adhesion to overlap impact – day joint (joint after 48 hours, up to a maximum of 7 days)	2.2.13.2	Type 1	P4, T5	≥ 1.5 (1.0) MPa
- overlapping adhesion - section joint (joint within 7 days to 6 months)	2.2.13.2	Type 1	P4, T5	≥ 1.5 (1.0) MPa
The materials in joint				
- change in hardness - water (WA)	2.2.14	Type 2	P1, S5.1	specify Δ IRHD
- change in hardness - alkali (Al)	2.2.15	Type 2	P1, S5.2	specify Δ IRHD
- change in hardness - bitumen (Bi)	2.2.17	Type 2	P1, S5.3	specify Δ IRHD
Temperature load resistance 70 °C @ 12 weeks	2.2.18 / 2.2.1	Type 1	P1, S2, T5	≥ 1.5 (1.0) MPa
Force of adhesion with asphalt protective layer				
- protective asphalt layer MA	2.2.22	Type 3	P1,S1.1,T5	≥ 1.2 MPa
- protective asphalt layer AC or SMA	2.2.22	Type 3	P1, S1.2, T5	≥ 0.7 MPa
Resistance to freezing/thawing (20 cycles)	2.2.25 / 2.2.1	Type 1	P1, S3, T5	≥ 1.5 (1.0) MPa

* Additional test conditions are specified in the test standards associated with EAD 030675-00-0107

5.8 Requirements for the Republic of Slovenia for liquid applied waterproofing systems for system A.3

Property	**Point EAD 030675-00-0107**	**Type of test specimen**	**Test conditions***	**Requirement**
Adhesion to a cement concrete surface	2.2.1	Type 1	P1, T5	≥ 1.5 (1.0) MPa
Resistance to chloride ion penetration	2.2.3	Type 1	P1, T5	<0.04%
Resistance to dynamic perforation	2.2.4.1	Type 1	P1, T5	suitable
Watertightness	2.2.7	Type 2	P1, T5	suitable
The influence of the substrate				
- adhesion to substrate influence – moisture	2.2.13.1	Type 1	P3, T5	≥ 1.5 (1.0) MPa
- adhesion to overlap impact – day joint (joint after 48 hours, up to a maximum of 7 days)	2.2.13.2	Type 1	P4, T5	≥ 1.5 (1.0) MPa
- adhesion to overlap impact – section joint (joint within 7 days to 6 months)	2.2.13.2	Type 1	P4, T5	≥ 1.5 (1.0) MPa
The materials in joint				
- change in hardness - water (WA)	2.2.14	Type 2	P1, S5.1	specify Δ IRHD
- change in hardness - alkali (Al)	2.2.15	Type 2	P1, S5.2	specify Δ IRHD
Temperature load resistance 70 °C @ 12 weeks	2.2.18 / 2.2.1	Type 1	P1, S2, T5	≥ 1.5 (1.0) MPa
Resistance to freezing/thawing (20 cycles)	2.2.25 / 2.2.1	Type 1	P1, S3, T5	≥ 1.5 (1.0) MPa

* Additional test conditions are specified in the test standards associated with EAD 030675-00-0107

5.9 Requirements for the Republic of Slovenia for liquid applied waterproofing systems for systems B and C

Property	**Point EAD 030675-00-0107**	**Type of test specimen**	**Test conditions***	**Requirement**
Adhesion to a cement concrete surface	2.2.1	Type 1	P1, T5	≥ 1.5 (1.0) MPa
Crack-bridging ability:				
Resistance to chloride ion penetration	2.2.3	Type 1	P1, T5	<0.04%
Resistance to dynamic perforation	2.2.4.1	Type 1	P1, T5	suitable
Watertightness	2.2.7	Type 2	P1, T5	suitable
The influence of the substrate				
- adhesion to substrate influence – moisture	2.2.13.1	Type 1	P3, T5	≥ 1.5 (1.0) MPa
- adhesion to overlap impact – day joint (joint after 48 hours, up to a maximum of 7 days)	2.2.13.2	Type 1	P4, T5	≥ 1.5 (1.0) MPa
- adhesion to overlap impact – section joint (joint within 7 days to 6 months)	2.2.13.2	Type 1	P4, T5	≥ 1.5 (1.0) MPa
The materials in joint				
- change in hardness - water (WA)	2.2.14	Type 2	P1, S5.1	specify Δ IRHD
- change in hardness - alkali (Al)	2.2.15	Type 2	P1, S5.2	specify Δ IRHD
- change in hardness – mineral oil, diesel, petrol	2.2.16	Type 2	P1	specify Δ IRHD
UV radiation resistance (for exposed surfaces)	2.2.19		P1	specify
Slip resistance (for walking surfaces, system B)	2.2.23	Type 1	P1	specify
Abrasion resistance (for walking surfaces)	2.2.24	Type 1	P1	specify
Resistance to freezing/thawing (20 cycles)	2.2.25 / 2.2.1	Type 1	P1, S3, T5	≥ 1.5 (1.0) MPa

* Additional test conditions are specified in the test standards associated with EAD 030675-00-0107

THE REPUBLIC OF SLOVENIA

MINISTRY OF INFRASTRUCTURE

TECHNICAL SPECIFICATION TSG-211-XXX: 2025

TSG-211-XXX: 2025

Pursuant to Article 13 of the Roads Act (Official Gazette of the Republic of Slovenia, Nos 132/2022, 140/22 – ZSDH-1A, 29/23, and 78/23 – ZUNPEOVE) and Article 50(6) of the Railway Safety Act (Official Gazette of the Republic of Slovenia, Nos 30/18 and 54/21), the Minister of Infrastructure issues the following technical specification:

BRIDGE STRUCTURES

EXECUTION OF WATERPROOFING ON CONCRETE BRIDGE STRUCTURES

(implementation of waterproofing systems)

TSPI - PG.07.452: 2025

Minister of Infrastructure

M.Sc. Alenka Bratušek

Number:

Ljubljana,

1 Contents

Technical guideline TSPI PG.07.452 (Volume 2) sets out the procedures for the implementation of horizontal surface waterproofing systems on concrete bridge structures and other traffic surfaces made of concrete on public roads and railways in the Republic of Slovenia. The guideline does not apply to white box systems and to road and railway tunnels.

2 Determination of the entire waterproofing system and implementation

The waterproofing system is determined by the design, which must also define the entire upper structure for the bridge structure in question, including protective, connection or levelling and wear-resistant layers, and determine the sequence of implementation.

During construction work, especially renovation work, unforeseen circumstances may require changes to the waterproofing system, changes to the thickness of asphalt layers, etc. The changes must be addressed in the project supplement and in the Technological Expert's Detailed Report.

2.1 Technological Expert's Detailed Report

Before commencing construction work on an individual building, the contractor must prepare a Technological Expert's Detailed Report (TEDR) within a timeframe that allows the Contracting Authority to review, approve or return the report for amendments before work begins. Supplements must be approved before the start of the works. Individual TEDRs may contain independently treated works; it should be noted that TEDRs for waterproofing works and TEDRs for superstructures with protective, bonding and wear layers must contain at least the following information:

General information:

- road section / railway section,
- name of the bridge structure,
- stationing of a bridge structure,
- length, width of the structure, scope of work,
- description and complexity of the structure (e.g. screwdriving...),
- TEDR label and date,
- information about the manufacturer of the TEDR (company and person).

Responsible persons:

- responsible designer (company and person),
- the person responsible for preparing the basis (company and person),
- waterproofing (HI) contractor (company and person, as well as the entire HI implementation team by name, with proof of qualifications),
- the contractor of the protective, bonding and wearing course and the responsible person of the contractor,

- internal quality control contractor.

Equipment:

- information on the minimum equipment required to perform HI work, such as:
  - device for dry, dust-free sandblasting of concrete surfaces (with indication of power source)
  - a mechanical hammer for processing details,
  - a compressor to blow out the surface,
  - equipment for applying the base coat,
  - thermostatically controlled boiler for indirect heating of bituminous adhesive mixtures with forced mechanical mixing,
  - equipment for cutting/trimming of waterproofing,
  - gas heaters with flame regulator,
  - sleeves of 80–100 mm in diameter,
  - thermometers,
- information on the minimum equipment for the implementation of protective, bonding and wear barrier layers.

Materials:

- product certificates or Declarations of performance (DoP),
- technical data sheets with rules for the implementation and use of individual materials.

Method of implementation:

- information on the method of preparing the concrete surface (in the case of bridge renovation, also a description of the renovation method), a list of materials to be used for preliminary renovation of the concrete surface,
- determine the condition of the surface prior to waterproofing (cleanliness, moisture, roughness, cracks, dents, unevenness),
- the manner of controlling the evenness and gradients of the concrete surface and the arrangement for the drainage of rainwater during the execution of the works,
- the method of carrying out the sealing layer (bonding, overlapping),
- the minimum thickness of the individual layers of the HTN and the amount of consumption of individual materials to achieve this thickness,
- detail treatment; sealing around curbs, drains and downpipe drainage, drainage filter around curbs, sealing around expansion joints, etc.,
- possible errors in the implementation and correction of these errors,
- the manner in which the actual heights are controlled after the HI has been executed,
- information about all layers of the HI superstructure,
- the installation of asphalt layers must be addressed in the subject or separate TEDR,
- handling of the resulting construction waste.

Quality control content:

- list of internal control activities and frequency of implementation of the contractor's IQC activities.

3 Execution of the waterproofing system

3.1 Preparation of concrete surface

Regardless of the technology used to execute the waterproofing system, the concrete surface must be properly prepared. If the manufacturer of the waterproofing system does not condition a special technological procedure for the preparation of the concrete surface, the guidelines of this TSPI should be followed.

The subject TSPI specifies the procedures for the preparation of the concrete surface of bridge structures and other traffic surfaces made of concrete on public roads and railways for both new constructions and renovations of bridge structures.

3.1.1 Removal of existing waterproofing during the renovation of bridge structures

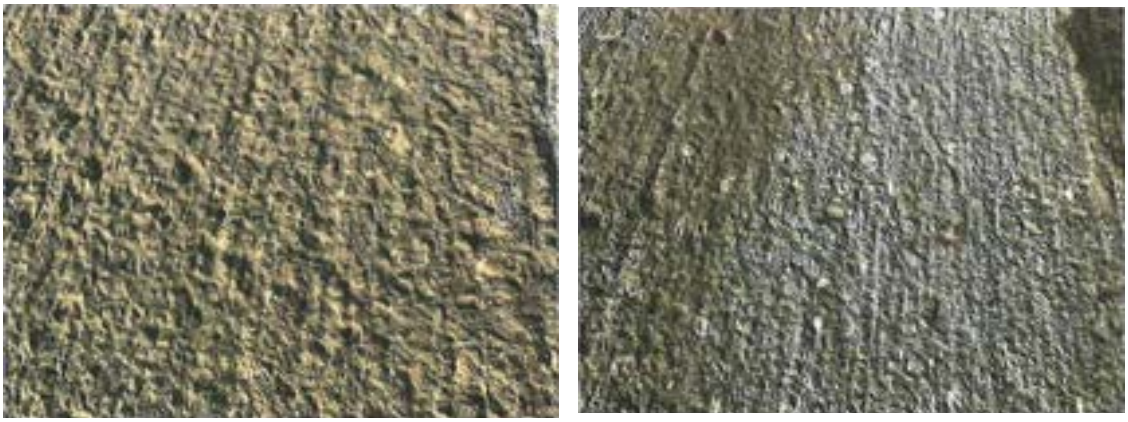
In the case of waterproofing renovation, all layers of protective and wear layers, including the existing waterproofing, must be completely removed from the bridge structure. As a rule, the asphalt layers are milled down to the waterproofing using a milling machine with a maximum tooth spacing of 15 mm on the drum. The remaining waterproofing shall be removed over the entire concrete surface, if necessary also mechanically (e.g. in the case of bituminous waterproofing, an excavator with a suitably sharp grading bucket may be used), up to approx. 15 cm from the edge of the sidewalks. After the coarse removal of the existing waterproofing system, a fine milling of the concrete surface is carried out by means of a milling machine with a maximum tooth spacing of 8 mm on the drum.

The pictures show three steps: the first step – removal of the existing asphalt pavement by milling down to the waterproofing (Figure 8.1 a), the second step – removal of the waterproofing with a grading bucket with an additional sharp blade for scraping (Figure 8.1 b) and the third step – milling of the surface of the concrete deck structure (Figure 8.2).

Figure 8.1: Preparation of the concrete surface a) and b)

Figure 8.2: Preparation of the concrete surface c)

The difference between milling with different machine equipment is in the texture of the milled surface. For the most commonly used drum intended for milling asphalt reinforcements where the spacing between the teeth is up to 15 mm, the theoretical height between the highest and lowest point in the texture is 4.33 mm (Figure 8.3 a), and for a “fine” drum where the spacing between the teeth is reduced to 8 mm, the theoretical height between the highest and lowest point in the texture is 2.31 mm (Figure 8.3 b).



(a) (b)

Figure 8.3: Surface after milling with drum with a spacing between the teeth a) 15 mm and b) 8 mm

3.1.2 Cleaning of the concrete surface (for new constructions and renovations)

During renovations, old coatings and waterproofing residues must be removed from the concrete surface as much as possible. If, despite cleaning, there are still traces of old coatings on the concrete surface, test areas (small test surfaces) should first be created to test the materials we intend to use. It must be determined whether the materials (old coatings and new primer) are compatible. Based on the results obtained on the test fields, a decision must be made as to whether the old coatings and epoxy patches should be completely removed, partially removed or simply roughened by sandblasting.

Before applying the waterproofing, all loose concrete particles, cement slurry or other substances (e.g. impurities) must be removed from the concrete surface. Removal by such processes that treat the surface evenly is permitted. No concrete surface preparation process

should damage the structure of the concrete surface, and the choice of surface preparation method must take into account the type of waterproofing system that will be applied to the treated concrete surface.

The following procedures are allowed:

- dry dust-free ball blasting or wet blasting,
- for the treatment of details, other methods of concrete surface preparation are also permitted, e.g. mechanical hammering, bush hammering, grinding, etc.,
- high-pressure washing with rotating nozzles, where the water pressure (from 500 to 2500 bar) must be set so as to achieve the required condition of the concrete surface without causing structural damage to the concrete surface.

These procedures must ensure that the concrete surface will be sufficiently rough and without sharp edges.

The substrate must be clean and dry (free of dust and oil stains) before waterproofing. Visible metal elements that do not serve a structural function (e.g. formwork tie rods) shall be removed. Metal elements that cannot be removed and onto which the waterproofing will be applied shall be thoroughly cleaned and protected against corrosion.

3.1.3 Inclination of the concrete surface

Concrete surfaces of road bridge structures and other traffic areas that are to be waterproofed shall, in order to prevent water ponding on the waterproofing surface, have a resultant slope of at least 2% at every point.
For railway bridge structures with spans of up to 30 m, the slope of the concrete surface follows the longitudinal level of the track, and in certain cases the deck slab may also be horizontal (culverts are an exception to this, with their usual roof slope).
In areas where the gradients of the concrete surface are not feasible due to structural constraints and there may be stagnation of water in the surface of the waterproofing or in the protective layers of waterproofing, the project must ensure that all lower surfaces are drained (e.g. by downpipe drainage, with drains connected with drainage gutters, etc.) before the start of the waterproofing.

3.1.4 Concrete surface flatness

The concrete surface must not have any protrusions (concrete lumps) or depressions. Local deviations from the flatness of the concrete surface must be checked with a 4.0 m lath. The investigation of the flatness check is described in Section 9.1.3 of this TSPI. Flatness measurements shall be carried out after the surface of the concrete has been prepared on each bridge structure. Representative locations are selected. The test site must be clean. The height “h” between the lath and the substrate shall be measured. Deviations below the four-meter lath (height difference h between the substrate and the lath) shall not exceed the given requirements in Table 8-1.

Table 8-1: Requirements for the flatness of the concrete surface at distances of 1 m, 2 m and 4 m

Distance between measurement points	1 m	2 m	4 m
For bitumen waterproofing sheets – mechanical installation or manual installation without pouring-in	h = 5 mm	h = 10 mm	h = 15 mm

For bitumen waterproofing sheets - manual installation with pouring of hot bituminous adhesive compound	h = 10 mm	h = 20 mm	h = 40 mm
For liquid applied waterproofing system	h = 10 mm	h = 20 mm	h = 40 mm

3.1.5 Concrete surface roughness

The test of the roughness depth measurement by the sand method is described in Chapter 9.1.2 of this TSPI. The result of the test is the average value of the roughness depth (Hrb) in mm.
The test is carried out after preparing the surface of the concrete before the execution of the base coat of the bituminous solution (or after the epoxy coating has been carried out). Table 8-2 sets out the requirements for the minimum and maximum surface roughness depth before carrying out the base coat of the bituminous solution or after carrying out the epoxy coating.

Table 8-2: Required depth of surface roughness before waterproofing

Waterproofing systems	Hrb and recesses
Epoxy coatings and bitumen sheets with pouring of hot bituminous adhesive compound (base coat system O1 or O2*)	Roughness after epoxy coating Hrb from 0.3 mm to 1.5 mm, permissible point recesses to a depth of 10 mm and a surface of approx. 2 cm^2
Bitumen solution and bitumen sheets with pouring of hot bituminous adhesive compound (base coat system PP3*)	Roughness Hrb from 0.3 mm to 1.5 mm, permissible point recesses to a depth of 5 mm and a surface of approx. 2 cm^2
Bitumen solution and bitumen sheets with welding (without an adhesive mixture) (base coat system PP3*)	Roughness Hrb from 0.3 mm to 1.0 mm, permissible point recesses to a depth of 5 mm and a surface of approx. 2 cm^2
Liquid applied waterproofing (unless otherwise specified by the manufacturer) (PP1 and PP2* systems)	Roughness Hrb up to 2.0 mm, permissible point recesses to a depth of 10 mm and a surface of approx. 2 cm^2

* Basic coat systems for waterproofing O1,O2, PP1, PP2, PP3 are described in point 8.2.1 of this TSPI.

If the depths of roughness are greater, they must be repaired, unless the Contracting authority and the Contractor agree otherwise, taking into account reference practice.

3.1.6 Moisture in concrete

The prepared concrete surface must be properly dry before the start of the waterproofing system or in accordance with the technical requirements of the material used for waterproofing.

The moisture content of concrete depends primarily on the age of the concrete and environmental conditions. When planning the entire waterproofing system for the structure in question, the drying time of the concrete structure must be taken into account. During planning, it shall be taken into account that, within a period of less than 28 days after completion of the concrete works, a waterproofing system shall be selected that allows a concrete moisture content of up to 6.0 m.% or is insensitive to moisture and can be applied to a concrete surface as early as 48 hours after casting.

For standard waterproofing procedures, the moisture content requirement for concrete is ≤ 4.0 m.%. This requirement does not apply to the special PP2 waterproofing system (Table 8-4) and an appropriate waterproofing system must be used.

The moisture content of the concrete must be checked using one of the following procedures:

- non-destructive with a moisture meter that operates on the principle of dielectric constant measurement,
- with the carbide method (CM) described in point 9.1.1 of this TSPI,
- gravimetrically by drying at a temperature of 110 +/-5°C to constant mass.

For concrete structures younger than 28 days, moisture must be checked non-destructively with a moisture meter and the CM method (on a concrete sample taken from a depth of 2 cm to 4 cm) and, in case of doubt, also gravimetrically. For concrete surfaces older than 28 days, only a moisture meter or CM method may be used. The tests must be carried out before the base coats (primers) are carried out. Representative locations are selected. Non-destructive measurements with the moisture meter shall be carried out throughout the execution of the waterproofing works. Special attention should be paid to details at expansion joints, concrete safety barriers (BVO), outlets and downpipe drainage, etc.

3.1.7 Levelling uneven concrete surfaces with mortar

Any deviations in the height of the cement concrete surface exceeding 5 mm above the values permitted in Table 8.1 must be levelled with an appropriate levelling layer of epoxy mortar or a layer of other suitable repair mortar in good time before applying the base coat. Unevenness or recesses of deviation above 5 mm shall be smoothed (reprofiled) in the ways given in Table 8-3.

Table 8-3: Rehabilitation measures depending on the depth of unevenness or recesses

Depth of the recess or thickness of the coating	Coating	Measure
from 5 mm to 20 mm	Levelling layer of epoxy mortar. Quantity of components (epoxy resin and stone material) according to the manufacturer's instructions	As with the OD* system — epoxy mortar and broadcasting
from 20 mm to 40mm		
from 20 mm to 40mm	Levelling layer – cement mortar with modifiers (e.g. micro-reinforced repair cement mortar). Recipe according to the manufacturer’s instructions.	Implementation according to the manufacturer's instructions
over 40 mm	Levelling layer - cement mortar with modifiers. Recipe according to the manufacturer’s instructions	Implementation according to the manufacturer's instructions

* OD system described in point 8.2.1 of this TSPI

Epoxy mortar is produced on site by adding hot-dried quartz sand to epoxy resin. A combination of quartz sands of grain sizes A and B, as specified in point 4.2.2 of this TSPI, is usually used (the grain size of the sand may be adjusted to the thickness of the required coating in agreement with the contracting authority). After the repaired area has been cleaned, hot-dried quartz sand of grain size B, as described in point 4.2.2 of this TSPI, is spread onto the still fresh mortar.
If the area of uneven concrete surface is very large, the most appropriate method of repairing

the concrete slab should be considered in the project supplement.
Cement materials must be specified in the project and must comply with the SIST EN 1504-1 to -10 series of standards.

3.1.8 Pull-off strength of concrete surface

The test is described in Chapter 9.1.4 of this TSPI. The test is carried out after the surface of the concrete has been prepared, before the application of base coatings.

Pull-off strength on concrete surface:
required average value: ≥ 1.5 MPa,
permissible minimum value: ≥ 1.0 MPa.

If the tests do not achieve the required tensile strength, the concrete base must be further prepared and reinforced (the Contractor shall specify the procedure in a supplement to the TEDR, which shall be reviewed and approved by the contracting authority).

3.2 Systems and application of base coats

If the manufacturer of the waterproofing system does not specify a special technological procedure for applying the base coat to the prepared concrete surface, the guidelines of this TSPI must be followed.

Waterproofing systems with BHT must have a base coat made of epoxy resin or a special bitumen solution.

HTNs contain a systemic primer compatible with the waterproofing membrane (specified in the system kit and approved by EAD – European Assessment Document).

3.2.1 Primer systems

The types and selection of primers and multilayer coating systems are described in Table 8-4.

The standard procedure O1 is most commonly used on new road bridge structures with moisture content in concrete ≤ 4m.%.

The standard procedures O2 and OD (standard and standard additional procedure) are most commonly used in the renovation of concrete bridge structures.

The special procedure PP1 is most commonly used on new or old concrete surfaces and on renovated concrete surfaces with moisture in concrete ≤ 4 m.%,

The special procedure PP2 is most commonly used on new or old concrete surfaces and on renovated concrete surfaces with moisture content in concrete ≤ 6 m.%,

The special procedure PP3 is most commonly used on new railway bridges and “buried” road structures and other traffic areas with moisture in concrete ≤ 4 m.%.

When renovating details of a bridge structure (e.g. replacing expansion joints), the project must also include a time frame for the renovation. For this, repair mortars with the properties of rapid compressive strength extraction and initial low moisture content should be selected

accordingly. As a result, the project shall also determine the appropriate coating system (from Table 8-4) and the implementation of waterproofing.

Table 8-4: System for applying primers

Label	Procedure	Use	Quantity and layers (over the entire surface)
O1	basic epoxy coating or PMMA coating (two-layer)	on new concrete surfaces of road and rail bridge structures with moisture in concrete ≤ 4 m. % (PMMA according to manufacturer's instructions)	• epoxy coating 1st layer: > 400 g/m^2 • broadcasting from 1.5 kg to 2.0 kg/m^2 grain size B • epoxy coating 2nd layer: > 300 g/m^2
O2	basic epoxy coating or PMMA coating (two-layer)	on old (milled) concrete surfaces of road and rail bridge structures with moisture in concrete ≤ 4 m. % (PMMA according to manufacturer's instructions)	• epoxy coating 1st layer: > 400 g/m^2 • broadcasting from 1.5 kg to 2.0 kg/m^2 grain size B • local epoxy mortar with dry quartz sand of grain size A, applied with a trowel and broadcast with grain size B • epoxy coating 2nd layer: > 300 g/m^2
OD	levelling local unevenness with epoxy mortar (in addition to system O1 or O2)	on new and old concrete surfaces with moisture in concrete ≤ 4 m.%, roughness of depth from 5 mm to 40 mm	• epoxy mortar with dry quartz sand of grain size A (grain size from 0.1 to 1.2 mm for smaller and 0.1 to 1.5 mm for larger recesses) • broadcasting: approx. 0.5 kg/m^2 locally, grain size B (actual consumption is taken into account)
PP1	primer	on new or old concrete surfaces and on renovated concrete surfaces with moisture in concrete ≤ 4 m.%	Liquid applied waterproofing system. Primers according to the requirements of the manufacturer of the waterproofing system.
PP2	primer for increased concrete moisture	on new or old concrete surfaces and on renovated concrete surfaces with moisture in concrete ≤ 6 m.%	Liquid applied waterproofing system. Primers according to the requirements of the manufacturer of the waterproofing system.
PP3	primer with bitumen solution	on new and old concrete surfaces of structures with moisture in concrete ≤ 4 m. % (mainly for buried structures)	The amount of primer depends on the concrete surface; the entire surface must be saturated with bitumen, and excess bitumen solution must not accumulate in recesses (usually for railway bridge structures with concrete protection or for road bridge structures with reduced traffic loads, as well as "buried structures")

The standard procedure O1, which is most commonly used on new road bridges, is shown in Figure 8.4.

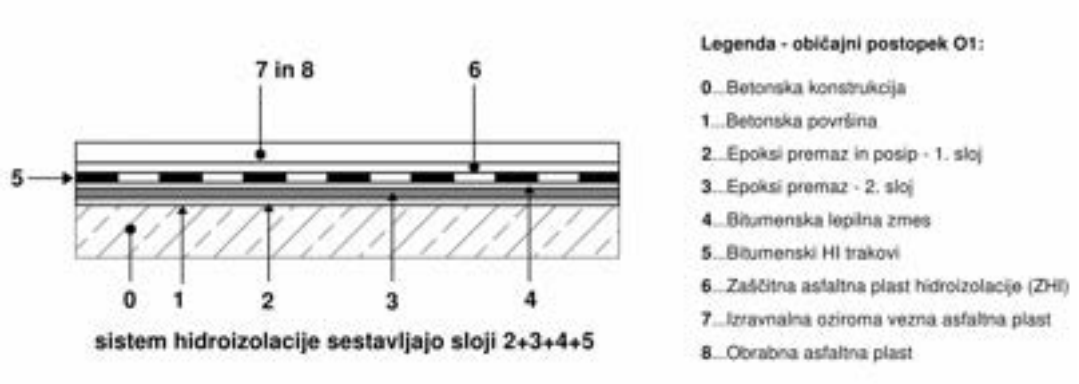


Figure 8-4: Standard procedure – O1

sistem hidroizolacije sestavljajo sloji	the waterproofing system consists of layers
Legenda – običajni postope O1:	Legend – standard procedure O1:
0. Betonska konstrukcija	0. Concrete structure
1. Betonska površina	1. Concrete surface
2. Epoksi premaz in posip – 1. sloj	2. Epoxy coating and broadcasting – 1st layer
3. Epoksi premaz – 2. sloj	3. Epoxy coating – 2nd layer
4. Bitumenska lepilna zmes	4. Bituminous adhesive mixture
5. Bitumenski HI trakovi	5. Bitumen HI sheets
6. Zaščitna asfaltna plast hidroizolacije (ZHI)	6. Protective asphalt layer of waterproofing (ZHI)
7. Izravnalna oziroma vezna asfaltna plast	7. Regulating or binder asphalt course
8. Obrabna asfaltna plast	8. Asphalt wearing course

The standard procedures O2 and OD (standard, additional procedure), which are most commonly used on renovated road bridges, are shown in Figure 8.5.

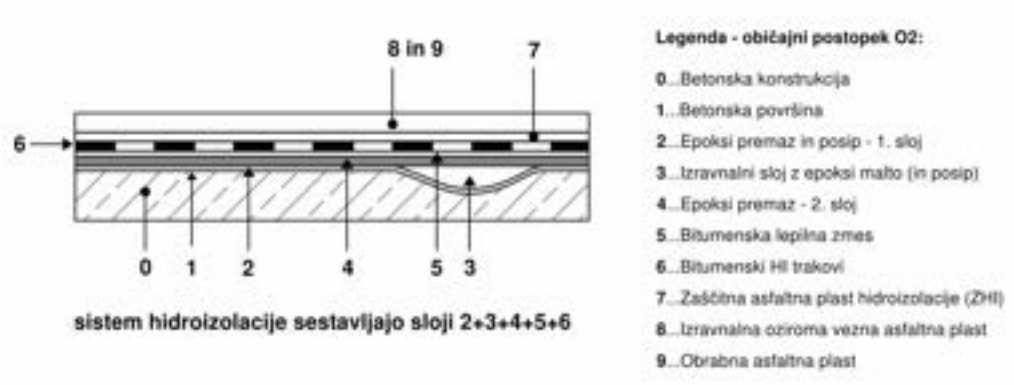


Figure 8-5: Normal procedure – O2 and OD

sistem hidroizolacije sestavljajo sloji	the waterproofing system consists of layers
Legenda – običajni postope O2:	Legend – normal procedure O2:
0. Betonska konstrukcija	0. Concrete structure
1. Betonska površina	1. Concrete surface
2. Epoksi premaz in posip – 1. sloj	2. Epoxy coating and broadcasting – 1st layer
3. Izravnalni sloj z epoksi malto (in posip)	3. Levelling layer with epoxy mortar (and broadcasting)
4. Epoksi premaz – 2. sloj	4. Epoxy coating – 2nd layer
5. Bitumenska lepilna zmes	5. Bituminous adhesive mixture
6. Bitumenski HI trakovi	6. Bitumen HI sheets
7. Zaščitna asfaltna plast hidroizolacije (ZHI)	7. Protective asphalt layer of waterproofing (ZHI)
8. Izravnalna oziroma vezna asfaltna plast	8. Regulating or binder asphalt course
9. Obrabna asfaltna plast	9. Asphalt wearing course

3.2.2 Test before and during the application of primers

The application of epoxy resins, PMMA coatings and bituminous solutions must be carried out in accordance with the material manufacturer's instructions.

The following parameters must be determined and recorded before the start of the execution of the primers and during execution:

- moisture content of the concrete surface prepared for the primer,
- air temperature and concrete surface temperature, air humidity and dew point temperature,
- temperature of the material being applied.

Table 8-5: Dew point temperatures depending on relative air humidity and air temperature

Relative air humidity	30%	40%	50%	55%	60%	65%	70%	75%	80%	85%
Air temperature	Dew Point Temperature									
1°C	-14,7	-11,1	-8,3	-7.0	-5,9	-4,8	-3,9	-2,9	-2,1	-1.2
2°C	-13,8	-10,2	-7.3	-6.1	-5.0	-3,9	-2,9	-2.0	-1.1	-0,3
3°C	-12,9	-9,3	-6,4	-5,2	-4,0	-2,9	-1,9	-1,0	-0,1	0,7
4°C	-12.0	-8,4	-5.5	-4,2	-3.1	-2.0	-1.0	0.0	0.9	1.7
5°C	-11.2	-7,5	-4.6	-3.3	-2.1	-1.0	0,0	0,9	1.8	2.7
6°C	-10.3	-6,6	-3.6	-2.3	-1,2	-0,1	1,0	1,9	2,8	3,7
7'C	-9,4	-5,7	-2,7	-1,4	-0,2	0,9	1,9	2,9	3,8	4,7
8°C	-8.5	-4,8	-1.8	-0.5	0.7	1.8	2,9	3.9	4.8	5.6
9°C	-7.6	-3,9	-0.8	0.5	1.7	2,8	3,8	4,8	5.7	6.6
10"C	-6.8	-3,0	0,1	1,4	2.6	3.7	4,8	5,8	6,7	7,6
11°C	-5.9	-2,0	1,0	2,3	3,6	4,7	5.8	6,8	7.7	8,6
12°C	-5,0	-1,1	1.9	3.3	4,5	5.7	6.7	7.7	8.7	9.6
13°C	-4,1	-0,2	2,9	4.2	5.5	6.6	7.7	8.7	9,7	10,6
14°C	-3,3	0,7	3,8	5.1	6,4	7,6	8,6	9,7	10,6	11,5
15°C	-2,4	1,6	4,7	6,1	7,3	8,5	9,6	10,6	11,6	12,5
16°C	-1.5	2,5	5.6	7.0	8,3	9,5	10.6	11,6	12,6	13,5
17°C	-0,6	3,4	6.6	8,0	9.2	10,4	11,5	12,6	13,6	14,5
18°C	0,2	4,3	7,5	8,9	10,2	11,4	12,5	13,5	14,5	15,5
19°C	1,1	5,2	8.4	9,8	11,1	12,3	13,5	14.5	15,5	16,4
20°C	2,0	6.1	9,3	10.8	12.1	13,3	14,4	15,5	16,5	17.4
21°C	2.9	7,0	10,3	11,7	13,0	14,2	15,4	16,4	17,5	18,4
22°C	3,7	7,9	11,2	12,6	14.0	15,2	16,3	17,4	18,4	19,4
23°C	4.6	8,8	12,1	13,6	14.9	16.1	17,3	18.4	19.4	20.4
24°C	5.5	9,7	13,0	14,5	15,8	17.1	18.3	19.3	20.4	21,4
25°C	6,4	10,6	14,0	15,4	16,8	18,0	19,2	20,3	21,3	22,3
26°C	7.2	11,5	14.9	16,4	17,7	19,0	20,2	21.3	22,3	23,3

27°C	8.1	12,4	15.8	17.3	18.7	19.9	21,1	22.2	23.3	24.3
26°C	9,0	13,3	16,7	18.2	19,6	20,9	22,1	23.2	24,3	25.3
29°C	9,8	14,2	17,7	19.2	20,5	21,8	23,0	24,2	25,2	26,3
30°C	10,7	15.1	18.6	20,1	21,5	22.8	24.0	25.1	26,2	27,2

Example of application of Table 8-5:

Air temperature 20°C, relative humidity 65% = dew point 13.3°C.

The surface temperature of the concrete must be at least 3°C above the dew point when the primer is applied, which in the example shown is 16.3°C.

3.2.3 Primer with epoxy resin or PMMA

Primer with epoxy resin or PMMA is applied in two steps:

- 1. epoxy coating – epoxy primer applied to the prepared concrete surface to ensure good adhesion between the concrete surface and the waterproofing system and to close the pores in the concrete,
- 2. epoxy coating - epoxy sealing coating which, in multi-layer epoxy coating processes, is the final coating before BHT is laid.

Works with epoxy resins cannot be carried out without appropriate protective measures under the following external conditions:

- during rainfall, dew formation or humidity due to fog,
- if the relative humidity of the air is greater than 85%,
- if the surface temperature of the substrate, i.e. concrete, is below +8 °C (exceptionally +5 °C, if the epoxy resin allows this and it is specified in the technical data sheet),
- if the surface temperature of the concrete substrate exceeds +35°C (exceptionally +40°C, if the epoxy resin allows this and it is specified in the technical data sheet) or
- if the air temperature rises or falls rapidly.

The surface temperature of the concrete for the application of the primer shall be at least 3°C above the dew point temperature, determined according to Table 8-5.

Multi-component PMMA coatings must be mixed according to the manufacturer's instructions. Changing the materials or their composition and mixing ratios is not permitted unless otherwise specified in the instructions.

The depth of roughness of the concrete substrate for the primer with epoxy resin is not specified as a rule (it is specified after the application of epoxy coatings, Table 8-2).

The first coat should be applied to the prepared concrete surface according to the manufacturer's instructions (with a brush, roller or scraper). The required amount of epoxy resin (usually 300 to 500 g/m^2) should be spread evenly so that no puddles remain. The fresh surface of the applied epoxy resin must be coated evenly with a suitable amount of dried quartz sand of grain size between 0.6 mm and 1.2 mm (Chapter 4.2.2).

Any loose material that is not adhered to the surface after the epoxy resin has hardened must be removed by brushing and blowing.

The joints of the individual layers of primers and layers of treated surfaces shall be stepped in a straight line and at least 10 cm apart from each other.

Epoxy coatings should also not be applied if the ambient temperature is rising rapidly. If necessary, the surface of the concrete shall be shaded in hot and sunny weather. The temperature of the epoxy coatings during storage must not exceed 30°C. In cold weather, the surface of the concrete shall be protected from cold and precipitation, heated and dried (ventilated tent).

3.2.4 Primer with bitumen solution

When sealing the surfaces of railway bridge structures, a suitable bituminous solution is usually used as the primer. When sealing horizontal surfaces of concrete road structures, a suitable bituminous solution may also be used as a primer under certain conditions (Table 8-4).

The depth of roughness of the substrate for the primer with bitumen solution is defined in section 8.1.5 of this TSPI.

Application cannot be carried out without appropriate protective measures in the following external conditions:

- during rainfall, dew formation or humidity due to fog,
- if the relative humidity of the air is greater than 85%,
- if the surface temperature of the substrate, i.e. concrete, is below + 5°C. If the manufacturer of the bituminous solution guarantees that the product can be applied at a lower temperature, this must be proven in advance by means of a test installation.
- if the air temperature or the surface temperature of the concrete base is above +35°C.

The surface temperature of the concrete for the application of the primer shall be at least 3°C above the dew point temperature, determined according to Table 8-5.

The prepared concrete surface (same as for epoxy coating) must be evenly coated with a cold bitumen solution (usually 200 to 400 g/m^2) using a brush or roller. The amount of binder applied must be without any excess.

3.2.5 Inspection after application of primer

Visual inspection must be carried out if the surface is uniform and properly treated (the surface must not be demolished, it must be flat, without recessess in which water may accumulate...). The pull-off strength shall be measured on the final coat of epoxy coatings and HTN primers. In case of doubt, or in case of execution under marginal conditions, the pull-off strength shall be measured on all layers of the epoxy coating.

3.2.6 Pull-off strength of epoxy or PMMA coatings and liquid applied waterproofing coatings

The test is described in Chapter 9.1.4 of this TSPI. It shall be carried out after application of epoxy coatings and rehabilitation with epoxy mortar.

Pull-off strength on epoxy coatings and HTN coatings:

required average value: ≥ 1.5 MPa,
permissible minimum value: ≥ 1.0 MPa.

If the required pull-off strength is not achieved with tests on epoxy or PMMA coatings and coatings for HTN, the causes must be investigated and, if necessary, the coatings must be removed and reapplied (the contractor shall specify the procedure in a supplement to the TEDR, which shall be reviewed and approved by the contracting authority).

3.3 Execution of waterproofing systems with bitumen waterproofing sheets (BHT)

This chapter lays down the procedures for the execution of BHT waterproofing systems on concrete bridge structures and other traffic surfaces made of concrete on public roads and railways.

3.3.1 Order of execution of the waterproofing system

Before the start of waterproofing works, the sequence of execution should be clearly specified in the TEDR. If the waterproofing system cannot be carried out in one phase, but must be divided into several phases, it must be possible to drain rainwater during the execution of the individual phases. Adequate covering of BHT joints must be ensured. The lower sheets are covered by the higher ones, so a plan for laying and covering the sheets must be drawn up.

The following implementation options are described and schematically illustrated below:

Method 1: BHT is laid across the entire width of the structure, including underneath (Figure 8.7).

Method 2: BHT is first laid only under the carriageway, and later in the areas under and part of the kerbs (Figure 8.8).

Method 3: BHT is first placed only under the corridors/edge kerbs, the kerb/edge kerb is constructed and then the BHT is placed under the carriageway (Figure 8.9).

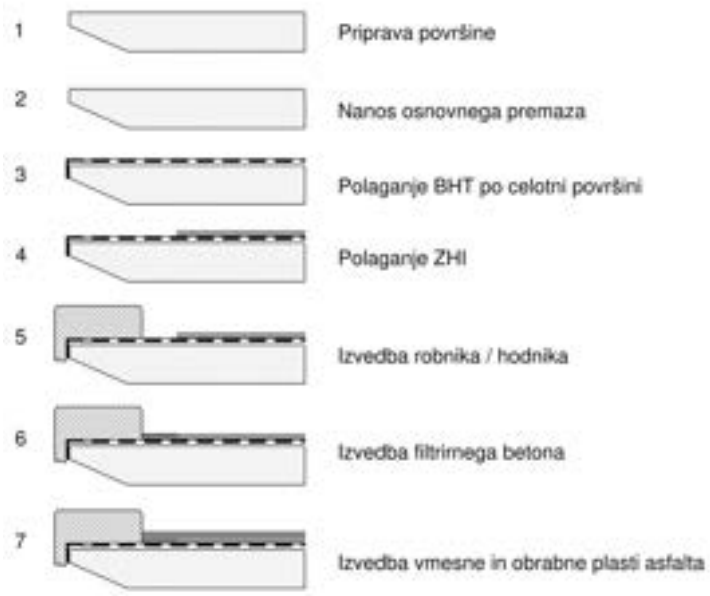


Figure 8.7: Schematic representation of the BHT implementation sequence over the entire surface

Priprava površine	Surface preparation
Nanos osnovnega premaza	Application of the primer
Polaganje BHT po celotni površini	BHT laying over the entire surface
Polaganje ZHI	Laying of ZHI
Izvedba robnika / hodnika	Construction of kerb / corridor
Izvedba filtrirnega betona	Implementation of filter concrete
Izvedba vmesne in obrabne plasti asfalta	Construction of intermediate and wearing courses of asphalt

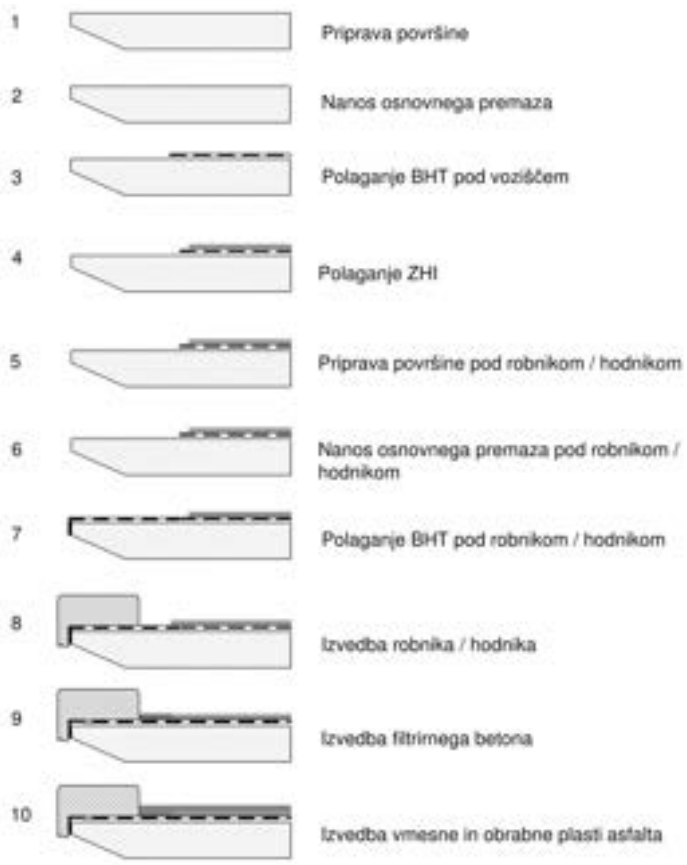


Figure 8.8: Schematic representation of the sequence of BHT implementation under the roadway and under the corridors

Priprava površine	Surface preparation
Nanos osnovnega premaza	Application of the primer
Polaganje BHT pod voziščem	Laying BHT under the carriageway
Polaganje ZHI	Laying of ZHI
Priprava površine pod robnikom / hodnikom	Preparation of the surface under the kerb/corridor
Nanos osnovnega premaza pod robnikom / hodnikom	Applying the primer under the kerb/corridor
Polaganje BHT pod robnikom / hodnikom	Laying BHT under the kerb/corridor
Izvedba robnika / hodnika	Construction of kerb / corridor
Izvedba filtrirnega betona	Implementation of filter concrete
Izvedba vmesne in obrabne plasti asfalta	Construction of intermediate and wearing courses of asphalt

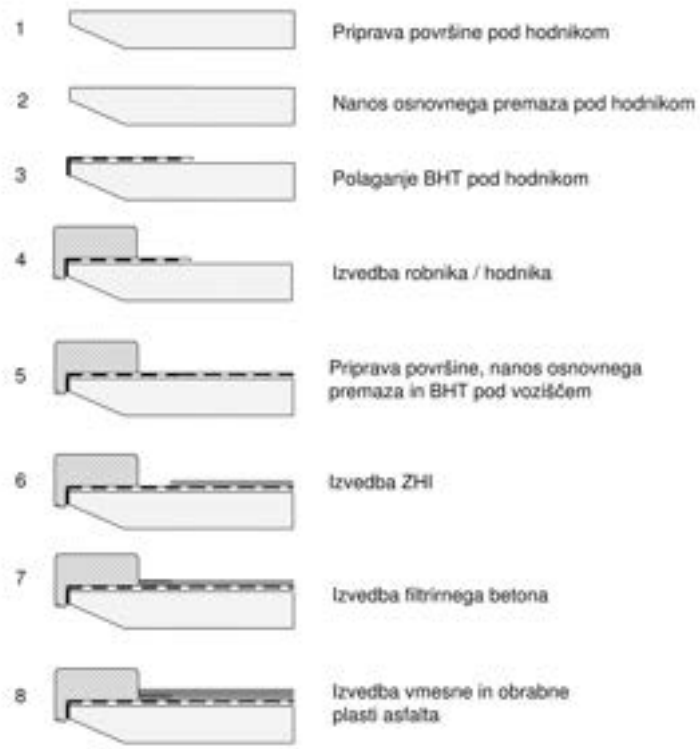


Figure 8.9 Schematic representation of the BHT execution sequence under corridors and under the carriageway

Priprava površine pod hodnikom	Preparation of the surface under the corridor
Nanos osnovnega premaza pod hodnikom	Application of primer under the corridor
Polaganje BHT pod hodnikom	Laying BHT under the corridor
Izvedba robnika / hodnika	Construction of kerb / corridor
Priprava površine, nanos osnovnega premaza in BHT pod vozišče	Surface preparation, application of primer and BHT under the carriageway
Izvedba ZHI	Execution of the ZHI
Izvedba filtrirnega betona	Implementation of filter concrete
Izvedba vmesne in obrabne plasti asfalta	Construction of intermediate and wearing courses of asphalt

3.3.2 Laying of bitumen waterproofing sheets

This chapter describes the installation of a single-layer BHT system using a system of bonding with heated sheets and simultaneous pouring of hot bituminous adhesive mixture or direct welding without pouring. The nominal thickness of BHT for the sealing of horizontal surfaces of bridge structures in both cases must be ≥ 5 mm and have the properties specified in SIST EN 14695, the national standard SIST 1031 and in point 4.2.5 of Volume 1 of this TPSI.

In the case of railway concrete bridge structures, the installation of the two-layered system follows the same procedure, in the case of no pouring the adhesive mixture, full bonding of the BHT with the substrate is required. When installing the second layer of BHT, full adhesion must also be ensured. The nominal thickness of BHT for the sealing of horizontal surfaces of railway bridge structures must be ≥ 4 mm or ≥ 5 mm and with the characteristics specified in SIST EN 13969 and in the national standard SIST 1031.

3.3.2.1 Checks before laying of bitumen waterproofing sheets

Before starting to lay the BHT, checks must be carried out and the results documented (Chapter 10 – Quality Assessment).

3.3.2.2 Laying of bitumen waterproofing sheets

Before laying, the prepared concrete surface and the applied primer shall be thoroughly cleaned and blown out with compressed air, which must be free of oils. Cleaning should take place just before the start of BHT laying. During the laying of BHT, the temperature of the concrete surface and the surrounding area must be at least +5°C.

The individual BHTs must first be unrolled and distributed around the structure and prepared for installation (e.g. cut, folded and cut to size). BHT remains shorter than 1 m may no longer be used. Several short pieces of BHT may not be laid one after the other. Where structural limitations arise (e.g. penetrations, drains, kerbs, etc.), additional elements must be installed to seal the details.

Properly prepared and adjusted BHT must be wound onto sleeves with appropriate rigidity. During the repeated slow unrolling, the BHT shall be heated uniformly (e.g. by a gas burner, multiple burners simultaneously or other uniform heat source) over the entire width of the sheet, thereby thermally activating the bituminous mixture beneath the carrier fabric. The basic conditions for heating BHT shall be specified by the manufacturer of the sheet. The temperature of the heat source (distance from the BHT and installation speed) must also be adjusted to external conditions (temperature, wind).

As a rule, BHT shall be laid in the longitudinal direction of the structure and only exceptionally in the transverse direction. The sheets of each layer must be laid with an overlap of 8 to 10 cm in the longitudinal direction and 10 to 12 cm in the transverse direction, with the sheets offset by at least 50 cm in the transverse direction (Figure 8.10). BHTs, which are laid higher in relation to the direction of water run-off, must be placed over the lower sheets and always laid in such a way as to ensure a smooth run-off of water. In the case of bridge structures with a transverse roof slope, the BHT must be laid from the lower-lying areas towards the highest part. In the case of a two-layer system, the coating of the second layer shall not be carried out at the same locations as the coating of the first layer was carried out.

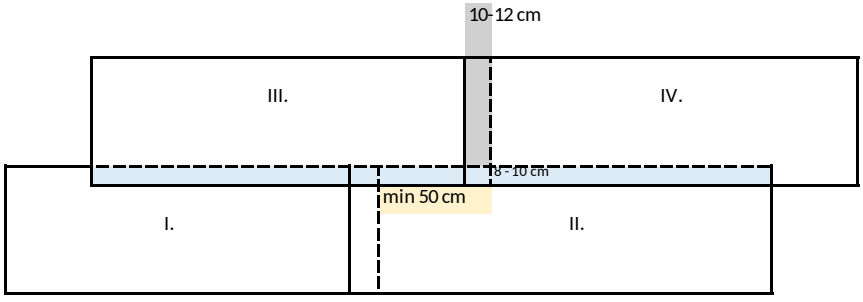


Figure 8.10: Schematic representation of BHT overlaps

The bituminous adhesive mixture must be heated in a boiler with indirect heating and thermostatic temperature control and with forced mechanical mixing to the temperature specified by the adhesive mixture manufacturer. Due to the technical properties of the adhesive mixture, only boilers with mixers may be used, which ensure that heating is indirect and uniform and that the mixture does not overheat locally. Boilers must have thermostatic temperature control, and the temperature must also be measured at the boiler outlet with a manual thermometer. The volume of the boiler must allow for the addition of unmelted adhesive mixture without causing excessive temperature fluctuations.

Bituminous adhesive mixtures must not be heated above 270°C in the boiler (unless otherwise specified in the manufacturer's instructions) and may be stored at this temperature for a maximum of 5 hours. The bituminous adhesive mixture must be heated slowly and applied evenly (poured from the boiler). The chilled remainder may be heated no more than once again.

When laying BHT, the appropriate amount of hot adhesive mixture must be poured directly under the BHT. It must be applied evenly and under the entire lower surface of the BHT in an amount of 2.0 kg to 2.5 kg/m^2 to achieve good adhesion. In the case of BHT supplied wound on a core of adequate stiffness, when re-unrolling for either welding or bonding, a sufficient amount of molten (plasticized) bituminous compound shall always be present to form a small ridge. Immediately after unrolling, the BHT shall be evenly pressed onto the substrate (e.g. with a roller) to ensure full-width adhesion and to expel all air from beneath the sheet.

When heating BHT with a burner flame, the sheet must be heated evenly across the entire width of the roll. The BHT may only be heated to the level specified by the manufacturer. The flame temperature of the burners must be adjusted to external influences, care must be taken not to damage the basic epoxy or bituminous coating.

Bituminous adhesive mixture that has run out at the edges of the BHT or has been squeezed out from under the sheets must be spread evenly at the contact point using appropriate smoothing tools. In the event of an excessive amount of extruded bituminous compound, it must be removed in an appropriate manner. If, at any part of the joint, the bituminous compound has not emerged or insufficient sealing is identified, such areas shall be additionally sealed by pouring or underpouring.

The migration of bituminous compound at the area of end joints of the BHT into the overlying asphalt mixture layers shall be prevented by covering the joint area with an approximately 20 cm wide self-adhesive bandage tape. Any additional bonding of these sheets to the substrate that may be necessary should be achieved by carefully heating the contact area.

If BHTs run over the edges of the structure, it must first be ensured that the edges are not sharp. The edges must be rounded with a radius of at least 5 cm (Figure 8-11).

Figure 8.11: BHT implementation over the edges

Special attention should be paid to drains, downpipe drainage and other elements where water flows away from the building. When connecting to bridge outlets or other elements of different shapes and materials, the appropriate condition of these elements must be ensured first (remove rust, paint, protect them,...). The element protection used must be compatible with bituminous bonding mixture and BHT.

Once laid, BHT must be immediately protected from possible mechanical damage and exposure to UV rays (e.g. with geosynthetics). Driving on laid BHT is prohibited, except for the purposes of applying a protective layer. However, when driving on laid BHT cannot be avoided, the vehicle must be moved and stopped slowly and without changing direction. It is prohibited to store construction materials and park machinery on the completed waterproofing.

3.3.2.3 Checks during and after the execution of the laying of bituminous waterproofing sheets

During BHT laying, weather conditions, the temperature of the adhesive mixture, the heating time of the adhesive mixture in the mixing boiler and the frequency of reheating in the boiler must be checked. During the execution of the works, it must be checked visually if the BHTs overlap adequately and if the bituminous adhesive mixture is applied uniformly. After the BHT installation has been carried out, the protection against possible mechanical damage and against UV loading (e.g. using a geosynthetic) must be checked.

3.3.2.4 Pull-off strength of bituminous waterproofing sheets

The test is described in Chapter 9.2.1 of this TSPI and is carried out after the BHT is laid.

Pull-off strength of bituminous waterproofing sheets at a temperature of 0°C:

the required average value: ≥ 0.8 MPa,

permissible minimum value: ≥ 0.5 MPa.

3.3.2.5 Visual inspection of laid bituminous waterproofing sheets

The test is described in section 9.2.2 of this TSPI and is performed after laying the BHT, over the entire surface of the laid sheets. The final visual check of the laid BHT must be carried out no more than 48 hours before the installation of the protective layer. If up to 5 unsealed areas are found on a surface of up to 250 m^2, the unsealed areas can be repaired. At the same time, it must be ensured that after remediation the waterproofing meets the minimum requirements and that the remediation does not affect water drainage. In the event of more than 5 unsealed areas per 250 m^2 of structure surface area, the existing BHT must be removed and the waterproofing reinstated. This also applies when repairing unsealed areas could reduce the functionality of the structure's waterproofing.

3.4 Procedures for the implementation of liquid applied waterproofing systems (HTN)

This Chapter lays down the procedures for the implementation of liquid applied waterproofing (HTN) systems on horizontal surfaces of concrete bridge structures and other traffic surfaces made of concrete on public roads and railways.

The most commonly used materials for HTN systems are:

- materials based on bituminous latex mixtures,
- methyl methacrylate-based materials (MMA, PMMA),

- materials based on polyisocyanates and polyamines (polyureas) and polyols and diisocyanates (polyurethane).

3.4.1 Implementation of liquid applied waterproofing systems

The preparation of the concrete surface and the procedures for checking the quality characteristics of the substrate is described in pt. 8.1 of this TSPI. The manufacturer of the HTN system may also specify special requirements for the preparation of the concrete surface. The required thickness of HTN must be determined based on the minimum thickness required by the product. As a rule, the thickness of such a waterproofing layer shall not be less than 2 mm nor greater than 6 mm.
The machinery for dosing and mixing liquid materials must allow for continuous control and verification of the mixing ratio, temperature of each component and material consumption.
The HTN application process must ensure proper dosing and mixing without errors, and the inclusion of air in the mixture must also be prevented.
If specified in the instructions, an appropriate bonding layer must be applied to the waterproofing layer before installing the protective layer.

3.4.1.1 Sequence of application of liquid applied waterproofing systems

The implementation of HTN must be carried out in accordance with the implementation guidelines provided by the system manufacturer. This applies in particular to the time intervals between individual work phases and weather conditions.
If the working joint cannot be made in a fresh state, an overlap of at least 20 cm in width is required. In this case, the thickness of each layer shall not be less than 2 mm and the edges shall be sharp. Depending on the age of the underlying layer to be upgraded on the overlay, an appropriate adhesive layer should be applied if specified in the manufacturer's instructions. The joints in the waterproofing must not extend into the wheel track area.

3.4.1.2 Controls before and during the execution of liquid applied waterproofing systems

Before starting HTN, checks must be carried out and the results documented (Chapter 10 – Quality Assessment). Control and testing of all liquid components as well as the entire waterproofing system shall be carried out in accordance with the provisions of the EAD - European Assessment Document and the relevant TSPI.

During implementation, the control tests include measurements of the thickness of the waterproofing layer (wet film thickness measurements). The test is described in Chapter 9.3.1 of this TSPI. It shall be carried out spot by spot during the application of each individual layer of waterproofing. The thickness at any point of the application shall not be less than that specified in the Technical Data Sheet of the system manufacturer.

3.4.1.3 Pull-off strength of liquid applied waterproofing systems

The test is described in Chapter 9.2.1 of this TSPI and is carried out after the waterproofing has been carried out in the event that unforeseen circumstances (e.g. unfavourable weather conditions) have occurred during the time period between the control of the pull-off strength of the primer and the waterproofing application. For one test, the pull-off strength is checked at three representative locations, and the result is the average value. The test sites must be visually clean, dry and free of blisters.

Pull-off strength on HTN systems:

- required average value: ≥ 1.3 MPa,
- permissible minimum value: ≥ 0.7 MPa.

3.4.1.4 Visual control of liquid applied waterproofing

If up to 5 unsealed areas are found on a surface of up to 250 m^2, the unsealed areas can be repaired. At the same time, it must be ensured that after remediation the waterproofing meets the minimum requirements and that the remediation does not affect water drainage. In the event of more than 5 unsealed areas per 250 m^2 of structure surface area, the existing waterproofing must be removed and then reinstated. This also applies when repairing unsealed areas could reduce the functionality of the structure's waterproofing. During the visual control, the overlay of the layers and the processing of details shall also be checked.

3.5 Protection of waterproofing with asphalt or concrete

This chapter refers to waterproofing systems with BHT and HTN, which are described in this TSPI. During execution, the current regulations for asphalt mixtures and for the execution of asphalt layers, as well as the valid regulations for concrete quality and for the execution of concrete works must be taken into account.

On railway bridge structures, there is usually no ice melting salt, the traffic load of trains is transmitted across the track bed. The waterproofing system is most commonly protected by a layer of concrete, specialised system protection elements or, in exceptional cases, moulded asphalt.

The waterproofing system on road bridge structures is usually protected by an asphalt layer. The requirements for the type of asphalt mixtures/layers must be predetermined in the project.

If the concrete deck slab of a road bridge structure is located deeper within the pavement structure and the bridge structure is to be provided with an unbound base course, the waterproofing protection may be executed using concrete.

3.5.1 Implementation of waterproofing protection with concrete

3.5.1.1 Implementation of protection of the waterproofing of railway bridge structures with concrete

On railway bridge structures, as a rule, concrete with a compressive strength class C 25/30 (exposure class XC2) and a maximum aggregate size of 8 mm is placed directly onto the completed waterproofing, without a separation layer, as protection of the waterproofing. The minimum thickness of the concrete protective layer shall be 50 mm, the maximum thickness of the concrete protective layer shall not exceed 100 mm. A reinforcement mesh marked Q195 must be installed in the middle of the concrete layer.

The usual thickness of the protective concrete layer together with the waterproofing is 60 mm. Railway expansion joints and expansion devices are also manufactured to this thickness.

Expansion joints and details of the connection between the concrete waterproofing protection and the wall limiting the track bed must be addressed in the design (for the design the following can be used: DB Ril 804.6101 Richtlinie Eisenbahnbrücken: Abdichtung von massiven Eisenbahnbrücken).

Requirements for concrete are given in SIST EN 206 and SIST 1026. The requirements for the execution of concrete layers are given in SIST EN 13670/A 101 “Execution of concrete structures – National Annex”.

In areas with vertical or steeply sloping finishes, where run-off water is expected to accumulate, a stone filter layer (DB Ril 804.6101 drainage concrete or drainage concrete blocks) must be installed as a protective layer and must be in contact with the protective concrete layer. A stone filter layer shall also be installed at the crossings of the bridge structures to the embankments.

3.5.1.2 Execution of waterproofing protection of road bridge structures or other traffic surfaces with concrete

Usually, geosynthetics should be placed on top of the waterproofing for primary protection. It must be laid immediately after the waterproofing is carried out in the longitudinal direction of the bridge until it passes to the building. However, where it is necessary to allow sliding between the concrete protection and the waterproofing, a polyethylene film ≥ 0.2 mm thick shall be placed on the waterproofing. The choice of the type of protection with geosynthetic or polyethylene film must be predetermined in the project.

The requirements for geosynthetic or polyethylene film must be predetermined in the project.

The following minimum requirements are recommended for geosynthetics:

- mass per unit of area ≥ 350 g/m^2 (SIST EN 9863-1)
- thickness: ≥ 1.0 mm (at 200 kPa) (SIST EN 9864)
- tensile strength - longitudinal/transverse ≥ 24/24 kN/m (SIST EN ISO 10319)
- elongation at break - longitudinal/transverse ≥ 50/50% (SIST EN ISO 10319)
- dynamic puncture (opening diameter) ≤ 14 mm (SIST EN ISO 13433)
- characteristic pore size ≤ 0.09 mm (SIST EN ISO 12956)

Concrete marked C 25/30 (exposure class XC2) with a maximum grain size of 8 mm is installed as a protective waterproofing layer. The minimum thickness of the concrete protective layer shall be 50 mm, the maximum thickness of the concrete protective layer shall not exceed 100 mm. A reinforcement mesh marked Q195 must be installed in the middle of the concrete layer.

Requirements for concrete are given in SIST EN 206 and SIST 1026. The requirements for the execution of concrete layers are given in SIST EN 13670/A 101 “Execution of concrete structures – National Annex”.

3.5.2 Protection of waterproofing with asphalt layers

Comprehensive requirements for the production and installation of asphalt mixtures are given in the series of standards SIST EN 13108 and in the national Slovenian standards of the series SIST 1038 and in TSC 06.300/06.410 “Guidelines and technical conditions for the construction of asphalt layers”. Special recommendations and requirements apply to asphalt mixtures and layers on concrete bridge structures, which must be taken into account and are listed in this chapter.

The asphalting team's competence to work on bridge structures must be demonstrated in advance on a test field or with reference structures that have already been completed.

3.5.2.1 Requirements for asphalt mixtures

The designation and requirements for asphalt mixtures are given in the series of standards SIST EN 13108 and in the national Slovenian standards series SIST 1038-1 to -7. Current knowledge of the profession must also be taken into account.

As a protective asphalt layer (ZHI), mastic asphalt (MA), asphalt concrete (AC), and stone mastic asphalt (SMA) mixtures with a maximum aggregate size of 8 mm or 11 mm may be used, with or without additives to facilitate compaction.

For all bridge structures, the use of mastic asphalt is recommended for protective asphalt layers, and for structures shorter than 50 m, the use of mastic asphalt is mandatory.

Regardless of the requirements in the SIST 1038 series standards, it is permissible and even recommended to use asphalt mixtures composed entirely of carbonate grains for the ZHI layer.

When designing asphalt mixtures, special conditions and recommendations for ZHI must also be taken into account, and they must be easily compactable and at the same time resistant to deformation. The compaction of asphalt layers on bridge structures is more demanding due to different circumstances (Chapter 8.5.2.4).

Table 8-7: Recommended properties of asphalt mixtures and layers for waterproofing protection

	Asphalt mixture for waterproofing protection						Asphalt layer	
	Bitumen content	Content of air cavities		Degree of filling of cavities KM with bitumen		DWTT	Content of air cavities	
	SIST EN 12697-1	SIST EN 12697-8		SIST EN 12697-8		SIST EN 12697-22	SIST EN 12697-8	
	B_{min}	V_{min}	V_{max}	VFB_{min}	VFB_{max}	$PRD_{air\ max.}$	V_{min} in a layer	V_{max} in a layer
	% (m/m)	% (V/V)	% (V/V)	% (m/m)	% (m/m)	%	% (V/V)	% (V/V)
Extremely heavy, very heavy and heavy traffic load								
SMA 8 (A1,A2) ZHI	6,5	1,5*	4,0	75	to be given*	7,0	1,5	5,0
SMA 11 (A1,A2) ZHI	6,3	1,5*	4,0	75	to be given *	7,0	1,5	5,0
AC 8 surf (A1,A2) ZHI	-	1,5*	4,0	65	to be given *	7,0	1,5	5,0
MA 11 (ZHI)	7,4	SIST EN 12697-20 indentation depth using a stamp: I_{min} 1.0; I_{max} 3.0; I_{nc} 0.4						
Medium traffic load								
AC 8 surf (A3) ZHI	-	1,5*	4,0	70	to be given *	-	1,5	5,0
SMA 8 (A3) ZHI	6,5	1,0*	3,5	80	to be given *	-	1,5	5,0
MA 8 (ZHI)	7,8	SIST EN 12697-20 indentation depth using a stamp: I_{min} 1.0; I_{max} 3.0; I_{nc} 0.4						
MA 11 (ZHI)	7,4	SIST EN 12697-20 indentation depth using a stamp: I_{min} 1.0; I_{max} 3.0; I_{nc} 0.4						
Light and very light traffic load								
AC 8 surf (A4) ZHI	-	1,5	4,0	75	to be given *	-	1,0	5,0
MA 8 (ZHI)	7,8	SIST EN 12697-20 indentation depth using a stamp: I_{min} 1.0; I_{max} 5.0; I_{nc} 0.6						
MA 11 (ZHI)	7,4	SIST EN 12697-20 indentation depth using a stamp: I_{min} 1.0; I_{max} 5.0; I_{nc} 0.6						
Cycle paths and pedestrian corridors								
AC 8 surf (A5) ZHI	-	1,0*	2,5	78	93	ng	1,0	4,0
MA 8 (ZHI)	7,8	SIST EN 12697-20 indentation depth using a stamp: I_{min} NR; I_{max} 10.0; I_{nc} NR						
MA 11 (ZHI)	7,4	SIST EN 12697-20 indentation depth using a stamp: I_{min} NR; I_{max} 10.0; I_{nc} NR						

*** additional project selection and prior approval of the ITT (permitted deviation from the requirements of SIST 1038-1 and SIST 1038-5 by taking into account the adequacy of the DWTT parameter)**

The choice of bituminous binder depends on the characteristics of the bridge structure:

- SIST EN 12591 Bitumen and bituminous binders – Specifications for paving grade bitumens
- SIST 1035 Bitumen and bituminous binders – Polymer modified road bitumens – Requirements – Rules for implementation of SIST EN 14023

For extremely heavy, very heavy and heavy traffic loads, the use of polymer modified binder is mandatory for SMA and AC asphalt mixtures.

3.5.2.2 Determination of the thicknesses of individual layers of asphalt

The technological thickness of the asphalt layer depends on the nominal grain size of the asphalt mixture. Table 8-8 of this TSPI specifies the requirements for asphalt layer thicknesses depending on the nominal grain size of the asphalt mixture.

For the purposes of economical routine and investment maintenance (periodic replacement of worn asphalt layers on road bridges), it is recommended that the minimum total thickness of the three asphalt layers on road bridges be 12 cm.

For extremely heavy, very heavy, and heavy traffic loads on new concrete bridge structures, a three-layer asphalt pavement with a total thickness of at least 12 cm shall be designed. For medium, light, and very light traffic loads, the designed two-layer asphalt pavement shall have a minimum thickness of 8 cm; however, a thickness of 12 cm is recommended. The total thickness, i.e. the thickness of the individual layers, depends on the choice of materials, climatic and traffic conditions. When determining the thicknesses and types of asphalt mixtures for each layer, the maintenance measures that will be required during the entire life of the bridge structure must also be taken into account.

As the existing total thicknesses of asphalt layers on bridge structures are mostly smaller, it is recommended that the minimum total thickness of new asphalt layers on existing concrete bridge structures be at least 8 cm, regardless of traffic load. For each individual case, the possibility of increasing the total thickness of the asphalt layers should be considered. During reconstruction, the concrete corridor/curb can be rebuilt, which, following a preliminary static assessment of the bridge structure, allows for thicker asphalt layers.

The top edge of the kerb on the bridge structure (or any other structural restriction) serves as the reference height for determining the thickness of the entire asphalt pavement. Based on the reference height, the unevenness of the concrete slab must be determined and specified (Figure 8.12).

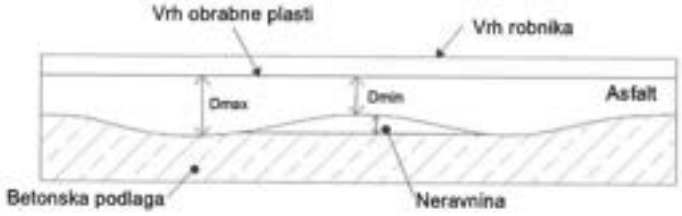


Figure 8.12: unevenness of the concrete slab – determination of the thickness of asphalt pavement

Vrh obrabne plasti	Top of the wearing course
Vrh robnika	Top of the kerb
D_{max}	D_{max}
D_{min}	D_{min}
Asfalt	Asphalt
Betonska podlaga	Concrete substrate
Neravnina	Unevenness

Both in new construction and in rehabilitation works, it is generally necessary—prior to preparing the concrete surface for waterproofing, or at the latest after the execution of the waterproofing—to measure and calculate, on the bridge structure, the vertical range between the actual surface of the concrete slab and the level of the asphalt wearing course.

During the execution of waterproofing on new and existing bridge structures, the elevation levels of the completed concrete slab and the heights of the edge kerbs (sidewalks) shall be measured on a grid of approximately 4x5 m (with a height measurement accuracy of +/-1 mm).

The purpose of the measurements is to check the design assumptions or to make an elevation control of the area for asphalt layers. Taking into account the necessary height of the kerb above the level of the road, a minimum and maximum thickness of the asphalt pavement shall be determined. The total thickness (D_{max} or D_{min}) is divided into the thicknesses of the individual asphalt layers. For rehabilitation, the decision on two-layer or three-layer execution of the asphalt pavement depends on the type of traffic loads, the measured total thicknesses (D_{max} or D_{min} respectively) and the nominal grains of the asphalt mixtures to be used.

With two-layer asphalt pavement, any unevenness must always be levelled after applying an evenly thick protective asphalt layer. The levelling layer must be determined on a case-by-case basis. In the case of three-layer asphalt pavement, unevenness must be levelled with a bonding layer, which also acts as a levelling layer. Figure 8.13 shows an example of a two-layer asphalt pavement consisting of a uniformly thick wearing course and a protective waterproofing layer, which also serves to level surface irregularities.

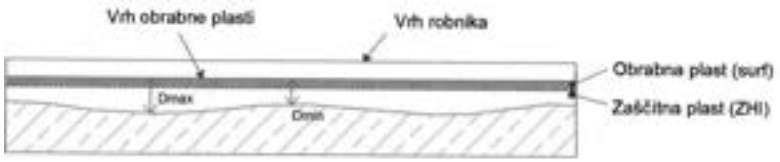


Figure 8.13: asphalt pavement consisting of two asphalt layers

Vrh obrabne plasti	Top of the wearing course
Vrh robnika	Top of the kerb
D_{max}	D_{max}
D_{min}	D_{min}
Obrabna plast (surf)	Wearing course - surfacing (surf)
Zaščitna plast (ZHI)	Protective layer (ZHI)

Figure 8.14 shows an example of a three-layer asphalt reinforcement consisting of a uniformly thick protective layer, an intermediate layer which serves as a binder layer and to level surface irregularities and a uniformly thick wearing course (surfacing).

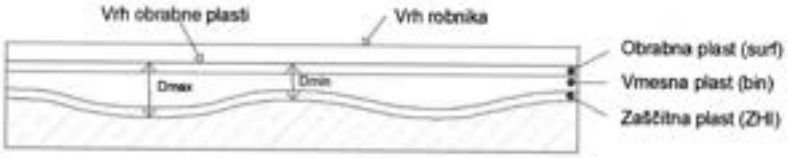


Figure 8.14: asphalt pavement consisting of three asphalt layers

Vrh obrabne plasti	Top of the wearing course
Vrh robnika	Top of the kerb
D_{max}	D_{max}
D_{min}	D_{min}
Obrabna plast (surf)	Wearing course - surfacing (surf)
Vmesna plast (bin)	Intermediate layer - binder (bin)
Zaščitna plast (ZHI)	Protective layer (ZHI)

When, in the case of a two-layer asphalt consolidation, it is not possible to carry out waterproofing protection in one of the above ways (e.g. due to the large roughness of the lower layer, it is not possible to ensure the appropriate thickness of the asphalt wearing course everywhere), levelling milling of the layers of already implemented waterproofing protection (ZHI) must be carried out. In such a case, the ZHI is executed to the appropriate technical thickness and locally milled using a so-called “fine” drum with a tooth spacing of 8 mm, in order to ensure the required thickness and flatness of the asphalt base prior to laying the wearing course (Figure 8.15).

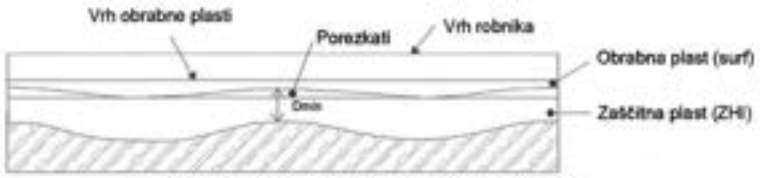


Figure 8.15: Pavement structure with milled ZHI layer

Vrh obrabne plasti	Top of the wearing course
Porezkati	to locally mill
Vrh robnika	Top of the kerb
D_{min}	D_{min}
Obrabna plast (surf)	Wearing course - surfacing (surf)
Zaščitna plast (ZHI)	Protective layer (ZHI)

When determining the thicknesses of individual asphalt layers or during execution, the technological thicknesses of asphalt layers on concrete bridge structures as given in Table 8-8 must be taken into account.

Table 8-8: Technological thicknesses of asphalt layers

Type of mixture	Nominal grain size (mm)			
	8	11	16	22
	Technological thicknesses of asphalt mixtures (mm)			
AC surf	25 to 40	30 to 50	-	-
SMA	20 to 40	25 to 50	-	-
MA	20 to 35	30 to 40	-	-
AC bin	-	-	50 to 80	60 to 100

3.5.2.3 Determination of the temperature of the asphalt mixture

The temperature of the asphalt mixture (hot asphalt and asphalt with or without additives for easier compaction) during installation must be such that the asphalt layer can bond with the base and be well compacted.

To ensure proper bonding between the waterproofing and the asphalt layers, the BHT manufacturer or the HTN manufacturer shall specify the minimum and maximum permissible temperatures of the asphalt mixture during installation.

The lowest recommended temperatures for laid asphalt mixtures without additives for better compaction of asphalt layers marked AC or SMA on bridge structures with a BHT waterproofing system are listed in Table 8-9.

Table 8-9: Recommended minimum temperatures of asphalt mixtures for waterproofing systems with BHT

Bitumen type	Minimum temperature of the asphalt mixture when installed without additives for better compaction
B 30/45	≥155 °C
B 35/50	
B 50/70	≥140 °C
B 70/100	
B 100/150	≥130 °C
B 160/220	
PmB 10/40-65	≥160 °C
PmB 25/55-65	
PmB 45/80-50	≥150 °C
PmB 45/80-65	

3.5.2.4 The execution of asphalt layers

Protection of waterproofing should be carried out as soon as possible after completion of the waterproofing works, but as a rule, due to cooling of the waterproofing carried out, not within the same day. An exception is the HTN, where the manufacturer's instructions for the waterproofing system must be followed. Driving on the completed waterproofing is not permitted, except for the purpose of applying the protective layer. Where driving on the waterproofing cannot be avoided, vehicles shall move slowly, without sudden braking and without changing direction.

The execution of asphalting works must be documented in accordance with the requirements of TSC 06.300/06.410.

Asphalt mixtures may only be installed under suitable weather conditions (no rain, no strong wind). The temperature of the base during the laying of the asphalt layers must, as a rule, be at least 5 °C. If the temperature of the base is lower than the above, the installation must be approved by the contracting authority.

The installation of the asphalt protective layer of waterproofing must be carried out mechanically with finishers with rubber wheels or tracks with undamaged rubber coatings. The distribution board must enable proper spreading of the asphalt mixture without accumulation of hot asphalt mixture in front of the distributing augers. Hot asphalt mix can remain in front of the distribution board for 1 to 3 minutes, depending on the ambient temperature. This also applies when stopping the asphalt paver. In the event of a prolonged stoppage, the paver shall be moved away and a construction joint shall be formed. The manual installation of asphalt protective layer is not permitted, except in special cases and with the approval of the contracting authority (defined in TEDR).

Before starting the asphalting process and installing the protective asphalt layer, the waterproofing must be inspected, cleaned if necessary, and any damage repaired. When installing the protective layer, the waterproofing must not be contaminated (with grains of loose asphalt mixture, petroleum derivatives, etc.). In the event of uncontrolled spillage of asphalt mixture, work must be stopped and the waterproofing surface cleaned manually.

During installation of the protective asphalt layer, there shall be no indentation or migration of bituminous compound from the waterproofing into the protective layer, as this would adversely affect the properties of the protective layer. When installing the protective layer, there must be no movement in the waterproofing layers, which must be taken into account especially on structures with greater longitudinal slopes. All asphalt layers shall be permanently and properly bonded to each other and to the waterproofing.

As a rule, the road structure on bridge structures must be constructed without cold construction joints. If, exceptionally, the protection of the waterproofing is planned to be carried out in two phases with jointing (e.g. a longitudinal joint), such an execution shall be specified in the TEDR. The longitudinal joints of the protective layer shall not be in the wheel track zone. Joints of individual layers shall not be executed directly above one another but shall be offset by at least 20 cm. If, exceptionally, jointing of two layers directly above one another is foreseen, a groove shall be formed through all asphalt layers (the waterproofing protection layer, the wearing course, and the binder/levelling course) and shall be properly sealed.

Only rollers with oscillatory vibration and static rollers (without the use of vertical vibration) may be used for compaction of asphalt layers.

When designing asphalt mixtures, it must be taken into account that the installation of asphalt layers on bridge structures is more demanding and that the installed condition of asphalt layers must be in accordance with TSC 06.300/06.410. The recommended target air void

content in asphalt mixtures is up to 5% v/v. The air void content in layers must be determined using a non-destructive method with a density meter, exceptionally on cores taken from asphalt layers.

3.5.2.5 Execution of joints at linear elements

In any case, a groove must be made between the wearing course of asphalt and the linear element (kerb) and filled with a material intended for sealing grooves. The joints must be watertight to prevent rainwater from seeping in. Rainwater shall drain over the wearing and sealing layer away from the structure or towards the drains located on the structure. Examples of filling the groove are shown in Figures 8.17 and 8.18. As a rule, the groove at the wearing course is filled with a bituminous joint sealant. A sealing insert must be installed between the drainage filter and the filling mixture to prevent the drainage filter from being flooded, or a layer of asphalt must be laid under the groove.

Before applying bituminous joint sealant, all surfaces within the groove shall be completely dry and clean and primed with a primer coat (if required by the sealant manufacturer).

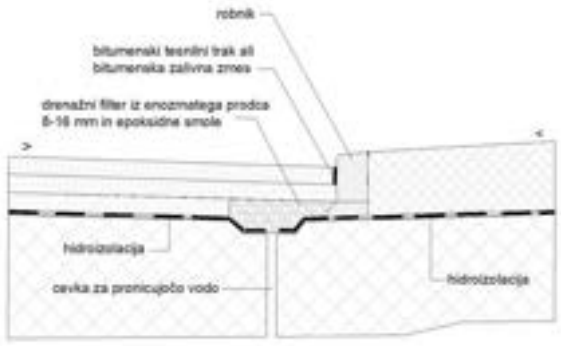


Figure 8.17: Filling the groove between the kerbs and installing a drainage filter

robnik	kerb
bitumenski tesnilni trak ali bitumenska zalivna zmes	bitumen sealing tape bituminous joint sealant
drenažni filter iz enozrnatega prodca 8-16 mm in epoksidne smole	drainage filter made of single-grain gravel 8-16 mm and epoxy resin
hidroizolacija	waterproofing
cevka za pronicujočo vodo	downpipe drainage
hidroizolacija	waterproofing

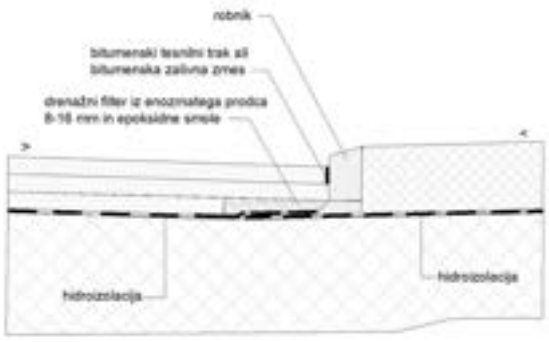


Figure 8.18: Filling the groove between the kerbs and installing a drainage filter

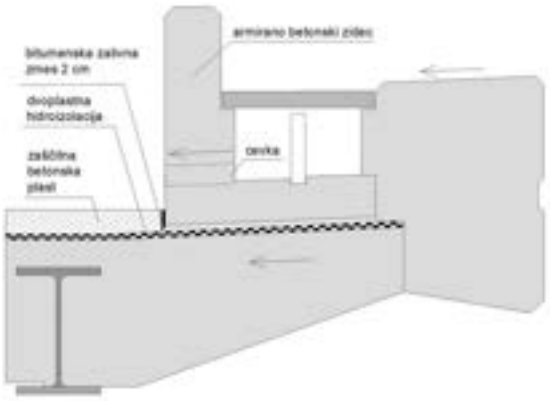


Figure 8.19: Filling grooves along kerbs on railway bridge structures

armirano betonski zidec	reinforced concrete wall
bitumenska zalivna zmes 2 cm	bituminous joint sealant 2 cm
dvoplastna hidroizolacija	double-layer waterproofing
zaščitna betonska plast	protective concrete layer
cevka	Tube

3.5.2.6 Drainage filter at kerbs

If specified in the project, connect the appropriate drains and downpipe drainage to the drainage filter gutter. Drainage is usually made of washed and dried gravel with a grain size of 8/16 mm with epoxy binder (average consumption up to 0.04 m^3/m^2). The drainage filter gutter is usually the same thickness as the asphalt waterproofing protection. The width of the filter belt varies depending on the details of the project.

Figure 8.20: Drainage filter gutter

3.5.3 Inspection of asphalt works on structures

The scope of the inspection should be consistent with the quality control programme, which depends on the size of the structure, the sequential nature of the execution of the works and other circumstances. All parameters shall be checked, which according to TSC 06.300/06.410 are checked during the installation of asphalt layers.

When laying the protective asphalt layer, it is necessary to constantly check for blistering and, if any occurs, the asphalting work must be stopped. The cause of the blistering must be determined, after which the Contractor shall prepare a remediation plan, which must be approved by the contracting authority.

The elevation angles of the individual layers of asphalt should be checked. If deviations from the target heights are found, these must be taken into account before laying the next layer.

After laying each asphalt layer, a visual inspection must be carried out to check that the drainage filter layer (drainage channel) is at the correct height and undamaged, and that the details at the kerbs and expansion joints are well executed.

4 Instructions for carrying out the tests

4.1 Tests on concrete surfaces

4.1.1 Moisture measurements in concrete by carbide method

The test is carried out using the carbide method (CM method) based on DIN 18560-4.

A concrete sample is taken to a depth of 4 cm. The sample is taken by chipping off the surface, the top 2 cm of the sample is discarded, and the test is performed on concrete from a depth of 2 to 4 cm. The sample must not be dried during the period before the test (stored and crushed in a PVC bag).

The crushed and weighed material sample (particles smaller than 2 mm) is poured into the measuring container, and steel balls and an ampoule containing calcium carbide are added. The container is immediately closed and shaken vigorously so that the steel balls crush the glass capsule and the calcium carbide mixes with the sample material. Test procedure: two minutes of shaking, 3 minutes of waiting, 1 minute of shaking, 4 minutes of waiting, 15 seconds of shaking and reading the value.

At a representative location, two measurements shall be carried out and the average value shall be expressed.

4.1.2 Surface roughness measurements using the sand method

The roughness measurements shall be carried out on the prepared concrete surface or on the epoxy coating (before starting the application of the adhesive mixture or the application of the liquid components of the waterproofing system). The surface must be clean and dry.

The depth of roughness is determined according to the procedure below, which is based on SIST EN 13036-1.

The measuring equipment includes:

- a cylindrical container of known capacity,
- glass beads or dry quartz sand of the grain size shown in Figure 8.1
- rubber rulers for spreading sand,
- criteria for determining the diameter size, spread sand and
- thermometer.

The procedure for measuring the depth of roughness by filling with sand must enable the diameter of the (circular) surface of the spread sand to be determined with an accuracy of +5 mm.

Figure 9.1: Granular structure of quartz sand for the test of the roughness of a concrete surface

Kremenčev pesek za preiskavo hrapavosti	Quartz sand for surface roughness testing
Presejek [m-%]	Screening [m-%]
Odprtina na situ [mm]	Sieve opening [mm]
spodnja mejna	lower limit
zgornja mejna	upper limit

The concrete surface roughness depth measurement procedure is based on the determination of the roughness index.

A measuring container of a capacity of 25000 mm^3 (+/-150 mm^3) is filled with standard sand and shaken on the measured surface. For spreading the sand, a wooden circular dolly with a diameter of approximately 65 ± 5 mm shall be used, to which a hard rubber plate of the same diameter and a thickness of approximately 2.0 ± 1.0 mm is attached on the underside. Using circular movements, spread the dry sand evenly around the circle so that all the gaps are filled up to the tips. The diameter of the sand circle is measured in three directions with an accuracy of 1 mm.

$$Hr_i = \frac{4.V}{\pi . D_i^2}$$

Hr_i is the depth of surface roughness at a specific location [mm]

V - volume of spread sand (usually 25 ml or 25,000 mm^3)

Di – average diameter of the sand spread circle at a specific location (mm)

The measurement procedure must be repeated at four more locations, which must be approximately 5 m apart. The result of the measurement is the roughness depth Hrb, which is the average of the measured roughness depth Hri at all five locations.

4.1.3 Flatness measurements of the concrete surface using a 4-metre straightedge

Flatness measurements with a four-meter straightedge shall be carried out on a prepared concrete base. They shall be carried out before the start of the application of the basic coatings, and additionally may be carried out on a prepared surface before the start of the

application of the adhesive mixture or sprayed components of the waterproofing system. The surface must be clean and dry.

Flatness measurements shall be carried out according to a procedure based on SIST EN 13036-7.

A 4 m long measuring straightedge made of rigid material (e.g. light metal, plastic or wood with a metal edge) with a rectangular cross-section is required for the test. The centre of the measuring straightedge must be marked.

The measuring straightedge shall be placed in the chosen location so that it rests well. The two bearing points shall each be located on their respective half of the measuring straightedge, at any position. At the location of the greatest height difference, a measuring wedge is inserted between the straightedge and the substrate, and the value “h” is measured.

Figure 9.2: Flatness measurements with a four-metre straightedge on a concrete surface

4.1.4 Measurements of pull-off strength on concrete surfaces or base coats

The test is based on SIST EN 1542. One result shall consist of testing on at least three points of the 30 x 30 cm representative surface. The measurement of pull-off strength on concrete surfaces (or primers) must be performed using a device that meets the following conditions:

- A metal dolly with a diameter of 50 +/- 1 mm and a minimum thickness of 20 mm (or an aluminium dolly with a minimum thickness of 30 mm). The bottom surface of the dolly shall be flat, with a permissible deviation of 0.1 mm over a length of 50 mm.
- The load transfer from the device to the dolly shall be such as to prevent any shear or bending stresses on the dolly or at the test location.
- The device must ensure a load increase rate of 0.05+/-0.01 MPa/s.
- It must have an analogue or digital force reader with an accuracy of +/- 2%.

Test performance:

Using a drill and diamond crown, a cylinder with a diameter of 50 +/-1 mm is drilled into the substrate to a depth of 15 mm (+/-5 mm). The thickness of the drilling crown shall be 1.5 +/- 0.5 mm in order to separate the area of the specimen from the surrounding concrete slab and to prevent the stress transfer from the specimen to the surrounding plate. Drilling must be carried out in such a way that no vibrations are caused and that the crown does not move sideways during drilling. After drilling (or after completion of the test), the diameter of the drilled hole is measured to an accuracy of 0.1 mm using a measuring device with a resolution of 0.1 mm.

The test surface and the surface of the dolly must be clean, dry and free of grease. A fast-binding, two-component epoxy adhesive or adhesive with similar characteristics shall be used for gluing the dolly. Apply a thin layer of adhesive, taking care not to let it get into the hole. The dolly is attached in such a way that no air pockets remain between the dolly and the test surface.

The device for measuring the pull-off force shall be mounted centrally on the dolly so that it cannot move during the test.

The test specimen is loaded at a constant stress rate of 0.05 ± 0.01 MPa/s until failure occurs. The pull-off strength at failure shall be determined for each dolly to an accuracy of 0.1 MPa using the following equation:

$$f_{Oi} = \frac{4.F}{\pi . D^2}$$

f_{0i}; pull-off strength of individual dolly [MPa]

F pull-off force [N] of each dolly

D mean diameter of specimen [mm] to 0.1 mm accuracy

If more than 10% of the failure occurs within the adhesive layer and the value exceeds 1.5 MPa, the test may be considered acceptable.

If more than 10% of the failure occurs within the adhesive layer and the value is below 1.5 MPa, the result shall not be considered and a repeat test shall be carried out.

The test area must be properly restored after the test has been carried out.

The report shall include the individual measured values, the mean pull-off strength of the three valid individual measurements, and a description/mode of failure (the layer in which the failure occurred and the depth of failure).

4.2 Tests on the executed waterproofing system with bitumen sheets

4.2.1 Pull-off strength on bitumen waterproofing sheets

The test is based on Austrian guideline RVS 11.08.81; chapter 7.1. One result shall consist of testing in at least three representative locations selected throughout the area under consideration in terms of the minimum number of damages due to testing the waterproofing carried out.

The test of the pull-off strength of the waterproofing system must be carried out with a device that meets at least the following conditions:

- Diameter of aluminium dolly with a diameter of 50 +/- 1 mm and a thickness of at least 30 mm.
- The bottom surface of the dolly shall be flat, with a permissible deviation of 0.1 mm over a length of 50 mm.
- The load transfer from the device to the dolly shall be such as to prevent any shear or bending stresses on the dolly or at the test location.
- The device must ensure a load increase rate of 0.05+/-0.01 MPa/s.
- It must have an analogue or digital force reader with an accuracy of +/- 2%.

Test performance:

Using a drill with a diamond crown, drill a cylinder with a diameter of 50 +/- 1.0 mm into the concrete substrate. Alternatively, the waterproofing layer can be pierced down to the substrate using a sharp knife - a chisel with a diameter of 50 +/- 1.0 mm. The area of the specimen shall

be separated from the surrounding waterproofing in order to prevent stress transfer from the specimen to the surrounding plate.

The surface on which the dolly is glued must be clean, dry and free of grease (the surface can be cleaned and dried, but its characteristics must not be changed by this). A fast-binding, two-component epoxy adhesive or adhesive with similar characteristics shall be used for gluing the dolly. Apply a thin layer of adhesive and firmly attach the dolly so that there are no air bubbles between the dolly and the sheet. Remove any excess glue immediately.

The time required to achieve a certain adhesive strength depends on the type of adhesive used and the environmental conditions – especially the temperature (see the adhesive manufacturer's instructions).

The temperature at the pull-off location (around each dolly) shall be forcibly reduced to 0°C +/-3°C using a cooling medium; an ice bath may be used. The test samples are conditioned until they reach a temperature of 0°C (+/-3°C) at least 10 minutes before the test.

The device shall be mounted on the dolly in such a way that it cannot move during the test. The test specimen is loaded at a constant stress rate of 0.05+/-0.01 MPa/s until failure occurs. For each dolly, determine the pull-off strength to an accuracy of 0.1 MPa using the following equation:

$$f_{Oi} = \frac{4.F}{\pi . D^2}$$

f_{0i}; pull-off strength of individual dolly [MPa]

F pull-off force [N] of each dolly

D mean diameter of specimen [mm] to 0.1 mm accuracy

If the point of failure is in the adhesive used to attach the dolly to the HI system and the measurement result is lower than the average value requirement, the result shall be disregarded and the measurement shall be repeated.

If more than 10% of the failure occurs within the adhesive layer and the value exceeds 0.6 MPa, the test may be considered acceptable. If more than 10% of the failure occurs within the adhesive layer and the value is below 0.6 MPa, the result shall not be considered and a repeat test shall be carried out.

The test area must be properly restored after the test has been carried out.

The report shall include the individual measured values, the mean pull-off strength of the three valid individual measurements, and a description/mode of failure (the layer in which the failure occurred).

4.2.2 Visual inspection and tapping of the horizontal waterproofing

The surface of the executed BHT must be inspected visually. Any unsealed areas should be located by tapping with a solid wooden rod (acoustic effect). The locations of all unsealed places shall be marked and the total number on a given surface shall be determined. The tapping must be carried out by experienced personnel. Special attention shall also be given to

overlaps, details, and connections to drains, and all potentially defective areas shall be marked.

The result of the inspection shall be a record of the findings (number and estimated surface area of unglued places before rehabilitation) and, if necessary, photographs of the details of the execution and the locations of unglued places.

4.3 Tests on the liquid applied waterproofing systems

4.3.1 Visual control and measurements of the thickness of liquid applied waterproofing

Thickness measurements shall be carried out according to one of the methods specified in SIST EN ISO 2808. Wet film thickness measurements (using a comb-type measuring device) are usually carried out during the execution of the waterproofing. One thickness measurement consists of testing at three representative locations. At least one thickness measurement must be taken every 250 m^2 or at least one on each structure. The thickness is considered acceptable when the requirements of the manufacturer and the provisions specified in this TSPI are met. The result of the tests shall be a record of the thickness measurements (number and locations of measurements) and, if necessary, a description with photographs of the details of the implementation.

4.3.2 Visual inspection and tapping on sprayed waterproofing

The surface of the liquid applied waterproofing must be visually inspected. Potentially unsealed areas must be located using one of the acoustic methods (e.g. tapping). The tapping is usually carried out with a wooden full rod. The locations of unsealed places shall be marked and the total number and total surface area of unsealed places shall be assessed. Particular attention shall be paid to details and connections to drains, and any potentially defective areas shall be recorded. The result of the visual inspection shall be a report of findings (number and estimated area of unbonded spots prior to repair), and, if necessary, photographs of construction details.

4.4 Laboratory testing

4.4.1 Flexibility of the adhesive mixture at low temperature

The test is based on SIST EN 1109.

Necessary equipment:

- bending device (compliant with SIST EN 1109),
- metal template 220 x 100 x 3 mm,
- a metal base plate,
- paste mixture of glycerine dextrin,
- metal shovel.

The metal frames on the inner side are coated thinly with a pasty mixture of glycerin dextrine, and the metal base plate is also coated. The adhesive mixture is heated to a temperature 80°C above the expected softening point (PK) and poured into the recesses on the template. After the adhesive mixture has cooled to room temperature, the excess adhesive mass is removed using a hot metal spatula. The metal frames are removed from the base plate and the adhesive strips are pulled out.

The flexibility test is performed in accordance with SIST EN 1109 at a temperature of -5°C. The adhesive mixture sample must not crack during the test.

4.4.2 Shear strength of adhesive mixture

The test is based on Austrian guideline RVS 15.03.12; item 8.3.2.

Necessary equipment:

- steel tiles 60x70 mm and mould in accordance with Figure 9.3,
- water bath, adjustable to 50 +/- 2°C,
- testing machine with a device for regulating movement of 50 +/-3 mm/min, with digital force measurement,
- a measuring device for recording the movement in the plane of the test specimen (if not already integrated in the test device).

The adhesive mixture applied between the steel plates must be between 0.5 mm and 1.0 mm thick. The actual thickness of the layer should be indicated when performing the test.

Shear strength is determined at a test temperature of 50 +/- 2°C, with three separate tests (two test specimens per set). The mould and the specimens shall be conditioned in the water bath for 120 minutes (+/-5 minutes) at a temperature of 50 ± 2 °C. The time between the removal of the mould from the water bath and the moment when the load "F_{max}" is reached may be a maximum of 30 s.

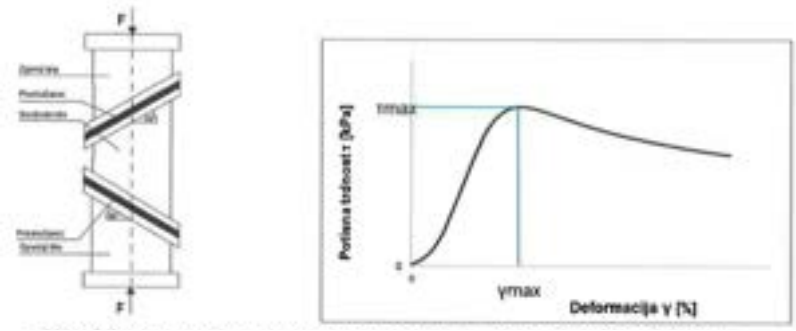


Figure 9.3: Schematic diagram of the testing device and the result and diagram of shear strength/deformation

The recorded displacement corresponds to the displacement in the plane of the sample in the direction of the force (at an angle of 30°). We calculate the shear strength from the displacement/force diagram:

$$\tau_{max} = \frac{F_{max}}{2.A}[MPa] \qquad \gamma_{0.08} = \frac{S_{0.08}}{2d_0}.100[\%]$$

Where:

F_{max} force [N]

$S_{0.08}$ displacement at τ=0.08 MPa [mm]

A sample area [mm²]

d thickness of the adhesive mixture [mm]

The individual values and the mean value of the shear strength T_{max} in MPa (given for 0.01 MPa) and the shear deformation $y_{0.08}$ in % (given for 0.1 %) must be given.

The requirement is not met when an individual value falls below the required average value by more than 25%. This value obtained is not taken into account and an additional test must be carried out instead (two test pieces in the set).

4.4.3 Moisture sensitivity of epoxy coating

The specimen shall be prepared in accordance with the instructions of SIST EN ISO 2815. The specimen - composite shall be stored under controlled conditions for 40 hours - at a temperature of 12 °C and at 85 % relative air humidity. The sample must not become sticky, must not change colour (no white spots), and must not show any visible particles (e.g. particle separation) or signs of blistering.

5 Quality assessment

After the completion of the individual phases of the works and/or the complete works, analyses of the results of the internal and external control tests must be carried out:

- all input raw materials and produced asphalt mixtures,
- installed waterproofing,
- installed asphalt layers.

The analyses of the results of the control tests must be prepared by the IQC and EQC contractors, each for their own work. Comparisons of the results of the analyses shall form the basis for assessing the conformity of the works carried out and for any corrective measures.

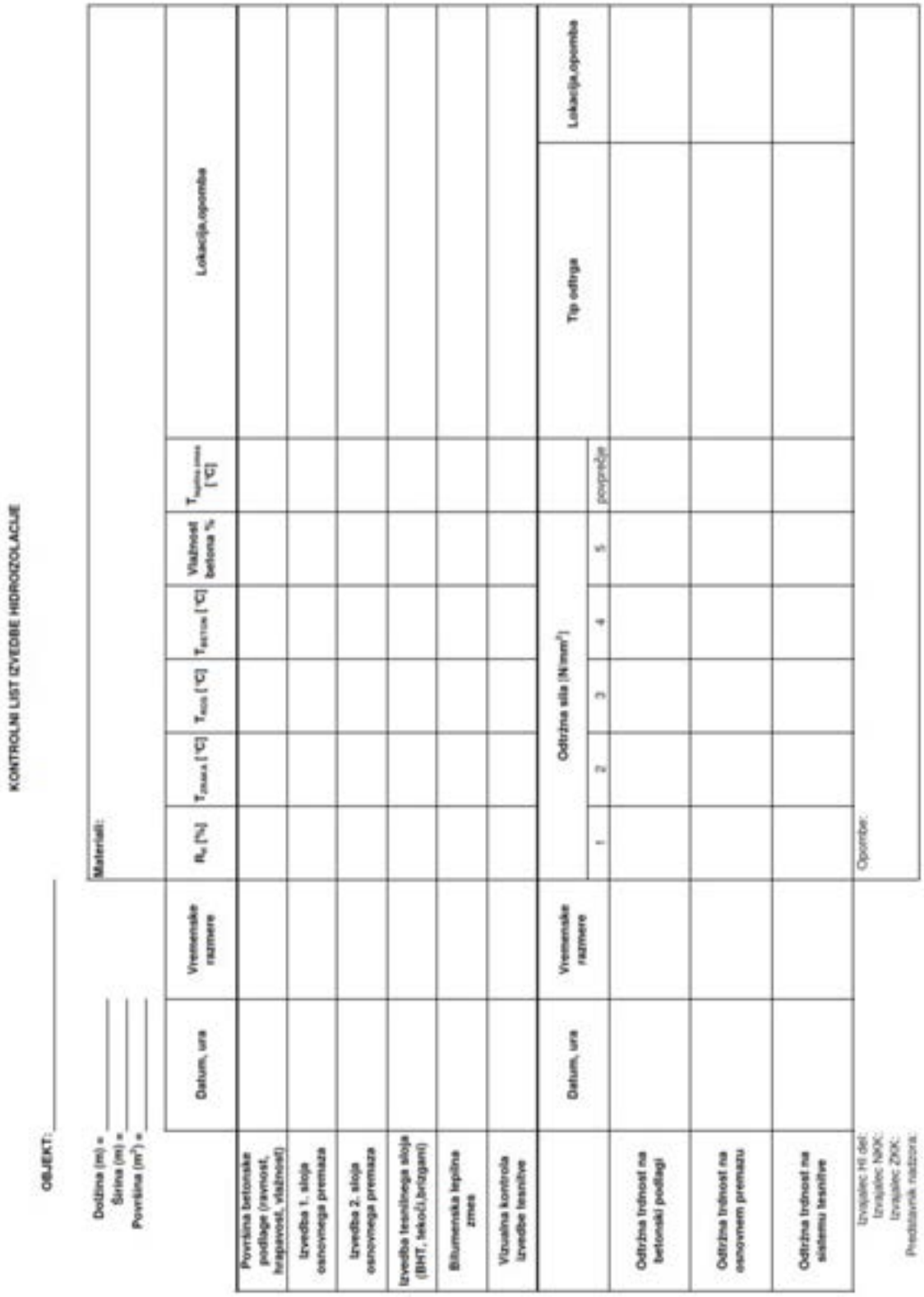
5.1 Internal and external quality control

Internal control tests during the execution of the works must be carried out by the contractor's laboratory or quality control unit (separate part of the organisation) or by another independent laboratory (third party). The IQC may be carried out by a company that has a management system and operates in accordance with the competence requirements with a proof of established accreditation according to SIST EN ISO/IEC 17025. If the IQC is carried out by a non-accredited company, the competence of the laboratory or IQC unit or other independent laboratory may be verified by the Contracting Authority in accordance with the IQC task items given in point 10.3 of this TSPI.

The contractor of the works is obliged to provide the results of the tests and measurements of IQC and the data of input materials to the contractor of the EQC on a regular basis. The EQC may only be carried out by a company (or its laboratory or department) that has a management system and operates in accordance with the competence requirements with a proof of established accreditation according to SIST EN ISO/IEC 17025.

5.2 Inspection sheet for the execution of waterproofing

The IQC and the EQC record the data during the execution of waterproofing in an inspection sheet.



KONTROLNI LIST IZVEDBE HIDROIZOLACIJE	INSPECTION SHEET FOR WATERPROOFING INSTALLATION
OBJEKT:	STRUCTURE:
Dolžina (m) =	Length (m) =
Širina(m) =	Width m =
Površina (m^2) =	Area (m^2) =
Materiali:	Materials:
Datum, ura	Date, time
Vremenske razmere RH[%]	Weather conditions RH[%]
T_{ZRAKA} [°C]	T_{AIR} [°C]
T_{ROS} [°C]	T_{ROS} [°C]
T_{BETON} [°C]	$T_{CONCRETE}$ [°C]
Vlažnost betona %	Concrete moisture %
$T_{lepilna\ zmes}$ [°C]	$T_{adhesive\ mixture}$ [°C]
Lokacija, opomba	Location, note
Površina betonske podlage (ravnost, hrapavost, vlažnost)	Surface of the concrete substrate (flatness, roughness, humidity)
Izvedba 1. sloja osnovnega premaza	Application of the first coat of primer
Izvedba 2. sloja osnovnega premaza	Application of the second coat of primer
Izvedba tesnilnega sloja (BHT, tekoči, brizgani)	Sealing layer application (BHT, liquid, sprayed)
Bitumenska lepilna zmes	Bituminous adhesive mixture
Vizualna kontrola izvedbe tesnitve	Visual inspection of the seal
Datum, ura	Date, time
Vremenske razmere	Weather conditions
Odtržna sila (N/mm^2]	Pull-off force (N/mm^2]
Tip odtrga	Type of pull-off
Lokacija, opomba	Location, note
Odtržna trdnost na betonski podlagi povprečje	Pull-off strength on a concrete base average
Odtržna trdnost na osnovnem premazu	Pull-off strength on primer coat
Odtržna trdnost na sistemu tesnitve	Pull-off strength on sealing system
Izvajalec HI del:	HI works contractor:
Izvajalec NKK:	IQC contractor:
Izvajalec ZKK	EQC contractor
Predstavnik nadzora:	Supervisory representative:
Opombe·	Notes

5.3 Minimum scope of internal and external quality control

	Test method		unit	IQC	EQC
			dimensions	per unit	per unit

Preparation of the concrete substrate - for all waterproofing system processes

Slope – longitudinal and transverse	TSPI HI Chapter 8	m^2	10 x 250 m^2 *	5 x 250 m^2 *
Flatness	TSPI HI Chapter 8	m^2	10 x 250 m^2 *	5 x 250 m^2 *
Roughness (PP3 system)	TSPI HI Chapter 8	m^2	2 x 250 m^2 *	1 x 250 m^2 *
Concrete pull-off strength	TSPI HI Chapter 8	m^2	1 x na 250 m^2 *	1 x na 500 m^2 *
Concrete moisture	TSPI HI Chapter 8	m^2	1 x 250 m^2 *	1 x 500 m^2 *

* proportional for structures < 250m^2 or minimum 1x per structure

Epoxy coating

Liquid components of epoxide	Declaration of performance (DoP) SIST 1504-2 and substantively compliant with point 4.2.1 TSPI Volume 1			
On the execution of waterproofing works:				
Application conditions	TSPI HI Chapter 8	structure	perm.	1 x per 500 m^2 *
Pull-off strength	TSPI HI Chapter 8	m^2	1 x per 250 m^2 *	1 x per 500 m^2
Roughness	TSPI HI Chapter 8	m^2	2 x 250m^2 *	1 x 250m^2 *
Flatness measurements of levelling layers	-	structure	total levelling layer	total levelling layer

* proportional for structures < 250m^2 or 1x per structure

Bituminous coating

Bitumen solution	Declaration of Performance (DoP) in accordance with point 4.2.3 of TSPI Volume 1			
On the execution of waterproofing works:				
Content of bituminous binder	SIST EN 13358	m^2	DOP	1 x per 1000m^2
Viscosity with an efflux viscometer	SIST EN 12846-2	m^2	DOP	1 x per 1000m^2
PK and pen. of the obtained binder	SIST EN 1426,1427	m^2	DOP	1 x per 1000m^2
Application conditions	TSPI HI Chapter 8	structure	continuous/daily	1 x 500m^2 *

* at least once per structure

Bituminous adhesive mixture

Bituminous adhesive mixture	Declaration of Performance (DoP) in accordance with point 4.2.4 of TSPI Volume 1			
On the execution of waterproofing works:				
Ash content	SIST EN ISO 6245	m^2	DOP	1 x per 1000m^2
Flexibility at low temperature	SIST EN 1109	m^2	DOP	1 x per 1000m^2
PK and binder penetration	SIST EN 1426,1427	m^2	DOP	1 x per 1000m^2
Shear strength and deformation	TSPI HI Chapter 8	m^2	DOP	1 x per 1000m^2
Temperature of the melted mixture	TSPI HI Chapter 8	structure	continuous/daily	1 x 350m^2 *

* at least once per structure

Test method	unit	IQC	EQC
	dimen sions	per unit	per unit

Bitumen waterproofing sheets

Bitumen waterproofing sheets	Declaration of performance (DoP) SIST EN 14695 and substantively compliant with point 4.2.5 TSPI Volume 1			
On the execution of waterproofing works:				
Visible abnormalities	SIST EN 1850-1	m^2	DOP	1 x per 1000 m^2
Weight per surface unit	SIST EN 1849-1	m^2	DOP	1 x per 1000 m^2
Thickness	SIST EN 1849-1	m^2	DOP	1 x per 1000 m^2
Bit. mass thickness above the carrier	SIST DIN 51123	m^2	Technical data sheet	1 x per 1000 m^2
Bit.mass thickness under the carrier	SIST DIN 51123	m^2	Technical data sheet	1 x per 1000 m^2
Flexibility at low temperature	SIST EN 1109	m^2	DOP	1 x per 1000 m^2
Flowing at high temperatures	SIST EN 1110	m^2	DOP	1 x per 1000 m^2
Tensile strength (MD+CMD)	SIST EN 12311-1	m^2	DOP	1 x per 1000 m^2
Elongation at break (MD+CMD)	SIST EN 12311-1	m^2	DOP	1 x per 1000 m^2
Filler content in bituminous mass	SIST DIN 52123	m^2	Technical data sheet	1 x per 1000 m^2
PK applied bituminous masses	SIST EN 1427	m^2	DOP	1 x per 1000 m^2
Work carried out:				
Visual inspection/tapping	TSPI HI Chapter 8	structure	total area	1x per 350 m^2 *
Pull-off resistance of the system	TSPI HI Chapter 8	m^2	1 x per 350 m^2	1 x per 500 m^2 *
Surface – measured on a 4 × 5 m grid	-	structure	total area	-

* at least once per structure

Liquid applied waterproofing system

Waterproofing systems	Declaration of performance (DOP) in accordance with point 5.3 of TSPI Volume 1			
On the execution of waterproofing works:				
Application conditions	TSPI HI Chapter 8	structure	continuous/daily	1 x per 500 m^2 *
Control of thickness/consumption of material	TSPI HI Chapter 8	structure	continuous/daily	1 x per 500 m^2 *
Work carried out:				
Control of unbonded spots	TSPI HI Chapter 8	m^2	total area	1x per 500 m^2 *
Pull-off resistance of the system	TSPI HI Chapter 8	m^2	In case of doubt	

* at least once per structure

Asphalt mixtures

	Test method	unit	IQC	EQC
		dimensions	per unit	per unit

Protective asphalt mixtures of types AC and SMA

Asphalt mixture	Declaration of performance (DOP) SIST EN 13108-1 or -5			
When performing asphalting works:				
Sampling, temp. measurements	SIST EN 12697-13,-27	m^2	1 x per structure	1 x per structure
Binder proportion, spatial properties	SIST EN 12697-1,8	m^2	1 x per structure	1 x per structure
Granularity	SIST EN 12697-2	m^2	1 x per structure	1 x per structure
Density measurements - isotope probe	ASTM D 2950 or other non-destructive method	m^2	at least 10 per structure or per 100 m^2	at least 10 per structure or per 200 m^2
Extracted binder	SIST EN 12697-3	m^2	-	1 x per structure
PK, penetration	SIST EN 1426,1427	m^2	-	1 x per structure
Fraass Breaking Point	SIST EN 12593	m^2	-	1 x per structure
Cohesive energy at 10°C (for PmB)	SIST EN 13589	m^2	-	1 x per structure
Elastic return deformation at 25°C (for PmB)	SIST EN 13398	m^2	-	1 x per structure
DSR PP 25 mm/spacing 1 mm, τ = 500 Pa, f = 1.59 Hz	SIST EN 14770	m^2	-	1 x per structure
MSCRT at 60°C (for PmB)	SIST EN 16659	m^2	-	1 x per structure
Work carried out:				
Core extraction	SIST EN 12697-27		In case of doubt	
Determination of thickness	SIST EN 12697-36		In case of doubt	
Determination of density and porosity	SIST EN 12697-9, -8		In case of doubt	

Protective asphalt mixtures of type MA

Asphalt mixture	Declaration of performance (DOP) SIST EN 13108-6			
When performing asphalting works:				
Sampling	SIST EN 12697-13	m^2	1 x per structure	1 x per structure
Temperature measurements	SIST EN 12697-27	m^2	perm.	1 x per structure
Binder proportion	SIST EN 12697-1	m^2	1 x per structure	1 x per structure
Granularity	SIST EN 12697-2	m^2	1 x per structure	1 x per structure
Depth of impression and growth	SIST EN 12697-20	m^2	1 x per structure	1 x per structure
Single-axle CTT	SIST EN 12697-25	m^2	structures with heavy traffic load	
Extracted binder	SIST EN 12697-3	m^2	-	1 x per structure
PK, penetration	SIST EN 1426,1427	m^2	-	1 x per structure

Fraass Breaking Point	SIST EN 12593	m^2	-	1 x per structure
Cohesive energy at 10°C (for PmB)	SIST EN 13589	m^2	-	1 x per structure
Elastic return deformation at 25°C (for PmB)	SIST EN 13398	m^2	-	1 x per structure
DSR PP 25 mm/spacing 1 mm, τ = 500 Pa, f = 1.59 Hz	SIST EN 14770	m^2	-	1 x per structure
MSCRT at 60°C (for PmB)	SIST EN 16659	m^2	-	1 x per structure
Work carried out:				
Core extraction	SIST EN 12697-27		In case of doubt	
Determination of thickness	SIST EN 12697-36		In case of doubt	

Asphalt binder or levelling layer

Asphalt mixture	Declaration of performance (DOP) SIST EN 13108-1 or -5			
When performing asphalting works:				
Sampling, temp. measurements	SIST EN 12697-13,-27	m^2	1 x per structure	1 x per structure
Binder proportion, spatial properties	SIST EN 12697-1,8	m^2	1 x per structure	1 x per structure
Granularity	SIST EN 12697-2	m^2	1 x per structure	1 x per structure
Density measurements - isotope probe	ASTM D 2950 or other non-destructive method	m^2	at least 10 per structure or per 100 m^2	at least 10 per structure or per 200 m^2
Extracted binder	SIST EN 12697-3		-	1 x per structure
PK, penetration	SIST EN 1426,1427	m^2	-	1 x per structure
Fraass Breaking Point	SIST EN 12593	m^2	-	1 x per structure
Cohesive energy at 10°C (for PmB)	SIST EN 13589	m^2	-	1 x per structure
Elastic return deformation at 25°C (for PmB)	SIST EN 13398	m^2	-	1 x per structure
DSR PP 25 mm/spacing 1 mm, τ = 500 Pa, f = 1.59 Hz	SIST EN 14770	m^2	-	1 x per structure
MSCRT at 60°C (for PmB)	SIST EN 16659	m^2	-	1 x per structure
Work carried out:				
Core extraction	SIST EN 12697-27		In case of doubt	
Determination of thickness	SIST EN 12697-36		In case of doubt	
Determination of density and porosity	SIST EN 12697-9, -8		In case of doubt	

Asphalt wearing course

Asphalt mixture	Declaration of performance (DOP) SIST EN 13108-1 or -5			
When performing asphalting works:				
Sampling, temp. measurements	SIST EN 12697-13,-27	m^2	1 x per structure	1 x per structure
Binder proportion, spatial properties	SIST EN 12697-1,8	m^2	1 x per structure	1 x per structure

Granularity	SIST EN 12697-2	m^2	1 x per structure	1 x per structure
Density measurements - isotope probe	ASTM D 2950 or other non-destructive method	m^2	at least 10 per structure or per 100 m^2	at least 10 per structure or per 200 m^2
Extracted binder	SIST EN 12697-3		-	1 x per structure
PK, penetration	SIST EN 1426,1427	m^2	-	1 x per structure
Fraass Breaking Point	SIST EN 12593	m^2	-	1 x per structure
Cohesive energy at 10°C (for PmB)	SIST EN 13589	m^2	-	1 x per structure
Elastic return deformation at 25°C (for PmB)	SIST EN 13398	m^2	-	1 x per structure
DSR PP 25 mm/spacing 1 mm, τ = 500 Pa, f = 1.59 Hz	SIST EN 14770	m^2	-	1 x per structure
MSCRT at 60°C (for PmB)	SIST EN 16659	m^2	-	1 x per structure
Work carried out:				
Core extraction	SIST EN 12697-27		In case of doubt	
Determination of thickness	SIST EN 12697-36		In case of doubt	
Determination of density and porosity	SIST EN 12697-9, -8		In case of doubt	

6 Measurement and acceptance of works

6.1 Measurement of works

All quantities must be measured according to the actual scope and type of work performed within the scope of the project measurements.

The work performed is measured in accordance with the general technical conditions and calculated in square metres (m^2), running metres (m^1) and kilograms (kg).

6.2 Acceptance of works

The Engineer shall accept the installed waterproofing, protective layers and superstructure with other layers upon written notification by the Contractor of the completion of the works and submission of the IQC and EQC reports with a positive assessment of the compliance of the results with this TSPI.

The contractor shall submit all data and the IQC report in a timely manner, containing information from the approved TEDR as well as measurements and tests from the approved testing program. The assessment of the compliance of the results with this TSPI shall be made by the EQC in the final report, on the basis of all the results of the IQC and the EQC.

The Engineer shall accept the installed waterproofing in accordance with the requirements of this TSPI and any additional requirements subject to the Contract Documents for the execution of the Works.

If, upon acceptance of the work, deficiencies and failure to meet minimum quality requirements are identified, the contractor is obliged to remedy these deficiencies before continuing with the work. The contractor is obliged to remedy the deficiencies at its own expense; this also

includes the costs of any additional measurements and tests that must be carried out after the deficiencies have been remedied.

For all works that do not meet the quality requirements in this TSPI or under the conditions in the project, which are the subject of the contract and which have not been corrected by the Contractor in accordance with the instructions of the Engineer, the contractor is not entitled to any payment. However, in such a case, the Contracting Authority may extend the guarantee period for all works that are dependent on non-repaired works to a minimum of 5 years.

7 Specification of works

Code	Unit of measurement	Description of the work
S 5 9 411	m^2	Preparation of the base - surfaces of cement concrete with isotopic washing (>500 bar) with rotary nozzles
S 5 9 412	m^2	Preparation of the base – surface of the cement concrete by milling (milling machine with a spacing between the teeth of up to 15 mm)
S 5 9 413	m^2	Preparation of the base - cement concrete surfaces with a mechanical hammer
S 5 9 414	m^2	Preparation of the base - cement concrete surfaces with dust-free sandblasting with steel balls
S 5 9 415	m^2	Preparation of the base - cement concrete surfaces with final brushing
S 5 9 416	m^2	Preparation of the base – surface of the cement concrete by milling (milling machine with a spacing between the teeth of up to 8 mm)
S 5 9 417	m^2	Preparation of the base - cement concrete surfaces with:
S 5 9 423	m^2	Application of a primer coat with epoxy resin in a single layer at a rate of 0.41–0.5 kg/m^2 (with a broadcast of dried quartz sand (grain size 0.7/1.2 mm) at a rate exceeding 1.5–2.0 kg/m^2)
S 5 9 432	m^2	Application of a primer coat with epoxy resin in a two layers at a rate of over 0.7–0.8 kg/m^2 (with an intermediate broadcast of dried quartz sand (grain size 0.7/1.2 mm) at a rate exceeding 1.5–2.0 kg/m^2)
S 5 9 433	m^2	Application of a primer coat with epoxy resin in a two layers at a rate of 0.81–1.0 kg/m^2 (with an intermediate broadcast of dried quartz sand (grain size 0.7/1.2 mm) at a rate exceeding 1.5–2.0 kg/m^2)
S 5 9 434	m^2	Application of a primer coat with epoxy resin in a two or more layers at a rate of 1.0–1.5 kg/m^2 (with an intermediate broadcast of dried quartz sand (grain size 0.7/1.2 mm) at a rate exceeding 1.5–2.0 kg/m^2)

S 5 9 452	m^2	Preparation of the primer coat with a cold bituminous binder solution in a quantity of more than 0.1 to 0.2 kg/m^2 (dry matter)
S 5 9 453	m^2	Preparation of the primer coat with a cold bituminous binder solution in a quantity from 0.21 to 0.3 kg/m^2 (dry matter)
S 5 9 454	m^2	Preparation of the primer coat with a cold bituminous binder solution in a quantity from 0.31 to 0.4 kg/m^2 (dry matter)
S 5 9 471	m^2	Levelling with epoxy mortar 1:3 using a trowel, thickness up to approx. 0.5 cm, average levelling thickness 0.2 cm, average 2.5 kg/m^2 Note: quantity assessed, calculation by measurement
S 5 9 472	m^2	Levelling with epoxy mortar 1:3 using a trowel, thickness up to approx. 1.0 cm, average levelling thickness 0.25 cm, average 5 kg/m^2 Note: quantity assessed, calculation by measurement
S 5 9 473	m^2	Levelling with epoxy mortar 1:3 using a trowel, thickness up to approx. 1.5 cm, average levelling thickness 0.5 cm, average 10 kg/m^2 Note: quantity assessed, calculation by measurement
S 5 9 474	m^2	Levelling with epoxy mortar 1:3 using a trowel, thickness up to approx. 2.5 cm, average levelling thickness 2 cm, average 40 kg/m^2 Note: quantity assessed, calculation by measurement
S 5 9 511	m^2	Waterproofing with single welded bituminous sheet (> 5 mm), overlapping joints
S 5 9 512	m^2	Waterproofing with double welded bituminous sheet (2 x 5 mm), overlapping joints
S 5 9 513	m^2	Waterproofing with double welded bituminous sheet (4 mm+ 5 mm), overlapping joints
S 5 9 514	m^2	Waterproofing with single bitumen sheet (5 mm), overlapping joints, bonding layer of bitumen adhesive mixture from 200 to 250 g/m^2
S 5 9 513	m^2	Waterproofing with double bitumen sheet (4 mm+ 5 mm), overlapping joints, bonding layer of bitumen adhesive mixture from 200 to 250 g/m^2
S 5 9 561	m^2	Supply and bandaging of end joints of bituminous sheets up to 20 cm wide using a self-adhesive tape
S 5 9 562	m^2	Supply and bandaging of end joints of bituminous sheets up to 20 cm wide using a bitumen tape

S 5 9 611	m^2	Manufacture of liquid applied waterproofing, including lower connecting layer, up to 2.5 mm in thickness
S 5 9 612	m^2	Manufacture of liquid applied waterproofing, including lower connecting layer, from 2.6 to 3.0 mm in thickness
S 5 9 613	m^2	Manufacture of liquid applied waterproofing, including lower connecting layer, from 3.1 to 3.5 mm in thickness
S 5 9 614	m^2	Manufacture of liquid applied waterproofing, including lower connecting layer, up to 2.5 mm in thickness and a finishing anti-slip treatment
S 5 9 615	m^2	Manufacture of liquid applied waterproofing, including lower connecting layer, up to 2.5 mm in thickness, and a bonding layer for overlaying with mastic asphalt (MA)
S 5 9 616	m^2	Manufacture of liquid applied waterproofing, including lower connecting layer, up to 2.5 mm in thickness, and a bonding layer for overlaying with AC or SMA asphalt
S 5 9 617	m^2	Manufacture of waterproofing from a two-component liquid bitumen latex membrane with manual spreading and a systemic protective layer of up to 3 mm
S 5 9 618	m^2	Manufacture of waterproofing from a two-component liquid bitumen latex membrane with manual spreading and a systemic protective layer of up to 6 mm
S 5 9 619	m^2	Manufacture of waterproofing from a two-component liquid bitumen latex membrane with manual spreading and a systemic protective layer of up to 12 mm
S 5 9 646	m^2	Construction of the end of the roadway using the technology of extending the waterproofing at the junction of the transition plate and the superstructure, according to the plan
S 5 9 651	m^2	Construction of a waterproofing system on a primer coat with epoxy resin in two layers in a quantity of over 0.7 to 0.8 kg/m^2 (and intermediate broadcasting with dried quartz sand with a grain size of 0.7/1.2 mm in a quantity of more than 1.5 to 2.0 kg/^{2}) with bitumen sheets, thickness > 5 mm, interlocking with overlap, bonding layer of bituminous adhesive mixture 200 to 250 g/m^2
S 5 9 652	m^2	Construction of a waterproofing system on a primer coat with epoxy resin in two layers in a quantity of over 0.7 to 0.8 kg/m^2 (and intermediate broadcasting with dried quartz sand with a grain size of 0.7/1.2 mm in an amount exceeding 1.5 to 2.0 kg/^{2}) with bitumen sheets > 5 mm thick, joined with an overlap

S 5 9 653	m^2	Construction of a waterproofing system on a primer coat using a cold bituminous binder solution in a quantity of over 0.21–0.3 kg/m^2 (dry matter), with bituminous sheets thicker than 5 mm, jointed by overlapping
S 5 9 654	m^2	Construction of a waterproofing system on a primer coat with a cold bitumen binder solution in a quantity of over 0.21 to 0.3 kg/m^2 (dry matter) with bitumen sheets > 5 mm thick, overlapping joints, bonding layer of bitumen adhesive mixture 200 to 250 g/m^2
S 5 9 662	m^2	Construction of a drainage channel made of dried gravel with a grain size of 8/16 mm, bound with epoxy resin, 3 cm thick and 15 cm wide. Note: longitudinal along the structure
S 5 9 663	m^1	Construction of a drainage channel made of dried gravel with a grain size of 8/16 mm, bound with epoxy resin, 4 cm thick and 15 cm wide. Note: longitudinal along the structure
S 5 9 664	m^1	Construction of a drainage channel made of dried gravel with a grain size of 8/16 mm, bound with epoxy resin, 4 cm thick and 20 cm wide. Note: longitudinal along the structure
S 5 9 711	m^2	Manufacture of a protective layer from a geosynthetic, according to the plan
S 5 9 712	m^2	Production of a protective layer made of geosynthetics with a surface mass of 500 g/m^2
S 5 9 713	m^2	Manufacture of a protective layer of polyethylene film of a thickness of 0.2 mm
S 5 9 721	m^2	Manufacture of protective layer made of XPS plates in thickness of up to 2.0 cm
S 5 9 722	m^2	Manufacture of protective layer made of XPS plates in a thickness of 2.1 to 3.0 cm
S 5 9 723	m^2	Manufacture of protective layer made of XPS plates in a thickness of 3.1 to 4.0 cm
S 5 9 724	m^2	Manufacture of protective layer made of XPS plates in a thickness of 4.1 to 5.0 cm
S 5 9 725	m^2	Manufacture of protective layer made of XPS plates in a thickness of more than 5.0 cm
S 5 9 741	m^2	Construction of a protective layer of cement concrete according to the plan
S 5 9 742	m^2	Construction of a protective layer of C 25/30 XC 2 cement concrete and Q195 reinforcement mesh with a thickness of 5 cm
S 5 9 743	m^2	Construction of a protective layer of C 25/30 XC 2 cement concrete

		and Q195 reinforcement mesh with a thickness of 6 cm
S 5 9 744	m^2	Construction of a protective layer of C 25/30 XC 2 cement concrete and Q195 reinforcement mesh with a thickness of 10 cm

S 5 9 751	m^2	Application of a protective layer of dimpled membrane
S 5 9 771	m^2	Production of a separating layer made of rubber sheets, 1 cm thick
S 5 9 772	m^2	Production of a separating layer made of rubber sheets, 2 cm thick
S 5 9 831	m^1	Sealing of boundary surfaces - joints up to 20 mm wide and 40 mm deep, with pre-coating of adjacent surfaces and filling with bituminous joint sealing compound
S 5 9 833	m^1	Sealing of boundary surfaces - joints up to 15 mm wide and 40 mm deep, with pre-coating of adjacent surfaces and filling with a mixture of synthetic organic materials
S 5 9 835	m^1	Sealing of boundary surfaces – joints up to 10 mm wide and up to 40 mm deep, with pre-coating of the adjacent surface of cement concrete, with glued bitumen sealing tape for joints

Asphalt protective layers (waterproofing), binding layers and wearing layers
Asphalt concrete – surf (AC surf), Stone mastic asphalt (SMA), Mastic asphalt (MA)

Code	Unit of measurement	Description of the work

See descriptions of works in TSC 06.300/06.410 Guidelines and technical conditions for the construction of asphalt layers.

8 Reference documentation

8.1 RVS Die Österreichische Forschungsgesellschaft Straße - Schiene - Verkehr Richtlinie

RVS 08.07.03 Abdichtung und Fahrbahn auf Brücken und anderen Verkehrsflächen aus Beton

RVS 15.03.11 Brücken, Bauausführung, Abdichtung und Fahrbahn auf Brücken und anderen Verkehrsflächen aus Beton, Grundlagen und Begriffsbestimmungen

RVS 15.03.12 Brücken, Bauausführung, Abdichtung und Fahrbahn auf Brücken und anderen Verkehrsflächen aus Beton, Abdichtungssysteme mit Polymerbitumenbahnen

RVS 15.03.13 Brücken, Bauausführung, Abdichtung und Fahrbahn auf Brücken und anderen Verkehrsflächen aus Beton, Flüssig aufzubringende Abdichtungssysteme

RVS 15.03.14 Brücken, Bauausführung, Abdichtung und Fahrbahn auf Brücken und anderen Verkehrsflächen aus Beton, Ausgleichs- und lnstandsetzungsmörtel

RVS 15.03.15 Brücken - Bauausführung - Abdichtung und Fahrbahn auf Brücken und anderen Verkehrsflächen aus Beton, Fahrbahnaufbau

8.2 EAD - European Assessment Document

EAD 030675-00-0107 Liquid applied bridge deck waterproofing kits

9 Literature

9.1 SIST standards

SIST 1026 Concrete - Specification, performance, production and conformity - Rules for the implementation of SIST EN 206

SIST 1031 Bitumen sheets for waterproofing - Requirements

SIST 1038-1 Bituminous mixtures – Material specifications – Part 1: Bituminous concrete – Requirements – Rules for implementation of SIST EN 13108-1

SIST 1038-5 Bituminous mixtures – Material specifications – Part 5: Stone mastic asphalt – Requirements – Rules for implementation of SIST EN 13108-5

SIST 1038-6 Bituminous mixtures – Material specifications – Part 6: Mastic asphalt – Requirements – Rules for implementation of SIST EN 13108-6

SIST 1038-7 Bituminous mixtures – Material specifications – Part 7: Porous asphalt – Requirements – Rules for implementation of SIST EN 13108-7

9.2 SIST EN standards

SIST EN 206 Concrete - Specification, performance, production and conformity

SIST EN 933-1 Tests for geometrical properties of aggregates - Part 1: Determination of sieve analysis – sieving procedure (consolidated text)

SIST EN 933-2 Tests for geometrical properties of aggregates - Part 2: determination of sieve analysis – sieve opening size

SIST EN 1097-5 Tests for mechanical and physical properties of aggregates - Part 5: Determination of the water content by drying in a ventilated oven

SIST EN 1240 Adhesives - Determination of hydroxyl value and/or hydroxyl content

SIST EN 1242 Adhesives - Determination of isocyanate content

SIST EN 1542 Products and systems for the protection and repair of concrete structures - Test methods - Measurement of bond strength by pull-off

SIST EN 1766 Products and systems for the protection and repair of concrete structures - Test methods - Reference concretes for testing

SIST EN 1767 Products and systems for the protection and maintenance or repair of concrete structures - procedure - Infrared analysis

SIST EN 1877-1 Products and systems for the protection and maintenance or repair of concrete structures – procedure – Reactive and functional groups of epoxy resins - Part 1: Determination of epoxy equivalent

SIST EN 1877-2 Products and systems for the protection and maintenance or repair of concrete structures – procedure – reactive and functional groups of epoxy resins - Part 2: Determination of amine functions using the total basicity number
SIST EN 10319 Geosynthetics – Wide-width tensile test (ISO 10319:2015)

SIST 1035 Bitumen and bituminous binders – Polymer modified road bitumens – Requirements – Rules for implementation of SIST EN 14023

SIST EN 12591 Bitumen and bituminous binders – Specifications for paving grade bitumens

SIST EN 12633 Procedure for determining the adhesion values before and after polishing

SIST EN 13036-4 Road and airfield surface characteristics - Test methods - Part 4: Method for measurement of slip/skid resistance of a surface: The pendulum test

SSIST EN 13036-6 Road and airfield surface characteristics - Test methods - Part 6: Measurement of transverse and longitudinal profiles in the evenness and megatexture wavelength ranges

SIST EN 13375 Waterproofing sheets - Waterproofing systems on concrete for bridges and other traffic areas - Rules for sampling and preparation of test specimens

SIST EN 13596 Waterproofing sheets - Waterproofing systems on concrete for bridges and other traffic areas - Determination of bond strength

SIST EN 13653 Waterproofing sheets - Waterproofing systems on concrete for bridges and other traffic areas - Determination of shear strength

SIST EN 13670 Execution of concrete structures

SIST EN 13670:2010/A101:2010/AC:2017 Execution of concrete structures - National Annex - Correction AC

SIST EN 13880-2 Hot applied joint sealants – Part 2: Test method for the determination of cone penetration at 25°C

SIST EN 13880-3 Hot applied joint sealants – Part 3: Test method for the determination of penetration and recovery (resilience)

SIST EN 13880-4 Hot applied joint sealants – Part 4: Test method for the characterization of heat resistance - Change in penetration value

SIST EN 13880-5 Hot applied joint sealants – Part 5: Test method for the determination of flow resistance

SIST EN 13880-13 Hot applied joint sealants – Part 13: Test method for the determination of the discontinuous extension (adherence test)

SIST EN 14188-1 Joint fillers and sealants - Part 1: Specifications for hot applied sealants

9.3 SIST EN ISO standards

SIST EN ISO 527-2 Artificial additives – Determination of tensile properties Part 2: Test conditions for mass forms and compressed masses (ISO 527-2 including Corr. 1: 1994)

SIST EN ISO 868 Artificial additives - Determination of indentation hardness measured with a durometer (Shore hardness) (ISO 868: 2003)

SIST EN ISO 2114 Plastics (polyester resins) and paints and varnishes (binders) - Determination of partial acid value and total acid value (ISO 2114:2000)

SIST EN ISO 2554 Plastics - Unsaturated polyester resins - Determination of hydroxyl value (ISO 2554:1997)

SIST EN ISO 2808 Paints and varnishes - Determination of film thickness

SIST EN ISO 2811-1 Paints and varnishes - Determination of density - Part 1: Pycnometer method (ISO 2811-1:1997) (consolidated text)

SIST EN ISO 2811-2 Paints and varnishes - Determination of density – Part 2: Immersed body (plummet) method (ISO 2811-2:1997)

SIST EN ISO 2811-3 Paints and varnishes - Determination of density - Part 3: Oscillation method (ISO 2811-3:1997)

SIST EN ISO 2811-4 Paints and varnishes - Determination of density - Part 4: Pressure cup method (ISO 2811-4:1997)

SIST EN ISO 3219 Plastics - Polymers/resins in the liquid state or as emulsions or dispersions - Determination of viscosity using a rotational viscometer with defined shear rate (ISO 3219:1993)

SIST EN ISO 3251 Paints, varnishes and plastics - Determination of non-volatile-matter content (ISO 3251:2008)

SIST EN ISO 3451-1 Plastics - Determination of ash - Part 1: General methods (ISO 3451-1:2008)

SIST EN ISO 3681 Binders for paints and varnishes - Determination of saponification value - Titrimetric method (ISO 3681:1996)

SIST EN ISO 9117-3 Paints and varnishes - Drying tests - Part 3: Surface-drying test using ballotini (ISO 9117-3:2010)

SIST EN ISO 9514 Paints and varnishes - Determination of the pot life of multicomponent coating systems - Preparation and conditioning of samples and guidelines for testing (ISO 9514:2005)

SIST EN ISO 10319 Geosynthetics - Wide-width tensile test (ISO 10319:2015)

SIST EN ISO 13433 Geosynthetics - Dynamic perforation test (cone drop test) (ISO 13433:2006)

SIST EN ISO 12956 Geotextiles and geotextile-related products - Determination of the characteristic opening size (ISO 12956:2019)

9.4 Other standards

ISO 48 Rubber, vulcanized or thermoplastic- Determination of hardness (hardness between 10 IRHD and IRHD)

ISO 3342 Textil glass- mats - determination of tensile breaking force

DIN 16945 Reaction resins, reaction agents and masses of reaction resins, test procedure

DB Ril 804.6101 Richtlinie Eisenbahnbrücken: Abdichtung von massiven Eisenbahnbrücken