Pursuant to Article 17(2) of the Construction Act (Official Gazette of the Republic of Croatia No 153/13, 20/17, 39/19, 125/19, 145/24)), the Minister of Physical Planning, Construction and State Assets hereby adopts the following

TECHNICAL REGULATION FOR CONCRETE PAVEMENT STRUCTURES

I GENERAL PROVISIONS

Subject of the Regulation

Article 1

(1) This Technical regulation (hereinafter: Regulation) lay down, in terms of the fulfilment of basic requirements for a structure intended for road traffic in motion and at rest (hereinafter: traffic structure), the technical properties for a concrete pavement structure as part of a traffic structure, the properties required for construction products in relation to their essential characteristics, and other requirements to be met by construction products intended for installation in a concrete pavement structure, as well as requirements for the design, construction, serviceability, maintenance and removal of a concrete pavement structure and other requirements relating to a concrete pavement structure.

(2) This Regulation lays down requirements for the properties of the subgrade on which the concrete pavement structure is constructed.

Article 2

The design, construction, maintenance, manner of use and removal of a traffic structure shall fulfil the requirements laid down in this Regulation.

Application of the Regulation

Article 3

(1) This Regulation shall apply to concrete pavement structures of traffic structures and to all other traffic areas related to road traffic (traffic areas of accompanying service facilities, refuelling stations, storage terminals, etc.).

(2) This Regulation is also applicable to concrete pavement structures of traffic structures intended for other purposes on surfaces intended for road traffic (maritime ports, agricultural roads, etc.), as well as to pedestrian and cycling paths.

(3) If, in the case referred to in paragraph 2 of this Article, a special regulation governing traffic areas of structures intended for other purposes for the area intended for road traffic lays down requirements of a different degree of strictness than the requirements of this Regulation, stricter requirements shall apply; if requirements other than the requirements of this Regulation are imposed, the requirements shall be met cumulatively.

Article 4

(1) This Regulation shall apply to traffic structures with a Class I and II traffic load.

(2) Class I from paragraph 1 of this Article shall include traffic structures with heavy, very heavy, extremely heavy and medium traffic loads (motorways, national roads, maritime ports and traffic areas with similar uses).

(3) Class II from paragraph 1 of this Article shall include traffic structures with medium traffic load (roads with a speed limit of no more than 40 km/h) and light and very light traffic load (unclassified roads, local roads, parking lots, agricultural roads and roads of similar use).

(4) In the event of doubt as to which class the traffic load of a traffic structure belongs to, the provisions of this Regulation relating to Class I shall apply.

Article 5

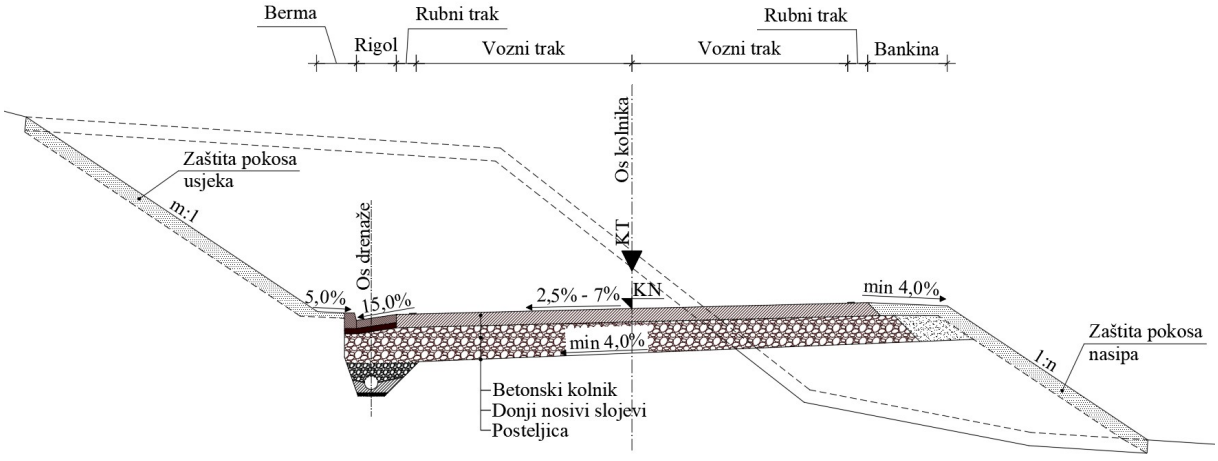
(1) This Regulation shall apply to traffic structures with categories of verification of the construction of concrete pavement in relation to the importance of the designed traffic structure according to the following categorization:

— Category 0 - cycling and pedestrian areas, agricultural roads and roads of similar use

— Category 1 - unclassified roads, local roads, parking lots and maritime ports of local significance

— Category 2 - motorways, national and county roads, maritime ports of county-level significance, ports of significance to the Republic of Croatia or of a particular (international) economic interest to the Republic of Croatia, and traffic areas of similar uses

(2) In the event of doubt as to the category of verification of the construction of a concrete pavement of a traffic structure, the provisions of this Regulation relating to Category 2 shall apply.



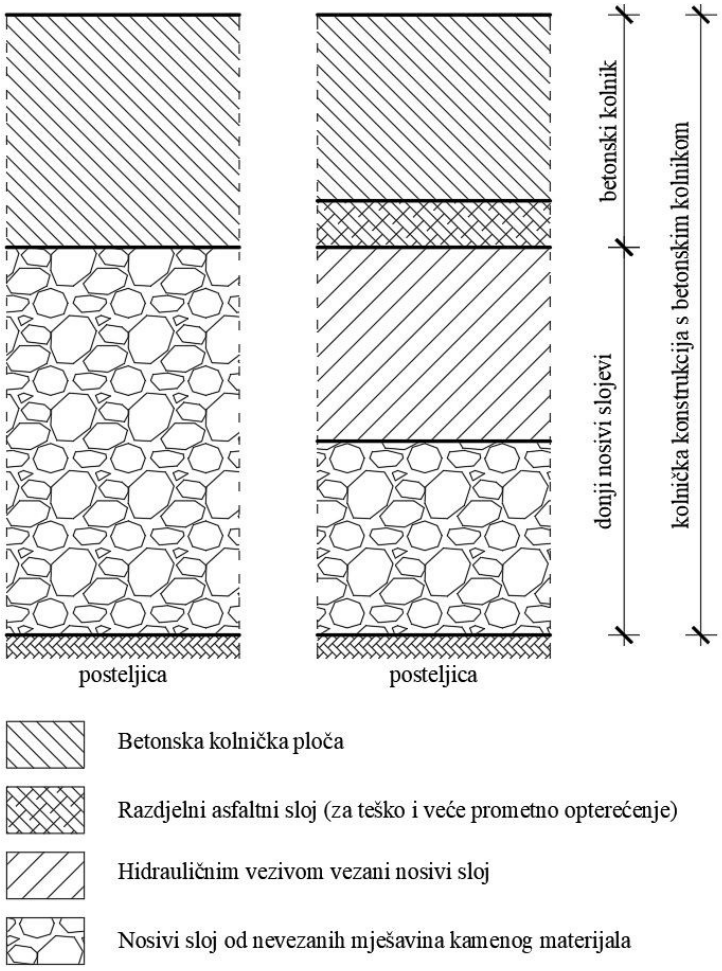
Berma, Rigol, Rubni trak, Vozni trak, Bankina	Berm Gutter Curb lane Lane Shoulder
Zaštita pokosa usjeka, Os drenaže, Os kolnika, Betonski kolnik, Donji nosivi slojevi, Posteljica, Zaštita pokosa nasipa	Slope protection of cut Drainage axis Pavement axis Concrete pavement Lower bases Subgrade Slope protection of embankment

Figure 1 Characteristic cross-section of a traffic structure with a concrete pavement structure

Definition of a concrete pavement structure

Article 6

(1) For the purposes of this Regulation, a concrete pavement structure (hereinafter: pavement structure) is a load-bearing structure which transfers the traffic load to the subgrade and is made of a concrete pavement as the final layer of the pavement structure, constructed on or without a separating asphalt layer, above a hydraulically bound sub-base and/or a sub-base made of unbound mixtures of stone material, as shown in Figure 1 and Figure 2.



Posteljica, donji nosivi sloveji, betonski kolnik, kolnička konstrukcija s betonskim kolnikom	Subgrade Sub-bases Concrete pavement Concrete pavement structure
Betonska kolnička ploča	Concrete pavement slab
Razdjelni asfaltni sloj (za teško i veće prometno opterećenje	Separating asphalt layer (for heavy and higher traffic loads
Hidrauličnim vezivom vezani nosivi sloj	Hydraulically bound base
Nosivi sloj od nevezanih mješavina kamenog materijala	Base made of unbound mixtures of stone material

Figure 2 – Characteristic layers of a concrete pavement structure

(2) The concrete pavement referred to in paragraph 1 of this Article shall be pavement to which the functional requirements laid down in this Regulation apply, as follows:

—dilated unreinforced concrete pavement,

— dilated reinforced concrete pavement,

— continuously reinforced concrete pavement,

— pavement with a continuously reinforced concrete base

— roller compacted concrete pavement,

— composite concrete pavement with an asphalt coating,

— concrete coating of concrete and asphalt pavements.

Annexes to the Regulation

Article 7

The following annexes form an integral part of this Regulation:

Annex A: Concrete,

Annex B: Component materials of concrete,

Annex C: Dowels, anchors, reinforcement and reinforcing steel,

Annex D: Products for the separating asphalt layer, hydraulically bound base and base made of unbound mixtures of stone material,

Annex E: Products for sealing concrete pavement dividers,

Annex F: Prefabricated elements for pavement structures,

Annex G: Designing pavement structures,

Annex H: Construction and maintenance of pavement structures,

Annex I: Pavements with an asphalt or concrete coating,

Annex J: Products and systems for the repair and protection of concrete pavements.

Annex K: Testing soil properties: dynamic modulus of deformation

Annex L: Testing soil properties: compressibility module

Annex M: Testing soil properties: field density testing

Annex N: Testing soil properties: static modulus of deformation

II FULFILMENT OF BASIC REQUIREMENTS FOR A STRUCTURE AND TECHNICAL PROPERTIES OF A CONCRETE PAVEMENT STRUCTURE

Fulfilment of basic requirements for a concrete pavement structure

Article 8

(1) Technical properties of a pavement structure shall be such that, during the service life of a traffic structure, if the prescribed and designed construction and maintenance works are carried out, the pavement structure can support all effects of normal use and environmental impacts, so that during its construction and use predictable effects on the structure shall not cause any of the following:

— damage to the driving surface that jeopardises traffic safety,

— deformations to an unpermitted degree,

— damage that is transferred to the subgrade,

— damage that is seriously disproportionate to its causes.

(2) In addition to the conditions set out in paragraph 1 of this Article, the technical properties of a pavement structure shall be such that, in the event of a fire to which a traffic structure is exposed, the load-bearing capacity of the pavement structure or part thereof is preserved for a specified period of time laid down by special regulations and that the safety of traffic is not jeopardised due to unauthorized adhesion of the driving surface.

(3) The technical properties of a pavement structure from paragraphs 1 and 2 of this Article shall be achieved through the design and construction of the pavement structure in accordance with the provisions of this Regulation.

(4) Preservation of technical properties of a pavement structure referred to in paragraphs 1 and 2 of this Article shall be achieved through the maintenance of the pavement structure in accordance with the provisions of this Regulation.

Article 9

(1) If a pavement structure has the technical properties laid down in Article 8(1) and (2) of this Regulation, it shall be assumed that the traffic structure meets the basic requirements regarding mechanical resistance and stability, fire safety, protection from noise, safety during use, and sustainable use of natural sources.

(2) When additional protection of a pavement structure is required in order to meet the requirements laid down in this Regulation, such protection shall be deemed an integral part of the technical design of the pavement structure.

(3) Paragraph 1 of this Article shall not apply to parts of a traffic structure that are not the pavement structure (bridges, tunnels, buildings of ancillary service facilities, etc.).

Article 10

In addition to fulfilling the requirements of this Regulation,, technical properties of a pavement structure shall also meet requirements defined in special regulations governing the fulfilment of other basic requirements for the structure.

Article 11

(1) After the reconstruction of the traffic structure of which the pavement structure forms an integral part which has affected the technical properties of the pavement structure, the pavement structure shall have the technical properties laid down by Article 8(1) and (2) of this Regulation.

(2) The requirement referred to in paragraph 1 of this Article shall apply only to the part of the pavement structure included in the reconstruction.

III DESIGN OF A CONCRETE PAVEMENT STRUCTURE

Article 12

(1) The structural design of a pavement structure which forms an integral part of the main design of a traffic structure (hereinafter: design of the pavement structure) shall, for the execution phase and for the designed (budgetary) service life of the traffic structure, provide for all effects on the pavement structure resulting from the design and order of construction, the conditions of normal use of the traffic structure and the foreseeable environmental effects on the traffic structure.

(2) The design of a pavement structure shall, in accordance with this Regulation, demonstrate that, during construction and the designed (budgetary) service life, the transport structure shall meet the basic requirements regarding mechanical resistance and stability, fire safety, noise protection, safety during use, sustainable use of natural resources and other basic requirements in accordance with special regulations.

(3) Unless otherwise provided by a special regulation, the designed (budgetary) service life of the pavement structure referred to in paragraph 1 of this Article shall be 40 years.

(4) The design of the pavement structure shall be carried out on the basis of the results of previous exploratory works. The type and scope of the required exploratory works shall be determined by the designer.

Article 13

(1) In the part in which the fulfilment of this basic requirement is ensured by the pavement structure, mechanical resistance and stability of a traffic structure shall be demonstrated in the design of the pavement structure through calculations of the load-bearing capacity and serviceability of the pavement structure or through other appropriate procedures depending on the road substructure (earth hull, bridges, culverts, viaducts, retaining walls, cladding walls, etc.), for predictable effects and impacts on the traffic structure.

(2) The fire resistance of a traffic structure in the part in which the fulfilment of the basic requirement of fire safety of the structure is ensured by the pavement structure shall be considered as fulfilled if the conditions listed in Annex A to this Regulation are met.

(3) By way of derogation from paragraph 2 of this Article, if the composition of the concrete of a pavement structure does not meet the requirements set out in Annex A to this Regulation, the fire resistance of the pavement structure at least to the level that would be achieved by meeting these requirements shall be demonstrated by calculation in the main design.

(4) Resistance to the passage of sound and acoustic properties of a traffic structure, in the part in which the fulfilment of this basic requirement is ensured by the pavement structure, shall be demonstrated in the design of the pavement structure by calculations laid down by a special regulation, for foreseeable noise sources and traffic load of the traffic structure.

(5) If the traffic area is constructed in accordance with the provisions of this Regulation, the basic requirement regarding the safety of the structure during use does not have to be specifically demonstrated.

(6) Sustainable use of natural sources shall be deemed proven if construction products are selected in the main design of the pavement structure in such a way that at least 2 % of all construction products originate from recycled or recoverable sources, or are recoverable or recyclable.

(7) Fulfilment of other basic requirements pursuant to special regulations shall be demonstrated in the design of the pavement structure in accordance with the requirements of this Regulation.

(8) Calculations referred to in paragraphs 1, 3, 4 and 7 of this Article shall be made by applying appropriate calculation procedures, which shall be supplemented with tests, if appropriate, taking into consideration all relevant parameters.

(9) The calculation and other models shall be such that, taking into account the reliability of input data and the accuracy of the construction, they correspond to the behaviour of the pavement structure during construction and use.

Article 14

(1) A test section shall be mandatory for traffic structures for which Category 1 or Category 2 checks of the performance of a concrete pavement is provided for in accordance with HRN EN 13877-2:2023 and Annex H to this Regulation.

(2) The length and the conditions for the construction of the test section referred to in paragraph 1 of this Article shall be determined in the design of the pavement structure.

Rules for the design of a concrete pavement structure

Article 15

(1) The design of a pavement structure shall be governed by the rules provided for in Annex G to this Regulation and the standards to which that Annex refers.

(2) Other rules for the design of pavement structures which differ from those laid down in Annex G and the relevant standards may be applied if it is demonstrated in the design of the pavement structure that the application of these rules meets the requirements of this Regulation at least at the level laid down in Annex G.

Content of the design of a pavement structure

Article 16

(1) The construction design of a pavement structure shall be prepared in accordance with the requirements of the special regulation governing the compulsory content and equipment of designs of structures.

(2) In addition to the requirement set forth in paragraph 1 of this Article, the design from paragraph 1 of this Article shall also include the following:

1. In the technical description

— description of the concrete pavement structure,

— description of impacts and the manner of use of the traffic structure, and environmental impacts on properties of the concrete pavement structure,

— data from traffic, geo-technical and hydrological reports and other reports, studies and bases, including the results of exploratory works that influence the properties of the pavement structure,

— description of the method of construction of the pavement structure and the road substructure, the installation of construction products, especially the manner of achieving safety of the driving surface and effective drainage.

2. In the calculation of load-bearing capacity and serviceability

— data on foreseen effects and impacts on the pavement structure related to the calculation of the load-bearing capacity and serviceability of the pavement structure,

— information on the required technical properties of the subgrade, which may not be less favourable than those laid down in point of Annex G to this Regulation;

— calculation of the load-bearing capacity and serviceability of the pavement structure for predictable effects and impacts and calculation of individual parts of the pavement structure for all phases of construction and use of the traffic structure.

3. In the quality control and assurance programme

— the properties of the essential characteristics which the construction products to be installed in the pavement structure must possess in relation to the intended use of the traffic structure, including the relevant data prescribed by the provisions on the labelling of construction products in accordance with the Annexes to this Regulation,

— the foreseeable effects and environmental impacts on the construction products during the designed service life of the traffic structure, including the conditions and method of maintenance of the construction products and, if the designed service life of the traffic structure exceeds the service life of the used construction product, the conditions and method of its replacement,

— the programme for the control of construction products to be installed in the pavement structure, which shall be carried out before, during and after its construction, and the category of verification of the construction of the concrete pavement in accordance with Annex H to this Regulation,

— in the event of a construction product manufactured or constructed on the construction site for the purpose of incorporation into a specific traffic structure, the additional content laid down in a separate regulation governing construction products,

— for a construction product in a non-harmonised area sold in another Member State of the European Union in accordance with its regulations, additional content stipulated by a specific regulation governing construction products,

— tests and procedures for demonstrating the load-bearing capacity and serviceability of the pavement structure,

— the conditions of construction and other requirements that shall be met during the construction of the pavement structure, which have an impact on the installation of construction products and the achievement of the designed or prescribed technical properties of the pavement structure and the fulfilment of the basic requirements for the construction, including the construction class of concrete pavement according to HRN EN 13670:2010,

— the conditions for the construction of the test section, if the construction of the test section is mandatory in accordance with Article 16 hereof,

— other conditions relevant to the fulfilment of the requirements stipulated by this Regulation and special regulations.

(3) Depending on the conditions, procedures and other circumstances of construction, the requirements referred to in paragraph 1 of this Article which were not known at the time of the preparation of the main design or which were not included in the main design, shall be further elaborated in the construction design, i.e., the design of the pavement structure, which forms an integral part of the working design of the traffic structure, or in the addendum to the main design of the pavement structure.

(4) The provision of paragraph 2 of this Article shall also apply if the quality control and quality assurance programme is not complete or if it does not contain all mandatory parts.

Article 17

If, in order to meet the requirements referred to in Article 16 of this Regulation, the design of the pavement structure sets forth the application of the standard referred to in the Annex to this Regulation in the manner specified in that Annex, the pavement structure which meets the requirements regulated by that standard shall be deemed to meet the prescribed requirements in the part of the area governed by the standard.

Article 18

In addition to the requirements laid down in Articles 14, 15, 16 and 17 of this Regulation, the design of the pavement structure for prefabricated or partially prefabricated concrete pavements shall contain a technical solution for:

— prefabricated elements of the pavement structure and the method of their production or manufacture,

— the transfer and transport of prefabricated elements (suspension points and a description of the lifting system, etc.) and the designed weight and permissible deviations of weight of prefabricated elements,

— the arrangement of supports, necessary pillars and other measures ensuring stability during storage, installation and fastening of prefabricated elements,

— the installation of prefabricated elements in the pavement structure, the method of laying and fastening prefabricated concrete elements, including the design and required properties of joint materials, and the method of connecting to the other elements of the pavement structure.

Content of the design for the reconstruction of a pavement structure

Article 19

(1) In addition to the provisions laid down in Articles 12 to 18 of this Regulation, the design for the reconstruction of a pavement structure that changes the geometry, technical properties and/or the technical solution of the original pavement structure shall contain information on the established technical properties of the pavement structure and the subgrade.

(2) Before designing the reconstruction of a traffic structure, the established technical properties of the pavement structure and its subgrade shall be determined through an inspection of the traffic structure, a review of documentation of the traffic structure, sampling, testing samples and parts of the pavement structure and its subgrade, calculations or other appropriate ways.

IV. CONSTRUCTION PRODUCTS FOR A PAVEMENT STRUCTURE

Construction products for a pavement structure

Article 20

(1) Construction products which have been proven to meet the requirements of this Regulation may be installed in a pavement structure

(2) By way of derogation from paragraph 1 of this Article, other construction products may be installed in the pavement structure if that is provided for in the design of the pavement structure.

(3) In the event referred to in paragraph 2 of this Article, the design of the pavement structure shall contain proof that the pavement structure will have the technical properties prescribed by this Regulation or more favourable technical properties, and that these technical properties will be able to be preserved at least during the designed service life set forth for traffic structures.

(4) The proof referred to in paragraph 3 of this Article shall guarantee a level of reliability of the use of the construction product in the pavement structure at least equivalent to the level of reliability provided by the use of the construction products referred to in the Annex to this Regulation.

Serviceability of construction products for a pavement structure

Article 21

(1) A construction product shall be deemed appropriate for installation in a pavement structure if its properties and essential characteristics comply with the provisions of this Regulation and design requirements.

(2) Serviceability of a construction product shall be demonstrated with appropriate and valid documents, in accordance with the regulation governing serviceability and other requirements for construction products intended for installation in structures.

Requirements for construction products for a pavement structure

Article 22

(1) The list of properties of construction products that shall be specified in the design of a pavement structure and other requirements that shall be met in relation to construction products intended for installation in pavement structures are laid down in annexes to this Regulation.

(2) The properties of construction products installed in a pavement structure shall meet general and special requirements relevant for their ultimate purpose in the structure.

(3) If no specific provision is made in the relevant Annex to this Regulation, the relevant specifications shall apply to product requirements and to the assessment and verification of performance and labelling of construction products:

— cement: HRN EN 197-1:2012 i HRN EN 197-5:2021

— aggregate: HRN EN 12620:2008

- water: HRN EN 1008:2002

— admixtures for concrete: HRN EN 934-2:2012

— fibres for concrete: HRN EN 14889-1:2007, HRN EN 14889-2:2008

— dowels: HRN EN 13877-3:2005

— steel for reinforcement: HRN 1130-1:2008, HRN 1130-2:2008, HRN EN 10080:2012, HRN EN 10060:2005, HRN EN ISO 15630-1:2019

— separating asphalt layer: HRN EN 13108-1:2007, HRN EN 13108-1:2007/Corr.1:2008

— hydraulically bound base: HRN EN 14227-1:2013

— base made of unbound mixtures of stone materials: HRN EN 13242:2008 and HRN EN 13285:2018.

Other requirements for construction products for pavement structures

Article 23

(1) Unless otherwise stipulated in the relevant Annex to this Regulation, immediately prior to installation, supervisory and other procedures (testing and other procedures carried out by the contractor and/or control procedures determined by the supervisory engineer) shall be carried out, as defined by:

— the specifications to which the relevant annex refers, or

— design of the pavement structure.

(2) For matters not regulated by this Regulation, the provisions of special regulations governing construction products shall also apply to construction products intended for installation in pavement structures.

V. CONSTRUCTION AND SERVICEABILITY OF A PAVEMENT STRUCTURE

Construction of traffic structures

Article 24

The construction of traffic structures containing a pavement structure shall be such that the pavement structure achieves and permanently retains its technical properties, with the prescribed maintenance, and that is meets other requirements laid down in this Regulation in accordance with the technical design of the traffic structure and the construction conditions provided in the design, as well as to ensure the preservation of those properties and the serviceability of the traffic structure throughout its service life.

Construction of a pavement structure

Article 25

(1) The construction of a pavement structure shall be such that the pavement structure achieves and permanently retains technical properties and that it meets the requirements defined in the design of the pavement structure and in this Regulation.

(2) Conditions for the construction of a pavement structure shall be defined in the quality control and assurance programme, which forms an integral part of the master design of the pavement structure, as at least in accordance with the provisions of Annex H to this Regulation.

(3) If the technical design of a pavement structure or the conditions under which the works are performed and other circumstances may influence technical performance of the concrete structure are such that they are not covered by Annex H to this Regulation, the quality control and assurance programme shall define special construction conditions which fulfil the requirement laid down in paragraph 1 of this Article.

(4) During the construction of a pavement structure, the contractor shall comply with the design of the pavement structure, the technical instructions for the installation and use of construction products and the provisions of this Regulation.

Serviceability of a pavement structure

Article 26

(1) A pavement structure shall be deemed to be serviceable and to have the designed technical properties if:

— construction products have been installed in the pavement structure in the prescribed manner and have valid documentation in accordance with the special regulation governing construction products, i.e., other documentation prescribed by this Regulation,

— the conditions of construction and other circumstances that may have an impact on the technical properties of the pavement structure are in accordance with the requirements set forth in the design of the pavement structure,

— the pavement structure has proof of serviceability established in accordance with Annex H to this Regulation,

and checks of above-mentioned requirements have been carried out, as demonstrated as statutory records and/or documentation.

(2) Serviceability of a concrete structure shall be deemed to be demonstrated if the requirements referred to in paragraph 1 of this Article and Article 24 of this Regulation have been fulfilled.

Article 27

(1) If a pavement structure is found to have technical properties which are less favourable than those laid down in the design of the pavement structure, a subsequent demonstration shall be made to demonstrate that the pavement structure meets the requirements of this Regulation.

(2) In the event referred to in paragraph 1 of this Article, proof that the pavement structure meets the requirements of this Regulation shall be considered to be a part of the detailed design of the pavement structure.

(3) If it is proven that the achieved technical properties of the pavement structure do not meet the requirements of this Regulation, it shall be necessary to draw up a design for the reconstruction of the pavement structure.

VI. MAINTENANCE OF A PAVEMENT STRUCTURE

Article 28

(1) Maintenance of a pavement structure shall be such as to ensure the preservation of the technical properties of the pavement structure throughout its service life and the fulfilment of the requirements defined in the design of the pavement structure and this Regulation, as well as other basic requirements that a pavement structure must fulfil in accordance with special regulations governing the lower part of a pavement structure and the substructure of a traffic structure.

(2) Maintenance of a pavement structure which was or is constructed in accordance with regulations that were previously in force shall be such as to ensure the preservation of the technical properties of the pavement structure throughout its service life, as well as the fulfilment of the requirements defined in the design of the pavement structure and regulations pursuant to which the pavement structure was constructed.

Article 29

(1) Only construction products for which the conditions prescribed in Title IV of this Regulation have been met may be used for the maintenance of a pavement structure.

(2) Maintenance of a pavement structure or other works subject to a regulation governing construction may not jeopardise the technical properties and fulfilment of the prescribed requirements for pavement structure.

Article 30

Performance of maintenance works on a pavement shall be subject to the provisions of this Regulation that apply to the construction of a pavement structure.

VII. REMOVAL OF A PAVEMENT STRUCTURE

Article 31

(1) Removal of a pavement structure shall be carried out in accordance with the regulations governing environmental protection and adaptation to climate change.

(2) The handling of material resulting from the removal of a pavement structure shall be carried out in accordance with the regulations governing the disposal of construction waste.

VIII FINAL PROVISIONS

Valid editions of the standards referred to in APPENDIX 1 for the application of this Regulation

Article 32

(1) The latest edition of standards listed in Appendix 1 to this Regulation, including their amendments, shall apply.

(2) By way of derogation from paragraph 1 of this Article, as regards technical specifications for construction products, the edition referred to in the separate regulations listing the harmonised or non-harmonised standards shall apply.

Entry into force

Article 33

This Regulation shall enter into force on the eighth day after this publication in the Official Gazette of the Republic of Croatia.

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FILE NUMBER: 531-07-2-25-
Zagreb, 08. October 2025

DEPUTY PRIME MINISTER AND
MINISTER

BRANKO BAČIĆ

ANNEX A: CONCRETE

A.1 Scope and general requirements

(1) In accordance with Article 22 of this Regulation, this Annex sets forth the properties and other requirements for concrete to be installed in a concrete pavement (hereinafter: concrete).
(2) For the purposes of this Regulation, concrete is a construction product composed of cement, aggregates and water. Mineral and chemical admixtures and fibres that meet the requirements of Title IV of this Regulation may also be added to the concrete.
(3) Concrete which meets the requirements of the following standards may be incorporated into a concrete pavement:
— HRN EN 206:2021 (Concrete: Specification, performance, production and conformity),
— HRN 1128:2023 (Concrete -- National requirements to HRN EN 206:2021),
— HRN 1128/A1:2023 (Concrete -- National requirements to HRN EN 206:2021),
— HRN EN 13877-1:2023 (Concrete pavements -- Part 1: Materials),
— HRN EN 13877-2:2023 (Concrete pavements -- Part 2: Functional requirements for concrete pavements).
(4) Designed concrete of compressive strength adapted to the traffic load, i.e., for the given traffic load, adapted to the required tensile strength of the concrete, shall be installed in a concrete pavement.
(5) By way of derogation from point A.1(4), if provided for in the design of the pavement structure, concrete of a defined composition shall also be installed in the concrete pavement.
(6) The properties of fresh and hardened concrete selected in accordance with point A.4(1)(2) and point A.6(1), respectively, shall be such that the properties of installed concrete specified by the design of a pavement structure are attained after the concrete has bee installed into the concrete pavement. When choosing the properties of the concrete to be installed in the concrete pavement, the differences between the properties of concrete tested on samples taken during the installation of the concrete and samples taken from the structure, resulting from the method of installation, hardening and environmental conditions, shall be taken into account.
(7) The upper layer of concrete of the constructed concrete pavement shall have resistance to wear of the class laid down in Table A.5.
(8) Concrete in the lower layer that is exposed to freezing shall have resistance to freezing of class XF3 pursuant to HRN 1128:2023 and HRN 1128/A1:2023.
(9) For roller compacted concrete, the following is laid down:
— an aggregate content between 75 % and 85 % by volume of the mixture,

— a proportion of fine particles smaller than 0.063 mm between 2 % and 7 % by volume of the mixture,
— particle size distribution of the aggregate allowing maximum compactness, as well as good capability for installation and surface treatment.
(10) The requirement from point A.1(9) indent 3 is considered to be met if the particle size distribution is determined in accordance with Table B.3 and Figure B.1, respectively. In the event of a different particle size distribution, compliance with the requirements of point A.1(9) indent 3 shall be demonstrated by testing samples of roller compacted concrete.

A.2 Specified properties, assessment and verification of properties and labelling

A.2.1 Specified properties

Properties of concrete shall be specified pursuant to HRN EN 206:2021, and in accordance with HRN 1128:2023 and HRN 1128/A1:2023, as well as:
— for fresh or hardened concrete intended for installation in a concrete pavement, in the manner laid down in Table A.1 and Table A.2, and
— for concrete in a constructed concrete pavement, in the manner laid down in Table A.3.

A.2.2 Assessment and verification of properties

Assessment and verification of properties of concrete in relation to its essential characteristics shall be carried out by means of procedures governed by HRN EN 206:2021, with the application of HRN 1128:2023, HRN 1128/A1:2023 and HRN EN 13877-1:2023 , as well as the provisions of the specific regulations governing construction products.

A.2.3 Labelling of concrete

There are no specific requirements regarding the labelling of concrete in relation to Article 22(3) of this Regulation.

A.3 Testing and other procedures

(1) The properties of a concrete pavement shall be tested on samples taken from the concrete pavement, i.e., on cores drilled from the concrete pavement in the quantity and with the frequency of sampling determined in relation to the categories of verification of performance of concrete pavement, with the application of procedures regulated by HRN EN 13877-2:2023 (in accordance with Table A.3.) and prescribed by Annex H to this Regulation and points A.3(2) to A.3(4).
(2) When checking the conformity of the results of sample tests from a structure regulated by HRN EN 13877-2:2023 referred to in point A.3(1), the class of compressive strength of cores listed in Table 2 of HRN EN 13877-2:2023 shall refer to cylindrical samples with a length/diameter ratio of 1.0. If samples with a different length/diameter ratio have been tested, the correction factor stipulated in Table 4 of HRN EN 13877-2:2023shall be applied.
(3) The testing of the strength of concrete shall be carried out on samples in water-saturated state.
(4) The results of testing referred to in point A.3(1) shall be validated by the procedures set out in Table A.3, governed by EN 13877-2:2023 and laid down in Annex H to this Regulation.
(5) If, in accordance with point A.4(1)(4), the design of a pavement structure stipulates that tensile strength is determined by bending the hardened concrete from which the concrete pavement is made, it shall be verified indirectly by testing tensile strength by splitting the concrete samples taken from the constructed concrete pavement. The relationship between

tensile bending strength and tensile splitting strength shall previously be established on the basis of tests carried out on samples taken during the installation of concrete, in the manner prescribed in Table A.2.
(6) If the relationship of tensile strengths referred to in point A.3(5) has not been established, the relationship between compressive strength (fc) and tensile bending strength (ff) shall be established using the following expression:
f_f=0,5·f_c^(2/3)
(7) The requirement regarding resistance to wear referred to in point A.1.7. shall be demonstrated through procedures provided in Table A.3. and laid down in HRN EN 13877-2:2023.
(8) The requirement regarding freeze-thaw resistance referred to in point A.1.8 shall be demonstrated through procedures regulated by HRN CEN/TR 15177:2006.
(9) If the design of a pavement structure stipulates an air void spacing factor, the demonstration of the achievement of this property shall be carried out by testing governed by HRN EN 480-11:2005.
(10) If the design of a pavement structure specifies the depth of penetration of water under pressure, the demonstration of the achievement of this property shall be carried out by testing governed by HRN EN 12390-8:2019.
(11) If the design of a pavement structure specifies another property, the method of demonstrating the achievement of this property shall be defined in the design of the pavement structure.
(12) Properties of fresh concrete intended for installation in a concrete pavement shall be tested using the procedures laid down in the HRN EN 12350 series, in accordance with Table A.1.
(13) The taking, creation and curing of test samples and the testing of the properties of hardened concrete intended for installation in a concrete pavement shall be carried out through procedures governed by the HRN EN 12390 series and by the standards, technical specifications and technical reports referred to in Table A.2 and point A.3(8).
(14) Instead of the tests and other procedures prescribed in Table A.1 and associated points, the consistency of fresh roller compacted concrete shall be tested using the following:
— procedures laid down in HRN EN 12350-3:2019 (Vebe test), or
— procedures laid down in HRN EN 12350-4:2019 , with a modification relating to the measurement of the reduction of the height of compacted concrete in five points, of which an additional, fifth point is located at the highest place of the surface of roller compacted concrete.
(15) Instead of performing the tests and other procedures stipulated in Table A.1 and associated points, the air content of fresh roller compacted concrete shall be determined by the returned calculation of the recipe for concrete of known density.
(16) Instead of the tests and other procedures prescribed in Table A.1 and associated points, the density of fresh roller compacted concrete and water content, as well as the temperature of roller compacted concrete and air, shall be tested using the following:
— modified Proctor procedure regulated by HRN EN 13286-2:2010/Corr.1:2013, or
— the procedure defined in the quality control and assurance programme in the design of the pavement structure,
— the procedure laid down in Annex L to this Regulation, or
— the procedure laid down in Annex M to this Regulation
(17) In addition to the procedures referred to in point A.3(16), depending on the proposed equipment and technology for the installation of concrete, with the approval of the supervising engineer, water content shall also be determined by drying the fresh mass of roller compacted concrete to a constant mass at a temperature of (105±5) °C.
(18) Instead of testing and other procedures laid down in points A.3(1) to A.3(13), properties of hardened roller compacted concrete during manufacture and installation shall be tested using

the procedures laid down in HRN EN 12390, whereby installation in moulds is carried out pursuant to HRN EN 13286-50:2005 (Proctor equipment or vibrating table), HRN EN 13286-51:2005 (vibrating hammer), HRN EN 13286-52:2005 (vibrocompression) and HRN EN 13286-53:2005 (axial compression) and the preparation of samples for required dimensions is performed by cutting, and they shall be evaluated according to HRN EN 206:2021, HRN 1128:2023 and HRN 1128/A1:2023.
(19) The properties of hardened roller compacted concrete installed in a concrete pavement shall be tested and demonstrated in the manner prescribed in points A.3(1) to A.3(11).

A.4 Design

(1) The design of a pavement structure shall define the following:
— properties of concrete installed in a concrete pavement, by specifying properties pursuant to point A.2(1), depending on the conditions of use of the concrete pavement and traffic load,
— properties of fresh and hardened concrete in accordance with point A.2(1), if the design sets forth special conditions for the construction of a concrete pavement,
— the installation and composition of concrete of the assigned composition, if so required in accordance with the technical design of the traffic structure,
— the class of tensile splitting strength or tensile bending strength of concrete and/or the class of compressive strength of the concrete installed in a concrete pavement, depending on the properties of traffic load, but not less than the classes prescribed in Table A.5,
— the class of freeze-thaw resistance with de-icing salts FT1 or FT2 according to Table A.4, depending on the designed service life of the pavement, environmental conditions, or the degree of exposure to freezing and de-icing salts, if the upper layer of the concrete pavement is exposed to freezing and de-icing salts, according to Table A.3,
— the class of resistance to wear of the upper layer of the constructed concrete pavement, according to Table A.3,
— in the case referred to in point A.3(16)(2) of this Annex, the method of testing the density of roller compacted concrete and water content in fresh concrete, as well as the temperature of roller compacted concrete and air,
— other properties of concrete according to the corresponding specification, if necessary due to the technical design of the traffic structure.
(2) In relation to the properties of a constructed concrete pavement from point A.4(1)(1), the class of compressive strength of the core and/or class of tensile splitting strength or the class of compressive strength of core and tensile bending strength stipulated as a characteristic value of 95 % probability shall be specified.
(3) In the design of the pavement structure made with roller compacted concrete, instead of the content prescribed in point A.4(1) relating to the properties of the concrete, it shall be mandatory to determine the following:
— compressive strength of hardened roller compacted concrete, specified in accordance with HRN EN 13877-2:2023, and
— tensile splitting strength of hardened roller compacted concrete, specified in accordance with HRN EN 13877-2:2023,
— the appropriate final compaction of a concrete pavement made with roller compacted concrete, with indication of the permissible deviation from the final compaction at the edges of the pavement structure,
as well as, if necessary due to the technical solution of the traffic structure:
— density of hardened roller compacted concrete, by specifying the required value,
— tensile bending strength of hardened roller compacted concrete, specified in accordance with HRN EN 13877-1:2023,

— depth of penetration of water under pressure into hardened roller compacted concrete, specified in accordance with HRN 1128:2023 and HRN 1128/A1:2023,
— resistance of hardened concrete to wear, specified in accordance with HRN 1128:2023 and HRN 1128/A1:2023, Annex O,
— filling of apparent dividers in fresh roller compacted concrete.
(4) The requirement under point A.4(3)(3) shall be deemed to have been met if the design of the pavement structure lays down the final compaction of the concrete pavement made with roller compacted concrete as > 98 % compaction relative to compaction obtained by the modified Proctor procedure. If lower density is laid down, appropriateness shall be demonstrated in the design of the pavement structure.

A.5 Supervision and other procedures prior to installation

Regarding the performance of supervision immediately prior to the installation of concrete, there are no requirements other than those laid down in Article 23 of this Regulation.

A.6 Construction

If the design of a pavement structure does not stipulate special conditions for the construction of a concrete pavement, the contractor shall select properties of fresh and hardened concrete in accordance with standards HRN EN 13877-2:2023 , HRN 206:2021, HRN 1128:2023and HRN EN 13877-1:2023 on the basis of performance of concrete in a constructed pavement set forth in the design of the pavement structure, or the functional requirements specified in accordance with HRN EN 1128/A1:2023 and the intended method of construction.

A.7 Specifications

The list of standards and recognised technical requirements applicable under this Annex is set out in Appendix 1 to this Regulation.

Table A.1 Properties of fresh concrete intended for installation in a pavement structure specified pursuant to HRN EN 13877-1:2023

Property	Point of HRN EN 13877-1:2023	Specified according to	Testing according to	Note	Assessment of properties
Consistency	5.2.1	Class according to HRN EN 206:2021 Target value	HRN EN 12350-2:2019 HRN EN 12350-4:2019 HRN EN 12350-5::2019	Consistency shall be suitable for installation in a pavement	HRN EN 206:2021
Air content	5.2.2	Target value	HRN EN 12350-7 2019/Corr.1:2022	-	HRN EN 206:2021
Content of cement	5.2.3	Minimum value for compressive strength and exposure class according to HRN EN 206:2021 / HRN 1128:2023 and HRN 1128/A1:2023	Dosing – Value confirmed by initial testing	-	HRN EN 206:2021

Property	Point of HRN EN 13877-1:2023	Specified according to	Testing according to	Note	Assessment of properties
Particle content smaller than 0.25 mm	5.2.4	Pursuant to HRN 1128:2023 and HRN 1128/A1:2023	Dosing – Value confirmed by initial testing	-	HRN 1128:2023 and HRN 1128/A1:2023
Chloride content	5.2.5	Maximum class of chloride Cl 0.40	HRN EN 206:2021	For concrete with built-in steel (reinforcement, anchors, dowels)	HRN EN 206:2021

Table A.2 Properties of hardened concrete intended for installation in a pavement structure specified pursuant to HRN EN 13877-1:2023 and this Regulation

Property	Point of HRN EN 13877-1:2023	Specified according to	Testing according to	Note	Assessment of properties
Freeze-thaw resistance with de-icing salts	5.3.1	Class according to HRN EN 206:2021 and HRN 1128:2023	HRS CEN/TS 12390-9:2016	XF2, XF4	HRN 1128:2023 and HRN 1128/A1:2023
Mechanical strength	5.3.2	The mechanical strength of concrete samples shall be evaluated according to one or more of the four methods listed below.			
Compressive strength	5.3.2	Class according to HRN EN 206:2021, Table 12	HRN EN 12390-3:2019	C8/10 to C100/115	HRN EN 206:2021
Tensile splitting strength	5.3.2	Class according to HRN EN 13877-1:2023, Table 1	HRN EN 12390-6:2023	S1.3 to S6.0	HRN EN 206:2021
Tensile splitting strength of discs	5.3.2	Class according to HRN EN 13877-1:2023, Table 1	HRN EN 13863-6:2023	S1.3 to S6.0	HRN EN 206:2021 – as tensile splitting strength
Tensile bending strength	5.3.2	Class according to HRN EN 13877-1:2023, Table 2	HRN EN 12390-5:2019	F2 to F10	HRN EN 206:2021 – as tensile splitting strength
Resistance of concrete to wear	-	HRN 1128:2023 and HRN 1128/A1:2023	HRN 1128:2023, Annex O	XM1 to XM3	HRN 1128:2023 and HRN 1128/A1:2023

Table A.3 Properties of concrete installed in a constructed concrete pavement specified in accordance with HRN EN 13877-2:2003 and this Regulation

Property	Point of HRN EN 13877-2:2023	Specified according to	Testing according to	Note	Method of evaluation
Compressive strength of cores	4.2.2	Class according to HRN EN 13877-2:2023, Table 3	HRN EN 12504-1: 2019/Corr.1:2020 HRN EN 12390-3:2019 or the concept of maturity	CC25* to CC100	HRN EN 13877-2:2023, Annex A
Tensile splitting strength of cores	4.2.3	Class according to HRN EN 13877-2:2023, Table 5	HRN EN 12390-6:2023	SC2.4* to SC6.0	HRN EN 13877-2:2023, Annex A
Tensile splitting strength of discs	4.2.3	Class according to HRN EN 13877-2:2023, Table 5	HRN EN 13863-6:2023	SC2.4* to SC6.0	HRN EN 13877-2:2023, Annex A
Thickness of concrete pavement	4.3	HRN EN 13877-2:2023 and this Regulation	Method 1 (from cores) – according to HRN EN 13863-3:2005 Method 2 (non-destructive) – according to HRN EN 13863-1:2005 or another appropriate method	mean measurement value ≥ of designed, individual value ≥ 95 % of designed	HRN EN 13877-2:2023, point 4.3.1
Freeze-thaw resistance with de-icing salts	4.4	Table A.4	HRS CEN/TS 12390-9:2016	FT0 to FT2	Table A.4
Resistance of concrete pavement to studded tyres	4.5	Class according to HRN EN 13877-2:2023, Table 6	HRN EN 13863-4	WR0 to WR4	HRN EN 13877-2:2023, Table 6
Connection between two layers of concrete	4.6	Target value	HRN EN 13863-2	Normal value for ordinary concrete is 1.0 MPa	HRN EN 13877-2:2023, point 4.6
Resistance to penetration of fuel and oil	4.8	Target value	HRN EN 13877-2,:2023 Annex B (HRN EN 12390-8:2019)	Penetration depth not exceeding 30 mm	HRN EN 13877-2:2023, Annex B
Resistance to wear	-	This Regulation (national provision)	HRN 1128:2023, Annex O (on the upper surface of the sample dried to a constant weight at (105± 5) °C	XM1 to XM3	HRN 1128:2023 and HRN 1128/A1:2023
* but not less than the value set out in Table A5, depending on the traffic load					

Table A.4 – Classes of resistance of cores to freeze-thaw cycles

Class	Loss of mass after 28 cycles (m_{28})	Loss of mass after 56 cycles (m_{56})	Degree of loss m_{56}/m_{28}
FT0	No requirements	No requirements	No requirements
FT1	< 1.0 kg/m^2 on average and < 1.5 kg/m^2 individual result	No requirements	No requirements
FT2	<0.5 kg/m^2 on average	< 1.0 kg/m^2 on average and < 1.5 kg/m^2 individual result	≤ 2

Table A.5 Minimum classes of concrete strength and resistance to wear of a constructed concrete pavement in relation to the predicted traffic load

Predicted traffic load	Compressive strength class	Tensile splitting strength class	Tensile bending strength (f_f) (MPa)	Class of resistance to wear
Very heavy and extremely heavy	CC40	SC3.0	5,0	XM3
Heavy and medium heavy	CC30	SC2.7	4,5	XM2
Light and very light	CC25	SC2.4	4,0	XM1

ANNEX B: COMPONENT MATERIALS OF CONCRETE

B.1 Scope and general requirements

Pursuant to Article 22 of this Regulation, this Annex lays down properties and other requirements for materials (cement, aggregate, water, mineral and chemical admixtures to concrete and fibres) intended for the production or manufacture of concrete from Annex A (hereinafter: concrete).

B.1.2 Cement

(1) Unless otherwise provided for in this Annex, for the production of concrete, general-purpose cement according to HRN EN 197-1:2012 and HRN EN 197-5:2021, main types CEM I and CEM II, strength class 42.5, shall be used.
(2) In addition to the requirements under point B.1.2.(1), cement shall also meet the requirements of HRN EN 206:2021, HRN 1128:2023, HRN 1128/A1:2023 and HRN EN 13877-1:2023.
(3) By way of derogation from point B.1.2(1), cement of strength class 32.5 shall also be used for concrete intended for installation into the concrete pavement of unclassified roads.
(4) By way of derogation from point B.1.2(1), cements of the main type CEM III in accordance with HRN EN 197-1:2012 shall also be used for roller compacted concrete.

B.1.3 Aggregate

(1) For the production of concrete, aggregate pursuant to HRN EN 12620:2008 shall be used, with a grain density higher than 2,000 kg/m3 (hereinafter: aggregate) obtained at aggregate production plants, as follows:
— natural aggregate (aggregate from mineral sources subjected exclusively to mechanical processing),
— industrial aggregate (aggregate of mineral origin from industrial processes involving thermal or other changes),
— recycled aggregate (aggregate resulting from the processing of material of inorganic or mineral origin previously used in construction),
as well as a mixture of these aggregates, at least in accordance with the requirements laid down in Table B.1, Table B.2 and the requirements of this Annex.
(2) Regarding grain size, i.e., grain size range, aggregate shall be classified into the following groups:
coarse aggregate ($D > 4$ mm),
fine aggregate ($D \leq 4$ mm),
mixed aggregate (mixture of coarse and fine aggregate),
filler (aggregate that mostly passes through a 0.063 mm sieve, which is added to construction products to ensure certain properties).
(3) In addition to the requirements under point B.1.3(1), aggregate shall also meet the requirements of HRN EN 206:2021, HRN 1128:2023, HRN 1128/A1:2023 and HRN EN 13877-1:2023.
(4) If a concrete pavement is constructed as a pavement with two consecutively constructed layers, it is permissible for the concrete aggregate to be installed in the upper layer of the concrete pavement to be different from the concrete aggregate to be installed in the bottom layer in terms of:
— origin and method of production, and/or

— grain size,
but it is not permitted to install aggregate resulting from the processing of blast furnace slag into the upper layer of a two-layer concrete pavement.
(5) Aggregate in a single-layer concrete pavement shall meet the requirements of Table B.1 for the bottom layer of the concrete pavement, as well as the requirements for resistance to fragmentation, wear, smoothing, abrasion, carbonate content in the fine fraction, freezing, and acid-soluble sulphate content for the upper layer of the concrete pavement of Table B.1. (marked with ***).
(6) The use of aggregates containing components that affect the binding and hardening rate of concrete (organic substances, sugar, light particles, etc.) shall not be not allowed.
(7) The use of aggregates produced from air-cooled slag containing dissolved dicalcium silicate and dissolved iron shall not be allowed.
(8) If the aggregate contains potentially alkaline-reactive ingredients with the possibility of reaction with alkali (Na2O and K2O from cement or other source), reliable measures shall be taken to prevent an alkali-silicate and alkali-carbonate reaction in accordance with HRN EN 12620:2008.
(9) By way of exception, point B.1.3(8) shall not apply to concrete aggregates intended for incorporation into concrete pavements which are not exposed to moisture.
(10) The use of recycled aggregate complying with the following requirements is allowed:
— coarse recycled aggregate (D > 4 mm),
— recycled aggregate in which the constituents of the coarse fraction are determined in accordance with HRN EN 933-11:2009 , and in which no less than 95 % of components are derived from concrete, concrete products, mortar, unbound and hydraulically bound aggregate, natural stone,
— recycled aggregate for which tests have demonstrated resistance to alkaline-silicate and alkaline-carbonate reactions,
— recycled aggregate which, regarding the release of dangerous substances, meets the requirements of the Environmental Protection Act,
— recycled aggregate which, in addition to all the requirements laid down for natural aggregate, also meets the additional requirements laid down in Table B.2.
(11) The use of recycled aggregate containing hazardous substances in quantities harmful to human health and the use of that hazardous substance in quantities harmful to the environment shall not be allowed.
(12) Aggregate for roller compacted concrete shall:
— have fractions larger than 4 mm obtained exclusively from crushed aggregate,
In order to achieve the content of fine particulate matter required by point A.1(9), a filler or other mineral additive shall also be used as an aggregate for roller compacted concrete.

B.1.4 Water

(1) For the production of concrete, water pursuant to HRN EN 1008:2002 shall be used.
(2) In addition to the requirements under point B.1.4.(1), water shall also meet the requirements of HRN EN 206:2021, HRN 1128:2023, HRN 1128/A1:2023 and HRN EN 13877-1:2023.

B.1.5 Admixtures for concrete

(1) For the production of concrete, chemical and mineral admixtures pursuant to HRN EN 934-2:2012 shall be used.

(2) In addition to the requirements under point B.1.5.(1), chemical and mineral admixtures and shall also meet the requirements of HRN EN 206:2021, HRN 1128:2023, HRN 1128/A1:2023 and HRN EN 13877-1:2023..

B.1.6 Fibres

(1) For the production of concrete, steel fibres in accordance with HRN EN 14889-1:2007 or polymer fibres in accordance with HRN EN 14889-2:2008 shall be used.
(2) In addition to the requirements under point B.1.6(1), steel and polymer fibres shall also meet the requirements of HRN EN 206:2021, , HRN 1128:2023, , HRN 1128/A1:2023 i and HRN EN 13877-1:2023.

B.2 Specified properties, assessment and verification of properties and labelling

B.2.1 Specified properties

(1) The properties of cement, water, concrete admixtures and fibres are specified according to the following standards: HRN EN 197-1:2012, HRN EN 197-5:2021, HRN EN 1008:2002, HRN EN 934-2:2012, HRN EN 14889-1:2007 and HRN EN 14889-2:2008
(2) Properties of aggregates shall be specified in accordance with HRN EN 12620:2008 and in accordance with tables B.1 and B.2.

B.2.2 Assessment and verification of properties

There are no specific requirements for the assessment and verification of the properties of cement, aggregates, water, concrete admixtures and fibres in relation to Article 22(3) of this Regulation.

B.2.3 Labelling

There are no specific requirements for the labelling of cement, aggregates, water, concrete admixtures and fibres in relation to Article 22(3) of this Regulation.

B.3 Testing and other procedures

(1) The properties of aggregates specified in tables B.1 and B.2 shall be tested using the procedures regulated by the standards indicated in the tables.
(2) Particle density and water absorption of aggregates shall be tested using procedures laid down in HRN EN 1097-6:2022.
(3) Loose bulk density of aggregates shall be tested using procedures laid down in HRN EN 1097-3:2004.
(4) The presence of ingredients affecting the binding and hardening rate of concrete (organic matter, sugar, light particles, etc.) shall be tested using the procedures laid down in HRN EN 1744-1:2012, in conjunction with HRN EN 12620:2008, Annex C/G.
(5) Mineralogical and petrographic composition of aggregates shall be tested using procedures laid down in HRN EN 932-3:2022.,
(6) The presence of dissolved dicalcium silicate and dissolved iron shall be tested using procedures governed by HRN EN 1744-1:2012.

B.4 Design

(1) The type of cement shall be determined in the design of the pavement structure by specifying in accordance with point B.1.2.
(2) The design of a pavement structure shall define the following:
— construction of the concrete pavement in one or two layers, depending on the requirements for the upper surface of the concrete pavement,
— traffic load class (Class I or Class II), in accordance with Article 4 of this Regulation,
— aggregate fractions,
and, if necessary regarding the technical design of the pavement structure:
— particle density and water absorption of aggregates, in relation to HRN EN 12620:2008, point 5.4,
— loose bulk density of aggregates, in relation to HRN EN 12620:2008, point 5.4,
— mineralogical and petrographic composition of aggregates.
(3) In the case referred to in point B.4(2), the class of aggregate used for the upper layer of the concrete pavement shall be determined according to the traffic load class and the purpose of the traffic structure, in accordance with Table B.1.
(4) The properties of water shall be determined in the design of the pavement structure by specifying properties in accordance with point B.1.4.
(5) Where necessary in view of the technical design of the pavement structure, the design of the pavement structure shall determine the properties of chemical or mineral admixtures by specifying the properties in accordance with point B.1.5.
(6) Where necessary in view of the technical design of the pavement structure, the design of the pavement structure shall define the following:
— properties of steel or mineral fibres, by specifying the properties in accordance with point B.1.6,
— the use of steel or polymer fibres in concrete.

B.5 Supervision and other procedures prior to installation

For the performance of supervisory activities immediately prior to the installation of cement, aggregates, water, concrete admixtures and fibres, point A.5 shall apply.

B.6 Construction

For the installation of cement, aggregates, water, concrete admixtures and fibres, point A.6 shall apply.

B.7 Specifications

The list of standards applicable under this Annex is set out in Appendix 1 to this Regulation.

Table B.1 Requirements for the aggregate of upper and lower layers of concrete pavement

Property	Point of HRN EN 12620:2008	Testing standard	Aggregate of the upper layer of concrete pavement		Aggregate of the lower layer of concrete pavement or single-layer pavement with exceptions (***)
			Class I[a]	Class II[b]	
			Prescribed value or classes in accordance with HRN EN 12620:2008		
Maximum grain size (D)	4.3	HRN EN 933-1:2012	≤ 11.2 mm (11)	≤ 16 mm (16)	≤ 31.5 mm (32)
Aggregate fractions	4.3		0/1 or 0/2 or 0/4 +4/8+8/11	0/1 or 0/2 or 0/4 +4/8+8/16	0/4, 4/8, 8/16 and 16/32
Particle size distribution of small fractions (≤ 4 mm)	4.3		G_F85		G_F85
Particle size distribution of coarse fractions (> 4 mm)	4.3		$G_C85/20$		$G_C90/15$
Fine content in fine aggregate	4.6		f_3 – natural uncrushed*		f_3 – natural uncrushed*
			f_{12}– natural crushed**		f_{12}– natural crushed**
Assessment of fines	4.7	HRN EN 933-8:2015 or HRN EN 933-9:2022	for natural uncrushed: - $SE \geq 65$ or $MB \leq 1$ for natural crushed: - if fine content is ≤ 3 %: $SE \geq 60$ or $MB \leq 1$ - if the fine content is > 3 %: $SE \geq 60$ or $MB \leq 1.5$		
Fine content in coarse aggregate	4.6	HRN EN 933-1:2012	$f_{1,5}$		$f_{1,5}$
Grain shape of coarse aggregate	4.4	HRN EN 933-4:2008	SI_{20}		SI_{20}
Content of shells in coarse aggregate	4.5	HRN EN 933-7:2004	$<SC_{10}$		$< SC_{10}$
Resistance of coarse aggregate to fragmentation (***)	5.2	HRN EN 1097-2:2020	$< LA_{20}$	$< LA_{30}$	$< LA_{30}$
Resistance to wear (***)	5.3	HRN EN 1097-1:2024	$< M_{DE}15$	$< M_{DE}20$	-
Resistance to smoothing for surface-layer applications (polishing capacity) (***)	5.4.1	HRN EN 1097-8:2020	$> PSV_{50}$	$> PSV_{30}$	****
Resistance to surface abrasion (***)	5.4.2	HRN EN 1097-8:2020	$< AAV_{15}$	$< AAV_{20}$	-

Property	Point of HRN EN 12620:2008	Testing standard	Aggregate of the upper layer of concrete pavement		Aggregate of the lower layer of concrete pavement or
			Class I[a]	Class II[b]	
			Prescribed value or classes in accordance with HRN EN 12620:2008		
Carbonate content - tested on fine aggregate (***)	6.5	HRN EN 196-2:2013 / HRN EN 1744-1:2012	CO_2 < 15 %	-	-
Acid-soluble sulphates (***)	6.3.1	HRN EN 1744-1:2012	< $AS_{0,2}$		< $AS_{0.2}$ *(except air-cooled blast furnace slag)*
					< $AS_{1.0}$ *(air-cooled blast furnace slag)*
Total sulphur[c]	6.3.2	HRN EN 1744-1:2012	S_1		S_1 (except air-cooled blast furnace slag)
					S_2 (air-cooled blast furnace slag)
Chloride content	6.2	HRN EN 1744-1:2012	< 0,15% for unreinforced concrete, < 0,06% for reinforced concrete, < 0,03% for prestressed concrete		
Resistance to freezing	5.7.1	HRN EN 1367-1:2008 HRN EN 1367-2:2010	F_1 or MS_{18}		F_1 or MS_{18}
Volumetric stability – drying shrinkage	5.7.2	HRN EN 1367-4:2008	< 0,075 %		< 0,075 %

[a] Class I: heavy, very heavy, extremely heavy and medium traffic loads (motorways, national roads, maritime ports and traffic areas with similar uses)

[b] Class II: medium (maximum speed 40 km/h), light and very light traffic load (unclassified roads, local roads, parking lots, agricultural roads and roads of similar use)

[c] if aggregate contains pyrrhotite, an unstable form of iron sulphide (FeS), total sulphur content shall not exceed 0.1 %.

* natural uncrushed aggregate originating from gravel pits which has not been subjected to a crushing process

** natural crushed aggregate produced from mineral raw materials by crushing

*** see B.1.3(5).

**** maximum speed limit of 40 km/h

Table B.2: Additional requirements for recycled aggregate for use in pavement concrete compared to natural aggregate

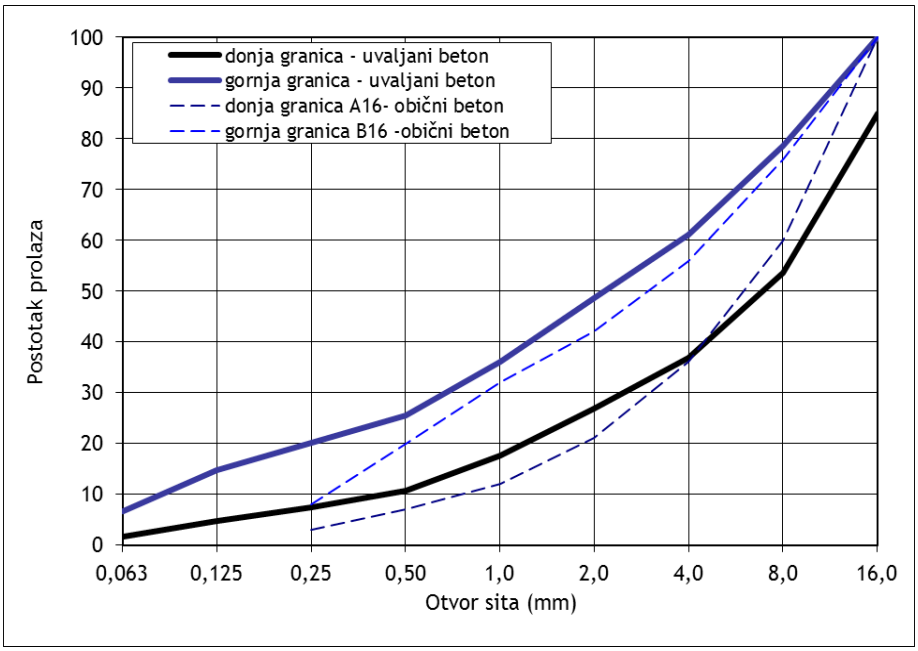
Property	Point of HRN EN	Testing standard	Prescribed value or classes in accordance with

	12620:2008		HRN EN 12620:2008
Water-soluble sulphate content	6.3.3	HRN EN 1744-1:2012	$SS_{0,2}$
Acid-soluble chloride content	6.2.	HRN EN 1744-5:2008	According to HRN EN 206:2021

Table B.3 Limits of particle size distribution A16 and B16 for concrete according to HRN 1128:2023, HRN 1128/A1:2023 and limits of aggregates for roller compacted concrete

Sieve opening (mm)	0,063	0,125	0,25	0,50	1,0	2,0	4,0	8,0	16,0
	Percentage of passage (%)								
lower limit – roller compacted concrete	1,7	5	7	11	18	27	37	54	85
upper limit – roller compacted concrete	6,7	15	20	25	36	49	61	79	100
lower limit A16 – plain concrete	-	-	3	7	12	21	36	60	100
upper limit B16 – plain concrete	-	-	8	20	32	42	56	76	100

Note: sieve passage is expressed numerically



Postotak prolaza, Otvor sita

Donja granica – uvaljani beton, gonja granica - uvaljani beton, donja granica A16 – obični beton, gonja granica B16 – obični beton

Percentage of passage, Sieve opening

Lower limit – roller compacted concrete, lower limit – roller compacted concrete, lower limit A16 – plain concrete, lower limit B16 – plain concrete

Figure B.1 — Limits of particle size distribution of aggregates for roller compacted concrete compared with limits A16 and B16 for concrete according to HRN 1128:2023 and HRN 1128/A1:2023

ANNEX C: DOWELS, ANCHORS, REINFORCEMENT AND REINFORCING STEEL

C.1 Scope and general requirements

(1) Pursuant to Article 22 of this Regulation, this Annex lays down the properties and other requirements for dowels and anchors intended for installation in concrete pavements, for reinforcement and for steel intended for reinforcement of concrete pavements.
(2) For the purposes of this Regulation, dowels are smooth steel rods which are partially coated and extend into adjacent slabs at the joints of a concrete pavement in order to improve load transfer and facilitate sliding.
(3) For the purposes of this Regulation, anchors are ribbed steel bars which are placed under longitudinal dividers in order to prevent their spread and the formation of deformations and cracks.
(4) Concrete pavement reinforcement means reinforcement made of reinforcing steel, manufactured in a central reinforcement plant (reinforcement works), in the reinforcement plant for the production of prefabricated elements or in the reinforcement plant present at the construction site for the needs of that construction site.
(5) For the purposes of this Regulation, reinforcing steel is a construction product intended for the manufacture of anchors and reinforcement.

C.2 Specified properties, assessment and verification of properties, proof of serviceability and labelling

C.2.1 Specified properties

(1) Properties of dowels shall be specified pursuant to Table C.1.
(2) Properties of anchors shall be specified pursuant to Table C.2.
(3) Properties of reinforcement shall be determined in the design of the pavement structure by specifying the properties of reinforcing steel from which it is made.
(4) Properties of reinforcing steel shall be determined in the design of the pavement structure by specifying the properties pursuant to HRN EN 13877-1:2023, point 6.7, HRN EN 10080:2012, HRN 1130-1:2008 and HRN 1130-2:2008.

C.2.2 Assessment and verification of properties and demonstration of serviceability

There are no special requirements regarding Article 22(3) of this Regulation for the assessment and verification of the properties of dowels and reinforcing steel, i.e., the demonstration of the serviceability of anchors and reinforcements.

C.2.3 Labelling

(1) The labelling of dowels shall be carried out in accordance with HRN EN 13877-3:2005. The type of steel and its dimensions are laid down in the design of the pavement structure.
(2) Labelling of the position of anchors shall be carried out according to the design of the pavement structure.
(3) Labelling of the position of reinforcement shall be carried out according to the design of the pavement structure.
(4) There are no special requirements for the labelling of reinforcing steel in relation to Article 22(3) of this Regulation.

C.3 Testing and other procedures

(1) Testing of dowels shall be carried out pursuant to Table C.1.
(2) Testing of anchors shall be carried out pursuant to Table C.2.
(3) There are no additional requirements for the testing of reinforcement.
(4) There are no additional requirements for the testing of reinforcing steel.

C.4 Design

(1) The properties of dowels shall be determined in the design of the pavement structure by specifying properties in accordance with point C.2.1(1).
(2) The design of a pavement structure shall define the following:
— the properties of the anchors, by specifying the properties in accordance with point C.2.1(2),
— demonstration of the serviceability of the anchors,
— method of labelling anchors.
(3) The design of a pavement structure shall define the following:
— the properties of reinforcement, by specifying the properties in accordance with point C.2.1(3),
— demonstration of the serviceability of the reinforcement,
— method of labelling reinforcement.
(4) The properties of reinforcing steel shall be determined in the design of the pavement structure in accordance with point C.2.1(4).

C.5 Supervision and other procedures prior to installation

(1) Immediately prior to installation, it shall be mandatory to visually inspect the geometric properties of dowels pursuant to Table C.1.
(2) There are no requirements other than those laid down in Article 23 of this Regulation for the performance of surveillance activities immediately prior to the installation of anchors, reinforcement and reinforcing steel.

C.6 Construction

There are no additional requirements for the installation of dowels, anchors, reinforcement and reinforcing steel.

C.7 Specifications

The list of standards applicable under this Annex is set out in Appendix 1 to this Regulation.

ANNEX D: PRODUCTS FOR THE SEPARATING ASPHALT LAYER, HYDRAULICALLY BOUND BASE AND BASE MADE OF UNBOUND MIXTURES OF STONE MATERIAL

D.1 Scope and general requirements

(1) Pursuant to Article 22 of this Regulation, this Annex lays down technical properties and other requirements for products for the separating asphalt layer, hydraulically bound base and base made of unbound mixtures of stone material.
(2) For the separating asphalt layer, the use of products which meet the requirements of a special regulation governing asphalt pavements is allowed in the part in which that regulation regulates bituminous mixtures for the surface layer of asphalt concrete, marked AC 16 surf50/70, mixtures of aggregates of the AG4 category, type M4, which meet the requirements of this Annex.
(3) For the hydraulically bound base, it is allowed to use mixtures bound with frost-resistant hydraulic binders:
— of class C2.3/3 according to HRN EN 14227-1:2013, for heavy traffic load, or
— of class of at least C3/4 according to HRN EN 14227-1:2013, for very heavy to extremely heavy traffic load.
(4) For the base made of unbound mixtures of stone materials, the use of aggregates for these mixtures that meet the requirements of this Annex is allowed.

D.2 Specified properties, assessment and verification of properties and labelling

D.2.1 Specified properties

(1) The properties of products for the separating asphalt layer shall be specified in accordance with the provisions of a special regulation governing asphalt pavements in the part in which that regulation regulates bituminous mixtures for the surface layer of asphalt concrete, marked AC 16 surf 50/70, mixtures of aggregates of the AG4 category, type M4, and in accordance with HRN EN 13108-1:2007 and HRN EN 13108-1:2007/Corr.1:2008, in accordance with Table D.1.
(2) The properties of hydraulic binders, aggregates for the hydraulically bound base and hydraulically bound mixtures shall be specified pursuant to HRN EN 14227-1:2013 and in accordance with HRN EN 13242:2008, in accordance with tables D.2, D.3, D.4, D.5, D.6, D.8 and D.9, as well as point B 1.2.
(3) The properties of aggregate for an unbound mixture of stone materials shall be specified pursuant to HRN EN 13242:2008 and HRN EN 13285:2018, in accordance with tables D.2, D.3, D.4, D.5 and D.7.

D.2.2 Assessment and verification of properties

(1) Assessment and verification of properties of products for the separating asphalt layer shall be carried out by means of procedures laid down in a separate regulation governing asphalt pavements in the part which this regulation regulates bituminous mixtures for the surface layer made of asphalt concrete, marked AC 16 surf 50/70, aggregate mixtures of category AG4, type M4, and procedures laid down in HRN EN 13108-1:2007 and HRN EN 13108-1:2007/Corr.1:2008, in accordance with Table D.1.
(2) The assessment and verification of properties of the hydraulically bound base shall be carried out by means of procedures governed by HRN EN 14227-1:2013, in accordance with Table D10.

(3) Assessment and verification of properties of aggregates for an unbound mixture of stone materials and the constructed layer shall be carried out by procedures laid down in HRN EN 13242:2008 and HRN EN 13285:2018, in accordance with Table D.11.

D.2.3 Labelling

There are no specific requirements in relation to Article 22(3) of this Regulation for the labelling of products for the separating asphalt layer, hydraulically bound base and base made of unbound mixtures of stone materials.

D.3 Testing and other procedures

Compliance with the requirements of point D.1(3) concerning resistance to freezing and thawing shall be demonstrated by means of procedures governed by HRS CEN/TS 13286-54:2016.

D.4 Design

(1) The properties of products for the separating asphalt layer shall be determined in the design of the pavement structure by specifying properties in accordance with point D.2.1(1).
(2) The design of a pavement structure shall define the following:
— properties of hydraulic binders and aggregates for the hydraulically bound base, specified pursuant to point D.2.1(2).
— requirements regarding resistance to freezing and thawing.
(3) The properties of products for the base made of unbound mixtures of stone materials shall be determined in the design of the pavement structure by specifying properties in accordance with point D.2.1(3).

D.5 Supervision and other procedures prior to installation

With the exception of supervisory actions carried out pursuant to Article 23 of this Regulation, immediately prior to the installation of the bituminous mixture, its temperature shall be tested in accordance with a special regulation governing the properties of the mixture for asphalt pavements.
D.6 Construction
The installation of products for the separating asphalt layer, hydraulically bound base and base made of unbound mixtures of stone materials are not subject to additional requirements.
D.7 Specifications
The list of standards and recognised technical requirements applicable under this Annex is set out in Appendix 1 to this Regulation.

Table D.1 Physical and mechanical properties of the bituminous mixture for the construction of the separating asphalt layer

Point of HRN EN 13108-1:2007 and HRN EN 13108-1:2007/Corr.1:2008	Property	Required value
Point 5.2.2 [(a)]	Void content, *V* % (*V*/*V*)	$V_{min\ 1.5}$
		$V_{min\ 4}$
Point 5.3.3.[(a)]	Voids filled with bitumen, *VFB* (%)	VFBmin70

Point of HRN EN 13108-1:2007 and HRN EN 13108-1:2007/Corr.1:2008	Property	Required value
		VFBmax86
Point 5.2.4 (b)	Minimum indirect tensile strength ratio, *ITSR* (%)	ITSR $_{70}$
(a) Samples are prepared using the Marshall compactor, 2×50 blows (HRN EN 13108-20:2016, point C.2, Table C.1, point C.1.2), while volumetric properties are determined pursuant to Annex D to HRN EN 13108-20:2016, point D.2 (b) Samples are prepared using the Marshall compactor, 2×35 blows, and are tested pursuant to Annex D to HRN EN 13108-20:2016, point D.3		

Note: Testing shall be carried out at a frequency of at least 1/1,000 tonnes of bituminous mixture or 1 test per day.

Table D.2 Geometrical properties of aggregates for unbound and hydraulically bound mixtures

Technical properties according to HRN EN 13242:2008	Point of HRN EN 13242:2008	Testing method	Base made of unbound mixtures			Hydraulically bound base		
Fraction size			Coarse	Fine	Mixed	Coarse	Fine	Mixed
			Requirements (classes according to HRN EN 13242:2008)					
Particle size distribution of aggregate	4.3.	HRN EN 933-1:2012	G_C85-15	G_F85	G_A5	G_C85-15	G_F85	G_A85
Limit values and tolerances on sieve *D*/1.4 for fractions in which *D*/*d*<4,	4.3.2 Table 3		GT_C 20/15	-	-	GT_C 20/15	-	-
Limit values and tolerances on sieve *D*/2 for fractions in which *D*/≥4,	4.3.2 Table 3		GT_C 20/17.5	-	-	GT_C 20/17.5	-	-
Tolerances from the declared typical particle size distribution on sieves *D*, *D*/2i 0.063 mm,	4.3.3 Table 4		-	GT_F 10	GT_A 20	-	GT_F 10	GT_A 20
Fine particle content (particle size up to 0.063 mm),	4.6 Table 8	HRN EN 933-1:2012	f_2	f_{10}	f_5	f_2	f_{10}	f_{12}
Quality assessment of fines — sand equivalent, or — methylene blue	4.7	HRN EN 933-8:2015 or HRN EN 933-	-	SE_{35} or MB_3	SE_{35} or MB_3	-	SE_{40} or MB_3	SE_{40} or $MB_{2.5}$

		9:2022						
Flatness index, *FI*,	4.4 Table 5	HRN EN 933-3:2012	FI_{35}	-	FI_{35}	FI_{35}	-	FI_{35}
Shape index,	4.4 Table 6	HRN EN 933-4:2008	SI_{40}	-	SI_{40}	SI_{40}	-	SI_{40}
Proportion of crushed, broken grains and perfectly round grains in coarse aggregate	4.5 Table 7	HRN EN 933-5:2022	Subject to testing	-	Subject to testing	Subject to testing	-	Subject to testing

Table D.3 Required physical and durability properties of aggregates for unbound and hydraulically bound mixtures

Technical properties according to HRN EN 13242:2008	Point of the standard	Testing method	Base made of unbound mixtures	Hydraulically bound base
resistance of coarse aggregate to fragmentation (*LA*)	5.2	HRN EN 1097-2:2020	LA_{40}	LA_{40}
resistance of coarse aggregate to wear (M_{DE})	5.3	HRN EN 1097-1:2024	$M_{DE}35$	$M_{DE}35$
Density	5.4	HRN EN 1097-6:2022	Subject to testing	
Water absorption	5.5	HRN EN 1097-6:2022	Subject to testing	
Water absorption for determination of freeze-thaw resistance	7.3.2	HRN EN 1097-6 :2022 (p.7 or 8 or Annex B)	$WA_{24}2$ or *W*cm 0.5	$WA_{24}2$ or *W*cm 0.5
Freeze-thaw resistance or magnesium sulphate	7.3.3	HRN EN 1367-1:2008 or HRN EN 1367-2:2010	*F*1 or MS_{18}	*F*2 or MS_{18}

Table D.4 Content/composition (chemical properties) of aggregate for unbound and hydraulically bound mixtures

Technical properties according to HRN EN 13242:2008	Point of the standard	Testing method	Base made of unbound mixtures Hydraulically bound base
Petrographic testing	B.2.2	HRN EN 932-3:2022	Subject to testing
Content of components of coarse recycled aggregate	5.6	HRN EN 933-11:2009	Subject to testing allowed (*R*c, *R*u, *R*g, *R*b, *R*a and *R*g)

Table D.5 Additional requirements for aggregate from special deposits and industrial aggregate for unbound and hydraulically bound mixtures

Technical properties according to HRN EN 13242:2008	Point of HRN EN 13242:2008	Testing method	Base made of unbound mixtures Hydraulically bound base
Property of 'Sonnenbrand' basalt on silicate rocks with visible Sonnenbrand signs,	7.2 Table 17	HRN EN 1367-3: 2004/AC:2006 and HRN EN 1097-2:2020	$SB_{LA.}$ shall be tested
Stability of air-cooled blast furnace slag	6.5.2.2	HRN EN 1744-1:2012	Slag shall not contain dissolved dicalcium silicate.
Stability of air-cooled blast furnace slag	6.5.2.3	HRN EN 1744-1:2012	Slag shall not contain dissolved iron.
Volume stability of steel slag	6.5.2.1 Table 16	HRN EN 1744-1:2012	Volume change shall not exceed V5.

Table D.6 Chemical properties of aggregate for hydraulically bonded mixtures

Technical properties according to HRN EN 13242:2008	Point of the standard HRN EN 13242:2008	Testing method	Hydraulically bound base
Acid-soluble sulphates,	6.2	HRN EN	$AS_{0.2}$ - for all aggregates except air-cooled slag

	Table 13	1744-1:2012	$AS_{1.0}$ - for air-cooled slag
Total sulphur content	6.4 Table 14	HRN EN 1744-1:2012	*S*1 - for all aggregates except air-cooled slag *S*2 - for air-cooled slag, — exceptionally, if the aggregate contains pyrrhotite (unstable form of ferric sulphide FeS) Total sulphur content ≤ 0.4 %
Water-soluble sulphates,	6.4 Table 13	HRN EN 1744-1:2012	$SS_{0.2}$*
Ingredients affecting the binding and hardening rate of hydraulically bound mixtures	6.5.1	HRN EN 1744-1:2012	These are tested on aggregates containing organic and other binding ingredients (organic substances, presence of fulvic acids)

* - Only for recycled aggregates

Table D.7 Prior testing of the material used for the fabrication of the base made of unbound mixtures

Technical properties	**Test standard**	**Required value**
Water content	HRN EN ISO 17892-1:2015/A1:2022	Subject to testing
Non-uniformity coefficient (particle size distribution)	HRN EN 17892-4:2015/A1:2022 HRN EN 933-1:2012	for natural gravel d_{60}/d_{10} between 15 and 100
		for crushed stone d_{60}/d_{10} between 15 and 50
1) Content of fines <0.02 mm, % (m/m)	HRN EN 17892-4:2015/A1:2022	< 3
Organic and light particulate matter content, %(m/m)	HRN EN 1744-1:2012 pt. 15.1 and 14.2	< 2
Dry bulk density, Mg/m³	HRN EN 13286-2:2010/ Cor.1:2013 (modified Proctor)	Subject to testing
California bearing ratio (CBR), %	HRN EN 13286-47:2021 (at 95 % of the maximum value of dry bulk density of the sample)	for natural gravel ≥ 40
		for crushed stone ≥ 80
Note 1): The proportion of grains smaller than 0.02 mm may also be greater than 3 %, but not greater than 5 % in areas of smaller freezing depths (mild climatic conditions), which should be approved by the supervising engineer and the designer.		

Table D.8 Particle size distribution of the aggregate curve for the hydraulically bound mixture of granulation 0/31.5 mm

Sieve (mm)	**Percentage of passage (through sieve) by mass**	
	Minimum	**Maximum**
45	100	100

31,5	75	100
16	49	90
8	33	73
4	21	60
2	14	47
1	8	36
0,5	5	27
0,25	2	18
0,125	0	12

Note: examples of other possible limit curves for hydraulically bound mixtures are provided in Annex B to HRN EN 14227-1:2013

Table D.9 Prior testing with hydraulically bound mixtures

Property	Testing standard	Required value (selected classes) Mixed aggregate 0/31.5 or 0/63 mm
Organic and light particulate matter content, %(m/m)	HRN EN 1744-1:2012 points 15.1 and 14.2	< 2
Optimal moisture and maximum dry bulk density (compaction energy 2.66 MN m/m^3)	HRN EN 13286-2: 2010/Corr.1:2013	Subject to testing
Compressive strength after 7 days, Rc / MN/m^2	HRN EN 1744-1:2012, HRN EN 13286-41:2021	C2.3/3 and C4/5 / 3.0–5.0
Compressive strength after 28 days,Rc / MN/m^2	HRN EN 1744-1:2012, HRN EN 13286-41:2021	C4/5 and C5/6 / 3.5–6.5
Resistance of cement-stabilised material to freezing, % (RA/RB)	HRS CEN/TS 13286-54: 54:2016 Compressive strength reduction index	≥ 80

Table D.10 Properties of hydraulic bonding mixes for the performance of the load-bearing layer

	Property	Test standard	Required value
Mixture	Particle size distribution[(c)]	HRN EN 933-1:2012 HRN EN ISO 17892-4:2015/A1:2022	Table D.9
	Compressive strength (MN/m^2) [(a)]	HRN EN 13286-41:2021	Table D.10

	Freeze-thaw resistance (%)	HRN EN 13286-54:2016	Table D.10
	Indirect tensile strength (MN/m^2)[(b)]	HRN EN 13286-42:2003	Subject to testing
	Elasticity module (MN/m^2)	HRN EN 13286-43:2003	Subject to testing

a) after 7 and 28 days on test bodies made of fresh stabilisation mixture
b) after 7 days on test bodies made of fresh stabilisation mixture
(c) particle size distribution shall be determined according to HRN EN 933-1:2012 for aggregate containing >0.063 mm grains; particle size distribution shall be determined according to HRN EN 17892-4: 2015/A1:2022 for aggregate containing <0.063 mm grains

Note: Testing shall be carried out at a frequency of 1/1,000 m^2 of the mixture or 1 test per day

Table D.11 Required properties of aggregate for unbound mixtures of stone material

Property	Testing standard	Required value (selected classes)
		Mixed aggregate 0/32 or 0/63
Particle size distribution of oversized and undersized grains.	HRN EN 933-1:2012 Table 2	G_A85
Tolerances from the declared typical particle size distribution on sieves D, D/2 and 0.063 mm, *Table 4*		GT_A10
Fine particle content (particle size up to 0.063 mm),	HRN EN 933-1:2012 Table 8	f_3
Flatness index, FI,	HRN EN 933-3:2012 Table 5	Subject to testing
Shape index, *Table 6*	HRN EN 933-4:2008 Table 6	SI_{40}
Resistance to fragmentation (‘Los Angeles’),	HRN EN 1097-2:2020 Table 9	LA_{40}
Density and water absorption	HRN EN 1097-6:2022 Point 7, 8 or 9	Subject to testing
Water absorption as an indicator of frost resistance	HRN EN 1097-6:2022, point 7 Tables 18 and 19**	$W_{24}1$;
	HRN EN 1097-6:2022, Annex B	$W_{24}0.5$
— freeze-thaw method, or — magnesium sulphate resistance method,	HRN EN 1367-1:2008 Table 20	F_2
	HRN EN 1367-2:2010 Table 21	MS_{25}
**When water absorption exceeds the prescribed classes, freeze-thaw resistance of aggregate shall be tested		

Note: Testing of particle size distribution and fine particle content shall be carried out at a frequency of 1/1,000 m^2 of the mixture or 1 test every day; other tests shall be carried out prior to the start of installation and subsequently as necessary.

ANNEX E: PRODUCTS FOR SEALING CONCRETE PAVEMENT DIVIDERS

E.1 Scope and general requirements

(1) In accordance with Article 22 of this Regulation, this Annex lays down the properties and other requirements for bituminous and non-bituminous products for sealing concrete pavement dividers (hereinafter: sealing products).
(2) The use of sealing products that have any harmful effect on the concrete of the concrete pavement shall not be allowed.

E.2 Specified properties, assessment and verification of properties and labelling

E.2.1 Specified properties

(1) Properties of bituminous sealing products, as defined in HRN EN 13877-1:2023, point 6.4, shall be specified as follows:
— for hot-applied products, they shall be specified pursuant to HRN EN 14188-1:2005,
— for cold-applied products, they shall be specified pursuant to HRN EN 14188-2:2005,
— for prefabricated (shaped) products, they shall be specified pursuant to HRN EN 14188-3:2007.
(2) Properties of non-bituminous sealing products shall be specified pursuant to HRN EN 15651-1:2012 and HRN EN 1561:2024.

E.2.2 Assessment and verification of properties

(1) Assessment and verification of properties of bituminous sealing products shall be carried out:
— for hot-applied products, by means of procedures regulated by HRN EN 14188-1:2005,
— for cold-applied products, by means of procedures regulated by HRN EN 14188-2:2005,
— for prefabricated (shaped) products, by means of procedures regulated by HRN EN 14188-3:2007.
(2) Assessment and verification of properties of non-bituminous sealing products shall be carried out by means of procedures regulated by the relevant specification according to which they were produced.

E.2.3 Labelling

There are no special requirements for the labelling of sealing products in relation to Article 22(3) of this Regulation.

E.3 Testing and other procedures

The fulfilment of the requirements of point E.1.2 regarding the safety of sealing products for concrete pavements shall be demonstrated in accordance with the design of the pavement structure.

E.4 Design

(1) The properties of bituminous sealing products shall be determined in the design of the pavement structure by specifying properties in accordance with point E.2.1(1).
(2) The properties of non-bituminous sealing products shall be determined in the design of the pavement structure by specifying properties in accordance with point E.2.1(2).

E.5 Supervision and other procedures prior to installation

Regarding the performance of supervision immediately prior to the installation of sealing products, there are no requirements other than those laid down in Article 23 of this Regulation.

E.6 Construction

Regarding the installation of sealing products, there are no additional requirements other than those stipulated in Title V of this Regulation.

E.7 Specifications

The list of standards applicable under this Annex is set out in Appendix 1 to this Regulation.

ANNEX F: PREFABRICATED ELEMENTS FOR PAVEMENT STRUCTURES

F.1 Scope

(1) Pursuant to Article 22 of this Regulation, this Annex lays down properties and other requirements for prefabricated elements for pavement structures.
(2) Unless otherwise provided for in this Annex, the rules laid down in a special regulation governing construction structures shall apply mutatis mutandis to prefabricated concrete elements in the part in which that regulation regulates prefabricated elements and/or prefabricated concrete elements.
(3) In application of the provisions of the special regulation referred to in point F.1(2), words ‘prefabricated element’ shall be replaced by words ‘prefabricated concrete element’, and words ‘design of a structure’ shall be replaced by words ‘design of a pavement structure’.

ANNEX G: DESIGN OF PAVEMENT STRUCTURE

G.1 Scope and general requirements

(1) Pursuant to Article 15 of this Regulation, this Annex lays down the rules for the design of the pavement structure of traffic structures.
(2) The provisions of this Annex relate to the design of a pavement structure taking into account basic operations and the basis of calculation and dimensioning.
(3) For the design and dimensioning of a pavement structure, the provisions of this Annex, standards, regulations and recognised technical rules listed in Appendix 1 to this Regulation shall apply.
(4) The dimensioning of a pavement structure shall involve determining the thickness of the layers and the total thickness of the pavement structure depending on the influence of traffic load, the properties of the subgrade, as well as weather and hydrological conditions.
(5) The width of a pavement structure shall include driving and curb lanes. If they are constructed, concrete curbs and gutters shall be connected to the concrete pavement slab.
(6) The design of a pavement structure shall ensure that, with the prescribed maintenance, the designed properties of all layers of the structure are maintained throughout the designed service life.
(7) The dimensioning of a pavement structure according to this Annex shall be based on the assumption that all the basic parameters to be taken into account in the designed section of the road are similar and shall not change by more than 10 % compared to predicted parameters during use. In that case, the designed service life and serviceability of the constructed concrete pavement structure shall be deemed to be ensured.
(8) If there is a need to verify the conformity of construction products to be installed in the pavement, the suitability of the method of installation, compacting and finishing of the surface, the design of a pavement structure shall determine the construction of the test section, also in cases where there is no obligation to do so under Article 12 of this Regulation.
(9) In the case referred to in point G.1(8), the design of a pavement structure shall explicitly state which properties and activities are to be checked during the construction of the test section, and shall specify the expected results and acceptable deviations from the expected results.
(10) The design of a pavement structure shall define requirements for checks and/or control procedures for the concrete pavement, which shall include at least the following:
— properties of concrete in the constructed pavement pursuant to Annex A and Table H.4,
— properties of the surface of the constructed pavement pursuant to Table H.5.
(11) The requirements for verification and/or control procedures of the properties of concrete in the constructed pavement referred to in point G.1(10) shall be determined in the design of a pavement structure according to the categories defined in Article 5 of this Regulation.
(13) The control procedures shall be established for pavement structures in relation to the control of concrete in the constructed pavement for categories 1 and 2 of verification of the construction of the concrete pavement, in accordance with the provisions of point H.2.13.
(14) The design of concrete pavements shall also be subject to the additional requirements laid down for individual construction products in the relevant annexes to this Regulation.

G.2 Basics of dimensioning

G.2.1 General

When dimensioning a pavement structure, the following basic parameters shall be taken into account:

technical properties of the subgrade,
traffic load and the designed service life (project period),
weather and hydrological conditions,
properties of the products and materials from which the pavement structure is made.

G.2.2 Required technical properties of the subgrade

(1) The pavement structure may be constructed on a subgrade which has the required technical properties and meets the requirements of Table G.1.
(2) Informative correlation values of load-bearing indicators for different materials are given in Table G.2.

G.2.3 Relevant traffic load

G.2.3.1 Method of determination

(1) The traffic load of a pavement structure shall be determined by the number of axles with an axle load equal to or greater than 20 kN passing over the road section relevant to the design during the designed service life.
(2) The relevant traffic load of the pavement structure during the designed service life shall be determined for an equivalent traffic load of 100 kN. The relevant traffic load Ni is determined by the total number of passes of the standard 100 kN axle during the designed service life.
(3) The designed service life of the pavement structure according to this Regulation is 40 years.
(4) For each axle (axle load) that will pass over the road section during the designed service life, the total number of passes of that axle during the designed service life shall be calculated, in accordance with the following formula:

n_{Pi} = 365 x n_{dPi} x f_{tp} x f_{pp} where:

n_{Pi} - total number of axle passes with corresponding axle load Pi during the designed service life,
n_{dPi} - daily number of passes at the beginning of the designed service life for the respective axle,
f_{tp} - traffic growth factor due to the growth of traffic during the designed service life,
f_{pp} - factor of distribution of traffic load on traffic lanes.
(5) Traffic growth factor is calculated according to the following formula:

$$f_{tp} = \sum_{n=1}^{k} ¿ \left(1 + \frac{r}{100}\right)^n$$

where:
k - designed service life in years,
r - annual traffic growth rate (%).
(6) Traffic load distribution factor fpp is selected from Table G.3 depending on the number of lanes.
(7) Total equivalent number of passes of a standard 100 kN axle shall be determined by the following formula:

$$\log N_{100-Pi} = \log n_{Pi} \times \sqrt{\frac{P_i}{P}}$$

where:

P_i- axle load in kN,
P - standard axle load of 100 kN = 100 kN
$N_{100\text{-}Pi}$ – equivalent number of passes of a standard 100 kN axle for the corresponding axle during the designed service life.
(8) Relevant traffic load Tn is obtained by adding the resulting equivalent numbers of passes of a standard 100 kN axle (N100-Pi) for all axles that will pass over the road during the designed service life.

G.2.3.2 Classification

Traffic load shall be classified into one traffic load group in accordance with Table G.4.

G.2.4 Impact of weather and hydrological conditions

(1) The minimum thickness of the pavement structure shall be determined pursuant to Table G.5 for the location of the relevant meteorological station.
(2) If the total calculated thickness of the concrete pavement structure is less than the minimum thickness of the pavement structure safe from the adverse effects of freezing and thawing according to Table G.5, it is necessary to increase the thickness of the sub-base or to construct the subgrade from materials resistant to the effects of freezing and thawing.

G.2.5 Properties of construction products

G.2.5.1 General

(1) When selecting the properties of construction products for pavement structures, the following shall be taken into account:
— the intended use of each type and layer of product,
— physical and mechanical properties of the product,
— economy of use.
(2) Specific properties, proof of serviceability, assessment and verification of performance and labelling of construction products, testing of construction products, specific design and construction features and necessary control procedures, as well as other requirements to be met by construction products to be installed in the concrete pavement, are set out in Annexes A to E and Annex I to this Regulation.

G.2.5.2 Composition of a pavement structure

(1) A pavement structure shall consist of:
— a concrete pavement slab,
— a 5 cm thick separating layer made from a bituminous mixture,
— a hydraulically bound base,
— a base made of unbound mixtures of granular stone material.
(2) Regardless of the traffic load group, the concrete pavement slab referred to in point G.2.5.2(1)(1) and the base made of unbound mixtures of granular stone material referred to in point G.2.5.2.1(1)(4) are mandatory components of a pavement structure.
(3) The 5 cm thick separating layer made from a bituminous mixture referred to in point G.2.5.2(1)(2) is a mandatory component of the pavement structure for heavy to extremely heavy traffic load groups.

(4) The hydraulically bound base referred to in point G.2.5.2.1(1)(3) shall be used in pavement structures for heavy to extremely heavy traffic load groups, but shall not be a mandatory component of a pavement structure.

G.2.5.3 Concrete pavement slab

(1) The products for a concrete pavement slab shall the properties and shall comply with the other requirements laid down in Annexes A, B and C to this Regulation.
(2) The constructed concrete pavement slab shall have the properties set out in Annex H to this Regulation.

G.2.5.4 5 cm thick separating layer made from a bituminous mixture

(1) The products for the 5 cm thick separating layer made from a bituminous mixture shall have the properties and shall meet other requirements laid down in Annex D to this Regulation.
(2) The constructed 5 cm thick separating layer made from a bituminous mixture shall have the properties prescribed in Annex H to this Regulation.

G.2.5.5 Hydraulically bound base

(1) The products for the hydraulically bound base shall have the properties and shall meet other requirements laid down in Annex D to this Regulation.
(2) The constructed hydraulically bound base shall have the properties prescribed in Annex H to this Regulation.

G.2.5.6 Base made of unbound mixtures of stone material

(1) The products for the base made of unbound mixtures of stone material shall have the properties and shall meet other requirements laid down in Annex D to this Regulation.
(2) The constructed base made of unbound mixtures of stone material shall have the properties prescribed in Annex H to this Regulation.

G.2.5.7 Material replacement coefficients

When determining the types and dimensions of a base, average values of material replacement coefficients (a_{sn}) shall be used:
— for hydraulically bound mixtures: $a_{sn} = 0.23$,
— for unbound mixtures: $a_{sn} = 0.12$ for fractions of crushed materials of stone origin, and
— for unbound mixtures: $a_{sn} = 0.11$ for fractions of uncrushed materials of stone origin.

G.3 Dimensioning

G.3.1 General

(1) The process of dimensioning a concrete pavement structure comprises the following:
determination of relevant input dimensioning parameters according to the procedures laid down in point G.2,
determining the thickness and type of layers according to the properties of the material and the traffic load.
(2) When calculating the necessary thickness in order to prevent adverse effects of freezing and thawing, the separating layer made of a bituminous mixture shall not be included in the calculation of the load-bearing capacity of the pavement structure, but its thickness shall be included in the total thickness of the pavement structure.

G.3.2 Determination of thickness of components of a pavement structure

(1) The thickness of the individual components of a pavement structure, as well as the total thickness of a pavement structure, shall be such that the stresses on the lower surface of the concrete pavement slab shall not exceed the critical stresses determined according to point G.3.5.1(14) and that the entire pavement structure shall be resistant to the adverse effects of freezing and thawing according to point G.2.4.
(2) The required thickness of the concrete pavement slab shall be determined depending on the properties of the subgrade, the traffic load and the physical and mechanical properties of concrete, primarily its tensile strength. The thickness of an unreinforced concrete pavement and of a reinforced concrete pavement shall be determined by separate methods.
(3) The required thickness of the other components of the pavement shall be determined according to the properties of the subgrade and the traffic load and shall be equal to or greater than the thickness given in Table G.7 and Table G.9.
(4) The total thickness of a pavement structure with a concrete pavement shall meet the requirements for resistance to the adverse effects of freezing and thawing specified in point G.2.4. If the subgrade is made of a material resistant to the effects of freezing and thawing, its thickness shall be taken into account during the calculation of the total thickness of the structure, which shall be resistant to the effects of freezing and thawing.
The thickness of the layers of the pavement structure obtained by dimensioning or reading from nomograms shall be rounded up to 10 mm.

G.3.3 Surface properties of a concrete pavement

(1) The surface of a concrete pavement shall be designed so as to achieve surface properties that depend on the traffic load prescribed in Table H.6.
(2) Adhesion of pavements shall be achieved by selecting the type of aggregate, the fractions of the stone aggregate, the treatment of the surface during the construction of the concrete pavement or its subsequent treatment.
(3) In road sections:
— with a longitudinal inclination of more than 6 % over a length of more than 100 m,
— where speed must be abruptly reduced,
— where vehicles are exposed to strong side winds; and
— in curves with a radius of less than 150 m,
the skid resistance shall be greater than 55 SRT units, regardless of the traffic load group.
(4) In order to improve the surface properties of a concrete pavement, it shall also be allowed to perform the coating with a new asphalt layer with bituminous mixture of type SMA 11 AG1 M1 in accordance with a special regulation governing asphalt pavements, with a minimum thickness of 35 mm, while ensuring the connection between the asphalt layer and the concrete pavement of at least 1.0 N/mm2, determined according to HRN EN 12697-48:2021. The properties of the constructed layer shall comply with the specific regulation governing asphalt pavements.

G.3.4 Dividers, dowels and anchors

(1) As a general rule, longitudinal and transverse dividers shall be designed as vertical space between concrete pavement slabs with a width of 4 to 8 mm. The dividers delimiting one slab of the concrete pavement shall be designed in a mutual position at a right angle.
(2) If the slabs of the concrete pavement are in acute-angled shape, apparent separators in places where cracks in the concrete are expected shall be designed.

(3) The dividers, their dimensions, arrangement and mutual position, shall be designed so as not to affect the flatness of the pavement.
(4) As a general rule, anchors shall be installed at the location of a longitudinal divider, while dowels shall be installed at the location of a lateral divider. Dividers above anchors or above dowels shall be designed with a width of min. 8 mm and a depth of min. 20 mm, with adding of a mass for filling in dividers.
(5) As a general rule, dividers without integrated dowels and anchors shall be designed with a width of up to 4 mm, without adding of a mass for filling in dividers.
(6) Longitudinal dividers shall be designed so that they separate traffic lanes on traffic areas.
(7) Transverse dividers shall be designed so that the ratio of width to length of the pavement slab is between 1:1 and 1:1.5.
(8) The distance between transverse dividers and the diameter of dowels in relation to the thickness of the pavement slab is prescribed by Table G.6.
(9) Dividers shall be designed at regular intervals, depending on the thickness of the slab, the strength of the concrete, the type of aggregate and weather conditions.
(10) Depending on the purpose they serve in a pavement structure, three types of dividers shall be designed: apparent, compressed and spatial.
(11) Apparent (contraction) dividers shall be designed as transverse and longitudinal, at a location where controlled breakage of concrete pavement with non-harmful in-use behaviour shall be ensured.
(12) Pressed (operating) dividers shall be designed as transverse and longitudinal, and they separate the concrete pavement slab along the entire thickness in a place where the contact surface of the concrete installed with a time gap shall be ensured.
(13) Dowels or anchors shall be installed in the pressed dividers.
(14) By way of derogation from point G.3.4(13), in case of a pavement with a thickness of less than 15 cm, dowels or anchors shall not be installed.
(15) Spatial dividers shall be designed as vertical dividers filled with a compressive filling mass, extending over the full thickness of the pavement slab at the joints of the concrete pavement and other structures or at the joints of various pavement structures where independent horizontal and vertical pavement displacements shall be provided.
(16) If spatial dividers are designed on the sections over which vehicles are to pass, the lower edge of the pavement slab shall be designed to be thicker by at least 20 % compared to the thickness of the pavement slab, but no less than 50 mm. The pavement slab shall have an increased thickness in a width of at least 1.20 m from the spatial divide.
(17) At the joints of dividers of different thickness (e.g., where lanes for passenger and heavy duty vehicles join), the substrate under the thinner slab shall be designed so as to ensure a gradual change of thickness over a minimum length of 1.2 m.
(18) The filling mass shall be resistant to repetitive displacements and deformations and shall prevent the penetration of water and solid particles into the divider.
(19) The properties of the filling mass shall be specified in the design of the pavement structure in accordance with the requirements for divider sealing products in accordance with Annex E to this Regulation.
The installation of dowels and anchors shall be designed for all concrete pavement slabs with a thickness of more than 15 cm, except for slabs made of roller compacted concrete, where load transfer is ensured by entrapment of aggregate grain.
(21) Dowels shall be designed as smooth steel pins to be installed in the middle of the height of a concrete pavement slab.
(22) Dowels shall be designed with a plan-view regular axial distance of 25 to 30 cm for dowels with a 25 mm diameter, and 30 to 38 cm for dowels with a 32 mm diameter. The distance of dowel axis from the outer edge of the plate shall be from 15 to 25 cm. Requirements

for dowel distance laid down in the design may not be less favourable than the minimum requirements regulated by HRN EN 13877-2:2023.
(23) The properties of dowels shall be specified in the design of a pavement structure in accordance with the requirements for dowels in Annex C and Table G.6 of this Regulation.
(24) Anchors shall be designed as smooth steel pins to be installed in the middle of the height of the concrete slab.
(25) Anchors shall be designed with a plan-view regular axial spacing of no more than 100 cm, regardless of the diameter of the anchor, and with at least three anchors per slab, where the distance of the anchor axis from the outer edge of the plate shall be no more than 25 cm. Requirements for anchor distance laid down in the design may not be less favourable than the minimum requirements regulated by HRN EN 13877-2:2023.
(26) The properties of anchors shall be specified in the design of the pavement structure in accordance with the requirements for anchors dowels in Annex C to this Regulation.

G.3.5 Methods of dimensioning a pavement structure

G.3.5.1 Dimensioning of an unreinforced concrete pavement

(1) The basic parameters for determining the dimensions of a pavement structure shall be:
- the design period, i.e., the designed service life of the pavement structure,
- load-bearing capacity of the subgrade (*CBR*),
- relevant traffic load (T_d *or* T_n),
- tensile bending strength of concrete.

(2) The thickness of a concrete pavement slab d_{bkp} shall be determined based on the nomogram in Figure G.1.
(3) The thickness of a concrete pavement slab shall be read on the curve 'd_{bkp},' at the point of intersection of the auxiliary line joining the load-bearing capacity of the substrate on the vertical line marked 'CBR' and the intersection of the auxiliary vertical line marked 'P' defined by the auxiliary line passing through the value of the total number of passes of the equivalent axle load during the design period (T_n) and the value of the characteristic tensile strength of the concrete on the vertical line marked with f_f. Graphical interpretation is given in Figure G.1.

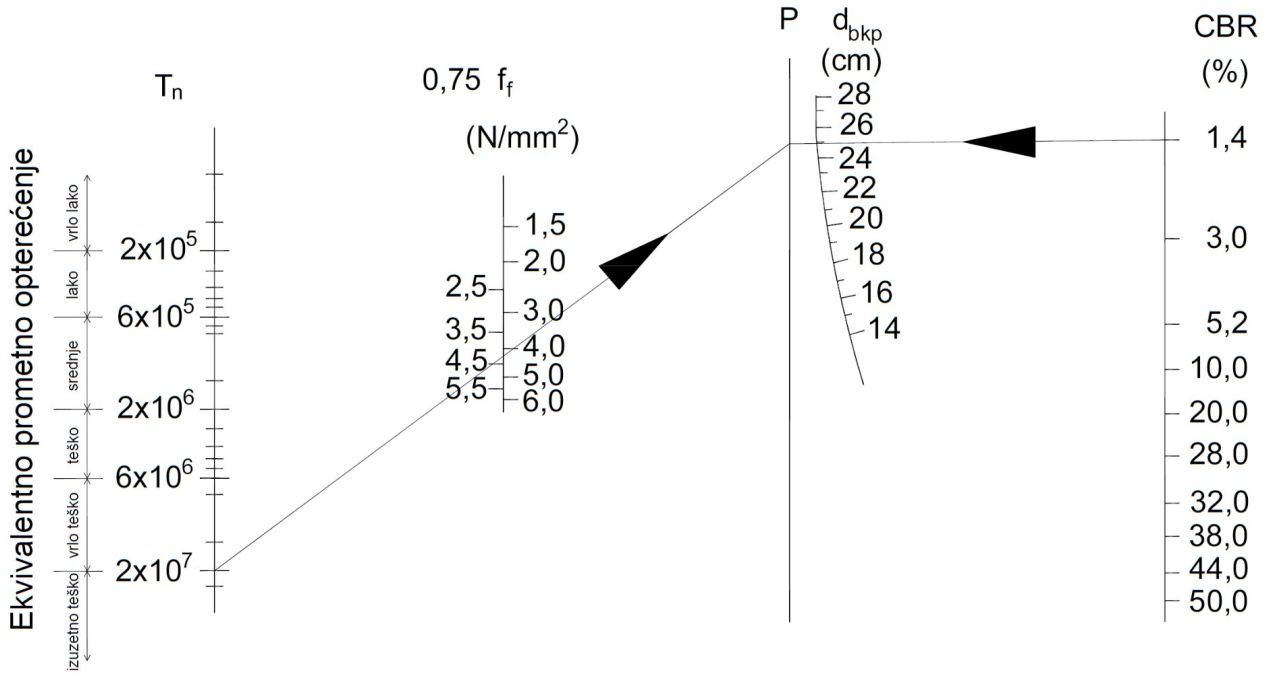


Figure G.1 Nomogram for determining the thickness of an unreinforced concrete slab

Interpretation of the markings in Figure G.1:

T_n – total number of passes of standard equivalent 100 kN axle load during the design period

f_f – characteristic tensile bending strength of concrete

P – auxiliary route

d_{bkp} – thickness of the concrete pavement slab

CBR – California bearing ratio of the subgrade (%).

(4) Thickness of the unbound base is determined from the diagram in Figure G.2.

(5) The thickness of an unbound base shall be read at the left ordinate at the height of the intersection of the bearing ratio of the subgrade *CBR* (in %) and the vertical line with the value of the total number of passes of the equivalent axle load of 100 kN during the design period (T_n) on the abscissa. Graphical interpretation is given in Figure G.2.

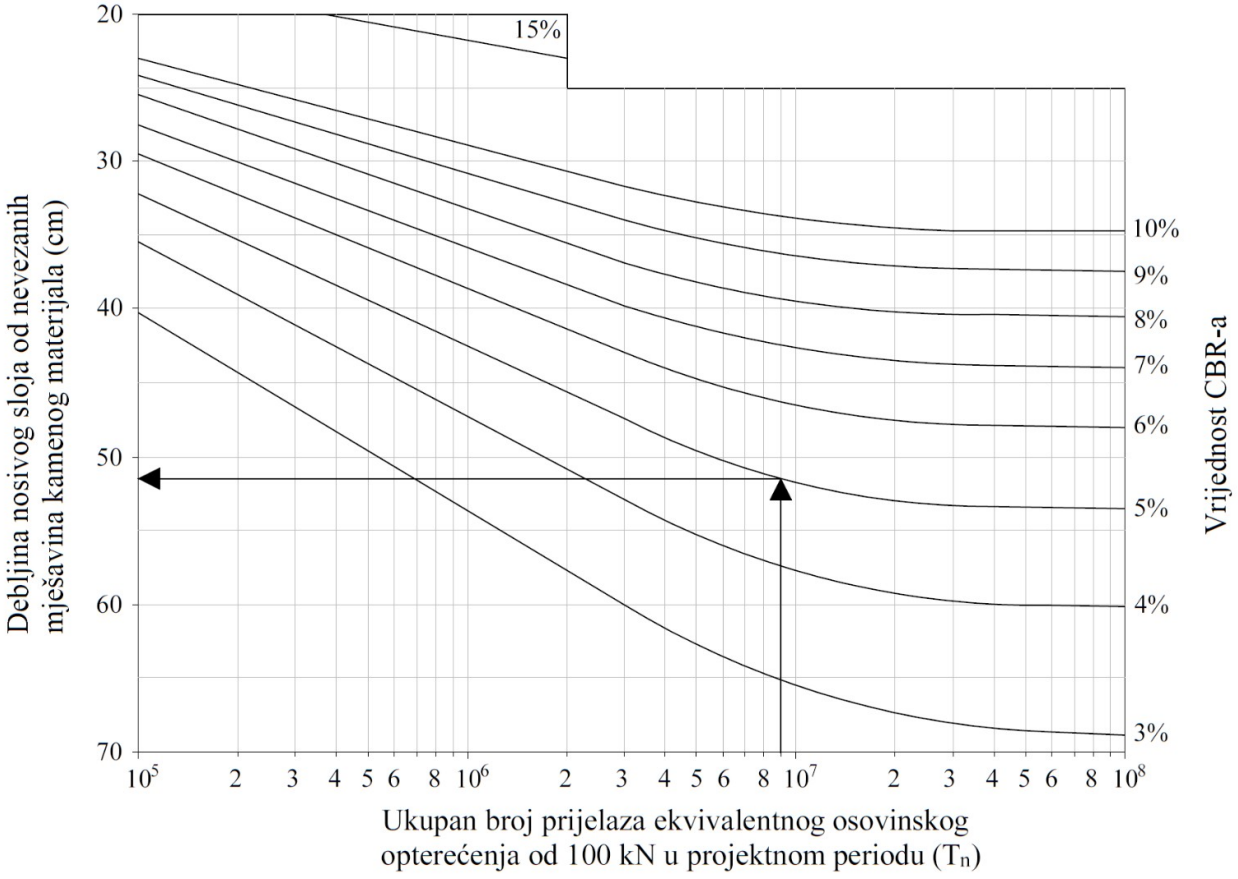


Figure G.2 Diagram for determining the thickness of an unbound base.

(6) A base made of unbound granular stone shall be partially replaced by the hydraulically bound base using the mixture replacement coefficients given in point G.2.5.7. Table G.7 provides the minimum values of the thickness of the layers of a concrete pavement structure depending on the predicted traffic load.

(7) By way of derogation from the thickness specified in Table G.7, on surfaces where the expected average annual number of passes of equivalent axle load is less than $2x10^5$, the minimum thickness of an unreinforced concrete slab shall be 10 cm.

(8) For purposes of durability, ensuring surface properties of the driving surface and resistance to external influences, it shall be permissible to design a concrete pavement slab for construction in two layers. In case of a two-layer concrete pavement slab, the thickness of the upper layer shall be selected according to Table G.8.

(9) For a concrete pavement slab, verification of stress created by following actions shall be carried out:

— traffic load, for critical positions (centre of the slab, centre of the edge of the slab, angle of the slab),

— uneven temperature variations, and

— combination of these actions,

as well as the verification of settlement resulting from the effects of the traffic load.

(10) The stresses exerted by the traffic load shall be determined from the following expression:

— centre of the slab

¿ $$\frac{0{,}275 * P}{d_{bkp}^{\,2}} \cdot (1+\nu) * \left[\log\left(\frac{E * d_{bkp}^{\,3}}{k * b^4} \right) - 0{,}436 \right] (MPa)$$

— centre of the edge of the slab

$$\sigma_{pr} = \frac{0{,}529 * P}{d_{bkp}^{\ 2}} \cdot (1 + 0{,}54 * \nu) * \left[\log\left(\frac{E * d_{bkp}^{\ 3}}{k * b^4} \right) + \log\left(\frac{0{,}1 * b}{1 - \nu^2} \right) - 1{,}08 \right] (MPa)$$

— angle of the slab

$$\sigma_{pu} = \frac{3 * P}{d_{bkp}^{\ 2}} * \left[1 - \left(\frac{12 * 10^4 * (1 - \nu^2) * k}{E * d_{bkp}^{\ 3}} \right)^{0{,}3} * (0{,}1 * r * \sqrt{2})^{1{,}2} \right] (MPa)$$

(11) The deformations (settlement) produced by the traffic load shall be determined from the following expression:

— centre of the slab

$$w_s = \frac{P}{8 * k * L_e^{\ 2}} (mm)$$

— centre of the edge of the slab

$$w_r = \frac{1}{\sqrt{6}} \cdot (1 + 0{,}4 * \nu) \cdot \frac{P}{k ¿ L_e^{\ 2}} (mm)$$

— angle of the slab

$$w_u = \frac{\left(1{,}1 - \frac{0{,}88 * \alpha}{L_e} \right) * P}{k * L_e^{\ 2}} (mm)$$

The indications in the expressions referred to in point G.3.5.1(10) and (11) shall have the following meaning:

P — wheel load:

P = 0.05 MN for an equivalent axle load of 100 kN,

P = 0.04 MN for an equivalent axle load of 82 kN,

P = 0.02 MN for surfaces for vehicles with a total mass up to 10 t,

p — contact pressure (equal to inflation pressure),

p = 0.7 (MN/m2) for an equivalent axle load of 100 kN,

p = 0.6 (MN/m2) for an equivalent axle load of 82 kN,

p = 0.6 (MN/m2) for surfaces for vehicles with a total mass not exceeding 10 t,

r — radius of the contact surface, (m)

$$r = \sqrt{\frac{P}{\pi * p}} (m)$$

d_{bkp}— thickness of the slab, (m)

$$b = \sqrt{1{,}6 * r^2 + h_0^{\ 2}} - 0{,}675\, h_0 (mm)\ z a \qquad r < 1{,}724 * h_0$$

E— concrete elasticity module, E = 30 000 MN/m^2

ν — Poisson's ratio for concrete, ($\nu \cong 0.15$),

a – load distance from the angle of the slab (mm)

K – substrate reaction module, (MN/m^3)

$$k = \frac{E_t}{\sum h ¿}$$

Where:

Et – soil elasticity module (MN/m^2)

E_1 – concrete elasticity module (MN/m^2)
E_2 – elasticity module of hydraulically bound base, (MN/m^2)
E_3 – elasticity module of base made of unbound granular stone material, (MN/m^2)
$h_1 = d_{bkp}$ – thickness of concrete pavement slab (m)
h_2 – thickness of hydraulically bound base (m)
h_3 – thickness of unbound base made of granular stone material (m)
h^*, h_1^*, h_2^* *i* h_3^* – appropriate equivalent thickness of layers (m)
Calculation of stress shall be performed for a single-layer system. The conversion of a multi-layer system into a single-layer system shall be carried out by introducing equivalent layer thickness according to the following expressions:

$$h_1^{¿} = n * h_1 * \sqrt[3]{\frac{E_1}{E_t}}$$

$$h_2^{¿} = n * h_2 * \sqrt[3]{\frac{E_2}{E_t}},$$

$$h_3^{¿} = n * h_3 * \sqrt[3]{\frac{E_3}{E_t}},$$

where:
n=0.90 – for unbound layers
N=0.83 – for cement-bound layers

$$L_e = \sqrt[4]{\frac{E * h^3}{12 * (1 - v^2) * k}}$$

where:
L_e – elastic length (mm)
If the edge of the slab is the edge of the pavement, the load distance from the corner of the slab shall be taken to be the value of r – the radius of the contact surface plus the width of the edge strip. This value shall also be increased by the width of the curb or gutter if they have been constructed in accordance with point G.1.5.
The conversion of the thickness of the layers of a multi-layer system into a single-layer system shall be carried out by applying the following formula:

$$h_0 = \sqrt[3]{\frac{E_1 * h_1^{\,3} + E_2 * h_2^{\,3} + E_3 * h_3^{\,3}}{E_1}}$$

where:
h_0 – thickness of equivalent single-layer system (m)
The bending moments of an equivalent single-layer system due to traffic loads are calculated by applying the following formulas:

$$M_1 = \frac{M_0 * E_1 * h_1^{\,3}}{E_1 * h_1^{\,3} + E_2 * h_2^{\,3}} \quad \text{(Nm)}$$

$$M_2 = \frac{M_0 * E_2 * h_2^{\,3}}{E_1 * h_1^{\,3} + E_2 * h_2^{\,3}} \quad \text{(Nm)}$$

Stress in the layers due to bending is calculated according to the following formulas:

$$\sigma_1 = \pm \frac{6 * M_1}{h1^2} \quad \text{(MPa)}$$

$$\sigma_2 = \pm \frac{6 * M_2}{h_2^2} \quad \text{(MPa)}$$

(12) Stress produced by the effect of an uneven change in temperature shall be determined using the following formula:
— in the middle of a square or rectangular slab with a side ratio up to a maximum of 1:1.2

$$\sigma_t = \frac{0{,}0148 * \left(L_{dil.} - 0{,}4\right)^2}{d_{bkp}} \quad \text{(MPa)}$$

— in the middle of a rectangular slab with a side ratio greater than 1:1.2

$$\sigma_t = \frac{0{,}0186 * \left(L_{dil.} - 0{,}4\right)^2}{d_{bkp}}$$

where:
$L_{dil.}$ — distance between dividers (m)
— on the edge of the slab

$$\sigma_t' = \left(1 - \nu\right) * \sigma_t$$

where:
ν - Poisson's ratio for concrete, ($\nu \cong 0.15$),

(13) The expressions referred to in point G.3.5.1.9 may not be applied if:
— the thermal dilatation coefficient is different from $\alpha = 1.0 * 10^{-5}$,
— the gradient of change in temperature per section height is different from $\beta = 90$ ℃/m'.
(14) The stress resulting from the combination of the action of traffic load and uneven temperature change shall be calculated:
— with safety factors
  — 1.0 for very light and light loads,
  — 1.1 for medium traffic load;
  — 1.2 for heavy to extremely heavy traffic loads.
— for stress combinations

the centre of the slab; the sum of the full stress from traffic and the full stress from temperature changes

edge of the slab; the sum of 85 % of the stress from temperature change and 70 % of the full stress from traffic in case of dowel use, i.e., the sum of the full stress from traffic and the full stress from temperature change in case of slabs without dowels.
(15) By way of derogation from point G.3.5.1(14), for concrete slabs referred to in point G.3.5.1(7), the stress resulting from the combination of the action of the traffic load and the non-uniform change in temperature shall be calculated with a safety factor of 1.25.
(16) Stress resulting from the combination of the action of the traffic load and the uneven temperature change plus the safety factor shall be less than or at most equal to the tensile bending strength of concrete.

G.3.5.1.1 Fatigue

(1) Total number of passes at which fatigue of the concrete slab occurs shall be determined from the following expression:

$$\frac{\sigma_{max}}{f_f} = 1 - 0{,}0685 * \left(1 - \frac{\sigma_{min}}{\sigma_{max}}\right) * \log$$

$$\log N = \frac{\sigma_{max}}{f_f \times 1 - 0{,}0685 * \left(1 - \frac{\sigma_{min}}{\sigma_{max}}\right)}$$

where:

Σ_{max} – maximum stress during the observation period, from the stress combination (MPa);

σ_{min} – minimum stress during the observed period, temperature change stress (MPa) shall be taken into account,

ff – characteristic tensile bending strength of concrete (MPa),

N the number of passes of the equivalent axle at which fatigue of the concrete slab occurs.

(2) Fatigue caused by traffic load and uneven temperature variation shall be determined by accumulating fatigue impact through all four seasons and shall meet the following requirements:

$$\sum_{i=1}^{k} \frac{n_i}{N_{\square}} \leq 1$$

where:

n_i – number of passes per year

k – designed service life according to point G.2.3.1(3).

G.3.5.2 Dimensioning of a continuously reinforced concrete pavement and a pavement with a continuously reinforced base

G.3.5.2.1 Thickness of slab

(1) The basic parameters for determining the dimensions of a pavement structure shall be:

- total number of passes of standard equivalent 100 kN axle load during the design period (Tn),
- bearing ratio of the subgrade (CBR),
- type of base (base made of unbound mixture of stone material or hydraulically bound base),
- tensile bending strength of concrete.

(2) The minimum thickness of the concrete slab of a continuously reinforced concrete pavement shall be 20 cm, while the minimum thickness of the continuously reinforced concrete base shall be 15 cm.

(3) The minimum required thickness of the lower layers depending on the bearing ratio of the subgrade and the type of base (hydraulically bound base or base made of unbound mixtures of stone aggregates) is given in Table G.9.

(4) The thickness of the concrete slab of a continuously reinforced concrete pavement and the concrete slab of a pavement with a continuously reinforced concrete base shall be determined from the nomogram in Figure G.3.

(5) The thickness of a concrete pavement with a continuously reinforced concrete base shall be read on the far left field of the nomogram vertically below the intersection of the horizontal line resulting from (in the central field of the nomogram) the relevant traffic load (T_n) and the

chosen lower layer (line (1) for hydraulically bound base, i.e., line (2) for the base made of unbound mixtures of stone material) with the curve of the chosen tensile bending strength of concrete.
(6) The thickness of a concrete pavement for a continuously reinforced concrete pavement shall be read on the far right field of the nomogram vertically below the intersection of the horizontal line resulting from (in the central field of the nomogram) the relevant traffic load (T_n) and the chosen lower layer (line (1) for hydraulically bound base, i.e., line (2) for the base made of unbound mixtures of stone material) with the curve of the chosen tensile bending strength of concrete.

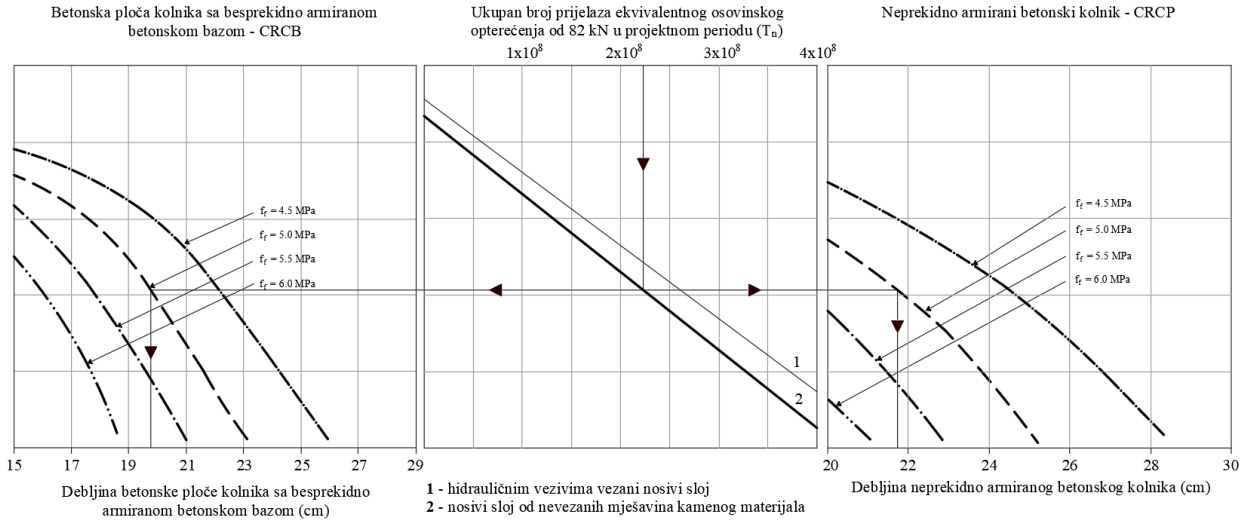


Figure G.3 Nomogram for determining the thickness of the concrete slab of a continuously reinforced concrete pavement and the thickness of the concrete slab of a pavement with a continuously reinforced concrete base. When using the nomogram, the link between the axle loads of 82 kN and 100 kN referred to in point G.2.3.1(7) shall apply.

(7) A wear and binding layer of asphalt of a minimum total thickness of 100 mm shall be constructed on a continuously reinforced concrete base. The requirements that bituminous mixtures and asphalt layers shall meet are set out in Annex I, point I.3. Composite pavements made of concrete with an asphalt coating.

G.3.5.2.2 Longitudinal reinforcement

(1) The spacing between reinforcement bars *S* (mm) shall be determined from the following expression:

$$200\,mm > S = \left(\frac{W-2t}{n-1}\right) > 100\,mm$$

where:
W – width of the slab (mm),
t – thickness of the protective layer of concrete, at least 75 mm up to D/2 (mm),
n = number of reinforcement bars (pcs).

(2) The number of reinforcement bars n (pcs) in the expression in point G.3.5.2.2.1 shall be determined from the following expression:

$$n = \left(\frac{4\, p\mathrm{s} * \mathrm{D} * \mathrm{W}}{\pi * d} \right)$$

where:

d – diameter of a ribbed steel bar (mm)

D – thickness of the slab (mm),

W – width of the slab (mm),

p_s – the amount of reinforcing steel shall be determined in accordance with point G.3.5.4(2), where the minimum permissible amount of reinforcement expressed in % of the cross-sectional area of the slab is 0.6

(3) The number of bars (*n*) and the diameter of reinforcement bars (*d*) in the expression referred to in point G.3.5.2.2(2) shall also meet the required ratio of the surface area of steel for reinforcement and the volume of concrete *Rb* (m^2/m^3), determined from the following expression:

$$Rb = \frac{n * \pi * d}{D * W}$$

where:

N – number of reinforcement bars (pcs),

d – diameter of a ribbed steel bar (mm)

D – thickness of the slab (mm),

W – width of the slab (mm).

(4) The minimum value of the ratio of the surface area of reinforcing steel and the volume of concrete shall be 1.2 m^2/ m^3; for construction during the spring-summer-autumn period, it shall be 1.6 m^2/ m^3.

(5) In order to increase the protective layer of concrete, reinforcement shall be placed at a distance of one third (minimum 75 mm) to one half of the thickness of the slab from the surface of the concrete.

(6) In case of slabs with a thickness greater than 20 cm, it is allowed to place reinforcement in two rows.

(7) The continuation of reinforcement shall be carried out with the displacement of adjacent bars at a distance of at least half the width of the pavement.

G.3.5.2.3 Transverse reinforcement

(1) The quantity of transverse reinforcement pt (%) shall be determined from the following expression:

$$p\mathrm{t} = 100 \times \left(\frac{\gamma c * Ws * F}{20\, f\mathrm{s}} \right) < 0{,}1\,\%$$

where:

γc – density of concrete (kg/m3)

*W*s – total width of pavement (m)

F – friction coefficients according to Table G.10

fs – steel release limit (kPa).

(2) The spacing between bars (Y) shall be determined from the following expression:

$$120\,cm \geq Y = 100 * \left(\frac{\pi * d^2}{4 * p \qquad D} \right) \geq 60\,cm$$

where:

Y – spacing between bars (mm),

D – diameter of a ribbed steel bar (mm),
pt – amount of reinforcement in the cross-section (%),
D – thickness of the slab (mm).
(3) Anchors for connecting longitudinal dividers shall be designed approximately in the middle of the slab thickness, where the amount of transverse reinforcement *ptb* (%) shall be determined from the following expression:
*p*tb=100 * ¿
where:
ɣc – density of concrete (kg/m3),
W'' – distance of the joint to the free edge (m),
F – friction coefficients according to Table G.10
*f*s – steel release limit (kPa).

(4) The length of anchors *t* (mm) shall be determined from the following expression:

$$t = \frac{1}{2} * \left(\frac{f\,\mathrm{s} * \mathrm{d}}{f\,\mathrm{b}} \right) + la$$

where:
fb – strength of the connection between anchor and concrete (2.44 MPa is assumed),
fs – steel release limit (kPa),
D – diameter of a ribbed steel bar (mm),
la – factor of safety, la = 76 mm.

G.3.5.3 Dimensioning of a dilated reinforced concrete pavement

(1) The thickness of a dilated reinforced concrete pavement shall be determined from the following expression:

$$\ln(H1) = \left| Ln(Tn) - R - 3{,}171 \ln(Rc) - 0{,}326 \ln(E) + 45{,}150 \right| / 4{,}786$$

where:
$\ln(H1)$ natural logarithm of value H1
R=9.071 for 600 mm^2/m of reinforcement (0.6 % of the cross-sectional area),
R=9.289 for 700 mm^2/m of reinforcement (0.7 % of the cross-sectional area),
R=9.479 for 800 mm^2/m of reinforcement (0.8 % of cross-sectional area).

$$H2 = 0{,}934\,H1 - 12{,}5$$

H1 – thickness of concrete slab without 1 m wide edge strip (mm), at least 150 mm,
H2 – thickness of concrete slab with a 1 m wide edge strip (mm),
Tn – total traffic load over the design period, no more than 4*10^8 of equivalent axle load of 100 kN,
Rc – compressive strength of concrete, (MPa),
E – rigidity of hydraulically bound base (MPa); E = 10,000 MPa.

(2) The quantity and position of longitudinal reinforcement shall be determined according to point G.3.5.2.2, of transverse reinforcement according to point G.3.5.2.3, and of dowels and anchors according to point G.3.4.
(3) The minimum required thickness of lower layers depending on the bearing ratio of the subgrade shall be determined in accordance with point G.3.5.2.1, Table G.9 (for a hydraulically bound base).

G.3.5.4 Dimensioning of concrete coating

(1) The basic parameters for determining the dimensions of concrete coating shall be:
– relevant traffic load,
– required thickness of the pavement structure based on the traffic load over the design period, D_F,
– effective thickness of the existing pavement structure, $D_{eff.}$

(2) Bound concrete coatings shall be designed as dilated reinforced concrete pavements if they are to be constructed over existing reinforced pavements, or as dilated unreinforced concrete pavements if they are to be constructed over existing unreinforced concrete pavements or asphalt pavements.

(3) Dividers shall be designed at a distance of 12 to 18 times the thickness of the concrete coating, and the longitudinal divider may not be in the position of the wheel track.

(4) Transverse and longitudinal dividers from the existing concrete pavement shall be accurately transferred and constructed on the newly constructed coating, with the processing of dividers pursuant to point G.3.4 and without the use of dowels and anchors.

(5) Reinforcement of the bound concrete coating with a thickness of more than 7.5 cm shall be designed at the bottom of the cross-section, and reinforcement of the bound concrete coating with a thickness of more than 12 cm shall be designed in the middle of the cross-section.

(6) The quantity and position of reinforcement shall be determined in accordance with point G.3.5.2.2 for longitudinal reinforcement and in accordance with point G.3.5.2.3 for transverse reinforcement, or in accordance with point G.3.5.4(2).

(7) Unbound concrete coating shall be constructed as continuous reinforced or dilated concrete and reinforced concrete pavements. Dividers shall be placed at the distance defined in point G.3.5.

(8) Unbound concrete coating shall be designed with a width which ensures that the wheel track is at least 1.0 m away from the free edge.

(9) The thickness of bound concrete coating on an existing concrete pavement shall be determined from the following expression:

$$D_{OL} = D_F - D_{eff}$$

where:
D_{OL} – required thickness of bound concrete coating, (m)
D_F – required thickness of the concrete slab for the designed traffic load, (m)
D_{EFF} – effective thickness of the existing pavement structure, (m).

(10) The thickness of bound coating as an unreinforced concrete slab for the designed traffic load is determined by reading from the nomogram in Figure G.1, but it may not be less than 10 cm, while the thickness of bound coating as an continuously reinforced concrete slab by reading from the nomogram in Figure G.3, but it may not be less than 20 cm. The thickness of bound coating as dilated reinforced concrete slab shall be determined in accordance with point G.3.5.3.

(11) For the purpose of determining the effective thickness of a pavement structure, exploratory works shall be carried out, which shall include at least a visual inspection, the extraction of samples from layers of pavement and the examination of their physical and mechanical properties and thickness.

(12) In addition to the exploratory works referred to in point G.3.5.4(11), for the purposes of determining the effective thickness of a pavement structure, it is permissible to include the determination of the modulus of elasticity in the exploratory works.

(13) Effective thickness of an existing pavement concrete slab shall be determined from the following expression:

$$D_{eff=} F_{jc} \times F_{dur} \times F_{fat} \times D, \quad \text{(m)}$$

where:
F_{jc} – coefficient of adjustment of the condition of dowels and cracks, taken in the amount of:
0.90-0.99, or
1.0, if all dividers and cracks have been repaired
F_{dur} – durability status adjustment coefficient, taken to be:
1.0 in the absence of stability-disrupting cracks
0.96-0.99 there are cracks, but no scaling
0.80-0.95 there are cracks and scaling
F_{fat} – fatigue status adjustment coefficient, taken to be:
0.97 - 1.00 some transverse cracks or impact holes, JPCP < 5 % broken plates, CRCP < 2 ruptures of pavement /km
0.94 - 0.96 frequent transverse cracks or impact holes, JPCP 5 - 15 % broken plates, CRCP 2 - 6 ruptures of pavement /km
0.90 - 0.93 many transverse cracks or impact holes, JPCP > 15 % broken plates, CRCP > 6 ruptures of pavement /km
CRCP – continuously reinforced concrete pavement,
JPCP – dilated concrete pavement,
D – thickness of existing concrete slab (m)
(14) If *Fdur* referred to in the expressions from point G.3.5.4(13) is between 0.80 and 0.95, bound coating may not be used.
(15) The necessary thickness of unbound concrete coating on an existing concrete pavement shall be determined from the following expression:

$$D_{ol} = \sqrt{D_f^2 - D_{eff}^2}$$

where:
D_{ol} – required thickness of unbound concrete coating (m)
D_f – required thickness of the concrete slab for the designed traffic load (m)
D_{eff} – effective thickness of the existing concrete slab (m).

(16) The thickness of unbound coating as an unreinforced concrete slab is determined by reading from the nomogram in Figure G.1, but it may not be less than 15 cm, while the thickness of unbound coating as an continuously reinforced concrete slab by reading from the nomogram, Figure G.3.
(17) The thickness of unbound coating as dilated reinforced concrete slab shall be determined in accordance with point G.3.6.3.
(18) For the purposes of determining the effective thickness of a pavement structure, exploratory works shall be carried out pursuant to points G.3.5.4.9(11) and (12).
(19) Effective thickness of an existing pavement concrete slab shall be determined from the following expression:

$$D_{eff=} F_{jcu} \times D \text{ (m)}$$

where:
F_{jcu} – coefficient of adjustment of the condition of dowels and cracks, taken in the amount of:
0.90 - 0.99, or
1.0, if all dividers and cracks have been repaired
D – thickness of existing concrete slab (m).
(20) The required thickness of the unbound concrete coating (D_{ol}) on an existing asphalt pavement shall be determined from the following expression:

$$D_{ol} = D_f$$

where:
D_f – thickness of the concrete slab for the designed traffic load (m).

(21) For the construction of an unbound concrete coating on an asphalt pavement, an interlayer shall be constructed, the structural value of which shall not be added to the structural value of a new pavement structure, and the existing pavement structure shall be the base for the unbound coating. The minimum thickness of asphalt layers of an existing pavement before the construction of coating shall be 75 mm.
(22) The structural value of the layers of an existing asphalt pavement shall be equal to or greater than the structural value of the given in Table G.7 for non-reinforced concrete slab coating, or in Table G.8 for reinforced concrete slab coating.
(23) The structural value of layers (*SN'*) given in Table G.7 for unreinforced concrete slab coating and in Table G.9 for reinforced concrete slab coating are determined from the following expression:

$$SN' = \sum a_{sn,i} * D_i$$

where:
$a_{sn,i}$ – material substitution coefficient of each layer
D_i – thickness of each layer of the pavement structure (cm).
(24) The mean values of the substitution coefficients of the materials of the newly constructed layers to be installed in an asphalt pavement are given in Table G.11.
(25) The structural value of existing pavement layers (*SN'*) shall be evaluated using reduced material replacement coefficients (Table G.12) due to material degradation of an existing pavement structure and shall be determined from the following expression:

$$SN'' = \sum k_i * a_{sn,i} * D_i$$

where:
k_i – substitution coefficients reduction factor for different layers depending on the type of material and the condition of the layer as determined according to Table G.12

G.3.5.4 Dimensioning of a concrete pavement according to Eurocode

(1) The requirements of this Annex governing the determination of slab thickness shall not apply to the dimensioning of the concrete pavement slab.
(2) For a concrete slab, a calculation of the cutting forces shall be made, depending on the properties of the subgrade and other components of the pavement structure, for the effects of:
— traffic load, for critical positions (centre of the slab, centre of the edge of the slab, angle of the slab),
— uneven temperature variations, and
— combinations of these effects,
as well as the verification of settlement resulting from the effects of the traffic load.
(3) The calculation of the limit state of load-bearing capacity and the limit state of serviceability and the required amount of reinforcement shall be carried out according to HRN EN 1992-1-1, with the appropriate application of HRN EN 1990, and other standards of the HRN EN 1992 series.

Table G.1 Required technical properties of the subgrade

Technical property	Method of indication	Required value
Compressibility module M_S (slab Ø 30 cm), MN/m^2	Testing in accordance with Annex L to this Regulation	earth materials ≥ 20 MN/m^2
		mixed materials ≥ 35 MN/m^2
		stone materials ≥ 40 MN/m^2
CBR, %	Testing according to HRN EN 13286-47:2021	≥ 3 %
Flatness of surface of layer measured with a 3 m long lath	Testing according to HRN EN 13036-7:2004	up to ± 30 mm
Height position of derived layer at points below the edges of pavement, and centre of the pavement	Geodetic surveying	up to ± 25 mm
Gradient of the layer	Geodetic surveying HRN EN 13036-8:2008	up to ± 1.0 %

Table G.2 Indicative correlation values of indicators of the bearing capacity of soil

Classification of materials pursuant to USCS	California bearing ratio *CBR*, %	Compressibility module M_S , MN/m^2	Deformation module E_{v2}, MN/m^2	Substrate reaction module *k*, MN/m^3
ML, MH, CH	3	4	15	25
CL, SC	5	8	20	38

GC,SM	7	13	45	47
GC, SP	10	20	60	54
SW, GM	15	35	80	65
GP, GW	20	50	100	

Table G.3 Factors of distribution of traffic load on traffic lanes

Number of traffic lanes	Factor of load distribution on traffic lanes f_{pp}					
1	1,00					
2	0,50			0,50		
3	0,50			0,05		0,45
4	0,45		0,05	0,05		0,45
5	0,45		0,05	0,02	0,08	0,40
6	0,40	0,08	0,02	0,02	0,08	0,40

Table G.4 Groups of traffic load

Group of traffic load	Total number of passes of equivalent axle load of 100 kN over the design period (T_n)
Extremely heavy	more than $2 \cdot 10^7$
Very heavy	between $6 \cdot 10^6$ and $2 \cdot 10^7$
Heavy	between $2 \cdot 10^6$ and $6 \cdot 10^6$
Medium	between $6 \cdot 10^5$ and $2 \cdot 10^6$
Light	between $2 \cdot 10^5$ and $6 \cdot 10^5$
Very light	less than $2 \cdot 10^5$

Table G.5 Minimum thickness of pavement structure resistant to the harmful effects of freezing and thawing

No.	Measuring station	Minimum thickness of pavement structure (m)	No.	Measuring station	Minimum thickness of pavement structure (m)
1	Maksimir	0,57	21	V. Ličanke	0,64
2	Pleso	0,60	22	Bosiljevo	0,49
3	Jaska	0,59	23	Ogulin	0,60
4	Kostel	0,62	24	Slunj	0,57
5	Križevci	0,59	25	Ličko Lešće	0,64
6	Bjelovar	0,61	26	Baške Oštarije	0,67
7	Sisak	0,57	27	Gospić	0,69
8	Karlovac	0,52	28	Daruvar	0,55

No.	Measuring station	Minimum thickness of pavement structure (m)	No.	Measuring station	Minimum thickness of pavement structure (m)
9	Zelina	0,59	29	Virovitica	0,63
10	Ludbreg	0,61	30	Slatina	0,55
11	Varaždin	0,61	31	Novska	0,54
12	Koprivnica	0,58	32	Gradiška	0,55
13	Pazin	0,23	33	Požega	0,37
14	Učka	0,71	34	Našice	0,56
15	Čepić	0,14	35	Slavonski Brod	0,61
16	Gračac	0,46	36	Vinkovci	0,53
17	Knin	0,42	37	Osijek	0,60
18	Drniš	0,42	38	Brestovac	0,61
19	Parg	0,69	39	Miholjac	0,57
20	Zalesina	0,76			

Table G.6 Spacing between transverse dividers and diameters of dowels

Thickness of concrete slab, d_{bkp} (cm)	Spacing between transverse dividers, l (m)	Diameter of dowels (mm)
10 to 15 cm	up to 25 d	without dowels
15 to 20 cm	up to 32 d and up to 5.5 m	25 mm
More than 20 cm	up to 6 m	32 mm

Table G.7 Minimum thickness of layers of pavement structure with an unreinforced concrete slab depending on the predicted traffic load

Predicted traffic load	Minimum thickness of layers (cm)		
	Unreinforced concrete slab	Hydraulically bound base*	Base made of unbound mixtures
Very heavy to extremely heavy	Thickness read from nomogram	20	25
Heavy		20	20
Medium		-	20
Very light and light		-	20
*possible implementation instead of a separating layer for heavy to very heavy traffic load groups			

Table G.8 Prescribed thickness of the upper layer in two-layer concrete pavements

Total thickness of concrete pavement slab (cm)	Thickness of the upper layer (cm)
≤ 20	5
> 20	6

Table G.9 Minimum thickness of the load-bearing layers depending on the type of load-bearing layer and CBR values

Type of load-bearing layer	Value of California bearing ratio of subgrade [%]			
	3	5	10	15 and above
Base made of unbound mixtures of stone material (cm)	42	32	24	20
Hydraulically bound base (cm)	32	28	22	20

Table G.10 Friction coefficients for layers under the concrete pavement

Type of material under the concrete pavement	Friction coefficient *F*
Lime-stabilised base	1,8
Bitumen-stabilised base	1,8
Cement-stabilised base	1,8
Gravel base	1,5
Base made of crushed stone material	1,5
Natural subgrade	0,8

Table G.11 Mean values of material substitution coefficients of the layer

Type of material	Coefficient of substitution (a_{sn})
Asphalt wearing layer	
AC	0,42
SMA	0,44
Asphalt binding layer	
AC	0,40
Asphalt base	
AC	0,35
Bitumenised material for the lower bases	0,24
Cement-stabilised base	0,23
Lime-stabilised base	0,17
Base made of crushed stone material	0,12
Base made of natural material	0,11
Concrete slab	0,50

Table G.12 Factors of reduction of substitution coefficients for different layers of pavement structure depending on the type of material and the condition of the layer

Categorization of material	DESCRIPTION OF MATERIAL	Reduction factors of the material substitution coefficients (k_i)
I	Subgrade in cohesive soil	0,0
II	a) Improved subgrade, granular materials that may contain smaller amounts of dust and clay dominate and have PI<10 (improved subgrade means any layer or layers of improved material between cohesive soil and pavement structure). b) Lime-stabilised subgrade of high-plastic clay (clay with PI>10)	0.0 to 0.2 0.0 to 0.2
III	a) Lower or upper base made of unbound mixtures, made of a well-graded solid aggregate with some plastic particles and with a bearing ratio CBR > 20 %. b) Cement-stabilised lower and upper bases, made of low plasticity clay PI < 10.	0.2 to 0.3
IV	a) Base made of unbound mixtures that meets the standards for high-quality bases of crushed stone material. b) Asphalt curtains with wide, clearly visible cracks, which are broken along the cracks and with visible deformations in the ruts, with certain signs of instability. c) Cement-concrete pavement whose slabs have been broken into pieces of a maximum size of 60 cm prior to reinforcement. It is necessary to use the upper part of the area if there is a lower base, or the lower part of the area if the concrete slab is built on a plan of the lower structure. d) Upper bases of cement-stabilized soil with stronger cracks (possible occurrence of a "pumping" effect). The pavement is unstable to some extent.	0.3 to 0.5
V	a) Asphalt curtains and upper bases made of asphalt with significant fissures or traces of cracks, where edges of the fissures only slightly crumble, but are stable. Minor deformations of coverings in the form of ruts are possible. b) Significantly cracked and deformed cement-concrete pavement which cannot be successfully repaired. Sections of slabs of 1 m^2 to 3.5 m^2 in size, can be well compacted (pressed) into the subgrade with a heavy roller with rubber wheels. c) Upper bases of cement-stabilised soil with few cracks, where there are traces under the stable asphalt curtain.	0.5 to 0.7
VI	a) Asphalt curtain with few fine cracks, minor intermittent tracks of cracks and minor deformations in ruts; they are completely stable. b) Asphalt mixtures with diluted bitumen which are stable, uncracked, show no signs of bitumen ruptures on the surface and which are slightly deformed in ruts. c) Upper bitumen-stabilised bases, excluding asphalt concrete. d) Stable old cement-concrete pavement with few cracks, but without decomposition into pieces smaller than 1 m^2.	0.7 to 0.9
VII	a) Asphalt-concrete, bituminous bases, uncracked, with minor deformations in ruts. b) Stable cement concrete pavement without cracks, with good	0.9 to 1.0

Categorization of material	DESCRIPTION OF MATERIAL	Reduction factors of the material substitution coefficients (k_i)
	substrate. c) Cement-concrete base under the asphalt which is stable; there is no "pumping" effect and only small cracks on the surface are observed.	

ANNEX H: CONSTRUCTION AND MAINTENANCE OF A PAVEMENT STRUCTURE

H.1 Scope

(1) Unless otherwise stipulated by this Regulation, pursuant to Article 25 of this Regulation, this Annex lays down technical and other requirements and conditions for the construction of pavement structures, supervisory actions and control procedures during the construction of pavement structures, as well as maintenance of pavement structures of traffic structures.
(2) The technical and other requirements and conditions referred to in point H.1(1) of this Annex are defined, and the execution and maintenance of the pavement structure shall be carried out, in accordance with the standards referred to in points H.4(1) and H.4(2) of this Annex, the standards to which those standards refer and the provisions of this Annex, and in accordance with the provisions of the special regulation governing the maintenance of structures.
(3) Relevant standards for the construction and maintenance of other types of products to be installed in pavement structures in accordance with the regulations for those products shall also apply to the construction and maintenance of the pavement structure.
(4) Additional requirements laid down in relevant Annexes to this Regulation shall also apply to the installation of individual construction products, supervisory actions and control procedures.

H.2 Construction, supervisory actions and control procedures at the construction site

H.2.1 Construction

(1) Elements of pavement structure shall be constructed of products intended for installation in pavement structures and other products, or as prefabricated elements constructed or manufactured in accordance with Annex F, according to the design of the pavement structure and the provisions of this Annex.
H.2.2 Construction of a base made of unbound mixtures of stone materials
(2) A base made of unbound mixtures of stone materials constructed in accordance with Annex D to this Regulation shall be installed in a pavement structure in accordance with the requirements of this Annex and the design of the pavement structure.
(3) The constructed base made of unbound mixtures of stone materials shall meet the quality requirements according to Table H.1.

H.2.3 Construction of a hydraulically bound layer

(1) A hydraulically bound layer constructed in accordance with Annex D to this Regulation shall be installed in the pavement structure in accordance with the requirements of this Annex and the design of the pavement structure.
(2) A hydraulically bound layer designed in a thickness greater than 30 cm shall be installed in the pavement structures in two layers.
(3) The constructed hydraulically bound layer shall meet the quality requirements as set out in Table H.2.

H.2.4 Construction of the separating asphalt layer

(1) A separating asphalt layer constructed in accordance with Annex D to this Regulation shall be installed in a pavement structure in accordance with the requirements of this Annex and the design of the pavement structure.

(2) The asphalt layer made in accordance with Annex D to this Regulation shall be installed in the pavement structure in accordance with the requirements of the special regulation governing asphalt pavements in the part in which that regulation regulates bituminous mixtures for a wear layer of asphalt concrete, AC 16 surf 50/70, mixtures of aggregates of the AG 4 category and according to the design of the pavement structure.
(3) The constructed separating asphalt layer shall meet the quality requirements as set out in Table H.3.

H.2.5 Construction of a concrete pavement – installation of concrete

(1) Concrete produced in accordance with the provisions of Annex A to this Regulation shall be installed in the concrete pavement in accordance with the design of a pavement structure, standards HRN EN 13670:2010and HRN EN 13877-2:2023, standards referred to by these standards, and the provisions of this Annex.
(2) The transport and installation of concrete shall be adapted to the technology of the construction of concrete pavement. Manual or mechanical installation of concrete and the technology of installation of roller compacted concrete is allowed.
(3) Regardless of the chosen method of installation of concrete, the properties of the constructed concrete pavement shall comply with the requirements of the design of the pavement structure.
(4) The manual installation of concrete referred to in point H.2.5(2) refers to the installation by means of an internal vibrator, a vibro-beam or similar.
(5) The mechanical installation of concrete referred to in point H.2.5(2) refers to the installation by means of specialised self-propelled equipment/machines (pavers) and other machinery, such as a vibration roller.
(6) The direction of the installation of concrete pursuant to points H.2.5(4) and H.2.5(5) shall be parallel to longitudinal dividers.
(7) Pursuant to HRN EN 13670:2010 and HRN EN 13877-2:2023 , before the start of installation, the contractor shall check whether the concrete complies with the requirements of the design of the pavement structure and whether changes in the properties of concrete have occurred during its transport, which would affect the technical properties of the concrete pavement.
(8) Where formwork is used, it shall be sufficiently rigid and secured to prevent movement or deformation, either horizontally or vertically.
(9) The properties of fresh concrete during installation (consistency of concrete, amount of fine particles, particle size distribution, moisture of concrete and other properties) shall be adapted to the requirements and specificities of the intended method of installation.
(10) Concrete shall be installed continuously, with as few interruptions as possible. A pressed divider shall be used at points of interruption of concrete.
(11) If concrete is installed in hot or cold weather, the provisions of HRN EN 13670:2010, point 8 and Annex F should be applied.
(12) In case of concrete pavements made of roller compacted concrete, in addition to the relevant activities referred to in points H.2.5(1) to H.2.5(11), the following shall be performed:
— fresh roller compacted concrete shall be transported to the construction site by dump trucks, without mixing, and the mixture shall be covered in order to prevent the loss of moisture from fresh concrete and protect it from atmospheric influences,
— roller compacted concrete shall be installed using equipment for asphalt (pavers and rollers), special paving equipment for the installation of rolled concrete, or equipment suitable for this purpose and compact the installed roller compacted concrete to approximately 90 % of the required density of concrete, all in accordance with the requirements of the design of the pavement structure,

— the installed roller compacted concrete shall be compacted by rolling it to the final compaction required by the design of the pavement structure; the rolling shall begin immediately after the process of installing the roller compacted concrete with a paver, which should be completed within 60 minutes after the start of mixing concrete in a concrete plant (initial contact of cement and water); during hot summer days, this shall be completed within 45 minutes,
— only apparent dividers shall be placed by cutting concrete immediately after the initial rolling of concrete to a depth of 1/4 to 1/3 of the layer thickness of the roller compacted concrete, or according to the design of the pavement structure, in order to prevent uncontrolled cracking of concrete due to shrinkage and temperature changes,
— a pressed divider shall be placed on points of interruption of concrete,
and additionally, where provided for in the design of the pavement structure:
— apparent dividers shall be manually filled in fresh roller compacted concrete using a bitumen emulsion, which shall comply with HRN EN 13304:2009 , and
— after filling the apparent dividers, the concrete shall be processed until the required compaction of roller compacted concrete has been achieved.

H.2.6 Construction of a concrete pavement – installation of dowels, anchors and reinforcement

(1) Dowels and anchors manufactured in accordance with the provisions of Annex C to this Regulation and placed in the position and at the distance determined by the design of the pavement structure shall be installed:
— using a vibration device in freshly incorporated concrete, or
— before the concrete is installed, by placing them in special holders which ensure the position of dowels or anchors during concreting.
(2) Unless otherwise specified in the design of the pavement structure, dowels and anchors shall be installed in half of the cross-section of the concrete slab.
(3) In the event of continuation of concreting, anchors and dowels shall be installed in drilled holes on positions laid down in the design.

H.2.7 Construction of a concrete pavement - treatment of upper surface, curing and protection of concrete

(1) The constructed upper surface of a concrete pavement shall be roughened or furrowed while it is fresh, in accordance with the requirements of the design of the pavement structure, or means intended to slow the binding of the concrete of the upper surface of the pavement shall be applied in case of the construction of concrete pavements with an exposed (washed) aggregate surface.
(2) Regarding the curing and protection of the upper surface of concrete, the provisions of HRN EN 13670:2010, point 8.5, and point H.2.7.3 of this Regulation shall apply.
(3) For surface protection of a concrete pavement, it shall be permitted to use chemical products to prevent the evaporation of moisture from the surface layer of concrete, the properties of which have been specified according to the manufacturer’s specifications and the efficacy of which has been demonstrated by the procedures regulated by HRN CEN/TS 14754-1:2007.

H.2.8 Construction of a concrete pavement - construction and sealing of dividers

(1) Dividers shall be designed so as to maintain the longitudinal and transverse flatness of the pavement and not to damage the edges of the dividers and the surface of the concrete.

(2) Dividers shall be placed when the concrete achieves sufficient strength not to be damaged, and in any event before appearance of cracks. The optimum time for cutting concrete is determined under specific environmental conditions and in view of properties of concrete.
(3) Apparent dividers may be constructed by cutting in the surface of newly bound concrete to a depth of 1/4 to 1/3 of the thickness of the slab or by initiating a crack.
(4) If the shape and position of a divider manifold are important, the apparent divider shall be placed by notching.
(5) The timing and technology for placing dividers shall be adapted to the type of aggregate.
(6) If dowels are installed in an apparent divider, they shall be installed in fresh concrete.
(7) Wooden or plastic crack initiators shall also be used for apparent dividers on the underside of the concrete slab prior to the execution of the concrete pavement, while a groove in the fresh concrete is formed on the upper side; the depth of the groove shall be at least 1/4 of the thickness of the slab.
(8) Cross-pressed dividers are placed in the event of interruption of concreting (at the conclusion of daily works or in case of alternating installation of segments), while longitudinal dividers connect lines that have not been concreted simultaneously (concreting of only one lane).
(9) Before resuming the works, the surface of a pressed divider shall be shaped by cutting or grinding. When so provided by the design of the pavement structure, they shall be fitted with dowels or anchors.
(10) Spatial dividers shall be constructed in such a way that the space of the divider is pre-formed with a filling material which prevents fresh concrete from binding to another structure or another pavement structure during and after concreting. The filling shall extend over the entire thickness of the slab, from the lower edge of the slab up to 2 cm to 3 cm below the surface of the slab so that the divider may be filled with sealing tape and filling compound.
(11) The types of dividers, methods of construction and sealing shall be in accordance with the design of the pavement structure.

H.2.9 Construction of a concrete pavement - installation of prefabricated concrete elements and products

Prefabricated concrete element or product made or manufactured in accordance with Annex F to this Regulation shall be installed in a concrete pavement according to the design of the pavement structure, HRN EN 13670:2010, , the standards to which these standards refer and the provisions of this Regulation.

H.2.10 Verification of the properties and quality of products and works during the construction of pavement

(1) The contractor shall verify the achieved properties and quality of the construction of the base made of unbound mixtures of stone materials in accordance with Table H.1 and the design of the pavement structure.
(2) The contractor shall verify the achieved properties and quality of the construction of the hydraulically bound layer in accordance with Table H.2 and the design of the pavement structure.
(3) The contractor shall verify the achieved properties and quality of the construction of the separating asphalt layer in accordance with Table H.3 and the design of the pavement structure.
(4) The contractor shall verify the achievement of the properties and quality of fresh and hardened concrete before and during the execution of the works in accordance with the

requirements of HRN EN 13670:2010, HRN EN 13877-1:2023 for the selected specified properties referred to in point A.2.1 and in the manner prescribed in that point.
(5) The contractor shall check the achievement of the properties and quality of fresh and hardened roller compacted concrete before and during the execution of the works in accordance with the requirements of HRN EN 13670:2010, HRN EN 13877-1:2023 for the selected specified properties referred to in point A.3(14)-(18) and in the manner prescribed in those points, at least for the following:
— water content, i.e., testing the moisture in relation to the specification of the roller compacted concrete at the start of the section and in case of doubt
— density of roller compacted concrete in relation to design specification, minimum 3 tests for surfaces < 1,000 m2 or every 500 m2 for surfaces > 1,000 m2
(6) The contractor shall verify the achievement of the properties and quality of the concrete of the constructed pavement according to the requirements of HRN EN 13877-2:2023 for the selected specified properties referred to in point A.2.1 and in the manner prescribed therein, with the frequency of testing prescribed in Table H.4 of this Annex.
(7) The contractor shall verify the achieved properties and surface quality of the constructed concrete pavement in accordance with the design of the pavement structure, and at least in accordance with Table H.5.

H.2.11 Control procedures

(1) The execution of all works and the performance of all the activities of the contractor required by points H.2.1 to H.2.10 shall be supervised by a supervising engineer in accordance with the provisions of the special regulation governing professional supervision of construction, who shall also determine the implementation of the control procedures referred to in this point, in accordance with the category of verification of properties of concrete pavement and according to the design of the pavement structure.
(2) The control procedures of the achieved properties and quality of performance of the base made of unbound mixtures of stone materials shall be carried out according to Table H.1 of this Annex, with a frequency of at least 50 % of the tests prescribed in Table H.1 and according to the design of the pavement structure.
(3) The control procedures of the achieved properties and quality of performance of the hydraulically bound base shall be carried out according to Table H.2 of this Annex, with a frequency of at least 50 % of the tests prescribed in Table H.2 and according to the design of the pavement structure.
(4) The control procedures of the achieved properties and quality of performance of the separating asphalt layer shall be carried out according to Table H.3 of this Annex with a frequency of at least 50 % of the tests prescribed in Table H.3 and according to the design of the pavement structure.
(5) Control procedures for hardened concrete during the execution of the works shall be carried out for the selected specified properties referred to in point A.2.1 and in the manner prescribed therein, covering at least 50 % of the tests prescribed in points H.2.10(4) and H.2.10(5) and according to the design of the pavement structure.
(5) Control procedures for achieved properties of the constructed concrete pavement shall be carried out for the selected specified properties referred to in point A.2.1 and in the manner prescribed therein, covering at least 50 % of the tests prescribed in points H.2.10(6) and Table H.4 and according to the design of the pavement structure, while respecting the provision on the smallest number of samples.
(5) Control procedures for surface properties of the constructed concrete pavement shall be carried out for the selected specified properties referred to in point H.2.10.7 and in the manner

prescribed therein, with the scope of testing set forth in point H.2.10(7) and Table H.5 and according to the design of the pavement structure.

H.2.12 Demonstration of the serviceability of the constructed base made of unbound mixtures of stone materials

(1) The properties and method of demonstrating the achieved properties of the constructed base made of unbound mixtures of stone materials are prescribed in Table H.2.
(2) Demonstration of the serviceability of the constructed base made of unbound mixtures of stone materials shall be carried out in accordance with Annex L or Annex N to this Regulation. Control tests shall be carried out at a volume of 50 % of the scope of checks for a specific category of verification of the construction of the pavement structure.
(3) Geometric tolerances of the constructed base made of unbound mixtures of stone materials are laid down in Table H.2.

H.2.13 Demonstration of serviceability of the hydraulically bound base

The properties and method of demonstrating the achieved properties of the hydraulically bound base are prescribed in Table H.1.

H.2.14 Demonstration of serviceability of the separating layer made of a bituminous mixture

The properties and method of demonstrating the achieved properties of the constructed separating layer made of a bituminous mixture shall be carried out in accordance with the requirements of special regulations governing asphalt pavements, in the part where these regulations regulate bituminous mixtures for the wearing layer made of asphalt-concrete.

H.2.15 Demonstration of serviceability of a concrete pavement

(1) Serviceability of a concrete pavement shall be demonstrated by assessing results of testing of concrete samples taken from the constructed pavement in accordance with Table H.4 and assessed in accordance with HRN EN 13877-2:2023.
(2) In addition to the proof referred to in point H.2.15.1, the serviceability of a concrete pavement shall be demonstrated by testing the pavement surface by carrying out the tests given in Table H.5, and the assessment of the results obtained shall be carried out according to the requirements of the design of the pavement structure.
(3) The properties of fresh and hardened concrete tested on samples taken during the installation of the concrete shall be assessed in accordance with HRN EN 206:2021, HRN 1128:2023, HRN 1128/A1:2023 and HRN EN 13877-1:2023.

H.2.16 Demonstration of serviceability of surface properties of concrete pavement

(1) The properties and method of demonstrating the achieved surface properties of the constructed concrete pavement are laid down in Table H.5.
(2) By way of derogation from point H.2.16(1), no tolerances shall be allowed regarding the flatness of the surface of a concrete pavement causing visible roughness or the retention of water on the pavement.

H.2.17 Construction of the test section and putting the pavement structure into construction site traffic

(1) If the design of the pavement structure provides for the construction of a test section, it shall be carried out in accordance with the design requirements for the entire pavement structure, with additional requirements that the design specifies exclusively for the test section.
(2) A concrete pavement constructed at ambient temperatures above 7 °C shall be put into urban traffic after it has achieved 70 % of the 28-day compressive strength of the installed concrete, and shall be put into normal traffic after 7 days, unless otherwise specified by the design of the pavement structure.

H.3 Maintenance of a concrete pavement

The provisions of Article 28 of this Regulation shall apply to the maintenance of concrete pavements.

H.4 Specifications

The list of standards and recognised technical requirements applicable under this Annex is set out in Appendix 1 to this Regulation.

Table H.1 Properties of a constructed base made of unbound mixtures

Property		Test standard or procedure referred to in this Regulation	Road category [a]	
			BC, JC I and II cat. and NC of appropriate traffic level	JC III and IV cat. and NC of appropriate traffic level
			Required values	
Particle size distribution[b]		HRN EN 933-1:2012 HRN EN ISO 17892-4:2015/A1:2022	Table D.2	
Moisture: tolerance max. % [c]		HRN EN 1097-5:2008	± 2	
Degree of compaction [%]		Annex M	≥ 100	≥ 98
Compressibility module (∅ 30 cm) [MN/m^2]		Annex L	≥ 100 (80) [d]	≥ 80
Static modulus of deformation (∅ 30 cm) [MN/m^2]	E_{V2}	Annex N	≥ 120 (100) [d]	≥ 100
	E_{V2}/E_{V1} [e]		≤ 2,0 (2,2) [d]	≤ 2,2
Dynamic modulus of deformation (∅ 30 cm) [MN/m^2]		Annex K	≥ 60 (50) [d]	≥ 50
Surface flatness: permissible tolerance mm		HRN EN 13036-7:2004	± 15	not required

Height position: permissible tolerance mm [f] [g]	-	±15
Slope: tolerance % (aps.) [f]	-	±0,4

[a] in accordance with the Decision on the implementation of the technical categorisation of public roads in the Republic of Croatia
[b] particle size distribution of the sample of the mixture taken at the site of installation prior to compaction shall be determined in accordance with HRN EN 933-1:2012 for a sample containing aggregate particles of >0.063 mm, and with HRN EN 17892 4:2015/A1:2022 for a sample containing aggregate particles of <0.063 mm
[c] in relation to optimal moisture determined by the modified Proctor process
[d] the value in brackets refers to the quality requirements where a hydraulically bound base is constructed over a base made of unbound mixtures
[e] E_{v2}/E_{v1} not relevant if $E_{v1} \geq 50$ % of the required value E_{v2}
[f] through geodetic surveying at locations below both the edges of the pavement and the middle of the pavement
[g] with the approval of the supervising engineer, downward tolerances may be up to a maximum of -30 mm; deviation in height shall be compensated with a subsequent layer at the contractor's expense

Note: tests shall be carried out with a frequency of 1/3,000 m^2 of the installed mixture and 1/250 m^2 of the constructed layer (surface flatness every 50 m, height position and cross-fall on each profile).

Table H.2 Properties of a constructed base made of hydraulically bound mixtures

	Property	Test standard or procedure referred to in this Regulation	Required values
Constructed layer	Degree of compaction (%)	Annex M	≥ 98
	Surface flatness: permissible tolerance, (mm)	HRN EN 13036-7:2004	± 15
	Thickness of layer: permissible tolerance, (mm)	-	± 15
	Height position: tolerance, (mm) [a]	-	±15
	Cross-fall: permissible tolerance, (%) (aps) [a]	-	±0,4

[a] through geodetic surveying at locations below both the edges of the pavement and the middle of the pavement

Note: testing shall be carried out at a frequency of 1/250 m^2 of the installed mixture or 1 test per every day of construction.

Table H.3 Properties of the constructed separating asphalt layer

Property		Test standard	Required values
Void content, (%) (*V/V*)		HRN EN 12697-8:2019	1.5 to 5.5
Degree of compaction, %		--	≥ 97
Tolerance from the design thickness of the layer [a](mm):	- individually, maximum	--	- 15 %
	- mean value, maximum	--	- 5 %
Flatness of layer – IRI(100), maximum (m/km)		HRN EN 13036-5:2019	2,5

Layer height: height tolerance of the layer compared to the designed height position, [mm] [(b)]	--	±10 on average and ±15 individually
Cross-fall: tolerance compared to the designed cross-fall (each profile), (%) (aps.)	--	± 0,4
Layer position: tolerance (horizontal position of left and right edges) compared to the designed height position, (mm)	--	± 50
[(a)] no thickness greater than 20 % of the designed layer thickness may be taken into account for mean values [(b)] if height tolerance values of adjacent profiles or edges are prefixed with the opposite sign, minimum longitudinal drops and cross-falls should be checked and secured		

Note: testing shall be carried out at a frequency of at least 1 test/2,000 m^2 of the derived layer or 1 for each day of performance; at least 3 samples shall be tested.

Table H.4 Number of samples drilled from the pavement for different categories of verification of the properties of concrete pavement

Requirement pursuant to HRN EN 13877-2:2023 *(point of the standard is provided in the brackets)*	Verification category of the construction of the concrete pavement specified in the design of the concrete pavement specified in the design of the pavement structure pursuant to point G.1.12.			Note
	0	1	2	
	Number of samples according to HRN EN 13877-2:2023			
Concrete strength - compressive strength and/or tensile splitting strength (point 4.2)	No requirements	3 / 10,000 m^2	1 / 1,000 m^2	At least 4 samples shall be taken
Thickness of concrete pavement (point 4.3)	No requirements	3 / 10,000 m^2	1 / 1,000 m^2 (*)	* For surfaces up to 3,000 m^2, at least 3 samples shall be taken, and for each subsequent 1,000 m^2, 1 samples shall be taken
Freeze-thaw resistance with de-icing salts (point 4.4)	No requirements	3 / 10,000 m^2*	1 / 1,000 m^2 **	* Min. 4 samples for every 10,000 m^2 ** Min. 4 samples, groups of 4 samples are evaluated
Resistance of concrete pavement to studded tyres (point 4.5)	No requirements	No requirements	3 / 100,000 m^2	-
Connection between two layers of concrete (point 4.6)	No requirements	3 / 10,000 m^2	1 / 1,000 m^2	In order to achieve a statistically significant result, a minimum of 9 samples (cores) shall be taken.

Requirement pursuant to HRN EN 13877-2:2023 *(point of the standard is provided in the brackets)*	Verification category of the construction of the concrete pavement specified in the design of the concrete pavement specified in the design of the pavement structure pursuant to point G.1.12.			Note
	0	1	2	
	Number of samples according to HRN EN 13877-2:2023			
Resistance to penetration of fuel and oil (point 4.8 and Appendix B)	No requirements	3 / 10,000 m^2	1 / 1,000 m^2	This requirement shall be imposed in case of concrete pavements with a high risk of contamination by fuel or oil. – At least one batch of 3 samples shall be tested; groups of 3 samples shall be evaluated.
Resistance to wear (National provision – this Regulation)	No requirements	3 / 10,000 m^2	1 / 1,000 m^2	At least one batch of 3 samples, groups of 3 samples each are evaluated.

Table H.5 Properties and frequency of testing the surface of a constructed concrete pavement depending on the predicted traffic load

Property	Testing standard	Motorways and express roads	Category I public roads	Category II and III public roads	Category IV public roads	Frequency of control procedures
Longitudinal flatness (a) IRI100 (m/km)	HRN EN 13036-5:2019	≤ 1,0/1,5[a]	1,5/2,0 [a]	1,5/2,0 [a]	-	Continuous over the entire length
Longitudinal flatness of the layer – 3 m lath (mm)	HRN EN 13036-7:2004	4	6	8	8	Each layer
Adhesion (*SRT)*	HRN EN 13036-4:2012	≥ 58	≥ 55	≥ 55	≥ 55	Every 1,000 m^2
Texture (mm)	HRN EN 13036-1:2011	0,5-1,20	0,5-1,20	≥ 0,5-1,2	≥ 0,35[c]	Every 1,000 m^2
Layer height[b]: permissible height deviation of the layer from the designed height position, average/individual, mm	[d]	±10/±15	±10/±15	±18/±23	±20/±25	Every profile
Cross-fall: tolerance compared to the designed cross-fall (each profile), (%aps.)	d)	± 0,4	± 0,4	± 0,4	± 0,4	Every profile

Property	Testing standard	Motorways and express roads	Category I public roads	Category II and III public roads	Category IV public roads	Frequency of control procedures
Layer position: tolerance (horizontal position of left and right edges) compared to the designed height position (mm)	d)	± 25	± 25	± 50	± 50	Every profile

a) upper limit value of flatness index IRI_{100} if aggravating impacts of vertical and horizontal elements of the level line (slopes above 3 %, horizontal curve radius under 850 m), and interruptions on the driving surface (expansion joints, gutters, shafts) are involved

(b) if height tolerance values of adjacent profiles or edges are prefixed with the opposite sign, minimum longitudinal falls and cross-falls should be checked and secured

(c) exceptionally, smoothed surfaces of concrete pavements are permitted, at speeds of less than 30 km/h, in case of special maintenance requirements

(e) as part of geodetic survey

ANNEX I: PAVEMENTS WITH AN ASPHALT OR CONCRETE COATING

I.1 Scope

(1) Pursuant to Articles 15, 22 and 25 of this Regulation, this Annex lays down performance and other requirements for existing pavements with an asphalt or concrete coating (hereinafter: special pavements).
(2) Unless excluded by this Annex, the provisions of this Annex and any other provisions of this Regulation shall apply to special pavements, to the design of special pavements, to construction products to be installed in special pavements and to the operation and maintenance of special pavements.
(3) Special pavements are:
— composite concrete pavements with an asphalt coating,
— concrete and asphalt pavements with a concrete coating.
(4) Composite concrete pavements with an asphalt coating are:
— existing dilated unreinforced concrete pavement,
— existing dilated reinforced concrete pavement,
— existing continuously reinforced concrete pavement, and
— existing pavement with a continuously reinforced concrete base,
covered with an asphalt coating that forms the wearing layer of the composite pavement.
(5) Concrete coatings of concrete and asphalt pavements are a technical solution intended for pavement structures with a concrete or asphalt pavement that is:
— in good condition, with a view to extending the service life of the pavement,
— in such condition that is requires minor repairs, with a view to restoring the load-bearing capacity of the pavement,
— in such condition that is requires major repairs, with a view to increasing the load-bearing capacity of the pavement and/or extending the service life of the pavement.
(6) The purpose of the concrete coating referred to in point I.1(5) shall apply accordingly to pavement structures with a composite concrete pavement with asphalt coating.
(7) The provisions of this Annex shall apply to:
— existing concrete pavements to which an asphalt coating is applied,
— existing concrete pavements to which a concrete coating is applied,
— existing asphalt pavements to which a concrete coating is applied.
(8) The provisions of this Annex shall apply mutatis mutandis to:
— new concrete pavements constructed with a final layer of asphalt,
— new concrete pavements constructed with a final layer of concrete, and
— new asphalt pavements constructed with a final layer of concrete.
(9) In case referred to in point I.1(8), the provisions of this Annex relating to the established constructed condition and properties of an existing pavement shall apply mutatis mutandis to the designed condition and properties of the designed pavement.
(10) The operation of an existing asphalt or concrete pavement with a coating in accordance with the provisions of this Regulation shall be considered as maintenance.

I.2 Composite concrete pavements with an asphalt coating

I.2.1 General requirements

The service life of an asphalt coating shall be designed in accordance with the provisions of the regulations governing asphalt pavements.

I.2.2 Asphalt coating

(1) Asphalt coatings on dilated (unreinforced and reinforced) existing concrete pavements and on existing continuously reinforced concrete pavements shall be constructed in a single layer, from bituminous mixtures for wearing layers.
(2) Asphalt courses on existing pavements with a continuously reinforced concrete base shall be constructed in two layers, made of bituminous mixtures for wearing and binding layers, respectively.
(3) Coatings with a thickness of less than or equal to 50 mm shall be considered to be thin asphalt coatings.
(4) The minimum permissible thickness of an asphalt coating shall be 35 mm.
I.2.3 Existing pavement structure
(1) The status and properties of an existing concrete pavement, an existing concrete base or an existing pavement structure shall be determined by the procedures laid down in this Annex.
(2) Determining the condition and properties of an existing pavement structure includes the following:
— determination of the layers of the existing pavement structure,
— determination of the properties of the materials incorporated into the existing pavement structure,
— establishing the existence, type and scope of damage to an existing pavement structure,
— identification of the type, distance, depth and method of sealing dividers,
— determination of the existence of dowels in transverse dividers and anchors in longitudinal dividers, their length, quantity and position,
— determination of the condition and load-bearing capacity of the existing pavement structure,
— determination of the functional properties of the pavement driving surface, such as: flatness, roughness, adhesion and noise.
(3) The methods used in carrying out the actions referred to in point I.2.3(2) shall be specified in the ‘Study on the condition of the existing concrete pavement’ or ‘Study on the condition of the existing concrete base’ or ‘Study on the condition of the existing pavement structure’ respectively; the method shall be specified by reference to a standard or other publicly available technical specification. If this is not possible, a description of the method used shall be given in the Study.
(4) For the implementation of the actions referred to in point I.2.3(2), the following shall be compulsory:
— collection of data and records from the time of construction and use of the pavement structure, as well as data on future requirements,
— performance of a visual inspection in the field,
— taking of samples from the existing pavement structure, testing and assessment of test results,
— taking samples from existing asphalt layers of the pavement structure; testing and assessment of test results, taking samples and determining the thickness of asphalt layers in the pavement according to HRN EN12697-39:2020, determining the index of longitudinal unevenness of the wear layer according to HRN EN 13036-5:2019 and HRN EN13036-6:2008, determining the density of the asphalt mixture according to HRN EN12697-5:2019, determining the density of asphalt samples according to HRN EN13697-6:2008, determining the voids in asphalt samples according to HRN EN13697-8:2019,
— taking samples from the existing concrete slab of the pavement structure, testing and assessment of test results; extraction of concrete samples in accordance with the HRN EN 12504-1: 2019/Corr.1:2020, determination of compressive strength of concrete samples in accordance with the HRN EN 12390-3:2019, , determination of tensile splitting

strength of concrete samples in accordance with HRN EN 12390-6:2023, determination of thickness of concrete slab in accordance with HRN EN 13863-3,
— determination of the position, type and condition of the reinforcement using an appropriate method,
— taking samples from the existing load-bearing layer of the pavement structure, testing and assessment of test results, determining the particle size distribution according to HRN EN933-1:2012, determining the quality of fine particles according to HRN EN 933-8:2015 or HRN EN 933-9:2022,
— taking subgrade samples of the existing pavement structure, testing and assessment of test results, determination of particle size distribution in accordance with HRN EN 933-1:2012,
— preparation of a report on the assessment of the condition of the existing pavement structure.
(5) In order to carry out the actions referred to in point I.2.3(2), it shall also be permitted to carry out following:
— determination of the soluble content of the bituminous binder according to HRN EN 12697-1:2020,
— determination of the particle size distribution of the bituminous mixture according to HRN EN 12697-2:2025,
— determination of penetration of a separated bituminous binder according to HRN EN 1426:2024,
— determination of the softening point of the bituminous binder according to HRN EN 1427:2015,
— determination of the elastic return of modified bitumen according to HRN EN 13398:2018,
— determination of the tensile strength of asphalt specimens using the indirect tensile method according to HRN EN 12697-23:2017,
— determination of the stiffness of the asphalt sample in accordance with HRN EN 12697-26:2022,
— determination of the compressibility module of unbound bases and the subgrade according to Annex L and of the elasticity module according to Annex N to this Regulation
— determination of the California Bearing Ratio (CBR, California Bearing Ratio) of unbound bases and the subgrade according to HRN EN 13286-47:2021
— additional tests of the pavement surface, testing roughness according to HRN EN 13036-3:2004 and testing adhesion according to HRN EN 13036-4:2019,
— other procedures specific to a pavement.

I.2.4 Design

(1) In addition to the content prescribed in Article 19 of this Regulation, the design of a traffic structure which changes a pavement structure into a composite pavement structure shall contain information on the established condition and properties of the existing concrete pavement, existing concrete base or existing pavement structure in accordance with point I.2.3.
(2) The main design of a pavement structure with a composite pavement shall include an assessment of the established condition and properties of the existing concrete pavement, the existing concrete base, or the existing pavement structure, in order to determine whether the traffic structure is suitable for changing the existing concrete pavement or the existing concrete base with asphalt coating.
(3) In addition to the content prescribed in Article 16(1)(1) of this Regulation, the technical description of the pavement structure with composite pavement shall include a description of the following:
— method of treatment of the existing concrete pavement or existing concrete base prior to the application of the asphalt layer,

— method of preparing the substrate for the application of the asphalt layer.
(4) The design of the pavement structure with composite pavement shall also specify:
— the need to repair the existing concrete pavement before applying the asphalt coating, and the method of repair,
— the need to construct an interlayer between the existing concrete pavement and the asphalt coating, and the properties of the interlayer,
— width, depth and position of dividers in the asphalt coating,
— quantity, width of flap and density of the asphalt of the asphalt coating.

I.2.5 Technical properties

The provisions of the regulations governing asphalt pavements prescribed for the properties of asphalt pavements shall apply.

I.2.6 Construction products

(1) In composite concrete pavements with an asphalt coating, the construction products listed in Chapter III and Annexes A, B, C, E and J to this Regulation shall apply, with the following restriction: the component materials of the concrete shall meet the requirements laid down in Annex B relating to the lower layer of the double-layer concrete pavement.
(2) Bituminous mixtures used to make asphalt coatings shall have the properties and meet the requirements specified in the regulation governing asphalt pavements for the designed traffic load and specified in the design of the composite pavement.
(3) The binding material used for establishing a good connection between the asphalt and concrete layers of composite pavements shall provide a binding property of at least 1.0 N/mm² tested according to HRN EN 12697-48:2021.
(4) Non-woven geotextiles for the construction of the interlayer shall have properties in accordance with Table I.1.

I.2.7 Construction

I.2.7.1 Repair of an existing concrete pavement

(1) Repair of an existing concrete pavement shall be carried out in a manner appropriate to its condition and properties, in accordance with the provisions of this Annex.
(2) The method of repairing an existing concrete pavement shall ensure its load-bearing capacity and height uniformity and ensure that the displacements on the joints do not cause an unevenness of the driving surface greater than the one prescribed by a special regulation.
(3) The repair of an existing concrete pavement involves one or a combination of the following operations:
— sealing the dividers,
— mechanical milling of the upper surface of an existing concrete pavement, and
— installation and repair of dowels,
other procedures that achieve the following shall also be allowed:
— preventing the transfer of cracks and damage from the surface of the existing concrete pavement to the asphalt coating by local repairs that can be repairs in the surface of the existing concrete pavement and repairs in its full thickness,
— repair or installation of drainage on the edges of an existing concrete pavement,
— improving the load transfer between the adjacent slabs of the existing concrete pavement by installing transverse and longitudinal dividers where dowels (transverse dividers) or anchors

(longitudinal dividers) must be installed, thus reducing the likelihood of reflection of dividers in the form of cracks on the surface of the asphalt coating.
(4) In addition to the procedures referred to in point I.2.7.1(3), it shall be permitted to perform repairs of existing concrete pavements by processes involving the breaking of concrete:
— for existing concrete pavements, regardless of the properties of the lower layers of the pavement structure, it is allowed to perform this operation by cracking the concrete pavement through the entire thickness of the pavement into slab fragments of approximately 50 cm in diameter and by subsequently compacting the resulting debris by rolling until the levelled surface is achieved and the connections between the pavement concrete and the lower layers of the pavement structure are restored and properties according to Table H.1
— for existing concrete pavements whose substrate has a load-bearing capacity meeting the provisions of point H.2.10, it is allowed to perform this operation by crushing the concrete pavement into fragments of approximately 20 cm in diameter to an extent that prevents the transfer of load between pieces of concrete and by subsequently compacting the crushed material with vibration rollers and rollers with pneumatics.

I.2.7.2 Preparation of the surface of an existing concrete pavement

(1) Preparation of the surface of an existing concrete pavement prior to the application of the asphalt coating in order to achieve a good bond between the two layers of the composite pavement shall be carried out in the manner laid down in this Annex.
(2) A good bond between the concrete and asphalt layers of the composite pavement is achieved by applying one or a combination of the following procedures:
— by roughening the surface of the existing concrete pavement by transversal or longitudinal furrowing or diamond grinding,
— by removing impurities and debris by cleaning the surface of the existing concrete pavement by sweeping, blowing with compressed air or water with subsequent drying,
— by applying a binding agent.

I.2.7.3 Interlayer

(1) An interlayer shall be constructed if other procedures, in accordance with this Annex, do not prevent the reflection of cracks and dividers.
(2) The interlayer shall be constructed from:
— geotextiles,
— stress compensation composite materials (SAMI),
— a mixture for the relief of crack reflection (RCRI), consisting of a fine aggregate mixed with a highly elastic polymer modified binder.

I.2.7.4 Installation of asphalt

(1) Asphalt coating on an existing concrete pavement shall be constructed in one or more layers:
— directly on the upper surface of an existing concrete pavement, or
— directly on the upper surface of a previously repaired existing concrete pavement, or
— on a thin levelling asphalt layer constructed on the upper surface of an existing or previously repaired existing concrete pavement, or
— on the intermediate layer, if applicable.
(2) The asphalt of an asphalt coating shall be installed over the full width of the pavement or over the width of the traffic lane, in the designed thickness, by compaction until a maximum

layer density in accordance with the regulation governing asphalt pavements has been reached, for the designed traffic load, determined in the design of the composite pavement.

I.2.7.5 Cutting and sealing of an asphalt coating

(1) The dividers on the surface of an asphalt coating shall be introduced by cutting in places above transverse dividers on the concrete under the coating, at the earliest when the temperature in the asphalt layer drops below 30°.
(2) Unless otherwise specified by the design of a pavement structure with composite pavement, the width of dividers shall be 1 to 1.5 cm, and the depth shall be one third of the thickness of the asphalt coating. The dividers on the asphalt coating shall be located above the transverse dividers on concrete, within 1.5 cm.
(3) After cleaning, the sawn dividers shall be sealed with a sealing agent.
I.2.8 Demonstration of serviceability
(1) For the purpose of demonstrating the serviceability of all elements of a composite pavement other than the asphalt coating, none of the provisions of this Regulation and the corresponding Annexes shall be excluded.
(2) In order to demonstrate the serviceability of the asphalt coating of a composite pavement, the provisions of the regulations governing asphalt pavements shall apply.

I.2.9 Maintenance

(1) For the purpose of maintaining all elements of a composite pavement other than the asphalt coating, none of the provisions of this Regulation and the corresponding Annexes shall be excluded.
(2) In order to maintain the asphalt coating of a composite pavement, the provisions of the regulations governing asphalt pavements shall apply.

I.3 Concrete coatings of concrete and asphalt pavements

I.3.1 General requirements

The service life of a concrete coating shall be designed in accordance with the provisions of this Regulation governing concrete pavements.

I.3.2 Concrete coating

(1) The application of bound and unbound concrete coatings is allowed.
(2) Bound concrete coatings shall be designed and constructed at a thickness of 50 to 150 mm, in such a way as to achieve and maintain a bond between the coating and the existing pavement, with which they form a monolithic technical unit.
(3) By way of derogation from point I.3.2(2), greater thickness of the bound concrete coating shall be permitted, if so required due to the condition and properties of the existing pavement.
(4) Unbound concrete coatings shall be designed and constructed in such a way that they are not bound to the existing pavement.

I.3.3 Existing pavement structure

(1) Condition and properties of an existing concrete pavement, an existing concrete base, or an existing pavement structure shall be determined using the procedures stipulated in point I.2.3 of this Annex, provided that this point does not exclude some procedures.
(2) The following procedures shall be excluded from the determination of conditions and properties under point I.2.3, in conjunction with point I.3.3(1):
— identification of the type, distance, depth and method of sealing dividers.

I.3.4 Design

(1) In addition to the content prescribed in Article 19 of this Regulation, the design of a traffic structure covered with a concrete coating shall contain information on the established condition and properties of the existing concrete pavement, existing concrete base or existing pavement structure in accordance with point I.3.3.
(2) The main design of a pavement structure with a composite pavement covered with a concrete coating shall include an assessment of the established condition and properties of the existing concrete pavement or the existing pavement structure in order to determine whether the traffic structure is suitable for the reconstruction of the existing concrete pavement by adding a concrete coating.
(3) If, on the basis of the assessment of the condition of the existing pavement, an unbound concrete coating is selected, the design of the pavement structure with a concrete pavement with a concrete coating shall also determine the need for the construction of a separating layer, in the event that this layer should ensure the following:
— isolating the displacement of the existing concrete pavement from the concrete coating,
— preventing the reflection of cracks and irregularities from the existing concrete pavement to the concrete coating,
— drainage,
— reduction of stresses and impacts of dynamic loads due to traffic.
(4) The separating layer shall be constructed from:
— asphalt mixture,
— non-woven geotextile
— other suitable material.
(5) If a separating layer made from an asphalt mixture is designed, it shall have a thickness of at least 25 mm and a maximum thickness compatible with the needs given the geometrical irregularities of the existing concrete pavement.
(6) The properties of the separating layer and the materials from which it is composed or constructed shall be specified in the design of the pavement structure in accordance with this Annex.
(7) The design of the pavement structure with a bound concrete coating on the existing concrete pavement specifies the application of bonding agents for old and new concrete.
(8) If the design for the reconstruction of the pavement structure by adding a concrete coating provides for the removal of the surface layer of the existing pavement by machine milling the surface, the depth of removal or the transverse slope to be achieved shall be determined.
(9) The provisions of Annex G to this Regulation shall apply to the design of the concrete coating.

I.3.5 Technical properties

The provisions of this Regulation which are set forth for the properties of concrete pavements shall apply.

I.3.6 Construction product

(1) In concrete coatings, the construction products listed in Chapter III and Annexes A, B, C, D, E and J to this Regulation shall be used, with the following limitation: the maximum aggregate grain for unreinforced concrete coatings shall not exceed one third of the thickness of the coating.
(2) The non-woven geotextile from which the separating layer is constructed shall have properties in accordance with HRN EN 13249:2016.

I.3.7 Construction

I.3.7.1 Preparation of substrate

(1) Preparation of the substrate for bound concrete coatings on an existing concrete pavement shall in particular include the following:
— removal of the surface layer of an existing pavement with a minimum thickness of 0.5 cm or up to the designed depth or transverse slope by machine milling of the surface, where the adhesion value of the concrete substrate shall be greater than 1.5 N/mm², tested according to HRN EN 1542:2001,
— cleaning of the milled surface by washing with pressurised water or sand,
— repair and filling of larger recesses with concrete or a suitable concrete repair product, where necessary,
— thorough cleaning of the surface of the existing pavement by washing with pressurised water and blowing with compressed air immediately prior to the application of the coating.
(2) Preparation of the substrate for bound concrete coatings on an existing asphalt pavement shall in particular include the following:
— removal of the surface layer of the existing pavement to the designed depth or transverse slope by machine milling of the surface,
— thorough cleaning of the surface of the existing pavement with a broom and blowing with compressed air immediately prior to the application of the coating.
(3) Preparation of the substrate for unbound concrete coatings on an existing concrete pavement shall in particular include the following:
— removal of the surface layer of the existing pavement to the designed depth or transverse slope by machine milling of the surface
— construction of the separating layer from asphalt, without special prior mechanical treatment or from a non-woven geotextile with a pre-grooving with a maximum depth of the furrow up to 7 mm,
— thorough cleaning of the surface of the existing pavement by washing with pressurised water and blowing with compressed air immediately prior to the application of the coating.
(4) Preparation of the substrate for unbound concrete coating on an existing asphalt pavement shall in particular include the following:
— removal of elevations on the surface of the existing pavement by cutting if the surface is not to be treated by milling,
— removal of the surface layer of the existing pavement to the designed depth or transverse slope by machine milling of the surface,
— removal of waste asphalt material after cutting or milling,
— thorough cleaning of the surface of the existing pavement with a broom and blowing with compressed air immediately prior to the application of the coating.

I.3.7.2 Separating layer

(1) The construction of a separating layer made from non-woven geotextile shall in particular include the following:
— rolling of non-woven geotextile on the substrate without wrinkling and rippling immediately prior to the application of the concrete coating,
— overlapping of non-woven geotextile in a width of at least 15 cm and in no more than three layers in a way that its wrinkling and tearing due to construction transport are prevented and that allows the paver to work smoothly,
— ensuring that the edges of the non-woven geotextile extend beyond the drainage areas at least 10 cm behind the edge of the pavement and that they are stopped above, inside or with the drainage system of the pavement,
— fixing the non-woven geotextile to the substrate by appropriate means,
— limiting constructional traffic on the applied layer of non-woven geotextile.
(2) The construction of the asphalt separating layer shall be carried out in accordance with the provisions of the regulations governing asphalt pavements.

I.3.7.3 Securing the bond between the existing pavement and the bound concrete coating

(1) The bond between the existing pavement and the bound concrete coating of the prescribed properties shall be achieved by preparing the substrate in the manner prescribed in point I.3.7.1(1) and (2).
(2) If the concrete coating is constructed out on an existing concrete pavement, the surface shall be moistened, but there shall not be any free water on the surface, especially in case of a pavement surface temperature of more than 30 °C.

I.3.7.4 Transport and installation of concrete

The provisions of Chapter V and Annex H to this Regulation shall apply mutatis mutandis to the transport and installation of concrete into a concrete coating.

I.3.7.5 Treatment of upper surface, curing and protection of concrete

The provisions of Chapter V and Annex H to this Regulation shall apply mutatis mutandis to the treatment of the upper surface, curing and protection of concrete.

I.3.7.6 Construction and sealing of dividers

The provisions of Annex E to this Regulation shall apply mutatis mutandis to the construction and sealing of dividers in a concrete coating.

I.3.8 Demonstration of serviceability

(1) For the purpose of demonstrating the serviceability of a concrete coating, none of the provisions of this Regulation and the corresponding Annexes shall be excluded.
(2) If the thickness of a concrete coating is less than 10 cm, the compressive strength of the concrete coating shall be tested on samples of diameter less than 10 cm removed from the coating.
(3) In the case referred to in point I.3.8(2), if the compressive strength shall be tested on samples with a diameter of 5 cm; three times more samples shall be taken from the coating.

I.3.9 Maintenance

For the purpose of maintaining a concrete coating, none of the provisions of this Regulation and the corresponding Annexes shall be excluded.

Table I.1 – Properties of non-woven geotextiles for the construction of the interlayer

Property	Test standard	Required values
Mas per unit of area, g/m^2	HRN EN 9864:2005	≥ 140
Tensile strength, longitudinally, kN/m	HRN EN ISO 10319 :2024	≥ 10,0
Tensile strength, transversely, kN/m	HRN EN ISO 10319 :2024	≥ 10,0
Elongation, %	HRN EN ISO 10319 :2024	≥ 50

ANNEX J: PRODUCTS AND SYSTEMS FOR THE PROTECTION AND REPAIR OF CONCRETE PAVEMENTS

J.1 Scope and general requirements

(1) Pursuant to Article 22 of this Regulation, this Annex lays down technical properties and other requirements for construction products and systems for the protection and repair of concrete pavements (hereinafter: products and systems).
(2) Products and systems within the meaning of paragraph 1 of this point shall be manufactured products and systems by which concrete pavements are protected or repaired in order to preserve or establish the technical properties of the concrete pavement prescribed in this Regulation.
(3) A concrete pavement shall be protected or repaired using products meeting the requirements of the HRN EN 1504 series of standards.

J.2 Specified properties, assessment and verification and labelling

J.2.1 Specified properties

(1) The properties of products and systems shall be specified in accordance with the HRN EN 1504 series of standards, the standards to which those standards refer and the provisions of this Annex, depending on the type of products and systems referred to in point J.2.1.2.
(2) The types of products and systems are:
a) systems for surface protection,
b) products and systems for structural and non-structural repair,
c) structural adhesives,
d) products of the injection of concrete,
e) products for anchoring reinforcement,
f) products for the protection of reinforcement from corrosion.

J.2.2 Assessment and verification of properties

The assessment and verification of the properties of a product or system in relation to its essential characteristics shall be carried out, depending on the type of product or system, in accordance with the provisions of the Appendix ZA of the HRN EN 1504-2:2004 to HRN EN 1504-7:2007 series of standards, HRN EN 1504-8:2016 and the provisions of the special regulations governing construction products.

J.2.3 Labelling

Products and systems shall be labelled on the delivery note and on packaging in accordance with HRN EN 1504-2:2004 to HRN EN 1504-8:2016. The label shall contain a reference to the relevant standard, in accordance with the provisions of the specific regulations governing construction products.

J.3 Tests and other procedures prior to installation

(1) The examination of the properties of products and systems, depending on the type of product or system, shall be carried out in accordance with the relevant standards of the HRN EN 1504 series and the standards to which those standards refer.

(2) The taking and preparation of samples for testing shall be carried out in accordance with the standards of the HRN EN 1504 series and the standards to which these standards refer.

J.4 Design

(1) The design of the pavement structure shall define the performance of products or systems, by specifying the properties pursuant to point J.2.1(1), and depending on the type of products and systems referred to in point J.2.1(2), if the design provides for the protection of the concrete pavement with products and systems.

(2) If the protection of the concrete pavement with products and systems is required to meet the requirements of this Regulation, the project shall provide a technical solution for the protection of the concrete pavement. The project shall include the properties of the products and systems and the requirements for the installation, maintenance and/or restoration during the service life of the structure.

(3) If the existing concrete pavement is maintained by products and systems, the design shall provide a technical solution for the repair of the concrete pavement, which shall include a check of the suitability of the application of a particular product or system for that concrete pavement, the method of construction, including the properties of the products and systems and the conditions of their application, the necessary calculations and/or other appropriate evidence of compliance with the requirements of this Regulation after maintenance.

J.5 Supervision and other procedures prior to installation

In the event of suspicion that an individual property of a product or a product from the system has changed, control prior to installation shall be carried out by appropriate application of the standard referred to in the HRN EN 1504 series and the standards to which those standards refer.

J.6 Application of products

During the application of products and systems to a concrete pavement, the rules set out in Annex H to this Regulation and the details given by the design of the pavement structure with concrete pavement, the technical instruction for the installation and use of products and systems, HRN EN 1504-10:2017 and the standards to which that standard refers shall apply, relating to:

— all stages of the designed service life of a product or system,
— the conditions to be met by the substrate to which the devices and systems are applied,
— products and systems and standards certifying the conformity of these products and systems,
— testing the properties of products during and after installation (in hardened state),
— use and maintenance.

J.7 Specifications

The list of standards applied under this Annex is set out in Appendix 1 to this Regulation.

ANNEX K: TESTING PROPERTIES OF SOIL – DYNAMIC MODULUS OF DEFORMATION

K.1 Equipment

K.1.1 Equipment for measuring settlement

K.1.1.1 Circular load plate

A circular load plate (1) shall have a diameter of D = 300 mm and a thickness of 20 mm. The plate shall be equipped with a housing containing a sensor and a pin (2) for adjusting the guide (3). The mass of the circular load plate with all attachments, including the settlement measurement sensor, shall have a mass of 15 kg ± 0.25 kg.

K.1.1.2 Loading devices

The loading devices of the circular load plate shall allow for an impact (dynamic) load.
They shall consist of
— a guide (3), on which a freely falling weight with a annular handle (4) slides, to which it is attached
— a steel circular spring with housing (6) and an anti-drop device (7) at the bottom,
— closure (5) at the top.
Loading devices shall meet the following requirements:
— mass of falling weights (4) 10 kg ± 0.1 kg
— total mass of the guide, including steel spring with housing, anti-tilting device and closure 5 kg ± 0.25 kg
— maximum impact force Fs 7.07 kN
— impact duration ts 18 ms ± 2 ms

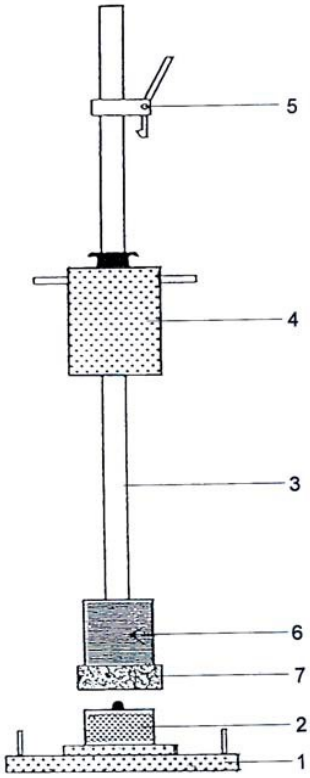


Figure K.1: Schematic drawing of a circular panel with equipment for measuring dynamic load and settlement

The elements of suspension and the height of the drop of weights shall be positioned so as to ensure the required impact force Fs with an accuracy of ± 1 % within a temperature range of 0 °C to 40 °C. The falling weight, made of steel, shall be designed so that it can be intercepted after it bounces. The guide (made of polished stainless steel) shall permanently ensure minimal friction of the falling weight.

K.1.1.3 Equipment for measuring settlement

The equipment for measuring settlement shall contain the following:
— a sensor with a connecting cable, mounted on a rigid circular load plate
— an electronic measuring instrument
The sensor or accelerometer shall ensure that, in the temperature range from 0 °C to 40 °C and in the frequency range from 8 Hz to 100 Hz, the accuracy of the result of measurement with an error of no more than 2 %. The accuracy of measurement for the amplitude of settlement shall be:
— in the range from 0.2 mm to 1 mm, at least ± 0.02 mm,
— in the range from 1 to 2 mm, at least ± 2 %.
An electronic measuring instrument for recording data shall generally be powered by a battery, which shall be charged automatically. The voltage and other properties of the electronic equipment used for the measurement of settlement shall be suitably aligned.

K.2 Test procedure

K.2.1 Conditions for measurements

Measurements of settlement with a circular panel may be carried out

— on coarse-grained materials,
— on mixed materials, and
— on cohesive soils that are difficult to compact to a firm consistency.
The content of grains larger than 63 mm or more than 1/4 of the diameter of the plate in the material shall be negligible.
In case of fast-drying materials, uniformly granular sands, soils which have a crust or are currently softened or moistened on the surface, or materials which have been modified in the upper part in any other harmful way, measurements shall be carried out with the plate below the modified area. The density of the material subject to testing shall remain as constant as possible.
For fine-grained soils (dust, clay), plate measurement is carried out if the soil is compacted to a firm consistency. In cases of suspicion, the water content of the soil, which has a decisive influence on the measurement result, shall be determined at different depths up to 3 r below the surface of the measuring point. The results of plate measurements are generally not realistic or useful if measurements are conducted on frozen material.

K.2.2 Preparation of test surface

The test surface shall be adapted to the size of the circular measuring plate. Appropriate flatness of the test surface shall be ensured using an appropriate tool (steel ruler, trowel, spatula). Loose (moving) grains of the material shall be removed (swept). If the slope of the substrate is greater than 5°, a horizontal surface must be provided for the test:
— for bound soils, by excavating a part of the upper layer, removing protruding coarse grains and filling local holes with sand
— for unbound materials, by adding a sand layer/pin to the height of the horizontal substrate.
The centre of the test surface shall be determined in advance by a vertical line below the pressure pin grip on the counterweight.
K.2.3 Testing dynamic modulus of deformation
The circular load plate must lie firmly on the prepared substrate throughout the contact surface. All voids shall be filled, and minor unevenness shall be levelled with a layer of dry medium-grained sand with granulation up to a few mm. The plate is then placed as horizontally as possible on the prepared surface and pressed into the sand by turning (around the vertical axis) and tapping lightly, so that no voids remain between the plate and the surface.
A guide with all the parts required for the test is be placed centrally and vertically on the integrated circular load plate.
To ensure strong adhesion of the circular load plate, a three-impact pre-load is applied at the measuring point from the specified (calibrated) height of the free falling weight. The weight shall be captured after each impact (bounce). Only after that may the equipment for measuring settlement be switched on.
Where appropriate, the installed measuring equipment shall be protected against the effects of weather (sun, wind). The installed measuring equipment and the counterweight shall not be subjected to vibrations during the measurement.

K.3 Calculation of the dynamic modulus of deformation

With a dynamic impact force *Fs* – 7 kN, a circular plate with a radius r = 150 mm and a surface of 700 cm2 is loaded with normal stress $\sigma = 0.1$ MN/m². According to the basic equation for the dynamic modulus of deformation,

$$E_{vd} = \frac{1{,}5 * r * \sigma}{s} \quad (MN/m^2)$$

ili

$$E_{vd} = \frac{22{,}5}{s} \quad (MN/m^2)$$

the value of the dynamic modulus of deformation $E_{vd.}$ shall be estimated directly using an electronic measuring instrument which estimates the maximum settlement by double integration of the measured acceleration. An average value of three tests is required for the assessment.

K.4 Record of testing

In order to provide the necessary characteristic testing data, a record shall be kept, which must, as a general rule, contain detailed information on

— the measurement site, and

— the interdependencies between the escalation of load and the resulting settlements under the rigid circular load plate or pressure pin.

The necessary data on the measurement site are primarily the following:

— exact location

— type of materials in the substrate

— weather conditions, temperature

— date and time of measurement

— special features

In addition to the above, the record shall also state the characteristics of the procedure (diameter of the load plate, test method). For each load level, all settlement, i.e., readings of measuring devices or other equipment used to measure settlement, and average settlement values estimated at a given load level shall be entered in the record. Settlements at the various load levels and the settlement flow shall be shown in the overview, as a general rule, and in graphic form.

ANNEX L: TESTING SOIL PROPERTIES – COMPRESSIBILITY MODULE

L.1 Equipment

— Press with a minimum pressing force of 5,000 kp
— Three measuring devices with a measuring range of at least 10 mm and a resolution of 0.01 mm
— Measuring device holder, whose stands are located approximately 1.5 m from the load plate
— Steel rigid plate with a diameter of 15.96 cm and a surface area of 200 cm2
— Steel rigid plate with a diameter of 29.86 cm and a surface area of 700 cm2
— Press support when the plate is loaded (truck or similar)
— Stopwatch
— Level
— Equipment for determining humidity

The division on the press manometer should be adapted to the type of substrate subject to testing of the press type. The measuring range of the manometer up to 2/3 of the maximum value should be use.

L.2 Test procedure

L.2.1 Preparation of test surface

The material should have approximately optimal humidity at the location of testing. Before the testing, the moisture of the material shall be tested. The test surface should be horizontal and protected from direct wetting and drying. Sufficient space for the equipment shall be made around the location of testing. In order to achieve an even distribution of pressure, it is necessary to remove protruding parts and fill the recesses with gypsum or fine sand, which shall be compressed.

L.2.2 Testing the compressibility module

For testing the subgrade, as well as the lower and upper bases, a circular plate of 200 cm^2 shall be used, while a circular plate of 700 cm^2 shall be used for testing the finished route. Place the circular plate on the prepared location and check if the plate is in a horizontal position with a level. Where necessary, the test surface shall be treated to achieve horizontal position of the plate. Place the press, resting on a support positioned in such a way that its centre of gravity is approximately in the axis of the press with the upper end, on the plate. Place the brackets of measuring devices so that their supports are about 1.5 m from the press. Place measuring probes of measuring devices on the plate at three points, which are properly spaced across the plate.

Load the plate with 0.2 kp/cm^2. Keep the load for one minute, then unload. Set the measuring devices to zero and start the test. The first load shall be 0.5 kp/cm^2. At the beginning of the application of the load, start the stopwatch. Observe and record settlement by reading the value on the measuring devices. Read the settlement every 60 seconds until a value of less than 0.05 mm is reached in the last three minutes if testing the, or in the last two minutes if testing the base. Increase the load by 0.5 kp/cm^2 until reaching the final load of:

2.5 kp/cm^2 for the subgrade
4.5 kp/cm^2 for bases
5.5 kp/cm^2 for final layers

The settlement value shall be the average value read on three measuring devices.

L.3 Calculation of the dynamic modulus of deformation

(1) Show the test in a diagram in which the plate load p (kp/cm^2) is applied to the horizontal axis and the settlement of the substrate s, (mm) is applied to the vertical axis. Calculate the compressibility module according to:

$$M_S = \frac{\Delta p}{\Delta s} * d$$

where:
Δp – difference between the two tested loads (kp/cm^2)
Δs – corresponding settlement difference (cm)
D – diameter of the circular plate (cm)
(2) In the diagram in which the load-settlement line is drawn (hereinafter: the p-s line), further three lines shall be marked and numbered one to three. These lines divide the diagram field into four zones and are called boundary lines.

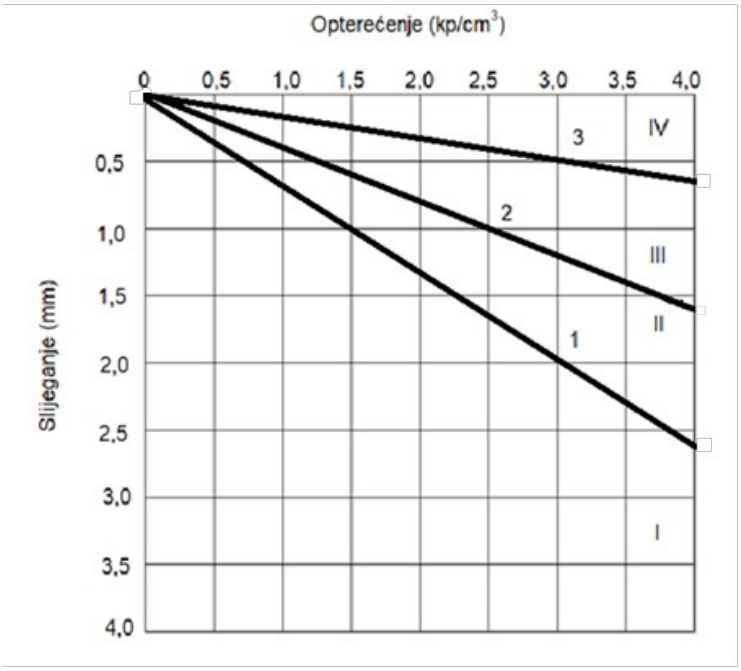


Figure L.1: Line diagram *p-s*

The zones are marked with I to IV and belong to the different load-bearing capacity levels of the different substrates:

Zone I, under line 1, soil (subgrade) of insufficient load-bearing capacity
Zone II, between lines 1 and 2, soil with sufficient load-bearing capacity
Zone III, between lines 2 and 3, lower base with sufficient load-bearing capacity
Zone IV, above line 3, upper base with sufficient load-bearing capacity

Therefore, depending on where the charted line *p–s* lies, it is assessed whether the load-bearing capacity of the tested subgrade corresponds to the intended purpose.
(3) When testing the final layer for drawing line *p–s*, use the diagram according to Figure L.2.

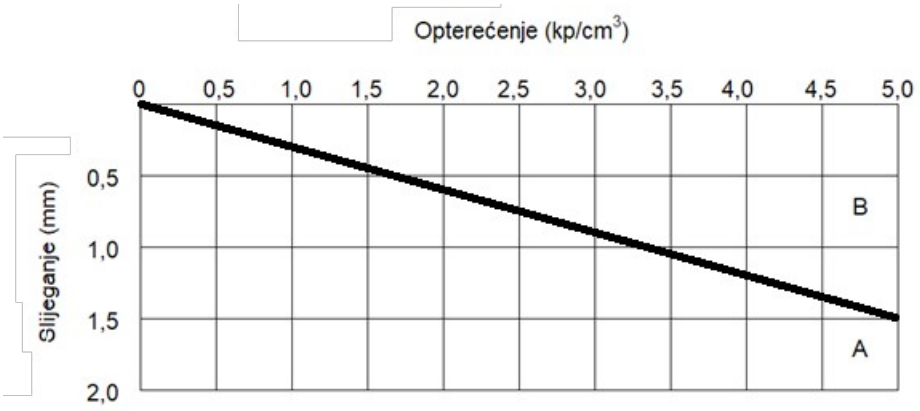


Figure L.2: Line diagram *p–s* for final layers

The boundary line drawn in the diagram divides the field of the diagram into zones A and B.

L.4 Assessment of results

(1) To assess the test results, two criteria are used
a) Line *p–s* drawn pursuant to point L.3(1) lies in the designated zone according to point L.3(2).
b) Calculated value of M_S shall be greater than or equal to the value stipulated for the tested substrate. The result may also be verified by merging two limit points corresponding to the difference Δp in the *p–s* diagram; the obtained line shall not have a greater slope than the corresponding limit line.

(2) For the position of line *p–s*:
Line p-s of the subgrade shall be entirely above boundary line 1 (in zone II or above) if the value M_S is assessed graphically, the line whose slope is compared to the slope of line 1 is obtained by connecting the points of line *p–s* for p=0.5 and p=1.5; if the slope of this line is less than or equal to the slope of line 1, it means that M_S >250 kp/cm^2

- Line *p-s* from the lower base shall be entirely above boundary line 2 (in zone III or above); the line indicating value M_S shall be obtained by connecting the points for p=1.5 and p=2.5 kp/cm^2; if the slope of this line is less than or equal to the slope of line 3, that means that $M_S$is >400 kp/cm2

- Line *p–s* of the upper base shall be entirely above boundary line 3 (in zone IV); the line indicating value M_S shall be obtained by connecting points for p=1.5 and p=2.5 kp/cm^2; if the slope is less than or equal to the slope of line 3, that means that M_S>1,000 kp/cm^2

(3) Line *p–s* of the final layer shall be entirely in Zone B of the diagram in Figure 2. The line indicating value M_S shall be obtained by connecting the points for p=2.5 and p=3.5 kp/cm^2. If the slope is less than or equal to the slope of the line separating zones A and B, that means that M_S>1,000 kp/cm^2.

(4) If line *p-s* of the tested substrate does not meet the conditions of paragraphs 2 and 3 of point L.4, the substrate shall be improved by an appropriate treatment or replaced by a material with a higher load-bearing capacity.

ANNEX M: TESTING SOIL PROPERTIES - FIELD DENSITY TEST

M.1 General

The methods described in this Annex are intended for use in earthworks and foundation work. This Annex specifies the in situ testing of soil density on the basis of measurements of mass and volume. The obtained results shall be used to calculate the porosity and degree of saturation of the soil and to assess its properties for construction purposes. Dry soil density, calculated from sample density, shall be used as a basic parameter in the calculations of soil mechanics.
The methods described in this Annex to the Regulation are suitable for all types of soil in which stable holes can be excavated. In soft cohesive and non-consolidated non-cohesive soils, the use of these methods may lead to incorrect results.

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Metoda	Simbol	Količina uzorka	Masa posude za uzorak s poklopcem	Vaga	
				Kapacitet	tolerancija greške
Rezanje valjaka	A	1,5 do 3 kg	1 kg	10 kg	1 g
Zamjena pijeskom	S	6 do 12 kg	1 do 2 kg	20 kg	10 g
Gumeni balon	B	6 do 12 kg	1 do 2 kg	20 kg	10 g
Zamjena tekućinom	F	6 do 20 kg	1 do 4 kg	25 kg	10 g
Zamjena gipsom	G	6 do 12 kg	1 do 2 kg	20 kg	10 g
Iskopavanje	Sch	0,7 t do 2 t	0,5 t do 3,5 t	10 t do 20 t	1 kg do 20 kg

Table M.1 Capacity and error limits of the weighing instrument used for determining the volume of the sample

M.2 Sample quantity

When testing fine-grained soil, the minimum sample quantity shall depend on the method used to determine the volume. If a sample contains large particles, its quantity shall not be less than 50 times the maximum largest estimated particle size.

M.3 Testing principle

The field test of soil density shall be determined:
a) by determining the mass of the sample, m or md, as referred to in point M.4
b) by determining the volume, V, of the wet sample, as referred to in point M.5.

M.4 Testing the mass of the sample

M.4.1 Equipment

a) Weighing instrument with a capacity suitable for determining the mass of the sample vessel, including the sample and the error limit suitable for determining the mass of the sample with the required accuracy (Table M.1)
b) Dryer with an operating temperature of 250 °C
c) Vessels for sample drying

M.4.2 Procedure

To determine the mass of a wet sample, *m*, the wet sample is weighed, together with the container into which it is placed after extraction, with an accuracy of 0.001 * *m* (to obtain a mass of m_1). Before this, the mass of the container, m_2, shall be determined. The mass of the wet sample shall be calculated using the following equation:

$$m = m_1 - m_2$$

If the containers used cannot be closed, the weighing shall be carried out on the location, immediately after extraction. Given the required error limits of the weighing instrument, priority shall be given to weighing in the laboratory when using the roller cutter method.

Vrsta tla		Prikladne metode	Neprikladne metode
Kohezivna tla	Ne sadrži krupne čestice	Sve metode	Nema
	Sadrži krupne čestice	Sve metoda s zamjenom	Rezač valjaka
Nekohezivna tla	Sitni do srednji pijesak	Rezač valjaka i sve metode sa zamjenom	Nema
	Mješavina pijeska i šljunka	Sve metode s zamjenom	Rezač valjaka
	Šljunak s malim udjelom pijeska	Gumeni balon, zamjena tekućinom, zamjena gipsom	Rezač valjaka, zamjena pijeskom, zamjena tekućinom, zamjena bentonitom
Kamenje s niskim udjelom sitnih čestica		Metoda iskapanjem	Sve ostale metode
NAPOMENA: Korištenje ovih metoda u mekim kohezivnim i nekonsolidiranim nekohezivnim tlima može dovesti do netočnih rezultata.			

Table M.2 Appropriateness of methods depending on the type of soil

After drying the sample to a constant mass at 105 °C, its dry mass, md, shall be determined in the same way or shall, alternatively, be calculated from m and the moisture content of the sample, w, using the following equation:

$$m_d = \frac{m}{1+w}$$

M.5 Testing the volume of the sample

M.5.1 Methods

The volume of the sample shall be determined directly from the internal volume of the extraction device (point M.5.2) or by measuring the hole formed during sample extraction. The methods described in points M.5.3 to M.5.7 differ mainly in the way the volume of the hole is measured. In the substitution methods described in points M.7.3 to M.5.6, the hole shall be filled with a replacement substance and the volume of the hole shall be determined from the volume of the substance necessary for filling. The suitability of these methods depends on the type of soil being tested (Table M.2).

M.5.2 Roller cutter method

M.5.2.1 Equipment

a) Cylindrical roller cutter, with an internal cutting edge, made of precision seamless steel, with an internal diameter of at least 96 mm, with a ratio of h/d_i of about 1.2 and a surface index:

$$C_a = \frac{d_a^2 - d_i^2}{d_i^2}$$ of 0.1 or less (Figure M.1)

b) End caps, for closing the roller cutter at both ends.
c) Adhesive tape.
d) Guide, with a welded ring base plate.
e) Steel ring.
f) Rammer or hammer.
g) Shovel.
h) Metal plate, with a sharpened edge, to limit the depth of penetration.
I) Smearing knife, with a flat blade.
j) Steel ruler.
k) Sampling tube.

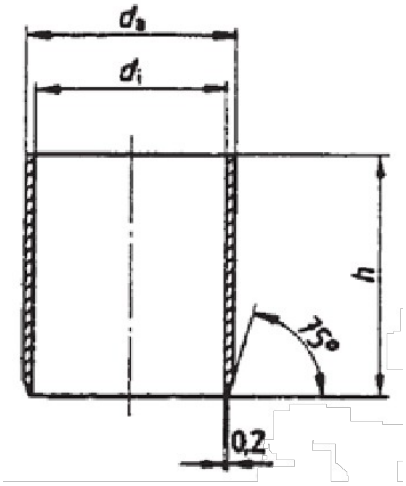


Figure M.1: Dimensional markings of roller cutter

M.5.2.2 Type of soil

The roller cutter method is suitable only for fine-grained soil (sand, sludge, clay), and especially for solid cohesive soil and medium-density fine sand. Where there are some coarse particles, the volume of the roller cutter shall not be less than 100 times the particle size of the maximum estimated volume, and the proportion of particles with a size of 0.02 mm² di or more shall be less than 10 %. In loose and dense non-cohesive soils and in semi-solid to solid cohesive soils, a sampling tube shall be used to take special samples from testing pits.

M.5.2.3 Procedure

Uncover an area large enough to accommodate the annular base plate at a depth of at least 50 mm below the ground surface and flatten with a ruler, and place the base plate with a guide tube in its place. Insert the roller cutter into the guide tube with the blade down and carefully press into the ground using a steel ring or, if not possible, ram into the ground as centrally as possible using a rammer or hammer. In cohesive soil, continue the ramming until the upper edge of the cutter is about 10 mm below the ground surface. In non-cohesive soil, it must be on the same level as the surface of the soil. Ramming into the sand may cause the sample to condense or swell in the cutter, so that the upper end of the sample is not level with the surrounding ground. In such cases, the sample volume shall be taken as equal to the internal volume of the cutter. A stop placed on the guide shall ensure that the cutter cannot be driven

deeper than the ground surface. This allows for the extraction of samples of uniform volume. After ramming, the soil is carefully removed from the outside of the cutter on one side to allow the metal plate to be pushed or lightly hit with a hammer to close the lower end of the cutter. The cutter with the plate beneath it is removed from the ground and placed on a solid substrate. In case of cohesive soil, the material protruding from the ends of the cutter must be carefully cut with a knife, and the ends of the sample must be trimmed at the level of ends of the cutter using a ruler. If the ruler leaves voids while removing particles protruding above the surface, they must be filled with lightly compacted soil. The upper and lower edges of the cutter shall be cleaned, and the cutter shall be closed at both ends using end caps, which shall be closed with adhesive tape, if necessary.

M.5.2.4 Evaluation

The volume of the sample, V, is determined from the inner volume of the roller cutter. It shall be calculated by taking the mean value of the three measurements of inner diameter and height made at three evenly spaced points with an accuracy of 0.1 mm.

M.5.3 Sand replacement method

M.5.3.1 Sampling equipment

a) Ringed steel cover plate, at least 5 mm thick, with inner diameter, di, not less than 200 mm, but more than four times the particle size of tested soil, and a minimum outer diameter equal to *di* + 200 mm (Figure M.2).

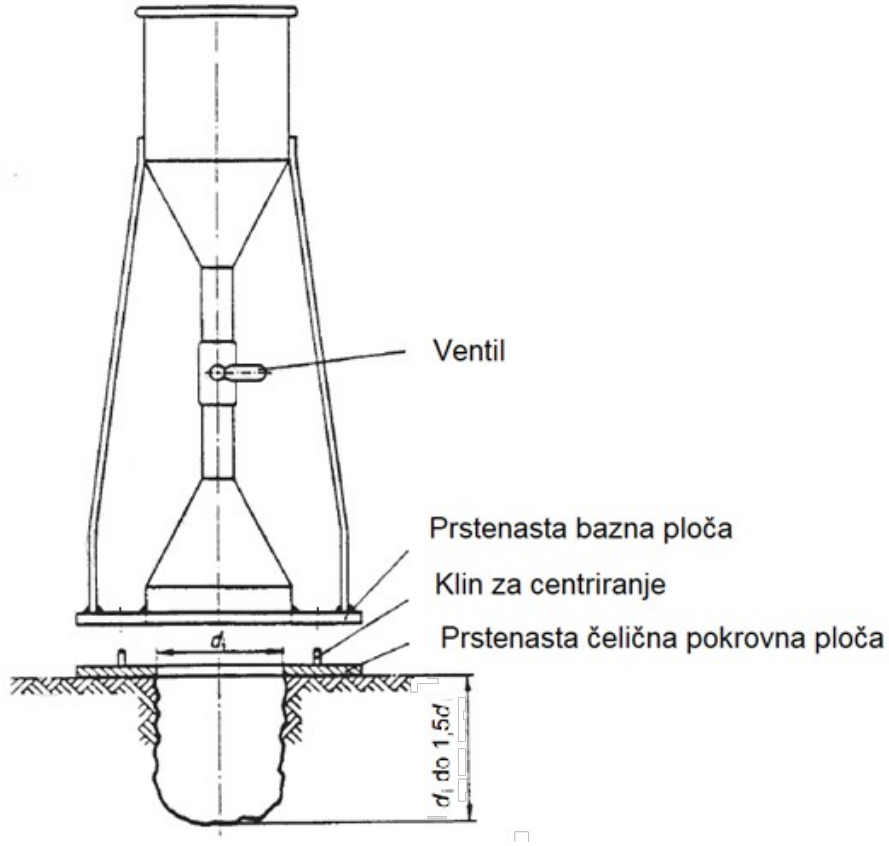


Figure M.2: Layout of apparatus for the sand replacement method

b) Steel ruler with a length of at least 400 mm.
c) Level.
d) Tools suitable for excavating and removing soil from holes (e.g., shovel, spatula, spoon, chisel, hammer, brush, hand brush).
e) Weighing instrument, with a minimum capacity of 20 kg and an error limit of 10 g.
f) Receptacle, with a capacity of 5 l to 10 l, with a well-adhering cover, for storage of samples.

M.5.3.2 Volume testing equipment

a) Double hopper, with a shut-off valve and a welded ring base plate, treated to correspond to the ring steel cover plate. The upper hopper shall have sufficient capacity to receive the total amount of sand required for the test (Figure M.2).
b) Calibration vessel, with an internal diameter equal to the diameter of the steel cover plate and an internal depth equal to approximately di to 1.5 * di, made of a water-repellent material. The shape and roughness of the surface of the container shall correspond to the actual test hole (Figure M.3)

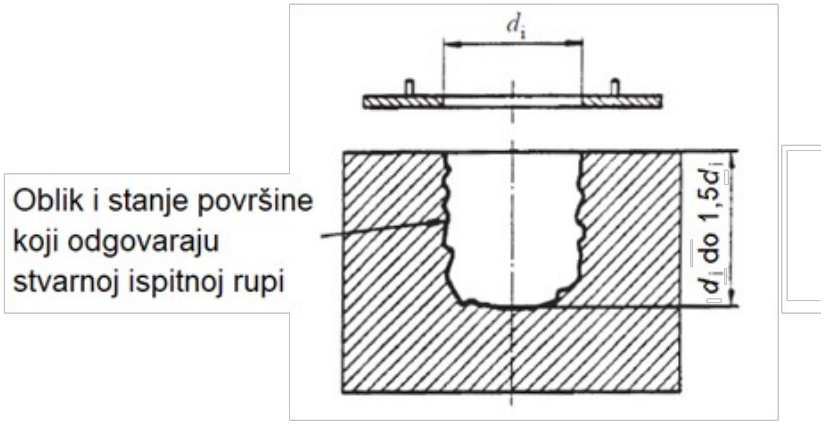


Figure 3: Calibration vessel with a steel cover plate

c) Oven-dried rough sand.
NOTE: Sand is considered to be dry if its moisture content is less than 0.2 %. Since a moisture content of 0.2 % or more causes changes in the density of the sand, which affects the accuracy of the results, dried sand should be stored in hermetically sealed containers.

M.5.3.3 Type of soil

The sand replacement method is suitable for mixed granular and coarse-grained cohesive and non-cohesive soils with a maximum particle size not exceeding the particle size of the gravel (63 mm), in which the drill for rollers cannot be introduced without distorting the structure of the soil. Voids or pores in the soil shall be small enough to prevent the sand used in the test from entering them.

M.5.3.4 Testing loose bulk density of substitute sand

Place the ringed steel cover plate on the calibration vessel and place the double hopper, filled with sand and weighed, on the top of the plate. Open the shut-off valve on the double hopper and let the sand fill the vessel and the bottom hopper up to the valve. Close the valve and weigh

the double hopper with the remaining sand to determine the mass of the sand used, m_a. Refill the double hopper with sand, weigh it, place it with the steel plate on a solid flat base and re-weigh to determine the mass of sand required to fill the ring space of the steel plate and the lower hopper, m_b. The mass of sand required to fill the vessel is calculated using the following equation:

$$m_E = m_a - m_b$$

The internal volume of the calibration vessel is determined by measuring the volume of water. Repeat this measurement three times with an accuracy of $\pm 3\ cm^3$. The volume is calculated from the mass of the filled water, m_w, and water density at the test temperature, ρ_{wt}, using the following equation:

$$V_E = \frac{m_W}{\rho_{wt}}$$

Calculate the loose bulk density of substitute sand from the mean value of the three individual tests using the following equation:

$$\rho_E = \frac{m_E}{V_E}$$

M.5.3.5 Procedure

M.5.3.5.1 Extraction of sample and preparation of test hole

Excavate an area large enough to place the ringed base plate at a depth of at least 50 mm below the ground surface and level it with a ruler, and place the plate in full contact with the ground surface. Through the central hole of the steel plate dig a test hole with a depth of about d_i to 1.5 d_i, ensuring that the sides of the hole are as vertical as possible and that the plate is not clipped. Place the excavated soil and any material loosened during digging in a container and close it.

M.5.3.5.2 Testing volume

Place a double hopper that is filled with sand and weighed (to obtain a mass of m_3) on the steel plate. Open the shut-off valve and allow the sand to flow out, taking care to ensure that the apparatus is not exposed to vibration during the process. When there is no further movement of sand, close the shut-off valve and weigh the double hopper with the remaining sand (to obtain mass m_c). Weight of the sand used, m'_c, calculated as the difference between m_3 and m'_c.

$$m_c = m_3 - m_3'$$

In case of soils that cannot be levelled into a flat surface due to coarse inclusions, a compensation layer of fine-grained material shall be placed between the steel plate and the soil surface. This will result in the rising of the steel plate relative to the surface of the soil and an increase in the ringed space. Determine the mass of sand needed to fill this space and the lower hopper, $m_{d\ enl}$, before the hole is excavated in the same way as mass mc. For all measurements involving sand, keep in mind that the loose bulk density of the sand is largely dependent on the humidity of the air. Therefore, determination of loose bulk density shall be carried out after any significant change in air humidity. The sand used to fill the test hole may not be reused without drying.

M.5.3.5.3 Evaluation

The mass of sand required to fill the test hole shall be calculated by subtracting the mass of sand used to fill the bottom hopper and ringed space of the steel plate, m_d, or the extended ringed space, $m_{d\ enl}$, from the mass used to fill the hole, steel plate and bottom hopper, m_c. Calculate the volume of the test hole, V, from the mass of sand required to fill the hole, $m_c - m_d$ or $m_c - m_{d\ enl}$, and the density of sand, ρ_E, using the following equation:

$$V = \frac{m_c - m_d}{\rho_E} \quad \text{ili} \quad \frac{m_c - m_{d\,enl}}{\rho_E}$$

M.5.4 Rubber balloon method

M.5.4.1 Sampling equipment

The required equipment is specified in point M.5.3.1.

M.5.4.2 Equipment for determining volume

a) Rubber balloon device, with a ringed base plate processed so as to conform to the ringed steel cover plate (Figure M.4). The flexible membrane (rubber balloon) shall have a wall thickness of not more than 0.25 mm and shall be of such size and shape as to fill the test opening in an unextracted state.
b) Plastic container, with a capacity of app. 10 l, with lid, for measuring liquid (water).

M.5.4.3 Type of soil

The rubber balloon method is suitable for cohesive and non-cohesive soils in which stable holes can be excavated, especially for fine-grained soils containing pebbles and stones, as well as for coarse-grained soils. The method is not suitable for soil containing angular material capable of piercing the rubber membrane.

M.5.4.4 Procedure

Uncover an area large enough to place the ringed base plate at a depth of at least 50 mm below the ground surface and level it with a ruler, and place the plate in full contact with the ground surface. Afterwards, place the apparatus on the steel plate and raise the pin far enough to prevent the rubber balloon from getting stuck. Push the nonius down to the limit; the valve will open, and the pin should be carefully moved down until the rubber balloon lies flat on the ground surface and the liquid level in the tube reaches the mark. The position of the pin shall be read on the nonius (zero reading, L_0). After that, pull the pin together with the rubber balloon, remove the apparatus from the steel plate and dig inside the plate for a test hole as specified in point M.5.3.5.1. After the test hole has been excavated, place the apparatus over the steel plate in the same position as that used for zero reading and the position of the to be read (L_1) without displacement of the nonius.
NOTE: Depending on the size of the test hole and the apparatus, further measurements may be made at the same point to determine the change in density with an increase of depth. For each measurement, the test hole must be deepened and the procedure used to determine L_1 must be repeated. This results in positions of the pin L_2 and L_3. Up to three consecutive density

measurements may be carried out with a 200 mm diameter cylinder, and up to four measurements may be carried out with a 300 mm diameter cylinder.

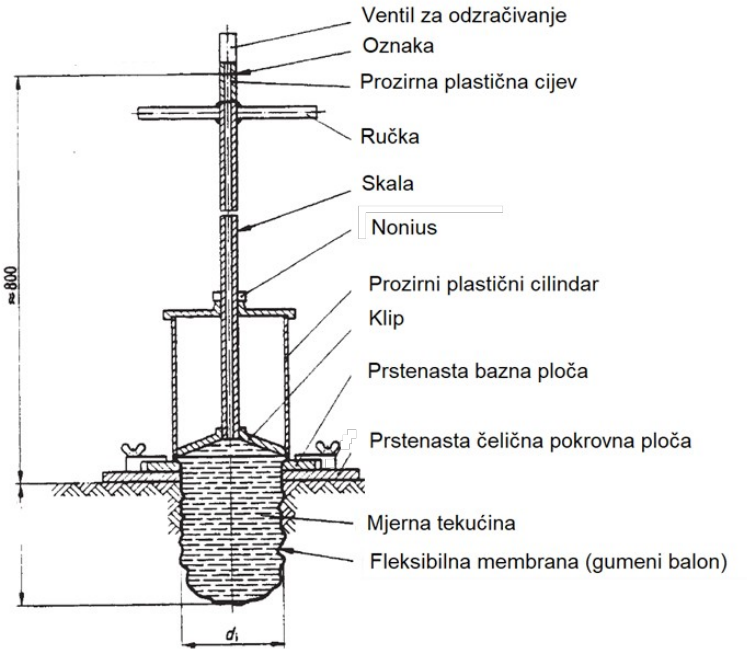


Figure M.4: Arrangement of apparatus for the rubber balloon method

M.5.4.5 Evaluation

The volume of the test hole, *V*, is equal to the volume of liquid squeezed by the pin between two readings. It is calculated using the following equation:

$$V = (L_1 - L_0)$$

where
L_1 reading of the pin position when the rubber balloon is lowered to the ground;
L_0 reading of the pin position before excavating the soil sample;
A cross-sectional area of the transparent plastic cylinder.

M.5.5 Liquid substitution method

M.5.5.1 Sampling equipment

The required equipment is specified in point M.5.3.1. Instead of a steel cover plate, a plate made of material of lower density may be used if its internal diameter is greater than 300 mm.

M.5.5.2 Volume testing equipment

a) Support for adjusting the level of liquid (Figure M.5).
b) Closing vessel with measuring liquid (bentonite suspension or water).
c) Mixer.
d) Plastic film with a thickness of 0.05 mm or flexible rubber membrane with a thickness of 0.2 mm to 0.5 mm.

e) Calibrated vessel, with a capacity of no less than 2 l, for determining the density of the liquid.
f) Ladle.

M.5.5.3 Type of soil

The liquid replacement method is suitable for coarse-grained and gravel sand, as well as for mixed soil in which stable holes can be excavated. Replacement of soil material with water using a plastic film or rubber membrane allows for measurement of large volumes of test holes in highly permeable coarse soil.

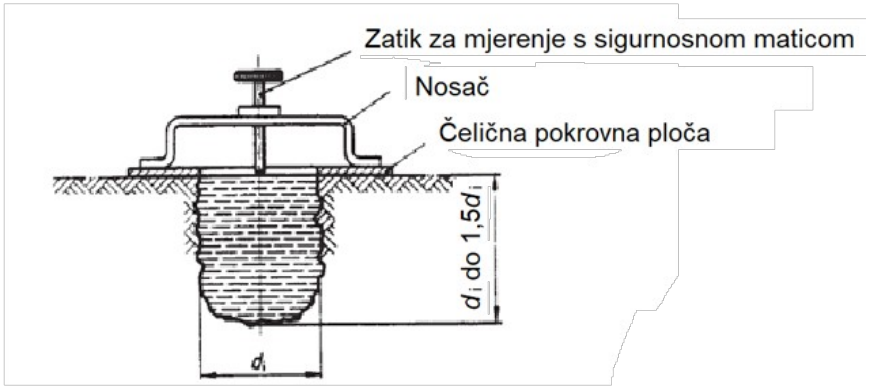


Figure M.5: Arrangement of apparatus for liquid replacement method

M.5.5.3 Procedure

M.5.5.3.1 Extraction of the sample and preparation of the test hole

Follow the procedure described in point M.5.3.5.1.

M.5.5.3.2 Testing volume

The excavated test hole is filled with a bentonite suspension of known density or, after a plastic foil or rubber membrane has been placed in the hole, with water. The liquid must settle at the level of the measuring needle, which is adjusted on the support to the ground surface prior to the excavation of the hole (Figure M.5). To determine the mass of the liquid required to fill the hole, the bucket must be weighed together with the liquid before and after the spilling (to obtain m_4 and m_5). In highly permeable soil (e.g., crushed stone, fine material with a small proportion of fine particles, coarse gravel), the use of the bentonite suspension would result in an excessively large volume, as the liquid would penetrate into existing cavities. In such cases, the plastic film or rubber membrane should be placed in the excavated hole and filled with water up to the mark. Given the roughness of such soil, the amount of excavated soil shall be about 10 l (with a minimum internal diameter of the steel cover plate of 250 mm).

M.5.5.3.3 Evaluation

The volume of the test hole is calculated from the mass of the bentonite suspension or the water used to fill the hole and the density of the substitute liquid, ρF, using the following equation:

$$V = \frac{m_4 - m_5}{\rho_F}$$

If water is used as the substitute liquid, ρ_F is taken as 1 g/cm^3.

M.5.6 Gypsum replacement method

M.5.6.1 Sampling equipment

The required equipment is specified in point M.5.3.1. Instead of a steel cover plate, a plate made of material of lower density may be used if its internal diameter is greater than 300 mm.

M.5.6.2 Apparatus and materials for determining volume

a) Plastic container for mixing gypsum.
b) Stirring stick.
c) Water.
d) Gypsum (about 4 kg to 5 kg per sample).
e) Flaxseed oil.
f) Cellulose.
g) Vaseline.
h) Wire.
i) Immersion vessel, with a capacity of approx. 10 l, with overflow and collecting device.

M.5.6.3 Type of soil

The gypsum replacement method is suitable for any soil in which stable holes can be excavated, especially for coarse-grained soil in which leachate cannot be used.

M.5.6.4 Procedure

M.5.6.4.1 Extraction of sample and preparation of test hole

Follow the procedure described in point M.5.3.5.1.

M.5.6.4.2 Testing volume

In order to prevent the gypsum from sticking to the sides of the hole and to avoid crumpling, the excavated hole is lined with oil-soaked cellulose strips. The gypsum is sprinkled in 3 to 4 litres of water, it is left to stand for about two minutes and then it is stirred until a homogeneous paste is formed that can be poured. The gypsum paste is poured into the hole without retention of air. As soon as the paste begins to harden, it must be aligned with the surface of the cover plate using a ruler, and a piece of wire formed in the form of a spiral must be twisted into it. After it has hardened for about 10 minutes, carefully excavate the gypsum block on one side and remove it together with the cover plate using the wire. Lightly hammer the cover plate to detach it from the gypsum block. Remove any soil adhering to the cellulose tapes with a hand brush. Store the plaster block in water until the air bubbles stop rising (about two hours), which indicates complete saturation. In this state, immerse the gypsum block in an immersion vessel filled with water until it overflows. The amount of water overflowing during immersion is taken as the volume of the plaster block, *V1*, which is given by

$$V_1 = \frac{m_G - m_{GA}}{\rho_{wT}}$$

where:
m_G - mass of the gypsum block;

m_{GA} - mass of the gypsum block when immersed in water;
ρ_{wT} - density of water at temperature T.
Alternatively, V_1 is determined by weighing under water.

M.5.6.5 Evaluation

Reduce V_1 by the volume of the ringed opening in the cover plate, ΔV, which is given by

$$\Delta V = \frac{d_i^2 x\pi}{4} h$$

where:
d_i - internal diameter of the cover plate;
h - thickness of the cover plate.
The volume of the test hole, V, is calculated using the following equation

$$V = V_1 - \Delta V$$

M.5.7 Excavation method

M.5.7.1 Equipment

a) Digging tools, for excavating and removing soil from holes (e.g., shovel, pickaxe).
b) Measuring tape.
c) Light transporter or several large containers.
d) Weighbridge.

M.5.7.2 Type of soil

The excavation method is suitable for coarse-grained soil such as coarse gravel containing boulders, blocks and crushed stone, in which holes with a volume of 0.5 m^3 to 1 m^3 and a regular cross-section may be excavated without collapsing on the sides.

M.5.7.3 Procedure

Excavate a rectangular hole of a regular cross-section, measuring between 0.5 m^3 and 1 m^3. Load the excavated material onto a transporter or fill it into several large containers.

M.5.7.4 Evaluation

The volume of the hole is calculated based on its dimensions, with each dimension being determined by taking the mean value of three individual measurements
NOTE: Since mass and volume may only be determined indicatively, the results obtained for density will be less accurate than those obtained by other methods.

M.6 Indication of results

The following shall be indicated:
a) soil density, ρ;
b) dry soil density, ρ_d;

c) moisture content, w;
d) grain density, ρ_s;
e) standard method code;
f) maximum particle size and sample volume, if containing coarse particles with a size greater than 6 mm.

ANNEX N: TESTING SOIL PROPERTIES – STATIC MODULUS OF DEFORMATION

N.1 Equipment

N.2.1 General equipment

a) reaction load system;
b) plate load device, consisting of a load plate, an adjustable level and a load system with a hydraulic pump, a hydraulic crane assembly and a high pressure hose;
c) devices for measuring the applied load and the settlement of the load plate at right angles to the loaded surface;
d) the means of calculating the modulus of deformation.

N.2.2 Reaction load system

The reaction load system shall produce a reaction load that is at least 10 kN greater than the maximum required test load. A loaded truck or roller or any other object of sufficient mass shall be used for this purpose.

N.2.3 Load plate

Steel load plates shall be machine-treated and shall have flatness and roughness tolerances in accordance with Figures N.1 and N.2. The load plate shall have two handles (Figure N.1).

1 Central pin for holding the force transducer with an articulated tip
2 Handle
3 Circle of the hole (e.g. 95 mm with three M6 screws (evenly distributed around the circle)
4 Measuring tunnel

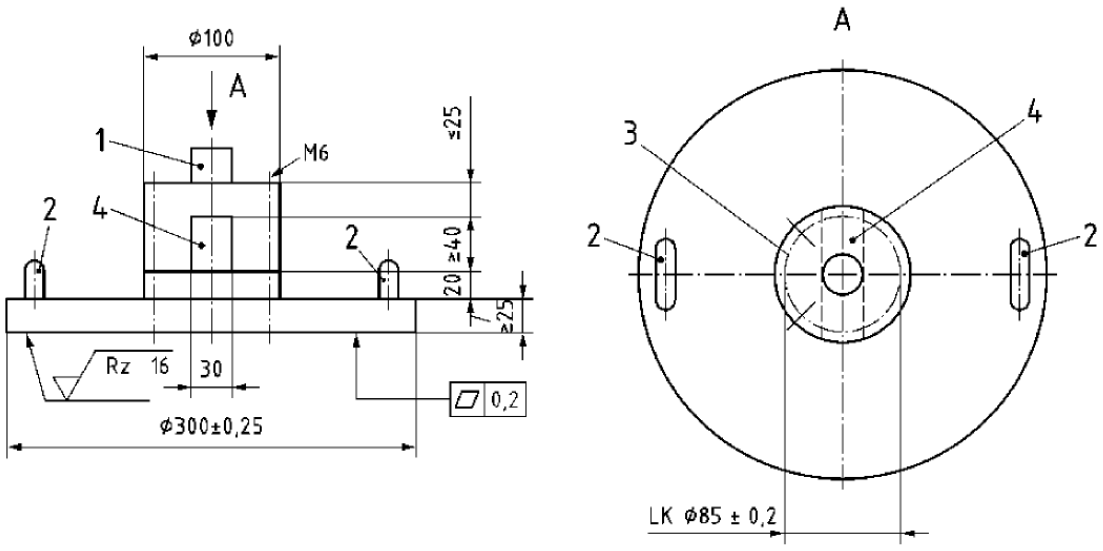
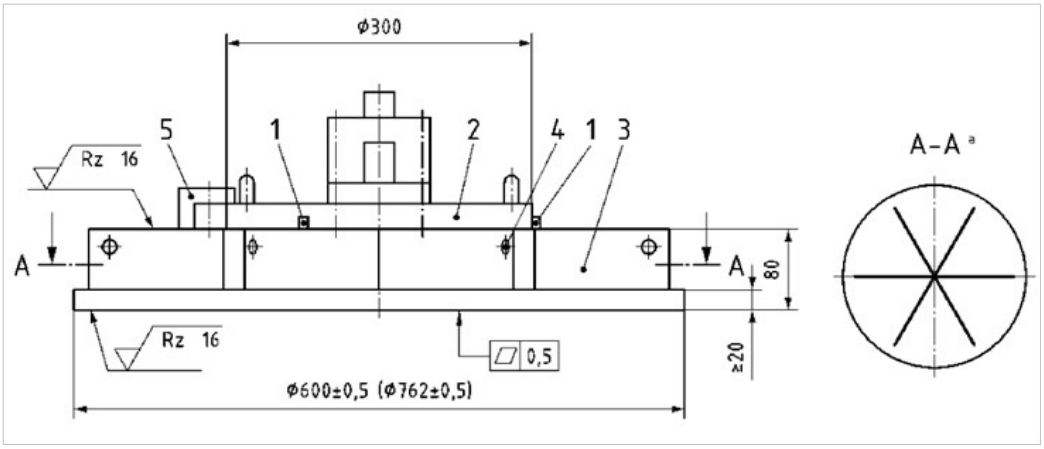


Figure N.1 — 300 mm load plate with measuring tunnel

Load plates with a diameter of 300 mm shall have a minimum thickness of 25 mm.
The load plates with a diameter of 762 mm shall have a minimum thickness of 20 mm and shall be equipped with equally spaced solidifications with flat upper surfaces parallel to the bottom

surface of the plate to enable the plate to be mounted 300 mm onto it. To keep the upper plate in position, centering pins and, if necessary, clamps shall be provided (Figure N.2).



1 - 300 mm load plate centering pins
2 – 300 mm load plate
3 - Fasteners (t = 20 mm)
4 - Handle attachment accessory
5 - Three clamps
a) Layout of fasteners reduced in scale and shown schematically
All measures are given in mm.

Figure N.2 Load plate 762 mm in diameter with evenly distributed stiffenings

N.2.4 Load system

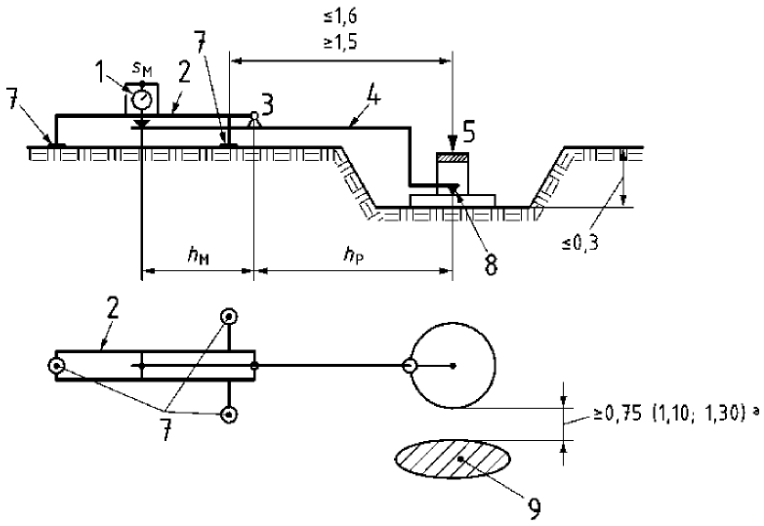
The load system shall consist of a hydraulic pump connected to a hydraulic crane via a high-pressure hose of a minimum length of 2 m. The system shall be capable of applying and releasing the load in phases. In order for the load to be applied correctly, the hydraulic crane shall be hinged on both sides and secured against tilting. The load plunger shall operate at least 150 mm. The height of the plate loading device during operation shall not exceed 600 mm. In order to compensate for differences in the heights of vehicles used as reaction loads, elements shall be provided to enable the initial length of the hydraulic crane to be increased to a minimum of 1,000 mm. To prevent the bending of these elements, appropriate means shall be provided.

N.2.5 Force measurement system

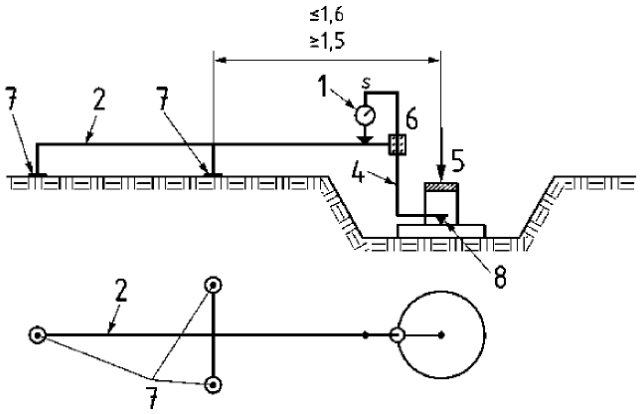
The mechanical or electrical force transducer shall be placed between the load plate and the hydraulic crane. It shall measure the load on the plate with a maximum permissible error of 1 % of the maximum test load. The stress shall be indicated with a resolution of at least 0.001 MN/m2 for a 300 mm load plate, or 0.0001 MN/m^2 for a 762 mm load plate. The resolution of the force measurement system shall be equal to the resolution of the force transducer.
The above requirements apply for the 0 °C to 40 °C temperature range.

N.2.6 Settlement measurement system

The arrangement in Figure N.3 shows a device for measuring settlement with a rotating contact arm and one with a contact arm moving horizontally in an axial direction (i.e., with a sliding bearing). A measuring device with a rotating contact arm shall only be suitable for tests in excavations no deeper than 0.3 m.
A measuring device with a contact arm that can be moved horizontally in an axial direction may also be used in deeper excavations.
The settlement measurement device shall consist of:
— a frame supported by three points (see “2” in Figure N.3),
— a vertically adjustable, torsion-resistant, rigid contact arm (see “4” in Figure N.3),
— displacement transducer or gauge with a pointer (see '1' in Figure N.3).
The distance from the centre of the load plate to the centre line of the support shall be at least 1.5 m and must not exceed 1.6 m (Figure N.3).
The ratio hp : hm (see Figure 3 a)) shall not exceed 2.0. It must be possible to lock the assembly so that the hp/hm ratio does not change during measurement.
The settlement measuring device shall be capable of measuring the settlement of the load plate with a maximum permissible error of 0.04 mm in the measuring range up to 10 mm when using a 300 mm load plate
The indication shall have a resolution of at least 0.01 mm.
The above requirements apply for the 0 °C to 40 °C temperature range.



a) Rotating contact arm according to the "weighing beam principle"; measurement of settlement taking into account the lever ratio h_P: h_M



b) Contact lever with sliding bearing; measurement of sinking at lever ratio 1:1
Where:
1 Measuring instrument or displacement transducer
2 Load-bearing frame
3 Opposition point
4 Contact lever
5 Load
6 Sliding guide
7 Support
8 Needle
9 Area occupied by the reaction load system
All measurements are in meters.
Figure N.3 — Settlement measuring device (examples)

The measurements of settlement using alternative metering devices shall be permitted if they have at least the same resolution, if they perform measurement with the same accuracy, and they are found not to be affected by the deformation of the soil resulting from the test.

N.2.7 Auxiliary equipment

a1 Shovel
2 Steel rulers, 400 mm, 700 mm and 85 mm long
3 Hand brush
4 Skimmer, trowel, square, plumb bob, folding ruler, dry middle sand, gypsum paste, oil
5 Tarpaulins or similar means of protection from the sun and wind.

N.3 Conditions for testing

The plate load test is carried out on coarse and composite soils, as well as on solid to solid and non-grained soils. Care should be taken not to place the load plate directly on particles larger than one quarter of its diameter. In the event of rapid drying of the sand or soil that has formed the surface crust, that has softened or is otherwise disturbed in its upper zone, this disturbed soil should be removed before the plate load test is carried out. The density of the soil subject to testing shall remain as constant as possible. For fine-grained soil (e.g., powder, clay), the plate load test shall be performed and satisfactorily assessed only if the consistency of the soil is solid to firm. In case of doubt, the consistency of the tested soil shall be determined at different depths to depth d below ground level (d = diameter of the load plate).
N.4 Plate load test procedure

N.4.1 Preparation of the test area

An area large enough to fit the test plate should be aligned using the appropriate tools (e.g., a steel ruler or trowel) or by turning or moving the testing plate back and forth. All loose material should be removed.

N.4.2 Installation of the load plate equipment

The load plate shall lie on the test surface and be in full contact with it. If necessary, a thin layer (only a few millimetres thick) of dry medium-grained sand or gypsum paste should be prepared to obtain a flat surface. The plate is placed on this surface by turning and slight tapping on the upper side. When gypsum paste is used as a substrate material, the plate shall be greased on the

underside. Use a spatula to remove the excess paste before it hardens. The test may not be started until the paste has hardened. The hydraulic crane shall be placed in the middle of the load plate and at right angles to it under the reaction load system and shall be secured against tilting. The minimum distance between the load plate and the contact surface of the reaction load shall be 0.75 m for a 300 mm plate, or 1.3 m for a 762 mm plate. The reaction load shall be secured against displacement at a right angle to the direction of the load. Ensure that the load system remains stable throughout the test. These requirements also apply to inclined test surfaces.

N.4.2 Arrangement of the apparatus of measuring settlement

The measurement of settlement shall be carried out by means of a measuring device, a displacement transducer or an alternative measurement system (point N.2.6).
To measure settlement, place the measuring probe (Figure N.3) in the centre of the load plate.
The distance between the frame holder and the surface occupied by the reaction load shall be at least 1.25 m. The measuring device or transducer shall be installed vertically (Figure N.3).
When placing the load plate, ensure that the measuring probe of the contact arm can be passed without obstacles into the measuring tunnel at the base of the load plate and placed centrally on the plate.
The settlement measurement device shall be protected from sunlight and wind. Ensure that the device and the reaction load system are not subjected to vibrations during the test.

N.4.3 Pre-load

Before starting test, the force transducer and the measuring device or displacement transducer shall be set to zero, after which a load corresponding to a stress of 0.01 MN/m^2 shall be applied when using a 300 mm plate, or 0.005 MN/m^2 for a 762 mm plate.
The reading of the measuring device or transducer may not be reset to zero for at least 30 s after the pre-load has been applied.

N.4.4 Loading and unloading

N.4.4.1 General

The maximum load and/or maximum required settlement is determined by the test objectives, as well as by the properties of the soil and the size of the load plate

N.4.4.1 Determining the modulus of deformation, EV

For the determination of the modulus of deformation, E_V, load shall be applied in at least six phases, in approximately equal steps, until the required maximum stress is reached. Any change in load (between phases) shall be completed within one minute. The load shall be released in three phases, at 50 %, 25 % and approximately 2 % of the maximum load. After removing the load, a further load cycle is carried out, in which the load should only be increased until the penultimate stage of the first cycle (so that full load is not reached).
When increasing and reducing the load, after reaching the previous load phase, it must pass 120 s before the start of the next phase. 60 s is sufficient for testing road substrate. The load shall be kept constant during this period. The reading shall be recorded at the end of each load phase.

To determine the modulus of deformation for road construction purposes, a load plate of 300 mm shall be used and the load shall be increased until a normal load under the plate of 0.5 MN/m^2 is achieved. If a settlement of 5 mm is first achieved, the normal load measured at this stage shall be taken as the maximum load. For a 762 mm plate, the limit values are 0.2 MN/m^2 and 13 mm.
If the test takes place in an unexpected manner (e.g., if the load plate overturns or quickly sinks), the soil at the test site shall be excavated to a depth equal to the diameter of the plate. If any local inhomogeneity is encountered (e.g., stones or soil of different consistency), this shall be recorded.
For soils with low particle strength or soils where the rapid deformation occurring as the load increases indicates an inevitable breakdown, the plate load test shall be interrupted at lower values of normal load.
If a greater load than the intended one is unintentionally applied during the load cycle, this load shall be maintained and this shall be indicated in the test report.
NOTE In order to verify the results obtained from the second load cycle, after the unloading in phases has been completed, perform the third cycle until reaching the same maximum load. However, this shall be applied immediately after the second load phase, without any further intermediate phases.

N.4.4.2 Determining the substrate reaction module

In order to determine the substrate reaction module, a 762 mm load plate must be used for the use in the design of the pavement. A pre-load of 0.005 MN/m^2 shall be maintained until the speed of plate settlement of is less than 0.02 mm/min. The load is then applied in increments, creating normal stress of 0.04 MN/m^{2,} 0.08 MN/m^{2,} 0.14 MN/m^2 and 0.2 MN/m^2. At each stage the load shall be maintained until the speed of plate settlement becomes less than 0.02 mm/min. The load may be released with one intermediate phase at a normal stress of 0.08 MN/m^2.

N.5 Evaluation and presentation of results

N.5.1 Load and settlement curve

For each increment of load, mean normal stress, σ_0, and associated reading of settlement, *M*, shall be recorded at the measuring device or displacement transducer (point N.6). For the assembly shown in Figure N.3, *M* should be taken as settlement, *s*, of the plate. For the assembly shown in Figure 3.a), *s* is obtained by multiplying the reading of the settlement, s_M, with lever ratio $h_P : h_M$, according to the following equation:

$$s = \frac{s_M * h_P}{h_M}$$

Normal stress shall be displayed in relation to settlement as shown in point N.6.1, Figure N.4. The load and settlement curve shall be drawn through the measuring points of the first load cycle and the repeated load cycle. The measuring points from the unloading cycle must be connected in a straight line. Loading and unloading cycles shall be marked with directional arrows.
The test report shall contain the following information:

- location of the test site;
- diameter of the load plate;
- type of settlement measuring device used, including the leverage ratio, if relevant;
- type of soil;
- type of substrate material under the plate;

weather conditions, including temperature;
time and date of measurement;
person performing the test;
all observations made during the test;
readings of settlement and corresponding normal stress;
load and settlement curves;
evaluation of the test;
where appropriate, a description of soil conditions underneath the plate after the test.

N.5.2 Calculation of the modulus of deformation, E_V

The calculation of the modulus of deformation, E_V, from the first and second load cycles shall be based on settlement curves. They shall be calculated using a second-degree polynomial according to the following equation:

$$s = a_0 + a_1 * a_0 + a_2 * \sigma_0^2$$

where
σ_0 - average normal stress under the plate, (N/mm2),
s- - settlement of the load plate, (mm),
a_0 - second degree polynomial constants, (mm),
a_1 - second degree polynomial constants, (mm(MN/m^2)),
a_2 - second degree polynomial constants, (mm/(MN^2/m^4)).
In order to determine the constants of the first load cycle, the first phase of the first load cycle (load phase 9 in Table N.1) should be disregarded.
In order to determine the constants of the second load cycle, the first phase of the second load cycle shall be taken into account (load phase 9 in Table N.2).
To calculate the polynomial constants from the measured values of the first and second load cycles, the normal equations of point N.7 shall be estimated.
If a computer program is used to determine the modulus of deformation, the program shall be verified using the example of the calculation given in point N.7.
The modulus of deformation, E_V, in MN/m^2, should be calculated using the following equation:

$$E_V = \frac{1{,}5 * r * 1}{a_1 + a_2 + \sigma_{0\,max}}$$

where
E_V - modulus of deformation, (MN/m^2),
r - radius of the load plate, (mm),
σ_{0max} - maximum average normal stress under the load plate in the first load cycle, (MN/m^2)
Index 1 should be used after E_V to indicate the first load cycle: index 2 should be used to indicate the second load cycle (point N.6.1) σ_{0max} from the first load cycle must also be used to determine the parameters of the second load cycle.

N.5.3 Calculation of the soil reaction module

The soil reaction module, k_s in MN/m^3 shall be calculated using the following equation:

$$k_S = \frac{\sigma_0}{s} = \frac{\sigma_0}{0{,}00125}$$

where:

k_S – soil reaction module (MN/m^3)
σ_0 - average normal stress (MN/m^2)
s^* - average settlement of the plate (m)
In road construction, normal stress, σ_0, which corresponds to settlement s^* of the 1.25 mm load plate shall be measured using a 762 mm load plate.
When the shape of the load-settlement curve requires the correction of origin, the tangent shall be drawn at the point of inclination, cutting the axis of the settlement s^* at 0^* (see example in 9.2).

N.6 Examples of uses

N.6.1 Testing the modulus of deformation E_V

Arrangement of the devices for measuring settlement as in Figure N.3. (h_P = 1.269 m; h_M = 0.945 m).
Leverage ratio:

$$\frac{h_P}{h_M}=\frac{1{,}260}{0{,}945}=1{,}333$$

The modulus of deformation E_{V1} and the modulus of deformation E_{V2} are calculated using the values given in Tables N.1 and N.2.
The load and settlement curves are shown in Figure N.4. A compilation of results is given in Table N.3.

Ciklus opterećenja	Teret F kN	Normalni pritisak σ_0 MN/m^2	Očitanje s_M mm	Slijeganje ploče s mm
0	0,71	0,01	0	0
1	5,65	0,080	0,86	1,15
2	11,31	0,160	1,57	2,09
3	17,67	0,250	2,15	2,87
4	23,33	0,330	2,44	3,25
5	29,69	0,420	2,85	3,80
6	35,34	0,500	3,16	4,21
7	17,67	0,250	2,97	3,96
8	8,84	0,125	2,78	3,71
9	0,71	0,01	1,94	2,59

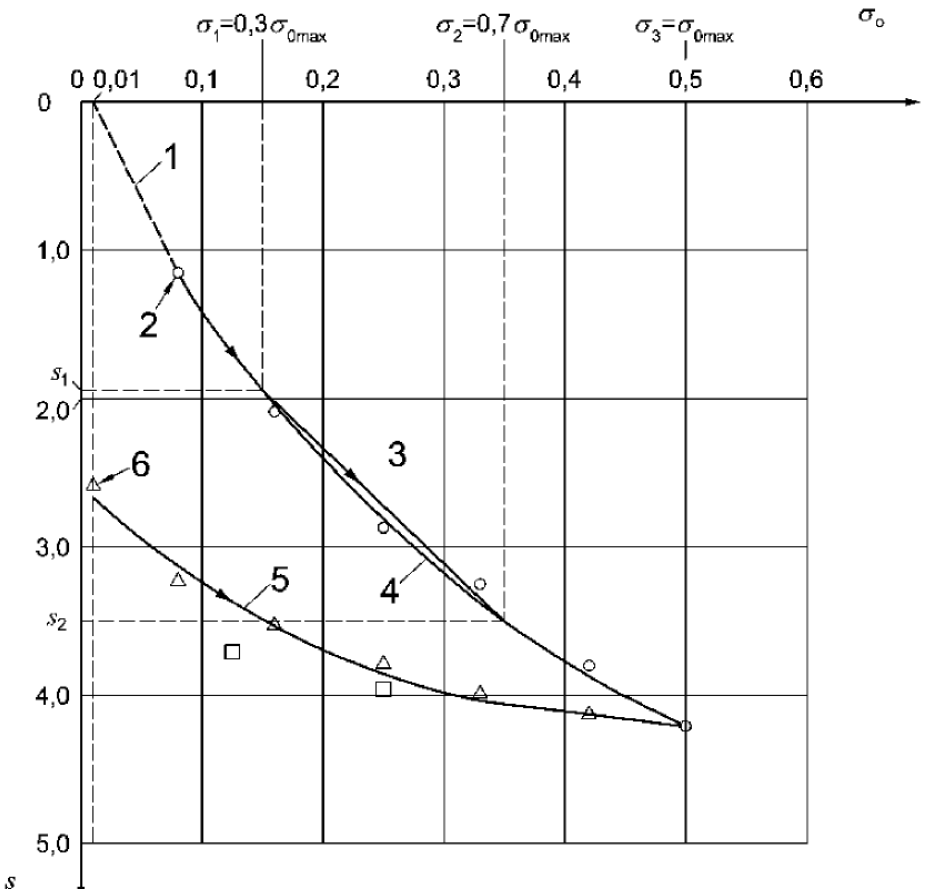
Table N.1 — Measured values for the first loading-unloading cycle

Ciklus opterećenja	Teret F kN	Normalni pritisak σ_0 MN/m^2	Očitanje s_M mm	Slijeganje ploče s mm
9	0,71	0,01	1,94	2,59
10	5,65	0,080	2,42	3,23
11	11,31	0,160	2,65	3,53
12	17,67	0,250	2,84	3,79
13	23,33	0,330	2,99	3,99
14	29,69	0,420	3,10	4,13

Table N.2 — Measured values for the second load cycle

Parametri		1. ciklus opterećenja	2. ciklus opterećenja
σ_{0max}	MN/m^2	0,500	0,500
a_0	mm	0,285	0,595
a_1	$mm/MN/m^2$	12,270	7,120
a_2	$mm/(MN^2/m^4)$	-9,034	-8,451
$E_V = \frac{1{,}5 \cdot r}{(a_1 + a_2 \cdot \sigma_{0max})}$	MN/m2	29,0	77,7
$\frac{E_{V2}}{E_{V1}}$		2,68	

Table N.3 — Aggregated results



○ Measurement points from the first load cycle

□ Measurement points from the unloading cycle

Δ Measurement points from the second load cycle

1 Point connection line (0.01 $MN/m^{2,}$ 0 mm) and first point from the first load cycle

2 First point from the first load cycle

3 Secant between 0.3 * σ_{0max} and 0.7 * σ_{0max}

4 Quadratic parabola between the first and last point on the first load cycle

5 Square parabola between the first and last point on the second load cycle

6 First point on second load cycle

s settlement (mm)

σ_0 normal stress (MN/m^2)

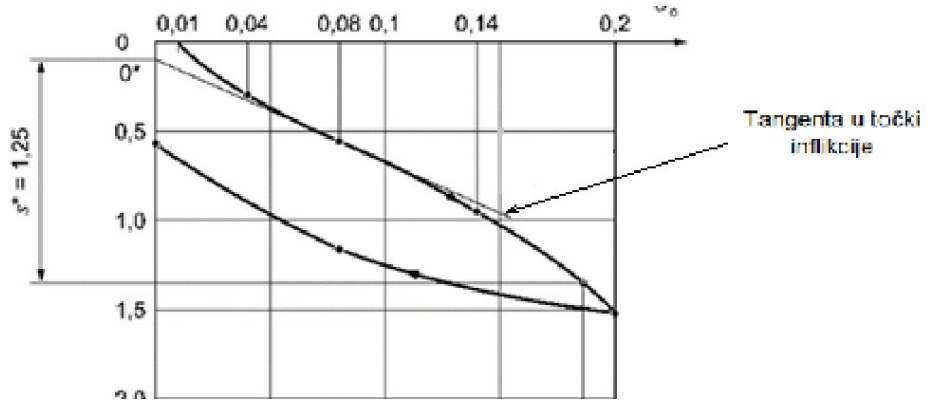
Figure N.4 – Load and settlement curve, setting curve according to Table N.1 and Table N.2 for the first and second load cycles.

N 6.2 Determining the substrate reaction module k_s

Arrangement of the devices for measuring settlement as in Figure N.3.
The substrate reaction module ks shall be calculated using the values in Table N.4. Load and settlement curves are shown in Figure N.5.

Ciklus opterećenja	Teret *F* kN	Normalni pritisak σ_0 MN/m^2	Slijeganje ploče *s* mm
0	4,56	0,010	0
1	18,24	0,040	0,31
2	36,48	0,080	0,56
3	63,85	0,140	0,97
4	91,21	0,200	2,53
5	36,48	0,080	1,16
6	0,00	0,000	0,57

Table N.4 Measured values



s – settlement (mm)

σ_0 – normal stress (MN/m^2)

a – tangent at the point of inflection

Figure N.5 — Load and settlement curve for the determination of the substrate reaction module, k_s

Result from the evaluation using the corrected starting point 0* and the corrected settlement s^*:

$$k_S = \frac{\sigma_0}{s} = \frac{0{,}186\,\frac{MN}{m^2}}{0{,}00125\,m} = 148{,}8\,\frac{MN}{m^3}$$

N.7 Principles underlying normal equations for the calculation of second degree polynomial constants for the load-settlement curve and for the calculation of the modulus of deformation, E_V

Normal equations for the calculation of parameters for the following equation

$$s = a_0 + a_1 * \sigma_0 + a_2 * \sigma_0^2$$

From test results (σ_{01} ; s_1), (σ_{02} ; s_2)… (σ_{0n} ; s_n), are the following:

$$a_0 * n + a_1 \sum_{i=1}^{n} \sigma_{0i} + a_2 \sum_{i=1}^{n} \sigma_{0i}^2 = \sum_{i=1}^{n} s_i$$

$$a_0 \sum_{i=1}^{n} \sigma_{0i} + a_1 \sum_{i=1}^{n} \sigma_{0i}^2 + \sum_{i=1}^{n} \sigma_{0i}^3 = \sum_{i=1}^{n} s_i * \sigma_{0i}$$

$$a_0 \sum_{i=1}^{n} \sigma_{0i}^2 + a_1 \sum_{i=1}^{n} \sigma_{0i}^3 + a_2 \sum_{i=1}^{n} \sigma_{0i}^4 = \sum_{i=1}^{n} s_i * \sigma_{0i}^2$$

Therefore, parameters a, 3, a1 and a2 are known.

The modulus of deformation E_{V1} may be calculated as a sequential module according to the theory of an elastic isotropic hemisphere. The secant is determined by the following points on the square parabola (Figure N.4):

$$p_1\left(0{,}3\,\sigma_{0\,max}; s_1\right); p_2\left(0{,}7\,\sigma_{0\,max}; s_2\right)$$

Therefore, the modulus of deformation E_{V1} may be calculated as follows:

$$E_{V\,1} = \frac{1{,}5 * r * \Delta\sigma}{\Delta s} = \frac{1{,}5 * r * \sigma_2 - \sigma_1}{s_2 - s_1}$$

$$¿\ \frac{1{,}5 * r * 0{,}7 * \sigma_{0\,max} - 0{,}3 * \sigma_{omax}}{\left[a_0 + a_1 * 0{,}7 * \sigma_{0\,max} + a_2 * \left(0{,}7 * \sigma_{0\,max}\right)^2\right] - \left[a_0 + a_1 * 0{,}3 * \sigma_{0\,max} + s_2 * \left(0{,}3 * \sigma_{0\,max}\right)^2\right]}$$

$$¿\ \frac{1{,}5 * r * 0{,}4 * \sigma_{0\,max}}{0{,}4 * a_1 * \sigma_{0\,max} + \left(0{,}7^2 * a_2 - 0{,}3^2 * a_2\right)\sigma_{0\,max}^2}$$

$$¿\ \frac{1{,}5 * r * 1}{a_1 + a_2 * \sigma_{0\,max}}$$

The modulus of deformation E_{V2} may also be calculated from the curve of the second loading cycle using σ_{0max} from the first loading cycle.

APPENDIX 1 – LIST OF STANDARDS

1.1. Concrete and cement

1.2.

HRN EN 206:2021 Concrete -- Specification, performance, production and conformity

HRN 1128:2023 Concrete -- National requirements to HRN EN 206:2021
HRN 1128/A1:2023 Concrete -- National requirements to HRN EN 206:2021
HRN EN 197-1:2012 Cement -- Part 1: Composition, specifications and conformity criteria for common cements
HRN EN 197-5:2021 Cement -- Part 5: Portland-composite cement CEM II/C-M and Composite cement CEM VI
HRN EN 12620:2008 Aggregates for concrete
HRN CEN/TR 15177:2006 Testing the freeze-thaw resistance of concrete: Internal structural damage
HRN EN 12350-2:2019 Testing fresh concrete -- Part 2: Slump-test
HRN EN 12350-3:2019 Testing fresh concrete -- Part 3: Vebe test
HRN EN 12350-4:2019 Testing fresh concrete -- Part 4: Degree of compactability
HRN EN 12350-5:2019 Testing fresh concrete -- Part 5: Flow table test
HRN EN 12350-7 2019/Corr.1:2022 Testing fresh concrete -- Part 7: Air content -- Pressure methods
HRN EN 12390-3:2019 Testing hardened concrete -- Part 3: Compressive strength of test specimens
HRN EN 12390-5:2019 Testing hardened concrete -- Part 5: Flexural strength of test specimens
HRN EN 12390-6:2023 Testing hardened concrete -- Part 6: Tensile splitting strength of test specimens
HRN EN 12390-7:2020 Testing hardened concrete -- Part 7: Density of hardened concrete
HRN EN 12390-8:2019 Testing hardened concrete -- Part 8: Depth of penetration of water under pressure
HRS CEN/TS12390-9:2016 Testing hardened concrete -- Part 9: Freeze-thaw resistance with de-icing salts -- Scaling
HRN EN 1008:2002 Specification for sampling, testing and assessing the suitability of water, including wash water from recycling installations in the concrete industry, as mixing water for concrete
HRN EN 934-2:2012 Admixtures for concrete, mortar and grout -- Part 2: Concrete admixtures -- Definitions, requirements, conformity, marking and labelling
HRN EN 14889-1:2007 Fibres for concrete -- Part 1: Steel fibres -- Definitions, specifications and conformity
HRN EN 14889-2:2008 Fibres for concrete -- Part 2: Polymer fibres -- Definition, specifications and conformity
HRN EN 12504-1: 2019/Corr.1:2020 Testing concrete in structures -- Part 1: Cored specimens -- Taking, examining and testing in compression
HRN EN 480-11:2005 Admixtures for concrete, mortar and grout -- Test methods -- Part 11: Determination of air void characteristics in hardened concrete
HRN EN 196-2:2013 Methods of testing cement -- Part 2: Chemical analysis of cement

1.2 Aggregate

HRN EN 1097-1:2024 Tests for mechanical and physical properties of aggregates -- Part 1: Determination of the resistance to wear (micro-Deval)
HRN EN 1097-2:2020 Tests for mechanical and physical properties of aggregates -- Part 2: Methods for the determination of resistance to fragmentation
HRN EN 1097-3:2004 Tests for mechanical and physical properties of aggregates -- Part 3: Determination of loose bulk density and voids
HRN EN 1097-6:2022 Tests for mechanical and physical properties of aggregates -- Part 6: Determination of particle density and water absorption
HRN EN 1097-7:2022 Tests for mechanical and physical properties of aggregates -- Part 7: Determination of the particle density of filler -- Pyknometer method
HRN EN 1097-8:2020 Tests for mechanical and physical properties of aggregates -- Part 8: Determination of the polished stone value
HRN EN 1097-9:2014 Tests for mechanical and physical properties of aggregates -- Part 9: Determination of the resistance to wear by abrasion from studded tyres -- Nordic test
HRN EN 1367-1:2008 Tests for thermal and weathering properties of aggregates -- Part 1: Determination of resistance to freezing and thawing
HRN EN 1367-2:2010 Tests for thermal and weathering properties of aggregates -- Part 2: Magnesium sulfate test
HRN EN 1367-3:2004 Tests for thermal and weathering properties of aggregates -- Part 3: Boiling test for "Sonnenbrand basalt"
HRN EN 1367-3:2004/AC:2006 Tests for thermal and weathering properties of aggregates -- Part 3: Boiling test for "Sonnenbrand basalt"
HRN EN 1367-4:2008 Tests for thermal and weathering properties of aggregates -- Part 4: Determination of drying shrinkage
HRN EN 933-1:2012 Tests for geometrical properties of aggregates -- Part 1: Determination of particle size distribution -- Sieving method
HRN EN 933-3:2012 Tests for geometrical properties of aggregates -- Part 3: Determination of particle shape -- Flakiness index
HRN EN 933-4:2008 Tests for geometrical properties of aggregates -- Part 4: Determination of particle shape -- Shape index
HRN EN 933-5:2022 Tests for geometrical properties of aggregates -- Part 5: Determination of percentage of crushed particles in coarse and all-in natural aggregates
HRN EN 933-7:2004 Tests for geometrical properties of aggregates -- Part 7: Determination of shell content -- Percentage of shells in coarse aggregates
HRN EN 933-8:2015 Tests for geometrical properties of aggregates -- Part 8: Assessment of fines -- Sand equivalent test
HRN EN 933-9:2022 Tests for geometrical properties of aggregates -- Part 9: Assessment of fines -- Methylene blue test
HRN EN 933-11:2009 Tests for geometrical properties of aggregates -- Part 11: Classification test for the constituents of coarse recycled aggregate
HRN EN 1744-1:2012 Tests for chemical properties of aggregates -- Part 1: Chemical analysis
HRN EN 1744-5:2008 Tests for chemical properties of aggregates -- Part 5: Determination of acid soluble chloride salts
HRN EN 13242:2008 Aggregates for unbound and hydraulically bound materials for use in civil engineering work and road construction
HRN EN 13285:2018 Unbound mixtures -- Specifications
HRN EN 932-3:2022 Tests for general properties of aggregates -- Part 3: Procedure and terminology for simplified petrographic description

HRN EN 13036-1:2011 Road and airfield surface characteristics -- Test methods -- Part 1: Measurement of pavement surface macrotexture depth using a volumetric patch technique
HRN EN 13036-4:2012 Road and airfield surface characteristics -- Test methods -- Part 4: Method for measurement of slip/skid resistance of a surface: The pendulum test
HRN EN 13036-5:2019 Road and airfield surface characteristics -- Test methods -- Part 5: Determination of longitudinal unevenness indices
HRN EN 13036-7:2004 Road and airfield surface characteristics -- Test methods -- Part 7: Irregularity measurement of pavement courses: The straightedge test
HRN EN 13036-8:2008 Road and airfield surface characteristics -- Test methods -- Part 8: Determination of transverse unevenness indices
HRN EN 1992-1-1:2013/NA:2015 Eurocode 2: Design of concrete structures -- Part 1-1: General rules and rules for buildings -- National annex
HRN EN 1992-1-1:2013 Eurocode 2: Design of concrete structures -- Part 1-1: General rules and rules for buildings
HRN EN 1992-1-1:2023 Eurocode 2 -- Design of concrete structures -- Part 1-1: General rules and rules for buildings, bridges and civil engineering structures
HRN EN 1992-1-2:2013/A1:2019 Eurocode 2: Design of concrete structures -- Part 1-2: General rules -- Structural fire design
HRN EN 1992-1-2:2013/NA:2013 Eurocode 2: Design of concrete structures -- Part 1-2: General rules -- Structural fire design
HRN EN 1992-1-2:2013 Eurocode 2: Design of concrete structures -- Part 1-2: General rules -- Structural fire design
HRN EN 1992-1-2:2023 Eurocode 2 -- Design of concrete structures -- Part 1-2: Structural fire design
HRN EN 1992-2:2013/NA:2013/Corr.1:2015 Eurocode 2: Design of concrete structures -- Part 2: Concrete bridges -- Design and detailing rules -- National annex
HRN EN 1992-2:2013/NA:2013 Eurocode 2: Design of concrete structures -- Part 2: Concrete bridges -- Design and detailing rules -- National annex
HRN EN 1992-2:2013 Eurocode 2: Design of concrete structures -- Part 2: Concrete bridges -- Design and detailing rules
HRN EN 1992-3:2013/NA:2013 Eurocode 2: Design of concrete structures -- Part 3: Liquid retaining and containment structures -- National annex
HRN EN 1992-3:2013 Eurocode 2: Design of concrete structures -- Part 3: Liquid retaining and containment structures
HRN EN 1992-4:2019/NA:2022 Eurocode 2: Design of concrete structures -- Part 4: Design of fastenings for use in concrete -- National annex
HRN EN 1992-4:2019 Eurocode 2: Design of concrete structures -- Part 4: Design of fastenings for use in concrete
HRN EN 1992-1-1:2013/A1:2015 Design of concrete structures -- Part 1-1: General rules and rules for buildings
HRN EN 1992-1-1:2013/Corr.1:2015 Design of concrete structures -- Part 1-1: General rules and rules for buildings
HRN EN 1992-1-1:2013/A1:2015 Design of concrete structures -- Part 1-1: General rules and rules for buildings
HRN EN 1992-1-1:2013/Corr.1:2015 Design of concrete structures -- Part 1-1: General rules and rules for buildings
HRN EN 1990:2011/NA:2011 Eurocode: Basis of structural design -- National annex
HRN EN 1990:2011 Eurocode: Basis of structural design

HRN EN 1990:2023 Eurocode -- Basis of structural and geotechnical design

1.4 Asphalt and bitumen

HRN EN 1367-1:2008 Tests for thermal and weathering properties of aggregates -- Part 1: Determination of resistance to freezing and thawing
HRN EN 1367-2:2010 Tests for thermal and weathering properties of aggregates -- Part 2: Magnesium sulfate test
HRN EN 1367-4:2008 Tests for thermal and weathering properties of aggregates -- Part 4: Determination of drying shrinkage
HRN EN 13398:2018 Bitumen and bituminous binders -- Determination of the elastic recovery of modified bitumen
HRN EN 12697-1:2020 Bituminous mixtures -- Test methods -- Part 1: Soluble binder content
HRN EN 12697-2:2025 Bituminous mixtures -- Test methods -- Part 2: Determination of particle size distribution
HRN EN 12697-5:2019 Bituminous mixtures -- Test methods -- Part 5: Determination of the maximum density
HRN EN 12697-3:2020 Bituminous mixtures -- Test methods -- Part 3: Bitumen recovery: Rotary evaporator
HRN EN 12697-8:2019 Bituminous mixtures -- Test methods -- Part 8: Determination of void characteristics of bituminous specimens
HRN EN 12697-23:2017 Bituminous mixtures -- Test methods -- Part 23: Determination of the indirect tensile strength of bituminous specimens
HRN EN 12697-26:2022 Bituminous mixtures -- Test methods -- Part 26: Stiffness
HRN EN 12697-36:2022 Bituminous mixtures -- Test methods -- Part 36: Determination of the thickness of bituminous pavement
HRN EN 12697-48:2021 Bituminous mixtures -- Test methods -- Part 48: Interlayer Bonding (prEN 12697-48)
HRN EN 13036-3:2004 Road and airfield surface characteristics -- Test methods -- Part 3: Measurement of pavement surface horizontal drainability
HRN EN 13036-4:2012 Road and airfield surface characteristics -- Test methods -- Part 4: Method for measurement of slip/skid resistance of a surface: The pendulum test
HRN EN 13036-5:2019 Road and airfield surface characteristics -- Test methods -- Part 5: Determination of longitudinal unevenness indices
HRN EN 13036-6:2008 Road and airfield surface characteristics -- Test methods -- Part 6: Measurement of transverse and longitudinal profiles in the evenness and megatexture wavelength ranges
HRN EN 1426:2024 Bitumen and bituminous binders -- Determination of needle penetration
HRN EN 1427:2015 Bitumen and bituminous binders –--Determination of the softening point -- Ring and Ball method
HRN EN 13304:2009 Bitumen and bituminous binders -- Framework for specification of oxidised bitumens
HRN EN 13108-1:2007 Bituminous mixtures -- Material specifications -- Part 1: Asphalt Concrete
HRN EN 13108-1:2007/Corr.1:2008 Bituminous mixtures -- Material specifications -- Part 1: Asphalt Concrete
HRN EN 13108-20:2016 Bituminous mixtures -- Material specifications -- Part 20: Type Testing

1.5 Pavement and reinforcement

HRN EN 13670:2010 Execution of concrete structures
HRN EN 13877-1:2023 Concrete pavements -- Part 1: Materials
HRN EN 13877-2:2023 Concrete pavements -- Part 2: Functional requirements for concrete pavements
HRN EN 13877-3:2005 Concrete pavements -- Part 3: Specifications for dowels to be used in concrete pavements
HRN EN 13863-1:2005 Concrete pavements -- Part 1: Test method for the determination of the thickness of a concrete pavement by survey method
HRN EN 13863-2:2005 Concrete pavements -- Part 2: Test method for the determination of the bond between two layers
HRN EN 13863-3:2005 Concrete pavements -- Part 3: Test methods for the determination of the thickness of a concrete pavement from cores
HRN EN 13863-4:2012 Concrete pavements -- Part 4: Test methods for the determination of wear resistance of concrete pavements to studded tyres
HRN EN 13863-6:2024 Concrete pavements -- Part 6: Test method for the determination of the tensile strength of concrete on cylindrical discs
HRN 1130-1:2008 Steel for the reinforcement of concrete -- Weldable reinforcing steel -- Part 1: Technical delivery conditions for class A
HRN 1130-2:2008 Steel for the reinforcement of concrete -- Weldable reinforcing steel -- Part 2: Technical delivery conditions for class B
HRN EN ISO 15630-1:2019 Steel for the reinforcement and prestressing of concrete -- Test methods -- Part 1: Reinforcing bars, rods and wire
HRN EN ISO 2178:2016 Non-magnetic coatings on magnetic substrates -- Measurement of coating thickness -- Magnetic method
HRN EN ISO 9227:2022/A1:2024 Corrosion tests in artificial atmospheres -- Salt spray tests -- Amendment 1: Footnote of warning
HRN EN 13036-1:2011 Road and airfield surface characteristics -- Test methods -- Part 1: Measurement of pavement surface macrotexture depth using a volumetric patch technique
HRN EN 13036-4:2012 Road and airfield surface characteristics -- Test methods -- Part 4: Method for measurement of slip/skid resistance of a surface: The pendulum test
HRN EN 13036-5:2019 Road and airfield surface characteristics -- Test methods -- Part 5: Determination of longitudinal unevenness indices
HRN EN 13036-7:2004 Road and airfield surface characteristics -- Test methods -- Part 7: Irregularity measurement of pavement courses: The straightedge test
HRN EN 10025-2:2007 Hot rolled products of structural steels -- Part 2: Technical delivery conditions for non-alloy structural steels
HRN EN 10060:2005 Hot rolled round steel bars for general purposes -- Dimensions and tolerances on shape and dimensions
HRN EN 10080:2012 Steel for the reinforcement of concrete -- Weldable reinforcing steel -- General

1.6 Aggregate mixtures

HRN EN 14227-1:2013 Hydraulically bound mixtures -- Specifications -- Part 1: Cement bound granular mixtures
HRN EN 13242:2008 Aggregates for unbound and hydraulically bound materials for use in civil engineering work and road construction
HRN EN 13285:2018 Unbound mixtures -- Specifications

HRN EN 13286-2:2010 Unbound and hydraulically bound mixtures -- Part 2: Test methods for laboratory reference density and water content -- Proctor compaction
HRN EN 13286-2:2010/Corr.1:2013 Unbound and hydraulically bound mixtures -- Part 2: Test methods for laboratory reference density and water content -- Proctor compaction
HRN EN 13286-42:2003 Unbound and hydraulically bound mixtures -- Part 42: Test method for the determination of the indirect tensile strength of hydraulically bound mixtures
HRN EN 13286-43:2003 Unbound and hydraulically bound mixtures -- Part 43: Test method for the determination of the modulus of elasticity of hydraulically bound mixtures
HRN EN 13286-47:2021 Unbound and hydraulically bound mixtures -- Part 47: Test method for the determination of California bearing ratio, immediate bearing index and linear swelling
HRN EN 13286-50:2005 Unbound and hydraulically bound mixtures -- Part 50: Method for the manufacture of test specimens of hydraulically bound mixtures using Proctor equipment or vibrating table compaction
HRN EN 13286-51:2005 Unbound and hydraulically bound mixtures -- Part 51: Method for the manufacture of test specimens of hydraulically bound mixtures using vibrating hammer compaction
HRN EN 13286-52:2005 Unbound and hydraulically bound mixtures -- Part 52: Method for the manufacture of test specimens of hydraulically bound mixtures using vibrocompression
HRN EN 13286-53:2005 Unbound and hydraulically bound mixtures -- Part 53: Methods for the manufacture of test specimens of hydraulically bound mixtures using axial compression
HRS CEN/TS 13286-54:2016 Unbound and hydraulically bound mixtures -- Part 54: Test method for the determination of frost susceptibility -- Resistance to freezing and thawing of hydraulically bound mixtures
HRN EN ISO 17892-1:2015/A1:2022 Geotechnical investigation and testing -- Laboratory testing of soil -- Part 1: Determination of water content
HRN EN ISO 17892-4:2016 Geotechnical investigation and testing -- Laboratory testing of soil -- Part 4: Determination of particle size distribution
HRN EN 13242:2008 Aggregates for unbound and hydraulically bound materials for use in civil engineering work and road construction

1.7 Products for sealing concrete pavement dividers

HRN EN 14188-1:2005 Joint fillers and sealants -- Part 1: Specifications for hot applied sealants
HRN EN 14188-2 :2005 Joint fillers and sealants -- Part 2: Specifications for cold applied sealants
HRN EN 14188-3:2007 Joint fillers and sealants -- Part 3: Specifications for preformed joint seals
HRN EN 15651-1:2012 Sealants for non-structural use in joints in buildings and pedestrian walkways -- Part 1: Sealants for façade elements
HRN EN 1561:2024 Founding -- Grey cast irons

1.8 Products and systems for protection and repair

HRN EN 1504-1:2005 Products and systems for the protection and repair of concrete structures -- Definitions, requirements, quality control and evaluation of conformity -- Part 1: Definitions

HRN EN 1504-2:2004 Products and systems for the protection and repair of concrete structures -- Definitions, requirements, quality control and evaluation of conformity -- Part 1: Definitions
HRN EN 1504-3:2005 Products and systems for the protection and repair of concrete structures -- Definitions, requirements, quality control and evaluation of conformity -- Part 3: Structural and non-structural repair
HRN EN 1504-4:2004 Products and systems for the protection and repair of concrete structures -- Definitions, requirements, quality control and evaluation of conformity -- Part 4: Structural bonding
HRN EN 1504-5:2013 Products and systems for the protection and repair of concrete structures -- Definitions, requirements, quality control and evaluation of conformity -- Part 5: Concrete injection
HRN EN 1504-6:2007 Products and systems for the protection and repair of concrete structures -- Definitions, requirements, quality control and evaluation of conformity -- Part 6: Anchoring of reinforcing steel bar
HRN EN 1504-7:2007 Products and systems for the protection and repair of concrete structures -- Definitions, requirements, quality control and evaluation of conformity -- Part 7: Reinforcement corrosion protection
HRN EN 1504-8:2016 Products and systems for the protection and repair of concrete structures -- Definitions, requirements, quality control and AVCP -- Part 8: Quality control and Assessment and verification of the constancy of performance
HRN EN 1504-9:2008 Products and systems for the protection and repair of concrete structures -- Definitions, requirements, quality control and evaluation of conformity -- Part 9: General principles for the use of products and systems
HRN EN 1504-10:2017 Products and systems for the protection and repair of concrete structures -- Definitions, requirements, quality control and evaluation of conformity -- Part 10: Site application of products and systems and quality control of the works
HRN CEN/TS 14754-1:2007 Curing compounds -- Test methods -- Part 1: Determination of water retention efficiency of common curing compounds
HRN EN 1542:2001 Products and systems for the protection and repair of concrete structures -- Test methods -- Measurement of bond strength by pull-off
HRN EN ISO 9864:2005 Geosynthetics -- Test method for the determination of mass per unit area of geotextiles and geotextile-related products
HRN EN ISO 10319:2024 Geosynthetics -- Wide-width tensile test