



# SLOVENSKI STANDARD

## SIST EN 1538:2011

01-februar-2011

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### Izvedba posebnih geotehničnih del - Diafragme

Execution of special geotechnical work - Diaphragm walls

Ausführung von Arbeiten im Spezialtiefbau - Schlitzwände

Exécution des travaux géotechniques spéciaux - Parois moulées

Ta slovenski standard je istoveten z: **EN 1538:2010**

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#### **ICS:**

93.020	Zemeljska dela. Izkopavanja.	Earthworks. Excavations.
	Gradnja temeljev. Dela pod	Foundation construction.
	zemljo	Underground works

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English Version

## Execution of special geotechnical work - Diaphragm walls

Exécution des travaux géotechniques spéciaux - Parois  
moulées

Ausführung von Arbeiten im Spezialtiefbau - Schlitzwände

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This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the CEN Management Centre has the same status as the official versions.

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EUROPEAN COMMITTEE FOR STANDARDIZATION  
COMITÉ EUROPÉEN DE NORMALISATION  
EUROPÄISCHES KOMITEE FÜR NORMUNG

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**EN 1538:2010 (E)****Foreword**

This document (EN 1538:2010) has been prepared by Technical Committee CEN/TC 288 "Execution of special geotechnical works", the secretariat of which is held by AFNOR.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by March 2011, and conflicting national standards shall be withdrawn at the latest by March 2011.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN 1538:2000.

The general scope of TC 288 is the standardisation of the execution procedures for geotechnical works (including testing and control methods), and of the required material properties. WG15 has been charged to revise EN 1538:2000, with the subject area of both retaining and cut-off diaphragm walls. This standard does not address the execution of barrettes, which is covered by EN 1536, *Execution of special geotechnical work — Bored piles*.

The design, planning and execution of retaining and cut-off diaphragm walls call for experience and knowledge in this specialised field. The execution phase requires skilled and qualified personnel and the present standard cannot replace the expertise of specialist contractors.

The document has been prepared to stand alongside EN 1997-1, *Eurocode 7: Geotechnical design — Part 1: General rules* and EN 1997-2, *Eurocode 7: Geotechnical design — Part 2: Ground investigation and testing*. This standard expands on design only where necessary (e.g. the detailing of reinforcement) and provides full coverage of the construction and supervision requirements.

This standard contains additional requirements on concrete complementing the respective provisions of EN 206-1 and of EN 13670. The three standards are not yet fully accorded. It is anticipated that during future revisions several provisions now contained in EN 1538, e.g. in 6.1, 6.3 and 8.8 could be transferred to EN 206-1 and EN 13670.

This document was revised by a working group comprising delegates from 11 European countries. The comments from 13 European countries have been received and taken into account.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and the United Kingdom.

## 1 Scope

This European Standard establishes general principles for the execution of diaphragm walls as either retaining walls or cut-off walls.

NOTE 1 This standard covers only structures constructed in a trench excavated with a support fluid or in dry conditions, where soil is removed and replaced by concrete or slurry and with wall thickness  $B \geq 40$  cm.

NOTE 2 Diaphragm walls can be permanent or temporary structures.

NOTE 3 The following types of structure are considered:

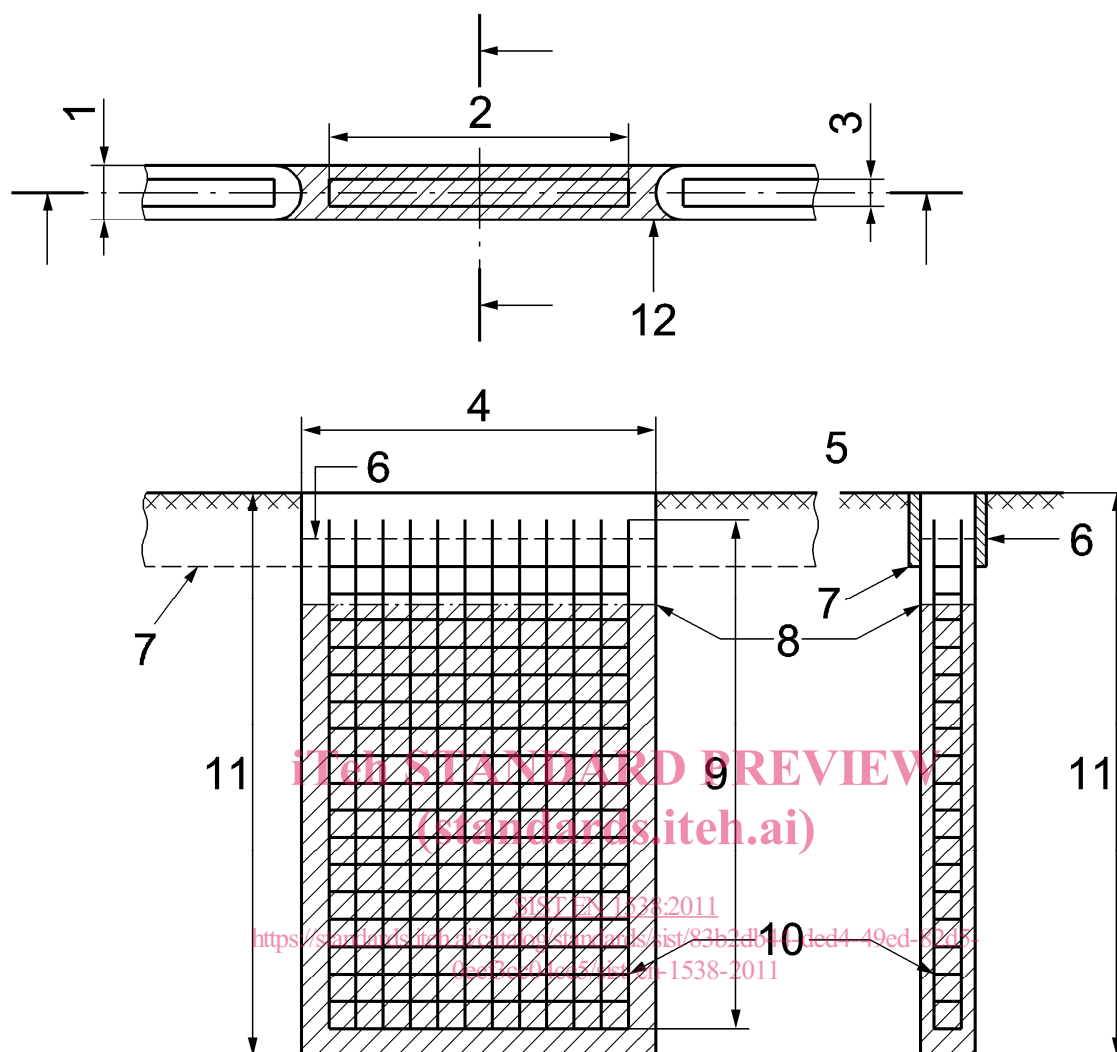
- a) retaining walls: usually constructed to support the sides of an excavation in the ground. They include:
  - 1) cast in situ concrete diaphragm walls;
  - 2) precast concrete diaphragm walls;
  - 3) reinforced slurry walls;
- b) cut-off walls: usually constructed to prevent migration of groundwater, clear or polluted, or of other contaminants present in the ground. They include:
  - 1) slurry walls (possibly with membranes or sheet piles);
  - 2) plastic concrete walls.

NOTE 4 Walls formed shallow vertical trenches (typically excavations with a ratio of depth over thickness  $D/B < 5$  or  $D < 5$  m) are not covered by this standard.

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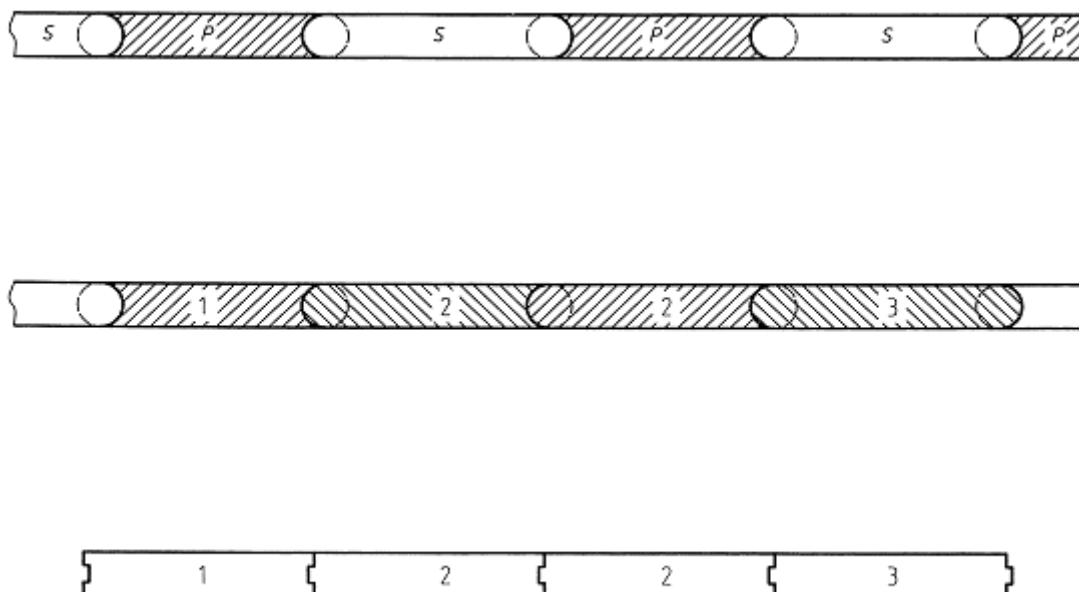


### Key

- |   |   |
|---|---|
| 1 Wall thickness ( $B$ )                  | 7 Guide-wall                            |
| 2 Horizontal length of reinforcement cage | 8 Cut off level                         |
| 3 Cage width                              | 9 Vertical length of reinforcement cage |
| 4 Length of panel                         | 10 Reinforcement cage                   |
| 5 Platform level                          | 11 Depth of excavation ( $D$ )          |
| 6 Casting level                           | 12 Concave portion of curved joints     |

Figure 1 — Geometry of a panel





### Key

- P Primary
- S Secondary
- 1 Starter
- 2 Intermediate
- 3 Closure

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Figure 2 — Schematic examples of different types of panels and joints (plan view)

## 2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 197-1:2000, *Cement — Part 1: Composition, specifications and conformity criteria for common cements*

EN 206-1:2000, *Concrete — Part 1: Specification, performance, production and conformity*

EN 791, *Drill rigs — Safety*

EN 934-2, *Admixtures for concrete, mortar and grout — Part 2: Concrete admixtures — Definitions, requirements, conformity, marking and labelling*

EN 1008, *Mixing water for concrete — Specification for sampling, testing and assessing the suitability of water, including water recovered from processes in the concrete industry, as mixing water for concrete*

EN 1990, *Eurocode — Basis of structural design*

EN 1991 (all parts), *Eurocode 1: Actions on structures*

EN 1992 (all parts), *Eurocode 2: Design of concrete structures*

EN 1997-1, *Eurocode 7: Geotechnical design — Part 1: General rules*

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EN 1997-2, *Eurocode 7 — Geotechnical design — Part 2: Ground investigation and testing*

EN 1998 (all parts), *Eurocode 8: Design of structures for earthquake resistance*

EN 10025-2, *Hot rolled products of structural steels — Part 2: Technical delivery conditions for non-alloy structural steels*

EN 10080, *Steel for the reinforcement of concrete — Weldable reinforcing steel — General*

EN 10210 (all parts), *Hot finished structural hollow sections of non-alloy and fine grain steels*

EN 10219 (all parts), *Cold formed welded structural hollow sections of non-alloy and fine grain steels*

EN 10248 (all parts), *Hot rolled sheet piling of non alloy steels*

EN 10249 (all parts), *Cold formed sheet piling of non alloy steels*

EN 12620, *Aggregates for concrete*

EN 13670, *Execution of concrete structures*

**3 Terms and definitions**

For the purposes of this document, the following terms and definitions apply.

**3.1****cast in situ concrete diaphragm wall**

**fr** paroi moulée en béton

**de** Ortbetonschlitzwand

wall made of plain or reinforced concrete, which is constructed in a trench excavated in the ground

**NOTE** The excavation is carried out in discrete length to form panels and the concrete is placed through tremie pipes immersed in the fresh concrete. In some cases the excavation and the concreting may be carried out in dry conditions.

**3.2****plastic concrete wall**

**fr** paroi moulée en béton plastique

**de** Tonbetonschlitzwand

wall made of plastic concrete, which is constructed in a trench in the ground

**NOTE** The excavation is carried out in panels and the concrete is placed through tremie pipes most of the time immersed in a support fluid. In some cases the excavation and the concreting may be carried out in dry conditions.

**3.3****precast concrete diaphragm wall**

**fr** paroi préfabriquée en béton

**de** Fertigteilschlitzwand

wall made of precast elements which are lowered into a trench excavated in the ground containing a hardening slurry

**3.4****reinforced slurry wall**

**fr** paroi moulée en coulis armé

**de** bewehrte Einphasenschlitzwand

wall made from a hardening slurry reinforced by steel beams, steel mesh or other suitable elements

**3.5****slurry wall**

**fr** paroi moulée en coulis

**de** Einphasenschlitzwand

wall made from a hardening slurry

NOTE In most cases, the excavation is carried out using a hardening slurry as the support fluid. Sealing elements such as membranes or sheetpiles may be inserted.

### 3.6

#### plastic concrete

fr béton plastique

de Tonbeton

low strength, low Young's modulus concrete capable of sustaining larger strains than normal concrete

NOTE It usually consists of low cement content concrete mixed at a high water cement ratio. It may include bentonite and/or other clay materials and/or other materials such as pulverized fuel ash (PFA) and admixtures.

### 3.7

#### hardening slurry

fr coulis autodurcissant

de selbsterhärtende Suspension

slurry which hardens with time

NOTE The slurry is a suspension which contains cement or another binder, and additional materials such as clay (bentonite), ground granulated blast furnace slag (GGBFS) or pulverized fuel ash (PFA), fillers, sand and admixtures. Hardening slurries are generally used in the precast concrete diaphragm wall technique and for slurry walls. They serve as support fluid during excavation, and, together with the fines from the natural ground, form the final, hardened material.

### 3.8

#### guide-walls

fr murettes-guides

de Leitwände

shallow depth, parallel temporary walls which are used to provide a guide for the excavating tool, to secure the sides of the trench against collapse at the trench top close to platform level, and to support and to facilitate the positioning of the reinforcement

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### 3.9

#### panel

fr panneau

de Schlitzwandelement

section of a diaphragm wall which is concreted as a single unit

NOTE A diaphragm panel may be linear, T-shaped, L-shaped, or of other configuration.

### 3.10

#### support fluid

fr fluide stabilisateur

de Stützflüssigkeit

fluid used during excavation to support the sides of the trench

NOTE It is usually a bentonite suspension, a polymer solution or a hardening slurry.

### 3.11

#### concreting pipe

fr colonne de bétonnage

de Betonierrohr

metal pipe comprising several joined lengths, surmounted by a hopper or chute for concreting under dry conditions

### 3.12

#### tremie pipe

fr tube plongeur

de Kontraktorrohr

concreting pipe, with watertight joints for submerged concrete placement

**EN 1538:2010 (E)****3.13****cover****fr** enrobage**de** Betonüberdeckung

distance between the outside of the reinforcement cage and the nearest concrete surface

NOTE The nearest concrete surface considered is the nearest excavated face as formed by the excavation tool.

**3.14****execution specification****fr** spécifications d'exécution**de** bautechnische Unterlagen

set of documents covering all drawings, technical data and requirements necessary for the execution of a particular project

NOTE The execution specification is not one document but signifies the total sum of documents required for the execution of the work as provided by the designer to the constructor. It includes the project specification prepared to supplement and qualify the requirements of this European Standard, as well as referring the national provisions relevant in the place of use.

**3.15****project specification****fr** spécifications de l'ouvrage**de** Projektspezifikationen

project specific document describing the requirements applicable for the particular project

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**4 Information needed for the execution of the work****4.1 General**

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4.1.1 Prior to the execution of the work, all necessary information shall be provided.  
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4.1.2 This information should include:

- any legal or statutory restrictions;
- the location of main grid lines for setting out;
- the conditions of structures, roads, services, etc. adjacent to the work, including any necessary surveys;
- a suitable quality management system, including supervision, monitoring and testing.

4.1.3 The information regarding the site conditions shall cover, where relevant:

- the geometry of the site (boundary conditions, topography, access, slopes, headroom restrictions, etc.);
- the existing underground structures, services, known contaminations, and archeological constraints;
- the environmental restrictions, including noise, vibration, pollution;
- the future or ongoing activities such as dewatering, tunnelling, deep excavations.

**4.2 Special features**

4.2.1 The special features shall cover, where relevant:

- execution specifications (see 3.14);
- previous use of the site;

- adjacent foundations (types, loads and geometry);
- geotechnical information and data as specified in Clause 5;
- presence of obstructions in the ground (old masonry, anchors, etc.);
- presence of headroom restrictions;
- presence of archeological remains;
- presence of natural and/or man made cavities (mines, etc.);
- presence of polluted ground;
- any specific requirements for the diaphragm wall, in particular those pertaining to tolerances, quality of materials, watertightness, and type of joints;
- where available, previous experience with diaphragm walls or underground works on or adjacent to the site;
- for slurry walls, permeability, strength and deformation properties of the wall material;
- proposed adjacent enabling or advance works such as underpinning, pre-treatment of soil, dewatering;
- diaphragm wall function (i.e. end bearing, retaining wall, cut off wall, environmental barrier, etc.).

**4.2.2** Necessity, extent, procedure and content for any survey of the conditions of structures, roads, services, etc. adjacent to the works area shall be established.

**4.2.3** The survey shall be carried out and be available prior to the commencement of the works and its conclusions shall be used to define the threshold values for any movement which may affect adjacent structures by the works area constructions.

**4.2.4** Any additional or deviating requirements falling within the permissions given in this European Standard shall be established and agreed before the commencement of the works and the quality control system shall be suitably amended.

NOTE Such additional or deviating requirements can be:

- reduced or increased geometrical construction deviations;
- application of different or varying construction materials;
- precast concrete elements;
- special anchorage or doweling of diaphragm walls to underlying rock;
- special reinforcement as the use of steel tubes or sections or of steel fibres;
- grouting of diaphragm walls shafts or bases;
- trimming of diaphragm walls heads by mechanical equipment.

## 5 Geotechnical investigation

### 5.1 General

**5.1.1** The geotechnical investigation shall fulfil the requirements of EN 1997 (all parts).

**EN 1538:2010 (E)**

**NOTE 1** The depth and the extent of the geotechnical investigation should be sufficient to identify all ground formations and layers affecting the construction, to determine the relevant properties of the ground and to recognize the ground conditions (e.g. where end bearing is to be relied on, it should demonstrate that any competent founding stratum is not immediately underlain by a weaker stratum where there is a possibility of a punching failure or excessive movements).

**NOTE 2** Relevant experience of the execution of comparable foundation works under similar conditions and/or in the vicinity of the site has to be taken into account when determining the extent of site investigation (reference to relevant experience is permitted if appropriate means of verification are taken e.g. by penetration, pressuremeter or other tests).

**NOTE 3** Guidance is given in EN 1997-2 on the depth and the contents of investigations.

**5.1.2** The geotechnical investigation report shall be available in time, to allow for reliable design and execution of the diaphragm walls (e.g. the choice of method of execution).

**5.1.3** The geotechnical investigation shall be checked to see whether it is sufficient for the design and execution of the diaphragm walls.

**5.1.4** If the geotechnical investigations are not sufficient, a supplementary investigation shall be conducted.

**5.2 Specific requirements**

**5.2.1** Particular attention shall be paid to the following aspects, which are relevant to the execution of diaphragm walls:

- the ground level at any point of investigation or testing relative to the recognised national datum or to a fixed reference chart datum;
- piezometric levels of all water-tables and permeability of the soils;
- presence of coarse, highly permeable soils or cavities (natural or artificial), which can cause sudden losses of support fluid and instability of the trench, and thus can require special measures;
- presence, strength and deformation characteristics of soft soils, such as very soft clay or peat, which can cause difficulties during excavation or concreting (deformation or instability);
- presence of boulders or obstructions which can cause difficulties during excavation and, an assessment of their size and frequency, when applicable;
- presence, position, strength of hard rock or other hard materials which can cause difficulties during excavation and may require the use of special tools;
- detrimental chemistry of groundwater, soil and rock, and water temperatures if required;
- detrimental chemistry of waste materials;
- presence of pretreated soil, which can have an adverse effect during excavation;
- mining beneath the site;
- site stability problems (slope stability for instance).

**5.2.2** The piezometric levels of the various water-tables existing on the site shall be monitored separately and over a sufficient period of time to estimate the highest piezometric levels which can occur during construction of the diaphragm wall.

**5.2.3** Particular attention shall be paid to artesian conditions.

**5.2.4** The strength of the soils and rocks shall be determined by laboratory tests and/or in situ tests over the full depth of the diaphragm wall and to a certain depth below the base depending on the nature of the ground and the function of the wall.

**5.2.5** When diaphragm walls are required to reach or penetrate into rock, the level of the rock surface shall be determined in both the longitudinal and transverse directions along the length of the diaphragm wall.

**5.2.6** When diaphragm walls are required to reach or penetrate into rock, the properties of the rock, including the degree of weathering and the extent and direction of fissuring, shall be determined.

## 6 Materials and products

### 6.1 Constituents

#### 6.1.1 General

**6.1.1.1** The constituents shall meet the requirements set in the respective European Standards, the provisions valid in the place of use and the provisions given in the project specification.

**6.1.1.2** The sources of supply of constituents shall be documented and shall not be changed without prior notification.

#### 6.1.2 Bentonite

**6.1.2.1** A distinction should be made between calcium bentonite, natural sodium bentonite and activated bentonite, which is a sodium bentonite produced from natural calcium bentonite by ion exchange.

NOTE 1 Bentonite is a clay containing mainly the mineral montmorillonite.

NOTE 2 Bentonite is used in support fluids either as a pure bentonite suspension or as an addition to polymer solutions. It is also used as a constituent part of hardening slurries and of plastic concrete.

**6.1.2.2** Bentonite used in bentonite suspensions shall not contain harmful constituents in such quantities as can be detrimental to reinforcement or concrete.

**6.1.2.3** The chemical and mineralogical composition of the bentonite shall be supplied.

#### 6.1.3 Polymers

Polymers can be used as sole constituent in supporting fluids or as additives to enhance rheological effectiveness.

NOTE 1 Polymers are materials formed of molecules from chained monomeric units.

NOTE 2 There are different types of polymers ranging from natural gums to specially tailored blends of synthetic products.

#### 6.1.4 Cement

**6.1.4.1** Cement for diaphragm walls shall be of the following types as defined in EN 197-1:2000:

- |                               |                        |
|-------------------------------|------------------------|
| — Portland cement             | CEM I;                 |
| — Portland-slag cement        | CEM II/A-S and II/B-S; |
| — Portland-silica fume cement | CEM II/A-D;            |
| — Portland-pozzolana cement   | CEM II/A-P and II/B-P; |
| — Portland-fly ash cement     | CEM II/A-V and II/B-V; |