



European Technical Approval ETA-12/0245

English translation prepared by DIBt - Original version in German language

Handelsbezeichnung <i>Trade name</i>	Verkalit-Betonelemente zur Verwendung in Deckwerken <i>Verkalit elements made of concrete used in revetments</i>
Zulassungsinhaber <i>Holder of approval</i>	BERDING BETON GmbH Industriestraße 6 49439 Steinfeld DEUTSCHLAND
Zulassungsgegenstand und Verwendungszweck <i>Generic type and use of construction product</i>	Verkalit-Betonelemente als Teil des "Verkalit- Deichbefestigungssystems" (Deckwerk) der BERDING BETON GmbH zur flächenhaften Befestigung von Böschungen an Küsten, Ästuaren und Flussdeltas <i>Verkalit elements made of concrete as a part of the "Verkalit dike fixing system" (revetment) of BERDING BETON GmbH used as an extensive fixing of slopes for coasts, estuaries and river deltas</i>
Geltungsdauer: <i>Validity:</i>	vom <i>from</i> bis <i>to</i>
Herstellwerke <i>Manufacturing plants</i>	BERDING BETON GmbH, DEUTSCHLAND Werk 13 Werk 18

Diese Zulassung umfasst
This Approval contains

21 Seiten einschließlich 10 Anhänge
21 pages including 10 annexes

I LEGAL BASES AND GENERAL CONDITIONS

- 1 This European technical approval is issued by Deutsches Institut für Bautechnik in accordance with:
 - Council Directive 89/106/EEC of 21 December 1988 on the approximation of laws, regulations and administrative provisions of Member States relating to construction products¹, modified by Council Directive 93/68/EEC² and Regulation (EC) N° 1882/2003 of the European Parliament and of the Council³;
 - *Gesetz über das In-Verkehr-Bringen von und den freien Warenverkehr mit Bauprodukten zur Umsetzung der Richtlinie 89/106/EWG des Rates vom 21. Dezember 1988 zur Angleichung der Rechts- und Verwaltungsvorschriften der Mitgliedstaaten über Bauprodukte und anderer Rechtsakte der Europäischen Gemeinschaften (Bauproduktengesetz - BauPG) vom 28. April 1998⁴, as amended by law of 31 October 2006⁵;*
 - Common Procedural Rules for Requesting, Preparing and the Granting of European technical approvals set out in the Annex to Commission Decision 94/23/EC⁶.
- 2 Deutsches Institut für Bautechnik is authorized to check whether the provisions of this European technical approval are met. Checking may take place in the manufacturing plant. Nevertheless, the responsibility for the conformity of the products to the European technical approval and for their fitness for the intended use remains with the holder of the European technical approval.
- 3 This European technical approval is not to be transferred to manufacturers or agents of manufacturers other than those indicated on page 1, or manufacturing plants other than those indicated on page 1 of this European technical approval.
- 4 This European technical approval may be withdrawn by Deutsches Institut für Bautechnik, in particular pursuant to information by the Commission according to Article 5 (1) of Council Directive 89/106/EEC.
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- 6 The European technical approval is issued by the approval body in its official language. This version corresponds fully to the version circulated within EOTA. Translations into other languages have to be designated as such.

¹ Official Journal of the European Communities L 40, 11 February 1989, p. 12

² Official Journal of the European Communities L 220, 30 August 1993, p. 1

³ Official Journal of the European Union L 284, 31 October 2003, p. 25

⁴ *Bundesgesetzblatt Teil I 1998*, p. 812

⁵ *Bundesgesetzblatt Teil I 2006*, p. 2407, 2416

⁶ Official Journal of the European Communities L 17, 20 January 1994, p. 34

II SPECIFIC CONDITIONS OF THE EUROPEAN TECHNICAL APPROVAL

1 Definition of the product and intended use

1.1 Definition of the construction product

(1) The "Verkalit dike fixing system" of the BERDING BETON GmbH (hereinafter referred to as "revetment") is made of non-reinforced Verkalit concrete elements (hereinafter referred to as "elements").

(2) The elements are made of concrete of a particular composition (formulation) and geometry. The revetment made of the elements shall be installed on a prepared base with a filter layer and a geotextile.

(3) The elements are manufactured in the following variations:

- Type 1 Verkalit revetment elements for permeable revetments,
- Type 2 Verkalit revetment elements for tight elements,
- Type 3 Verkalit revetment special elements.

(4) Due to their special shape and their high weight the elements have a particular composite action in all directions and a great resistance against wave and current attacks as well as changing tides.

(5) They are weather-resistant and insensitive to freeze-thaw cycle.

(6) With in regard to the reaction-to-fire performance the pre-fabricated elements satisfy class "A1" according to EN 13501-1.

1.2 Intended use

(1) The elements incorporated in the revetment are used in wave and current stressed areas of coastal areas, estuaries and river deltas in the context of coastal protection (see Annex 1).

(2) The elements are laid to a revetment such that they are resistant to water and held secure in place. The revetment protects the aforementioned slopes against attacks from rough seas and currents and ensures at the same time that water without erosion can run off. Attacks going beyond these stresses (e.g. ship-induced waves and currents) shall be taken into account separately in the context of planning.

(3) In order to ensure ascent-reducing properties of the revetment, elements of different heights (e.g. 180 mm and 250 mm) may be incorporated in a revetment.

(4) The elements are suitable for use in tight and/or permeable revetments.

(5) Tight and permeable revetments are accessible for pedestrians. Furthermore tight revetments shall be trafficable for vehicles, taking respective constructional provisions into account.

(6) The mounted parts may be fixed while setting on the elements by means of bonded anchors which are approved by national and/or European technical approvals according to specified constructional provisions.

(7) The provisions referred to in this European technical approval have been written based upon the assumed working life of the elements of at least 50 years, provided that the conditions for the transport/storage/installation/use/servicing/correction of the defect/utilization are met. The indications given on the working life cannot be interpreted as a guarantee given by the ETA holder, but are regarded only as a means for choosing the right products in relation to the expected economically reasonable working life of the works.

2 Characteristics of the product and methods of verification

2.1 General

(1) The elements of the revetment shall correspond to the drawings and indications given in the Annexes.

(2) The characteristics of the material, dimensions and tolerances which are not stated in this approval correspond to the information laid down in the technical documentation⁷ of this European technical approval.

(3) Requirements for elements from other fields of law will remain unaffected, e.g. requirements for the navigable waterway construction.

2.2 Properties

(1) The elements have the following properties:

- They are made of non-reinforced concrete.
- During the installation and use they have a particular composite action in all directions and a great resistance against waves and currents.
- They are sufficiently weather-resistant and in case of frost during high water saturation impervious to freeze-thaw cycles in the presence of fresh water and salt water (3 % salt solution), see Annex 4.
- They are skid-resistant for pedestrians during the period of installation, see Annex 4.

(2) The elements laid to a revetment have the following properties:

- They drain off hydraulic, constructive and special attacks from currents due to waves and water level in coastal slopes, embankment slopes and sea dike slopes.
- The stability of a revetment shall be determined according to Annex 4 and Annex 5 taking into account the geometry of the elements, the (permission) relevant significant wave height, the wave period (breaker parameter) and the related stability number.
- The elements laid in bond on a defined base (geotextile with filter layer) are position and pull-out protected
- The tight and/or permeable revetments are accessible for pedestrians.
- Tight revetments made of Verkalit-Special-elements Type 3-SP (Promenade block) are trafficable with vehicles taking into account the provisions according to Annexes 8 and 10 in horizontal and/or in gently sloped areas ($\leq 1 : 15$) of the expanded sea dike (e.g. promenade area). Therefore it should be ensured that the elements are installed on a load-spreading base mounted over its entire surface.

2.3 Formulation

(1) The concrete is used for the elements according to the composition (formulation) deposited. The concrete composition (formulation) for the elements is deposited with Deutsches Institut für Bautechnik.

(2) The concrete for the elements, cement, aggregates and concrete admixture shall comply with the information deposited and requirements given in Annex 3, Table 1.

(3) The geotextile and the components of the filter layer shall comply with the information deposited and requirements given in Annex 3, Table 1.

⁷ The technical documentation of this European technical approval is deposited with Deutsches Institut für Bautechnik and shall be made available to the approved bodies, who are involved in the procedure of conformity attestation, for the fulfilment of their tasks.

2.4 Emission of dangerous substances

(1) According to the applicant's declaration the elements taking account of the EU⁸ database do not contain any dangerous substances.

(2) In addition to the specific clauses relating to dangerous substances contained in this European technical approval, there may be other requirements applicable to the products falling within its scope (e.g. transposed European legislation and national laws, regulations and administrative provisions). In order to meet the provisions of the Construction Products Directive these requirements need also, if applicable, to be complied with.

(3) For dangerous substances falling under the scope of the CPD for which:

– no assessment and verification methods are given in this ETA,

or

– "no performance determined" is declared,

or

– the chosen verification and assessment method does not comply with the regulatory requirement of a particular Member State,

it may be necessary to have an additional assessment performed at national level.

(4) There may be other requirements applicable to the products resulting from other applicable national regulations and administrative provisions. These requirements need also to be complied with.

3 Evaluation and attestation of conformity and CE marking

3.1 System of attestation of conformity

According to the Decision 1999/94/CE of the European Commission, system 2+ of the attestation of conformity shall apply.

System 2+: Declaration of conformity of the product by the manufacturer on the basis of:

(a) Tasks for the manufacturer:

(1) initial type-testing of the product;

(2) factory production control;

(3) testing of samples taken at the factory in accordance with a prescribed test plan.

(b) Tasks for the notified body:

(4) certification of factory production control on the basis of:

– initial inspection of factory and of factory production control;

– continuous surveillance, assessment and approval of factory production control.

3.2 Responsibilities

3.2.1 Tasks for the manufacturer

3.2.1.1 Factory production control

(1) The manufacturer shall exercise permanent internal control of production. All the elements, requirements and provisions adopted by the manufacturer shall be documented in a systematic manner in the form of written policies and procedures, including records of results performed. The factory production control shall ensure that the product conforms with this European technical approval.

⁸ References in Guidance Paper H: A harmonised approach with regard to the handling of dangerous substances according to the Construction Products Directive, Brussels 18 February 2000.

(2) The manufacturer may only use initial and constituent materials stated in the technical documentation of this European technical approval. He shall inspect or control the initial materials within the framework of incoming goods inspection according to the control plan.

(3) The factory production control shall be in accordance with the control plan, dated 27 June 2012 for the European technical approval ETA-12/0245 which is part of the technical documentation of this European technical approval. The control plan is laid down in the context of the factory production control system operated by the manufacturer and deposited with Deutsches Institut für Bautechnik.⁹ The factory production control follows the properties given in the control plan. They are specified in the technical documentation.

(4) The results of factory production control shall be recorded and evaluated in accordance with the provisions of the control plan. The records shall include at least the following information:

- designation of the product, of the initial materials,
- type of inspection or test,
- date of the manufacture of the product, batch N° (if relevant) and date of the inspection or test of the product/the initial materials,
- results of the inspections or tests and, if applicable, comparison with the requirements,
- signature of the person responsible for the factory production control.

(5) The records shall be kept for a minimum of five years. On request they shall be presented to Deutsches Institut für Bautechnik.

(6) Details concerning extent, type and frequency of the tests or inspections to be performed within the scope of the factory production control shall correspond to the control plan which is part of the technical documentation to this ETA.

3.2.1.2 Other tasks for the manufacturer

(1) The manufacturer shall, on the basis of a contract, involve a body which is approved for the tasks referred to in section 3.1 in the field of elements in order to undertake the actions laid down in section 3.2.2. For this purpose, the "control plan" referred to in sections 3.2.1.1 and 3.2.2 shall be handed over by the manufacturer to the approved body involved.

(2) The manufacturer shall make a declaration of conformity, stating that the construction product is in conformity with the provisions of the European technical approval ETA-12/0245.

3.2.2 Tasks for the approved bodies

(1) The approved body shall perform the following tasks in accordance with the provisions of the "control plan":

- initial inspection of factory and of factory production control,
- continuous surveillance, assessment and approval of factory production control.

(2) The approved body shall retain the essential points of its actions referred to above and state the results obtained and conclusions drawn in a written report.

(3) The approved certification body involved by the manufacturer shall issue an EC certificate of conformity of the factory production control stating the conformity with the provisions of this European technical approval.

⁹

The "control plan" is a confidential part of the European technical approval and only handed over to the approved bodies involved in the procedure of attestation of conformity. See section 3.2.2.

(4) The verifications, on which the ETA is based, were furnished by samples taken from the current production, thus only a reduced initial type-testing according to the specifications in the control plan shall be performed.

(5) In cases where the provisions of the European technical approval and its control plan are no longer fulfilled the certification body shall withdraw the certificate of conformity and inform Deutsches Institut für Bautechnik without delay.

3.3 CE marking

The CE marking shall be affixed on the delivery note. The letters "CE" shall be followed by the identification number of the approved certification body and be accompanied by the following additional information:

- the name and address of the manufacturer (legal entity responsible for the manufacturer),
- the last two digits of the year in which the CE marking was affixed,
- the number of the EC certificate for the factory production control,
- number of the European technical approval
- essential properties:
 - geometry of the elements
 - raw density of the elements
 - indication of the water absorption class
 - indication of the freeze-thaw resistance class

4 Assumptions under which the fitness of the product for the intended use was favourably assessed

4.1 Manufacturing

(1) The elements are manufactured at the manufacturing plant 13 and 18 of BERDING BETON GmbH, Germany.

(2) The European technical approval is issued for the product on the basis of agreed information, deposited with Deutsches Institut für Bautechnik, which identifies the product that has been assessed and judged.

(3) Changes to the product or production process, which could result in this deposited information being incorrect, should be notified to Deutsches Institut für Bautechnik before the changes are introduced. Deutsches Institut für Bautechnik will decide whether or not such changes affect the approval and consequently the validity of the CE marking on the basis of the approval and if so whether further assessment or alterations to the approval shall be necessary.

4.2 Installation

4.2.1 Conditions for the installation

(1) The design of a revetment shall only be made by an expert designer.

The controllable design drawings and/or positioning plans for the installation of the elements shall be made by an expert designer taking account of the requirements at national level of the respective Member States for this field of application and the expected installation conditions.

(2) The requirements from other fields of law (occupational health & safety at work law) will remain unaffected.

(3) In case of new buildings and maintenance of facilities and of waterways network serving the general traffic (e.g. in G Federal waterways) additional requirements of the navigable waterway construction according to the provisions of the respective Member States shall be taken into account (e.g. in G. *Technisches Regelwerk - Wasserstraßen (TR-W)* ('Technical set of rules – Waterways').

(4) The elements are designed to be sufficient for the applications according to section 1. This shall only apply, provided that the base and the slope and/or dike body satisfy the provisions of the section 4.2.3 as well as Annexes 2 and 4.

(5) The planning includes the detailed description of the upper and lower connection of the revetment as well as the necessary installations (e.g. fixings, see Annex 10).

(6) The planning and design of the toe and head protection shall take the national provisions of the respective Member States (G: e.g. EAK¹⁰; NL: e.g. ENW Technical reports¹¹) for the respective object into account. For that purpose detailed descriptions of the loads and load transmissions should be made taking into account the connections to existing revetments, see annexes 9 and 10.

(7) In order to verify the suitability of the respective revetment for sea dikes on coasts, in estuaries or river deltas, current loads are often not the definite loads for revetments. Therefore, this load shall only be considered by the following verification (without checking by testing) when planning in accordance with Annex 4. Should this verification not suffice, the detailed current loads shall be verified for the respective subject experimentally and taken into consideration in planning, e.g. in G according to BAW Code of Practice: BAW-GBB¹².

(8) The installation of elements shall be designed on the load-bearing basis according to the provisions of this European technical approval (see Annexes 2 and 4) and the applicant's installation instructions. The flawless nature of the base and the sea dike body as well as the permissibility of the loads on the sea dike and slope body occurring shall be tested and verified separately. In case of sea dike and slope bodies with unfavourable or strongly varying deformation behaviour, the corrections have to be designed beforehand.

(9) The laying of the elements (joint plan), the filling and/or stay open of the joints between the elements shall be planned. Therefore shall be taking into account the national provisions of the respective Member States for these areas of use. The interaction between the selected joint filling material and the elements as well as the whole revetment shall take into account, see the and installation instruction of the approval holder

(10) The fixing on the elements shall only be carried out with national and/or European technical approved bonding anchors. The fixing of the mounted parts shall be designed for the relevant object taking the provisions of the respective approved bonded anchor into account.

4.2.2 Processing

(1) The installation of elements is carried out by firms according to section 4.2.5 only.

(2) For the proper installation of the elements the holder of approval shall draw up installation on the following points and assembling instructions which includes detailed descriptions:

- values and quality of the base and the base preparation,
- joint size/joint plan/element separation distance (min., max.),
- mounting and connecting the elements to adjacent revetments or installations,
- special installation instructions.

(3) The conditions of installation given in the approval and by the ETA holder shall be respected.

¹⁰ EAK: Federal Waterways Engineering and Research Institute, Technical Committee for Coastal Defence Works: "Presentation of recommendations for building coastal defence works", corrected version 2007, EAK, Karlsruhe, 2007

¹¹ ENW: Technical reports Expertise network water safety, technical reports, www.enwinfo.nl

¹² BAW-GBB: Federal Waterways Engineering and Research Institute (BAW): newsletter No 87 "Principles for the Design of Bank and Bottom Protection for Inland Waterways, (BAW-Mitteilungsblatt Nr. 87 "Grundlagen zur Bemessung von Böschungs- und Sohlensicherungen an Binnenwasserstraßen") Karlsruhe, May 2004 with addition note section 7.12, September 2005

(4) In case of setting up the bonded anchors into the elements of the revetment the provisions of the installing instructions by the approval holder shall be taken into account.

(5) The installing firm shall hand over a copy of this approval as well as installation and assembling instructions of the approval holder to the user of the revetment/sea dike in areas of coastal, estuaries and river deltas.

4.2.3 Base

Before laying the elements the suitability of the base shall be determined according to the provisions of section 4.2.1 (8). It shall not exceed the allowed values Annexes 2 and 4 shall not differ from provisions given in the installation and assembling instructions. The modulus of deformation " E_{V2} " of the slope and/or sea dike body shall be confirmed by means of the plate-pressure test.

4.2.4 Installation of pre-fabricated elements

(1) The upper, lower (toe- and head connections) and the connection to revetments or constructions at both sides (see Annexes 9 and 10) shall be carried out according to Annexes 9 and 10 taking into account the installation instructions by the approval holder.

(2) The base set-up shall meet the requirements of Annexes 2 and 4. The sufficient compaction of the base (E_{V2} value/Proctor density) shall be verified before laying the elements (once per object, at least 3 times per 5000 m²).

(3) Damaged elements may not be installed.

(4) The admissible joint geometry (see annex 2) shall be guaranteed.

4.2.5 Installing firm

(1) The installation of elements shall be only carried out by firms who (including their specialists) are authorised and trained by the approval holder. Further requirements for the installing firm can result from national provisions of the Member States.

(2) The confirmation of the conformity of the elements installed in a revetment with this approval shall be given with a declaration by the installing firm based on the controls according to section 4.2.6

(3) The results of controls shall be recorded and evaluated. The records shall include at least the following information:

- Revetment: "Verkalit-dike-fixing-system (revetment)"
- Approval number: ETA-12/0245
- Holder of Approval: name, address
- Installation on: date
- Installing firm: name, address
- Type of control or test (see section 4.2.6)
- Date of test
- Result of control and tests and comparison with the requirements
- Name of, and position held by, the person empowered to sign the declaration on behalf of the installing firm or of his authorized representative

(4) The documentation and the declaration of the installing firm shall be kept with the construction records of the respective object. On request they shall be presented to the approval body, the relevant construction supervision authority and the expert in accordance with the national regulations of the Member States.

(5) If there are insufficient test results the installing firm shall immediately take the necessary actions to remedy the deficiency. After having remedied the deficiencies the test shall be repeated this is necessary to verify that the defect has been eliminated if technically possible.

4.2.6 Control of the execution

- (1) The set-up of the base shall comply with representations of Annexes 2 and 4.
- (2) Control that the right components were used for the proper installation of the revetment according to this ETA as well as their marking according to section 3.3.
- (3) Control of the proper installing of the elements, especially in the area of the top and/or toe connections.
- (4) Control of the correct distances between the elements according to this approval.
- (5) Control that, for the fixing on the elements, only bonded anchors according to Annex 2 were used, taking into account the provisions of Annex 10.
- (6) During the laying of the elements, records on the verification of the proper installation shall be kept by the construction supervisor or his agent.
- (7) During the construction period records shall be available on site and on request shall be handed over to the construction supervision agent. Just like the delivery notes they shall be kept by the company after completion of the works for a minimum of five years.

4.3 Responsibilities for the ETA holder

- (1) It is the responsibility of the holder of approval to make sure that all those who use his elements will be appropriately informed about the specific conditions according to sections 1, 2, 4, and 5 including the annex to this ETA, the installation and processing instructions by the holder of approval and the not confidential part of the technical documentation to this ETA.
- (2) This information can be provided by reproduction of the relevant parts of the European technical approval.

5 Indications to the manufacturer

5.1 Transport and storage

5.1.1 Transport

- (1) The transportation to the place of installation occurs with an appropriate transport vehicle.

5.1.2 Storage

- (2) The storage and/or intermediate storage of the elements shall be performed on load distributing frost-free bases such that no inadmissible attacks can occur.

5.2 Use, maintenance, repair

- (1) In order to ensure the fitness for use of the elements and/or the revetment manufactured of these elements, the following measures are recommended. It is the task of the ETA holder to make sure that all parties involved are adequately informed.
- (2) The operator of the respective facility establishes operating instructions including the description of the necessary controls and measures:
 - control of the proper condition,
 - ensuring proper operation,
 - maintenance and cleaning of the elements/revetment and
 - measures in the event of damage.

The control intervals are specified by the operator. The results of controls are documented.

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(3) The operator assigns only those companies with maintaining, repairing and cleaning of the revetment, whose personnel is authorized and instructed for this field of application according to the provisions of the respective Member States.

6 Recommendations for the operator of a facility

Reference is made to the necessity of a permanent control by the operator of the functioning of the revetment in accordance with the requirements of the national regulations of the respective Member States.

Uwe Bender
Head of Department

beglaubigt:
Dr.-Ing. Kluge

Verkalit Concrete Elements

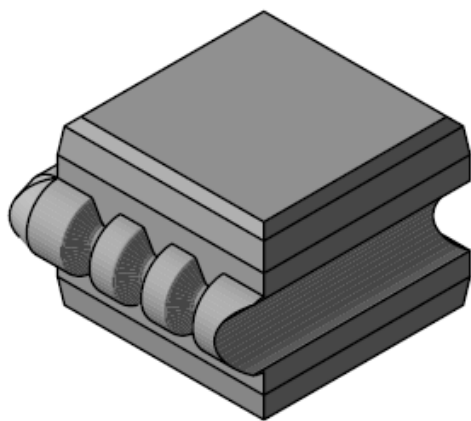
as part of the

"Verkalit dike fixing system" (revetment)
of BERDING BETON GmbH used as an extensive fixing of slopes for
coasts, estuaries and river deltas

Verkalit Revetment Elements

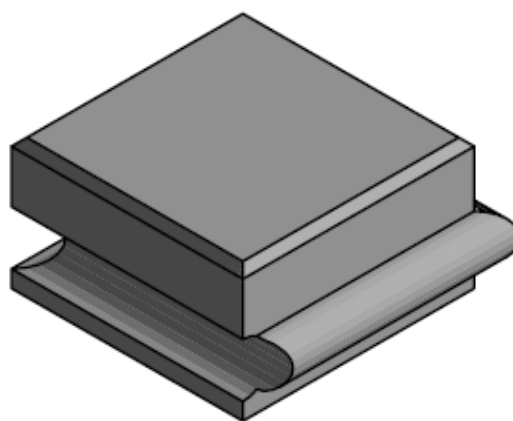
Type 1

for permeable revetments

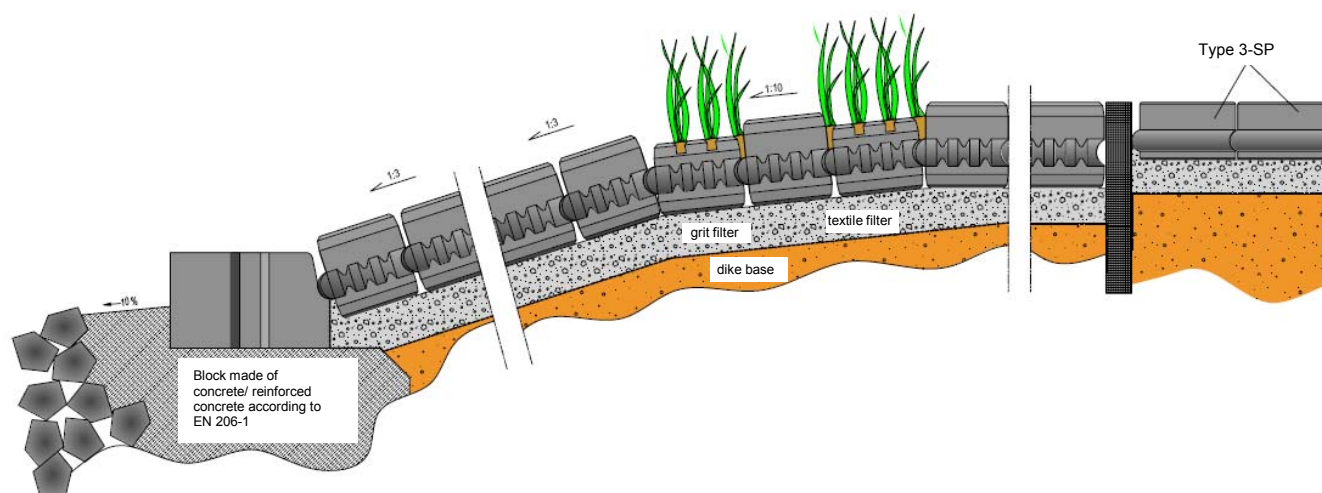


Type 2

for tight revetments



Example: Verkalit dike fixing system used for permeable revetments:



"Verkalit dike fixing system" (revetment) of BERDING BETON GmbH used as an extensive fixing of slopes for coasts, estuaries and river deltas

Example for the installation

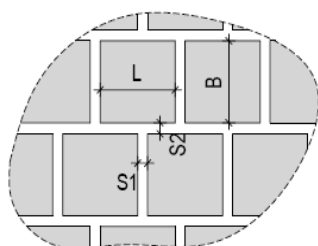
Annex 1

Table 1: Material and Properties

No	Value	Assessment
1	Verkalit element made of concrete	Concrete according to the documents deposited taking into account the provisions of this approval
	Aggregate	Aggregates according to the documents deposited taking into account EN 12620:2011-3
	Cement	Cement according to EN 197-1:2004-08
	Concrete admixture	BV according to EN 934-2
	Concrete additives	Hard coal fly ash according to EN 450-2
2	Geotextile	Textile material according to the requirements of the approval holder taking into account the requirements of the Member States, e.g. G requirements of the TLG of the Federal Waterways Engineering and Research Institute (BAW)
3	Filter layer made of aggregate	Aggregate according to the provisions of this approval and the additional requirements of the approval holder according to the information deposited
4	Fixing devices for mounted parts	Bonding anchors with national or European technical approval according to the provisions of this approval and the requirements of the approval holder

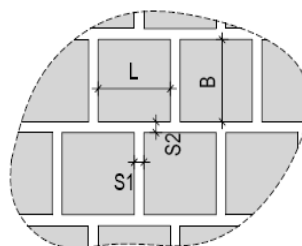
Joint geometry of the revetments:

Joint geometry type 1-S and 1-P



S1 = 18mm ± 3mm
S2 = 18mm ± 3mm
Length / Width = 306mm/306mm
Height difference between two elements: ≤ 5 mm

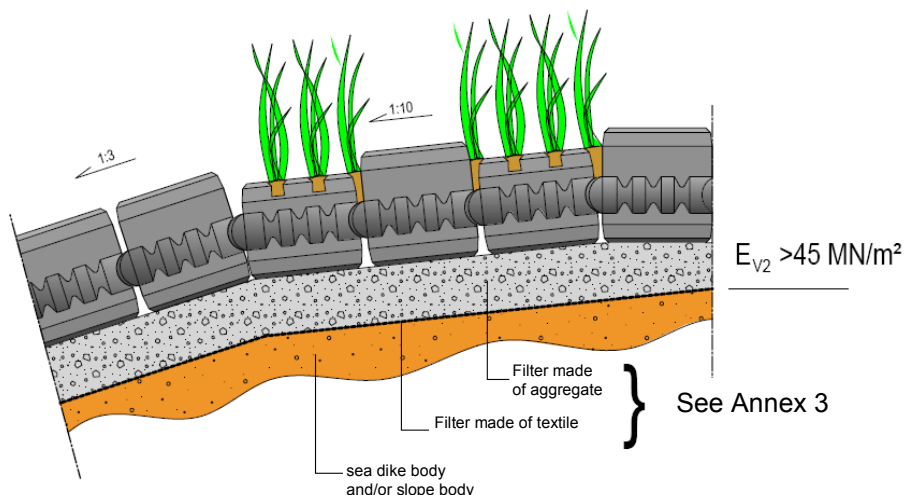
Joint geometry type 2-S and 2-P



S1 = 9mm ± 3mm
S2 = 9mm ± 3mm
Length / Width = 308mm/308mm
Height difference between two elements: ≤ 5 mm

Base of the revetment system, example:

The base shall be installed frost-free. The values of Annexes 3 and 4 shall be taken into account.



"Verkalit dike fixing system" (revetment) of BERDING BETON GmbH used as an extensive fixing of slopes for coasts, estuaries and river deltas

Material, properties, joint geometry and base for the revetment system

Annex 2

Table 1: Characteristic values of the construction element and the material

No	Characteristic Value	Requirement
Elements		
1	Fresh concrete for the elements	concrete mix (formulation) according to the information deposited
	– surveillance class	2
	– cement – cement type: – cement content:	cement according to EN 197-1 according to the information deposited $\geq 320 \text{ kg/m}^3$
	– admixtures	hard coal fly ash according to the information deposited
	– additives	concrete plasticiser according to the information deposited
	– water-cement ratio ¹⁾	≤ 0.4
	– aggregate – aggregate type: – , grading line:	according to the information deposited, alkali sensitivity class E I gravel, sand, stone chippings 0/11
	– mix proportion (for 1 m ³ of compacted fresh concrete)	according to the information deposited
2	Element:	
	– surveillance class	2
	– compressive strength	$\geq \text{C45/55}$
	– water absorption class	class 2, marking B: water absorption $\leq 5.0 \%$ by mass single value acc. to EN 1338
	– Geometry (width, length, thickness):	see Annexes 5 to 8
	– raw density	$\geq 2.3 \text{ kg/dm}^3$
– resistance to weather/ freeze-thaw resistance class (CDF)	Weather resistance/ CDF 1: freeze-thaw resistance	
Base:		
3	Geotextile:	
	– material :	according to the provisions of the Member States, e.g. G requirements of the TLG by the Federal Waterways Engineering and Research Institute (BAW) and the requirements of the approval holder
	– fibre type:	extruded fibres
	– structure :	needed material
	– surface weight [g/m ²]:	≥ 500
	– thickness ²⁾ [mm] for BT 1 to BT3:	≥ 4.5
	– thickness [mm] for BT 4:	≥ 6.0
	– maximum tensile strength (in length / cross direction) [kN/m ²]:	$\geq 12.0 / \geq 12.0$
	– penetration resistance [Nm]:	≥ 1200
– filter effectiveness	test according to the provisions of the Member States, e.g. G requirements of the TLG by the Federal Waterways Engineering and Research Institute	
– minimum overlapping length [cm]:	approx. 50	
4	Grain filter³⁾	
	– material [-]	grit
	– thickness [mm]	≥ 100
	– grain composition [-]	16/22
"Verkalit dike fixing system" (revetment) of BERDING BETON GmbH used as an extensive fixing of slopes for coasts, estuaries and river deltas		Annex 3
Characteristic values of the construction element and the material		

1) Air entraining agent not permitted.

2) Soil types with regard to the hydraulic filtration stability " k_{10} " according to the provisions of the Member States, e.g. G TLG by the Federal Waterways Engineering and Research Institute, BT 1: $k_{10} > 8 \cdot 10^{-4}$; BT 2: $k_{10} > 6 \cdot 10^{-4}$; BT 3: $k_{10} > 1 \cdot 10^{-4}$; BT 4: $k_{10} > 1 \cdot 10^{-7}$

3) If necessary, the geometry of the grain filter of the respective object shall be proven, taking the stresses into account, according to the provisions of the respective Member States in co-operation with the approval holder.

Table 1: Values for the planning of revetments

No	Characteristic Value	Requirement	
		Type 1 (permeable revetment)	Type 2 (tight revetment)
1	Revetment:		
1.1	relative element density, Δ [-] ¹⁾	≥ 1.3	
1.2	Thickness of the element, D [m]	see in Annexes 6 to 8	
1.3	angle of the external dike slope, α [°],	According to the object planning the maximum permitted slope angle shall be taken into account:°	
1.4	maximum permitted slope angle of the dike [-]	1:3	
1.5	Proctor density	95 %	
1.6	E_{v2} value of the base	$\geq 45 \text{ MN/m}^2$, deviation $\pm 25 \text{ MN/m}^2$	
1.7	Pull-out resistants [kN], decisive ²⁾	≤ 20	
2	Construction of the revetment:		
2.1	Joint width:		
	– permeable and tight revetment:	see Annexes 2 and 8	
	– relative opening width Ω [mm] concerning the area installed	6	3
2.2	– skid-resistant: (used only by pedestrians during installation)	$>55 \text{ SRT}$	

1) The respective relative element density influenced the stability factor. That shall be taken into consideration during the respective object planning.

2) The pull-out resistants does not apply to Type 3-SP "promenade element".

Table 2: Permitted attacks of the revetment¹⁾

No	Characteristic Value	Requirement	
		Type 1 (permeable revetment)	Type 2 (tight revetment)
1	stability factor [-] with H_s at the revetment toe ²⁾	$\leq 7,0$	
2	breaker parameter at the revetment toe, ξ_0 [-]	$\leq 3,0$	

1) The special element of the Type 3-SH "pillar element" can be used in tight and permeable revetment taking the requirements of Annexes 8 to 10 into account.

2) If the granular filter has larger permeability and larger layer thickness and/or bigger relative element density the stability will be lower

Simplified verification for planning of current attacks:

$$\frac{U}{\sqrt{\Delta g D}} < 1,2$$

U current velocity [m/s] according to the object planning
 Δ relative element density [-], see Annex 4, Table 1
g acceleration of gravity [m/s²]
D thickness of the element [m], see Annexes 6 to 8

"Verkalit dike fixing system" (revetment) of BERDING BETON GmbH used as an extensive fixing of slopes for coasts, estuaries and river deltas

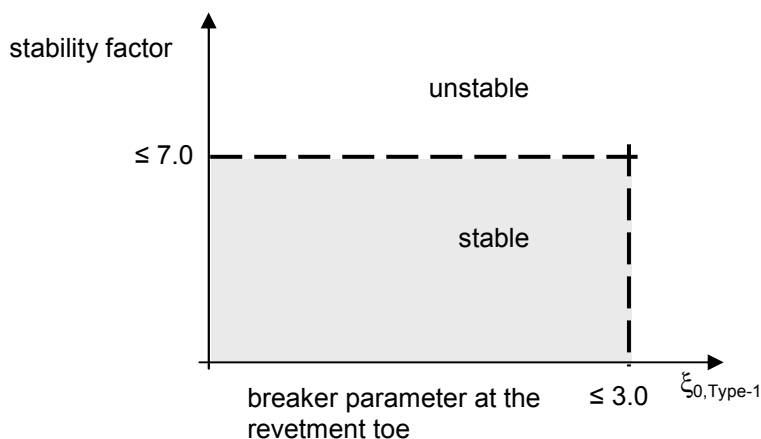
Values for the planning, permitted stress of the revetment and simplified verification for planning of current attacks

Annex 4

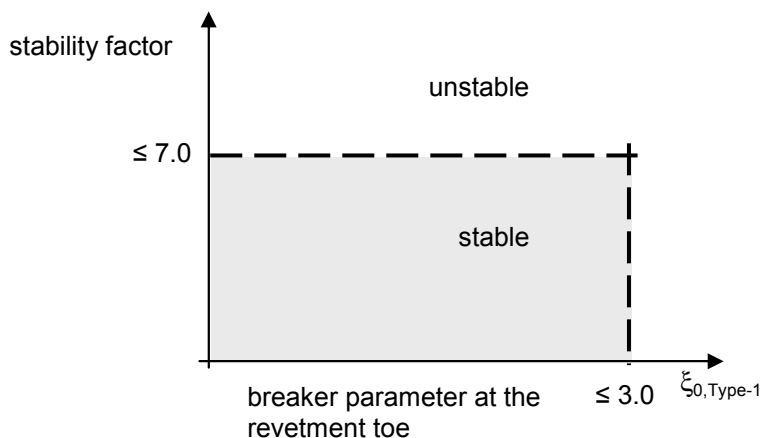
Verification of the revetment stability:

(The revetment stability is based on large-scale tests in the wave flume. If the granular filter has larger permeability and larger layer thickness and/or bigger relative element density the stability will be lower. That shall be taken into consideration during the respective object planning.

- Type 1 – Verkalit revetment element for permeable revetments



- Type 2 – Verkalit revetment element for tight revetments



$$\text{stability factor} = \frac{H_s}{\Delta D_s} \quad ; \quad \text{breaker parameter at the revetment toe, } \xi_0 = \frac{\tan \alpha}{\sqrt{\frac{H_s}{L_0}}}$$

- | | | |
|----------|---|------------------------|
| ξ_0 | breaker parameter at the revetment [-] | } see Annex 4, Table 2 |
| H_s | significant wave height at the dike toe [m] | |
| Δ | relative density of the revetment | |
| D | thickness of the revetment element | |
| α | angle of the external sea dike slope [°] | |
| L_0 | wavelength in deep water | |

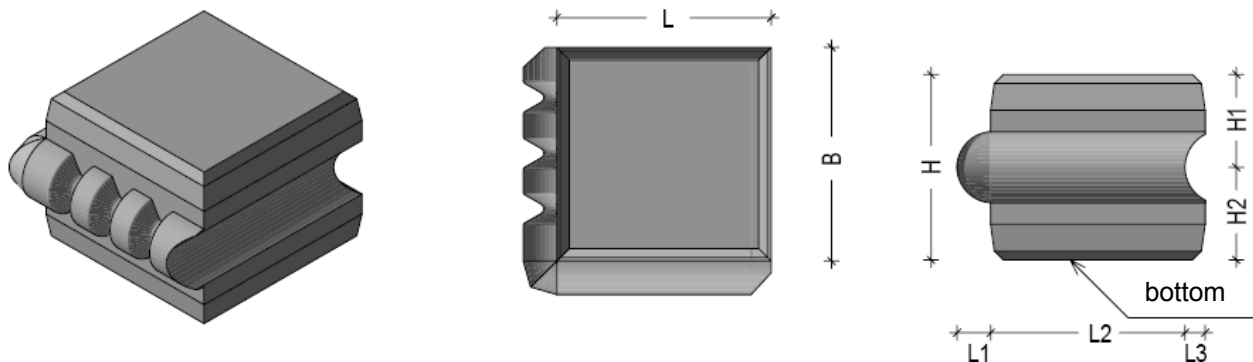
"Verkalit dike fixing system" (revetment) of BERDING BETON GmbH used as an extensive fixing of slopes for coasts, estuaries and river deltas

Verification of the revetment stability

Annex 5

Geometry of the revetment elements, **Type 1** for permeable revetments:

Type 1-S, standard element:



Type 1-P, profile element:

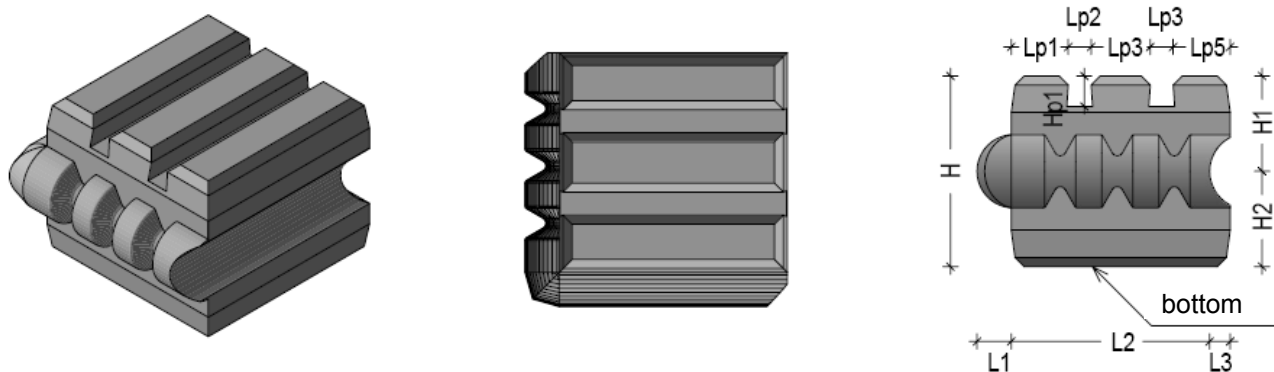


Table 1 Geometry Type 1 for permeable revetments

Element	L [mm]	L1 [mm]	L2 [mm]	L3 [mm]	Lp1 [mm]	Lp2 [mm]	Lp3 [mm]	Lp4 [mm]	Lp5 [mm]	HP1 [mm]	B [mm]	H [mm]	H1 [mm]	H2 [mm]
Type 1-S, standard element	288	45	261	27	-	-	-	-	-	-	288	180	55	125
												250	125	125
												300	175	125
Type 1-P, profile element	288	45	261	27	75	30	78	30	75	40	288	180	55	125
												250	125	125
												300	175	125

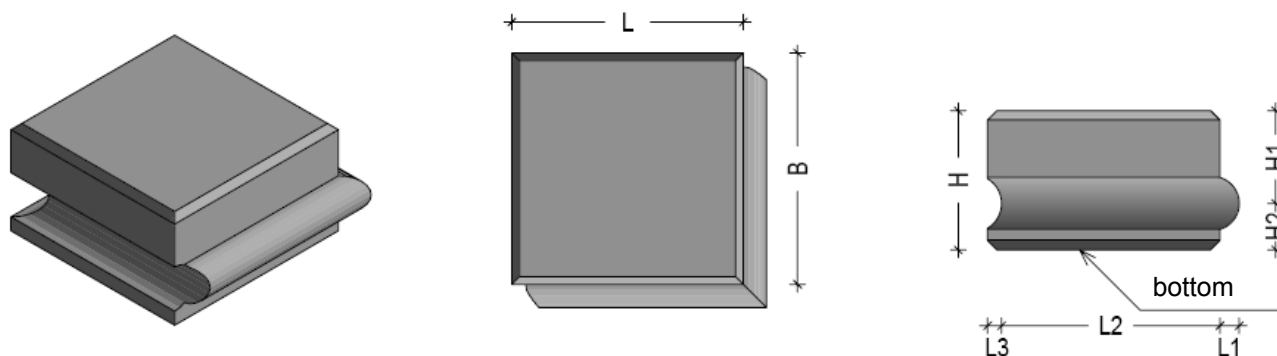
"Verkalit dike fixing system" (revetment) of BERDING BETON GmbH used as an extensive fixing of slopes for coasts, estuaries and river deltas

Geometry of the revetment elements, **Type 1** for permeable revetments

Annex 6

Geometry of the revetment elements, **Type 2** for **tight** revetments:

Type 2-S, standard element:



Type 2-P, profile element:

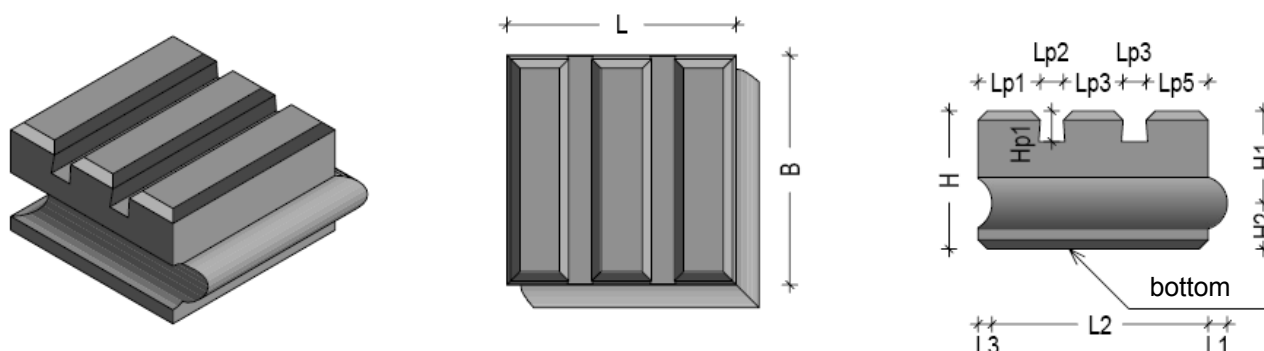


Table 1 Geometry Type 2 for tight revetments

Element	L [mm]	L1 [mm]	L2 [mm]	L3 [mm]	Lp1 [mm]	Lp2 [mm]	Lp3 [mm]	Lp4 [mm]	Lp5 [mm]	HP1 [mm]	B [mm]	H [mm]	H1 [mm]	H2 [mm]
Type 2-S, standard element	299	26	255	18	-	-	-	-	-	-	299	180	120	60
												250	190	60
												300	240	60
Type 2-P, profile element	299	26	255	18	81	30	77	30	81	40	299	180	120	60
												250	190	60
												300	240	60

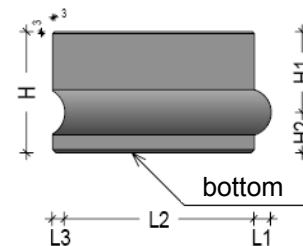
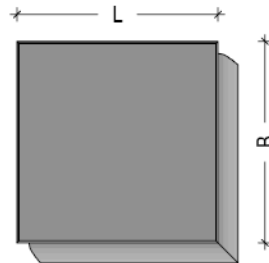
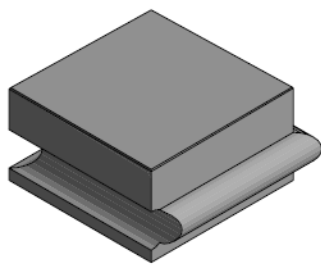
"Verkalit dike fixing system" (revetment) of BERDING BETON GmbH used as an extensive fixing of slopes for coasts, estuaries and river deltas

Geometry of the revetment elements, **Type 2** for **tight** revetments

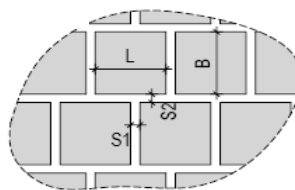
Annex 7

Geometry of the revetment elements, Type 3-S Verkalit special elements

Type 3-SP, promenade element:



Joint geometry for the installation of promenades with Type 3-SP:



S1 = 9mm ± 3mm
S2 = 9mm ± 3mm
Length/ width = 308 mm / 308 mm
Height difference between two elements: ≤ 3 mm

Type 3-SH, pillar element (as a connection element to secure toe and/or secure head):

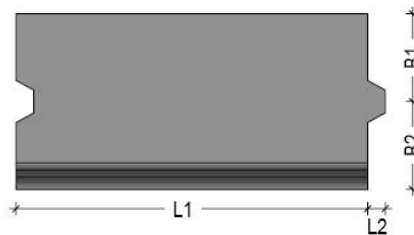
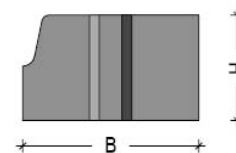
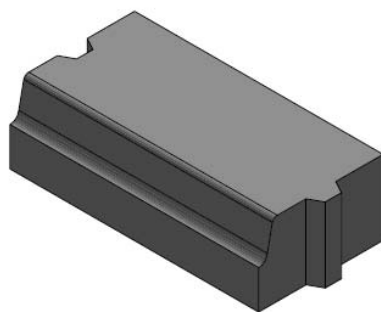


Table 1 Geometry Type 3-S, Verkalit special elements

Element	L [mm]	L1 [mm]	L2 [mm]	L3 [mm]	B [mm]	H [mm]	B1 [mm]	B2 [mm]
Type 3-SP, promenade element ¹⁾	299	26	255	18	299	150	90	60
						180	120	50
Type 3-SH, pillar element (connection element for toe protection)	1048	998	50	-	500	300	150	150

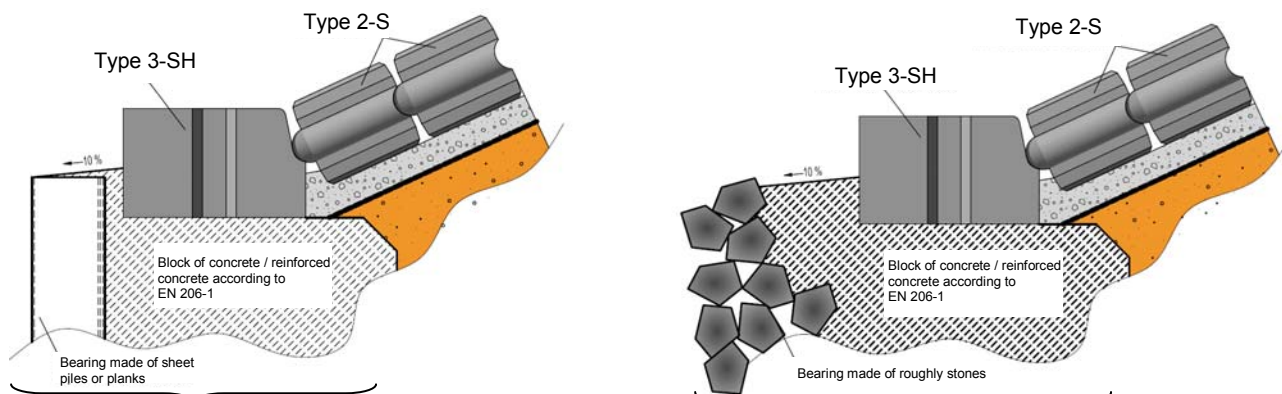
¹⁾ The horizontal and/or flat inclined areas of a dike (see section 2.2), expanded with Verkalit promenade elements Type 3-SP, may only be used for traffic if the requirements according to Annex 10 have been taken into account.

"Verkalit dike fixing system" (revetment) of BERDING BETON GmbH used as an extensive fixing of slopes for coasts, estuaries and river deltas

Geometry of the revetment elements, Type 3-S Verkalit special elements and joint geometry for Type 3-SP

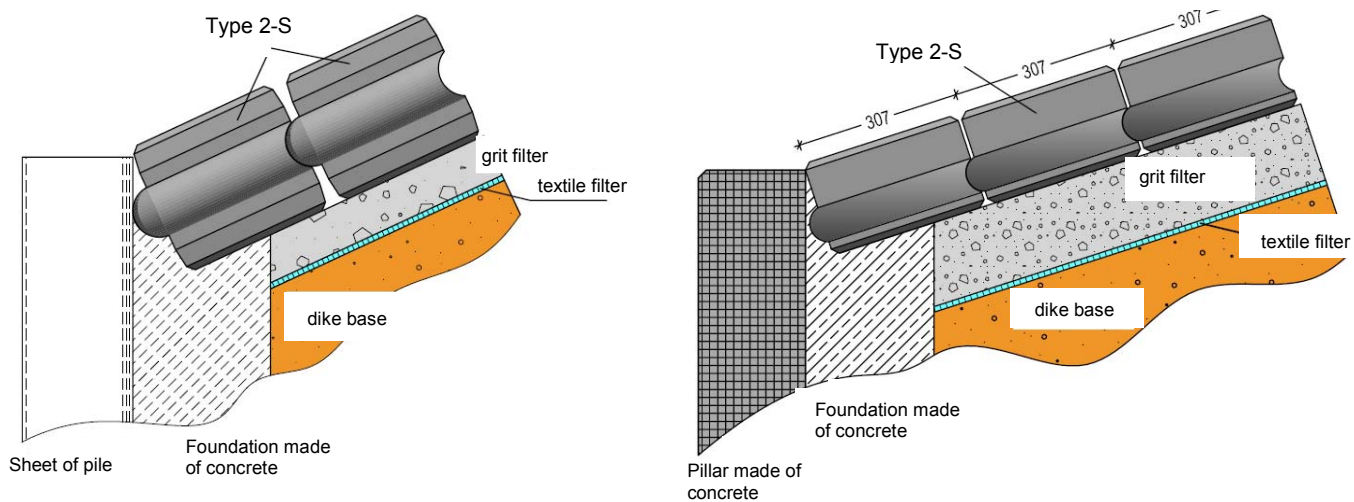
Annex 8

Installing examples of the pillar elements as a connection element for the toe protection:



The connecting construction to the not secured ground including the toe protection of the revetment shall be planned related to the respective situation of the object according to the provisions of the respective Member.

Installing examples of a toe protection without a connection element:



The connecting construction to the not secured ground including the toe protection of the revetment shall be planned related to the respective situation of the object according to the provisions of the respective Member.

"Verkalit dike fixing system" (revetment) of BERDING BETON GmbH used as an extensive fixing of slopes for coasts, estuaries and river deltas

Example of an installation of a toe protection

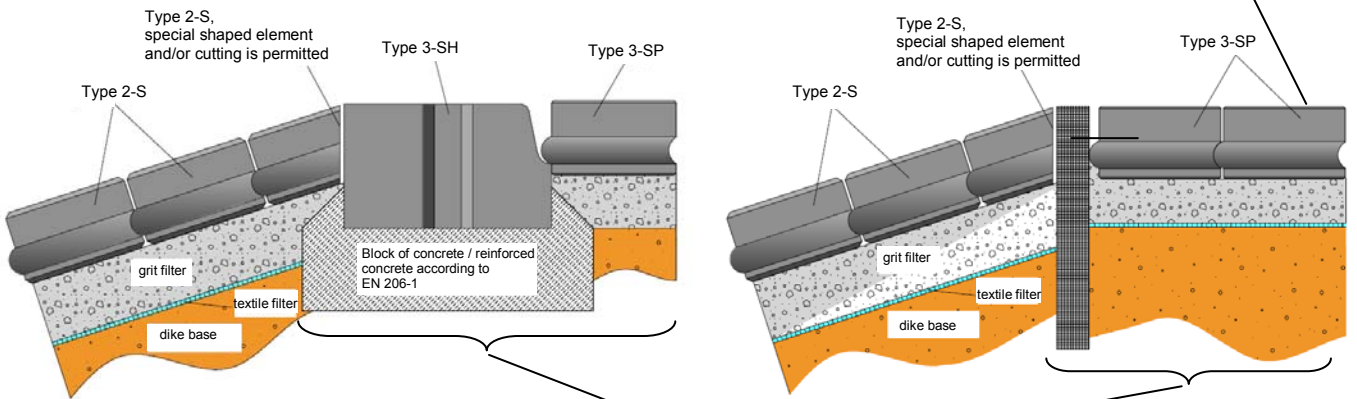
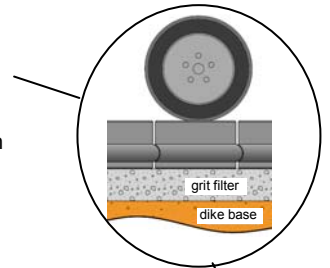
Annex 9

Example of head connections with connecting elements:

The trafficability of horizontal and/or flat inclined areas of the sea dike is only permitted if

- the area is expanded with Verkalit-Special-elements Type 3-SP and
- the load bearing and load transmission into the base and in the dike is planned and tested for the respective object.

Therefore the respective provisions of the Member States shall be taken into account, e.g. in G: RSTO-01, DIN-Report 101.



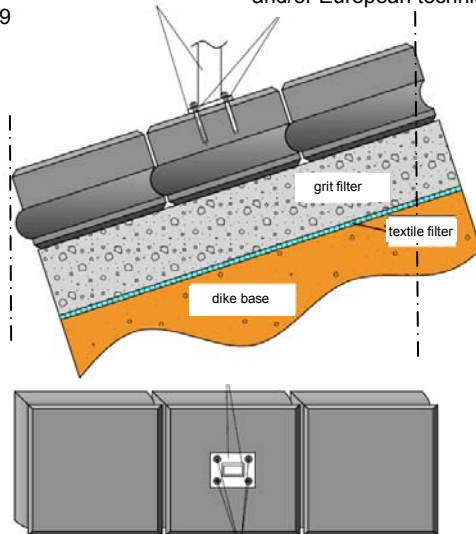
The connecting construction to the not secured ground including the toe protection of the revetment shall be planned related to the respective situation of the object according to the provisions of the respective Member.

Permitted fixing of mounted parts:

The installation only with deformation controlled anchors is permitted. The fixing shall be planned according to the provisions of the respective Member States

Design of steel structures: according to EC 3.
Steel structures made of steel with high resistance against corrosion in accordance with EN 10088, Mat.-No: 1.4539

Bonded anchors made of stainless steel with high resistance against corrosion, e.g. Mat.-No: 1.4539, with national and/or European technical approval



"Verkalit dike fixing system" (revetment) of BERDING BETON GmbH used as an extensive fixing of slopes for coasts, estuaries and river deltas

Example of head connections with connecting elements, trafficability and permitted fixing of mounted parts

Annex 10