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SIA 118/198:2007 Civil Engineering

507 198

REGISTERED CODE OF THE SWISS STANDARDS ASSOCIATION SNV

Replaces, together with the code SIA 197 and the code 198, 2004 issue,
the code SIA 198, 1993 issue, and the organisational part of the code SIA 195

Allgemeine Bedingungen für Untertagebau
Conditions générales pour constructions souterraines
Condizioni generali per costruzioni sotteranei

General Conditions for Underground Construction

General contract conditions applicable to code SIA 198
Underground Construction – Execution

118/198

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[1)] The numbering of Sections 1 to 7 is based on a standardised heading pattern for all *General Conditions for the Construction Industry (ABB)*. Headings which are not relevant to this code have been omitted. The numbering therefore contains individual gaps.

FOREWORD

As part of the revision of the Standard Bill of Quantities NPK for underground works, it became apparent that mechanical tunnelling in loose rock was in need of revision. A working group of the management commission for tunnelling of the SIA (NK 197) undertook this revision. In addition to the newly formulated Sections 14 and 15, Appendix F concerning pipe jacking has also been extensively revised.

Because there have also been revisions to the remainder, the SIA decided to undertake a new issue.

Content and purpose of the code

This code is part of the series of codes *General Conditions for the Construction Industry (ABB)*. Supplementing SIA 118 *General Conditions for Construction Work*, it contains detailed rules concerning the conclusion, content and implementation of contracts for construction work in the field of structures (general part) and in the field of underground construction work (special part). The code becomes legally binding if contracting parties stipulate it as constituting an integral part of their contract.

The ABB serve the purpose of regulating the rights and obligations of principal and contractor such that the requirements for the construction as described in the technical codes or as demanded by the principal are fulfilled efficiently in the execution of the construction work.

The following explanations contain information and instructions on the formulation of contracts using the ABB and other documents.

The foreword and explanations are intended solely for the information of the user. The rights and obligations of the parties to the contract are exclusively determined by the text in the general and special part of this code.

EXPLANATIONS

Basic principles for construction contracts

In addition to the technical part, previous SIA technical codes mostly also contained an organisational part. In order to create a standard basis for construction contracts, the rules previously contained in the organisational part of the technical codes have now been published independently as SIA 118/XXX *General Conditions for Construction Work (ABB)* codes.

As a parallel measure, the Schweizerische Zentralstelle für Baurationalisierung (CRB, Swiss Central Office for Building Rationalisation) is removing all contractual rules from the Normpositionen-Katalog (NPK, Swiss Standard Bill of Quantities), which is harmonised with SIA codes. These rules are being integrated into the ABB.

This results in the following harmonised system of basic rules for construction work contracts:

– Genral conditions

  SIA 118 *General Conditions for Construction Work* contains rules, which are, for the most part, suitable for all categories of work.

  The ABB (codes SIA 118/XXX), which are harmonised with SIA 118, contain supplementary rules for the individual categories of work as well as associated conditions for the description of work items in the NPK. A few of the ABB conditions contain individual rules, which replace unsuitable rules for the relevant areas of work in SIA 118. Rules in the ABB, which replace the rules of SIA 118, are in each case mentioned in Section 0.2 and identified as such in the text.

– Description of bill items

  The Normpositionen-Katalog (NPK, Swiss Standard Bill of Quantities) contains pre-formulated description of items of work, which can be used to draw up bills of quantities.

– Special conditions and cost basis

  NPK 102 contains instructions for the formulation of conditions specially applicable for a particular construction project in terms of Art. 7 para. 2 (2) of SIA 118. NPK 103 contains instructions on the definition of the cost basis in terms of Art. 62 of SIA 118.

Application of the basic principles

It is advantageous to incorporate SIA 118 together with the ABB, which correspond to the work covered by the contract, into the contract for construction work concluded between principal and contractor (see Section 0.2 of this code). Incorporating the ABB into the construction contract without at the same time incorporating SIA 118 does not produce a meaningful result and should be avoided.

The NPK can be used as a basis for the bill of quantities. The appropriate descriptions of work items are taken from the NPK and incorporated into the construction contract with defined parameters. To the extent that tenders drafted using the NPK deviate from the general conditions of SIA 118 and the ABB, the description of the bill items should be adapted accordingly.

SIA 118 and the ABB can also be incorporated into a works contract without simultaneous use of the NPK. In this case, the bill of quantities should normally be adapted to the rules of the ABB, or inappropriate rules from the ABB should be declared invalid if necessary.

The ”works which are not included” according to the ABB should if required be included in the description of bill items for the appropriate categories of work.

The use of NPK 102 *Special Conditions* and NPK 103 *Cost Basis* is also possible without using the description of the bill items in the NPK.

Incorporation of the ABB into service contracts with architects and engineers

The ABB describe responsibilities on the part of the principal, which the latter generally assigns to consultant architects, engineers or other specialists.

The ABB are not suitable for direct incorporation into contracts between the principal and the consultants commissioned by him. The responsibilities should be assigned individually according to the organisation of the project. If the regulations for services and fees (SIA regulations 102, 103 and 108) are used, then it is the duty, according to Art. 3.4.1 of these regulations, of the project management appointed by the principal to assign responsibilities within the design team. This also includes the assignment of those responsibilities referred to in the ABB.

The services of architects and engineers are described generally in SIA regulations 102, 103 and 108. Where the responsibilities assigned to the appointed specialists exceed the contractually agreed services on the basis of the regulations SIA 102, 103 and 108, they must, unless otherwise agreed, be additionally compensated by the client or employer.

Use of the ABB in contracts with general contractors

The ABB have been conceived for project organisation involving individual contractors. The incorporation of the ABB into contracts between the principal and general contractors is only practical if the services of the general contractor are described in detail. Necessary adaptations to the ABB must be set forth in an overriding part of the contract. In particular, the allocation of “responsibilities of the parties to the contract” according to the ABB needs to be adapted. The “services which are not included” according to the ABB must be included in the bill of quantities.

Generally, the ABB can be incorporated without amendment into contracts between general contractors and subcontractors. The general contractor then takes the place of the principal as a contract party.

Special status of technical codes

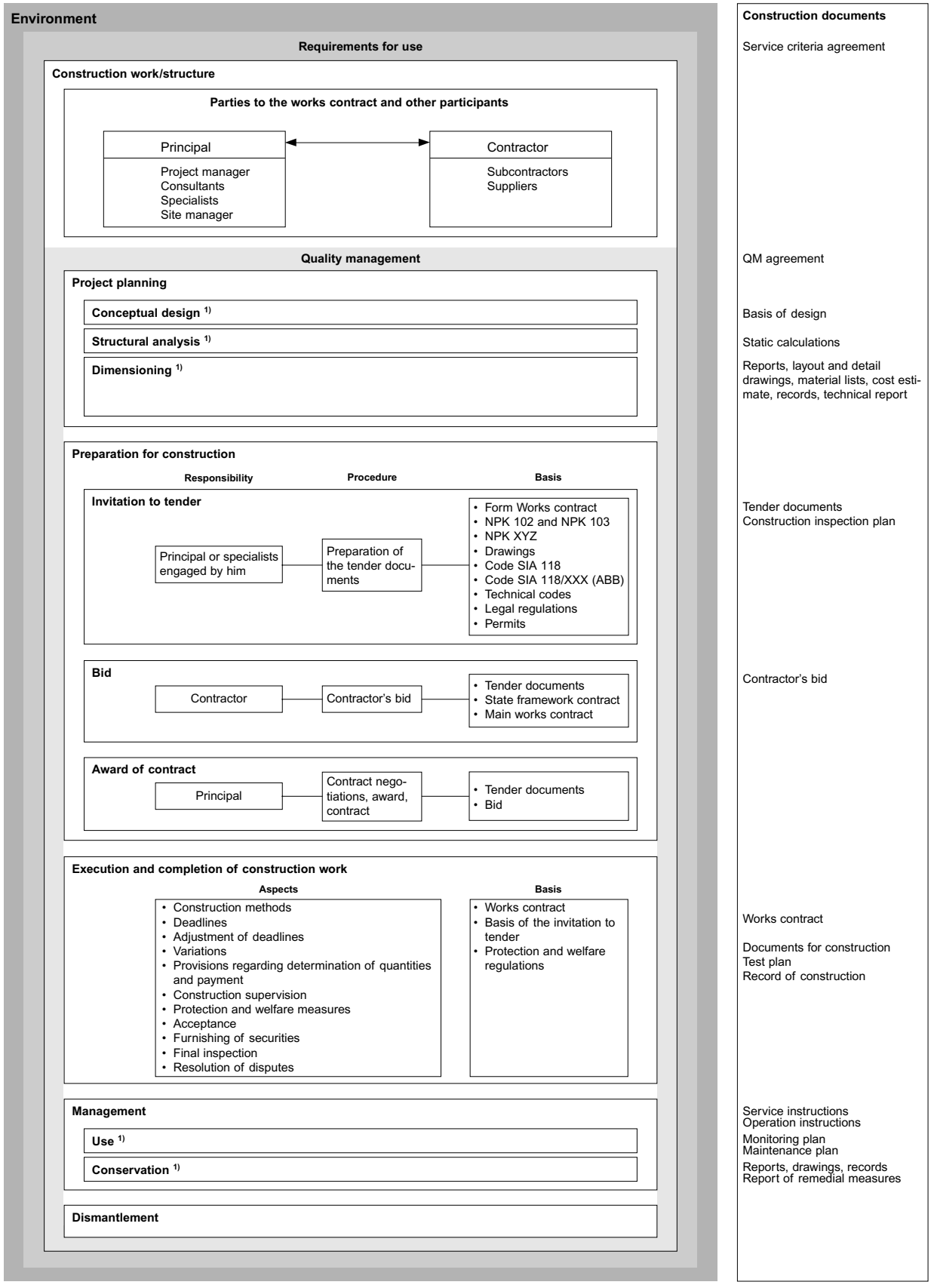
The generally recognised technical codes applied within the construction industry are generally referred to as the recognised rules of construction work. Taking into consideration the recognised rules of construction work is part of the duty of care of construction specialists, and the party ordering construction work may normally assume that these will be taken into consideration. In addition, Art. 1.3.1 of the regulations SIA 102, 103 and 108 obliges architects and engineers to observe the recognised rules in their specialist field. In order for them to be binding, it is not therefore necessary to agree that technical codes shall form a constituent part of contracts for the design or execution of construction work, but it is possible to do so.

The structural codes SIA 260 to SIA 267 and the supplementary stipulations (codes SIA 261/1 to SIA 267/1) primarily address technical aspects of design and construction. The aspects of construction, use and maintenance are addressed insofar as these are of importance to the design of the project.

Implementation of construction projects according to SIA codes

Figure 1 illustrates, for purposes of explanation, elements in the implementation of construction projects and their relationships as provided for in the SIA codes.

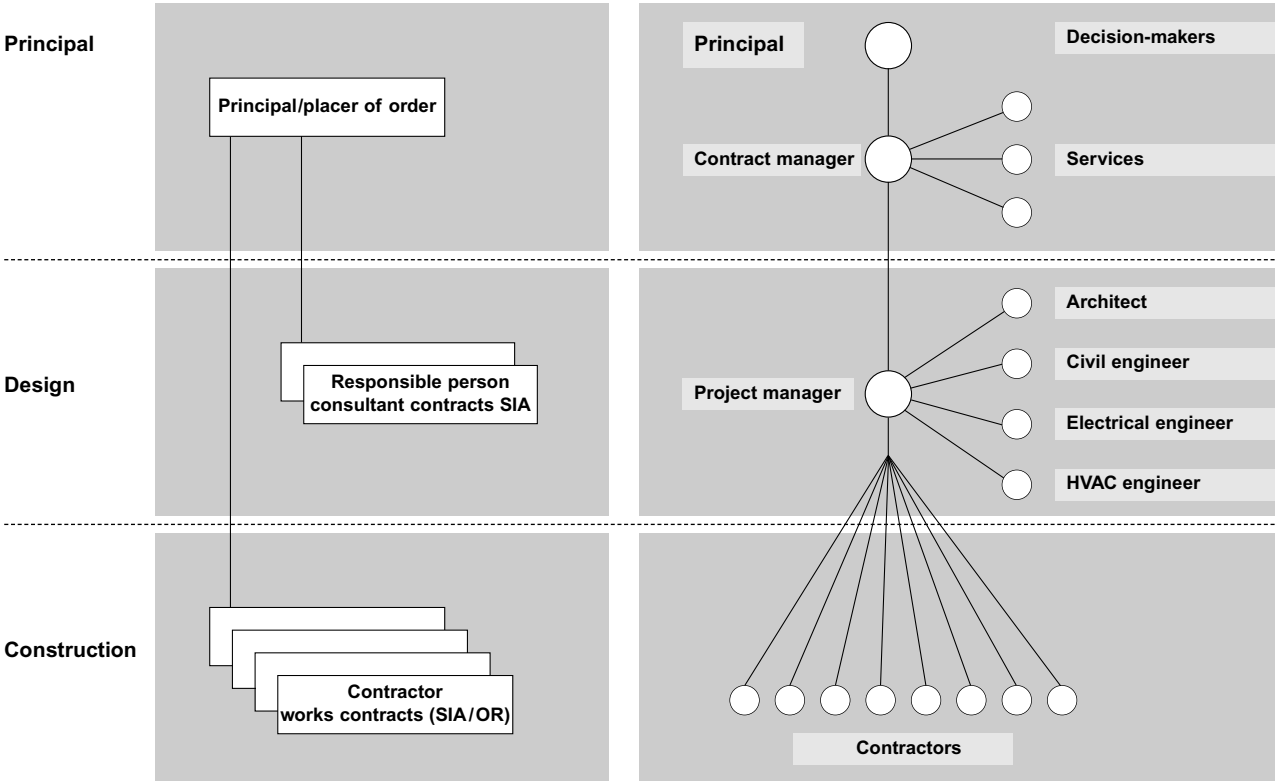
Figure 1: Elements in the implementation of construction projects and their relationships



1) Detailed information can be found in Figure 1 of SIA 260.

Advice on the form in which construction projects are implemented is contained in the SIA-documentation D 0174 *Models of collaboration: the erection and management of a structure*. An example is shown in Figure 2.

Figure 2: Principal, consultants, contractors: contractual relationship and project organisation



Contract scheme Organisational chart

0 SCOPE OF APPLICATION AND TECHNICAL TERMS

0.1 General

The terms principal or client (often also the owner) as used in this code also include the specialist consultants engaged by him, and the term contractor also includes the subcontractors and suppliers employed by him.

The present code is intended to apply to contracts for the execution of construction work by individual contractors. If the code is incorporated into contracts with general contractors, the conditions stipulated in the code should be adapted to the actual circumstances in an overriding part of the contract.

In the interests of clarity, the male form is always used for function descriptions in this code. The references apply equally to women holding these functions.

0.2 Agreement as an integral part of the contract

In order to make this code a legally binding part of a contract it, like SIA 118, must be identified in the formulation of the contract as constituting an integral part of the contract. This applies to the preparation of the tender documents (text of the proposed contract document) and to the drafting of the definitive contract document.

In the order of precedence of the integral parts of the contract according to Art. 7 and Art. 21 of the SIA 118, SIA 118/198 *General Conditions for Underground Construction Work* is grouped together with the other SIA codes.

This code contains the following amendments to SIA 118:
– Section 8.6 extends Art. 84 para. 1 of the SIA 118 concerning the forms of variations, and Art. 86 and 90 of SIA 118, concerning the effect of variations and the adjustment of deadlines, are replaced.
– Through Section 8.7, Art. 59 of the code SIA 118 concerning exceptional circumstances is partially altered.

In order for the aforementioned amendments to SIA 118 to be valid, it must be agreed in the contract document that they take precedence over SIA 118. In order to ensure that they are valid in their entirety, the following text should be used:

"The provisions of SIA 118/198 take precedence over provisions of SIA 118 in the case that they expressly replace such provisions."

0.3 Organisational terms

Bid deadline *Stichtag*	Date of submission of the bid or an earlier date specified in the tender documents (see Art. 62 para. 1 of SIA 118).
Contractor's bid *Angebot des Unternehmers*	See marginal number 1 24 (Art. 15 et seq.) of SIA 118.
Construction inspection plan *Kontrollplan*	Definition of the nature, scope, performance and timing of construction controls, including details of quality requirements and permissible deviations as well as regulating responsibilities and the flow of information.[1)]

[1)] The construction inspection plan is, in general, drawn up by the principal (see Section 1.4.3).

Included work *Inbegriffene Leistung*	Part of the contractually agreed performance of an individual item of work or ancillary activity in terms of Art. 39 para. 1 and 2 of SIA 118 or part of the section of the works or of the complete works in terms of Art. 40 para. 1 of SIA 118.
Not included work *Nicht inbegriffene Leistung*	Work, which, in addition to individual activities in terms of Art. 39 para. 1 of SIA 118 or in addition to a section of the works or the complete works in terms of Art. 40 para. 1 of SIA 118, is to be paid for separately, unless otherwise agreed.
Project manager *Gesamtleiter*	A person who is entrusted by the principal with the overall management of a project.
Quality management (QM) *Qualitätsmanagement (QM)*	Harmonised activities for the management and steering of an organisation relating to quality.
QM plan (contractor) *QM-Plan (Unternehmer)*	Definition of the planned measures and internal responsibilities for the containment of risks and exploitation of opportunities, for which the contractor bears responsibility.
QM requirements *QM-Anforderungen*	Transfer of responsibility for quality from the principal to the contractor. They define all QM-relevant demands imposed on the contractor by the principal.
QM system *QM-System*	That part of a management system which deals with quality management (QM).
Special conditions *Besondere Bestimmungen*	See Art. 7 para. 2 section 2 of Standard SIA 118.
Tender documents *Ausschreibungsunterlagen*	See marginal number 1 23 (Art. 7 et seq.) of Standard SIA 118.
Test plan *Prüfplan*	Definition of the nature, scope, performance and timing of construction controls to check the demanded quality (properties of the construction materials and of the building) as well as regulating responsibilities and the flow of information. [1)]

[1)] The test plan is, in general, drawn up by the contractor (see Section 1.4.3).

1 WORKS CONTRACT

1.1 Invitation to tender

1.1.1 Requirements exceeding those defined in technical codes should be described in the special conditions or in the specification and bill of quantities.

1.1.2 Art. 15 and 16 of SIA 118 apply with respect to amendments and additions to tender documents as well as comments and suggestions relating to these. In the case of principals, who are subject to the law regarding public procurement, the applicable regulations on the submission of bids take precedence (see Art. 4 para. 3 of SIA 118).

1.1.3 The tender documents prepared by the principal must fulfil the requirements of Art. 5 to 14 of SIA 118. In addition, Art. 40 para. 2 of SIA 118 must be complied with in the case of global or lump sum prices.

1.1.4 The special provisions in terms of Art. 7 para. 2 Section 2 of SIA 118 for a particular construction project can be formulated on the basis of the Swiss Standard Bill of Quantities (NPK) 102 (see Appendix A).

1.1.5 The principal can prepare the bill of quantities and the cost basis forms on the basis of the NPK which is harmonised with the codes of the specialist associations.

1.1.6 The specification and bill of quantities should not contain any superfluous information and should be restricted to the planned construction work. Construction variants, for which the principal is requesting parallel bids, must be identified as such in the specification and bill of quantities.

1.1.7 General quantity surcharges on work items should be avoided. Separate items should be included in order to take into account hindrances or work, which cannot be exactly estimated.

1.2 Contractor's bid

1.2.1 Static calculations for site equipment and installations, falsework, scaffolding and other auxiliary structures planned by the contractor are the responsibility of the contractor. They are to be delivered to the principal after the contract is concluded and count as being included in the price for the work.

1.2.2 Alternative proposals tendered by the contractor should contain all documents required for their technical and financial evaluation, as well as suggestions for the necessary adaptation of the contract documents, specifically the special conditions.

1.2.3 The principal may not make use of contractor's alternative proposals without authorisation (Art. 5 (a) of the federal law against unfair competition UWG). In particular, he may not invite bids for these from competitors in the tendering process; the principal may not use alternative proposals offered by unsuccessful bidders.

1.3 Responsibilities of the parties to the contract

1.3.1 General

1.3.1.1 Before commencing the design and before carrying out construction work, the principal and contractor should completely and unequivocally regulate the duties, competences and responsibilities of the persons involved in the construction work.

1.3.1.2 In practice, various combinations are possible depending on the nature and scope of the construction tasks, from the delegation of the principal's responsibilities to various persons to the complete combination of the tasks in one person (project manager).

1.3.1.3 If the delegation of the principal's responsibilities leads to several persons representing the principal with respect to the contractor, Art. 35 of SIA 118 applies.

1.3.1.4 The lists of responsibilities of the parties to the contract in the general part and in the special part of the code are not final and can be adapted and supplemented for a specific project.

1.3.1.5 Unless otherwise agreed, the responsibilities of the contractor described in this code count as inclusive services.

1.3.1.6 The construction inspections defined in the construction inspection plan take the form of spot checks. They do not exempt the contractor from the obligation to carry out all checks which are necessary in order to be able to compliance with the requirements.

1.3.1.7 Unless otherwise agreed, the contractor is not entitled to demand that the principal supervises the fulfilment of the contract. The principal is only liable for the consequences of lack of checking or inspection by the principal if the check or inspection, which was not carried out, is described individually and is contractually agreed or has been demanded by the contractor according to a provision in a part of the contract. A further condition is that the contractor has demanded that the check or inspection be carried out by the principal in good time. Otherwise, the contractor's obligations regarding reporting and the issue of formal reminders according to Art. 25 of SIA 118 apply.

1.3.2 Preparation for construction

1.3.2.1 The principal (or the project manager employed by him) has the following duties:
- Co-ordinating and managing the specialists employed by him
- Definition of the relevant process and product-related QM requirements
- Ensuring the flow of information and documentation, including organisation of the exchange of technical and administrative data between the participants in the project
- Orientation of the specialists employed by him and the contractor concerning those aspects, to which particular attention must be paid during the execution of work
- Obtaining the permits required for the construction project
- Organising utility supplies and waste disposal on the construction site
- Co-ordinating the preparation of the construction dossier.

1.3.2.2 The principal (or the consultant specialists employed by him) has the following duties:
- Clarification of local circumstances and special requirements
- Preparation of the technical construction documents such as structural and geotechnical calculations, drawings and material lists as well as information on the assumed and specified properties of the materials
- Preparation of the construction inspection plan
- Checking of the construction and assembly procedures for compatibility with the project and approval of these procedures.

1.3.2.3 The contractor has the following duties:
- Designation of the site manager in charge of the execution of construction work
- Delegation of the contractor's responsibilities to subcontractors and suppliers including conclusion of the necessary contracts
- Description of complex working procedures
- Preparation of the test plan
- Preparation of the construction schedule
- Planning of the site installations, construction and assembly procedures and scaffolding to be used for falsework, protection and working platforms
- Development of a plan for safety at work, adapted to the object and complying with the guidelines of the Swiss Accident Insurance Institution (SUVA)
- Obtaining the necessary approvals for the site installations
- Obtaining the necessary permits in connection with the execution of work
- Preparation of instructions in the event of environmental incidents.

1.3.3 **Execution**

1.3.3.1 The principal (or the specialists employed by him) has the following duties:
- Comparison of the correctness of the design data prepared in advance and the assumptions made during the execution of work
- Monitoring quality control by the contractor
- Deciding on further action in the event of deviation from specified values
- Monitoring construction according to construction inspection plan
- Verifying the correctness of the design data and assumptions defined for the project
- Setting out the axes, identifying the fixed reference points and handing over the surveying documents to the contractor
- Preparation of the minutes of site meetings and keeping a construction journal
- Checking the practicality of the construction site installations and the construction schedule
- Examining and recording the condition of the ground.

1.3.3.2 The contractor has the following responsibilities:
- Implementation of a construction site organisation appropriate for the construction project
- Monitoring of the execution of work (execution controls according to test plan)
- Control of quality by means of documented procedures
- Proper transportation and storage of construction materials and components to and on the construction site
- Preparation of the daily reports.

1.4 Quality management

1.4.1 Taking into account the complexity and the risks of the project as well as the principle of proportionality, the principal decides the level of requirements for quality management in the special conditions:
- Level I: no actual QM system is required, but it is assumed that the rules, codes and guidelines drawn up by the professional associations will be applied consistently
- Level II: a QM system is required and must be documented
- Level III: a QM system certified on the basis of the SN EN ISO 9001 *Quality Management System – Requirements* is required.

1.4.2 If Level II or Level III is stipulated, Sections 1.4.3 and 1.4.4 apply to all construction work.

1.4.3 The following provisions regarding QM must be made, as a priority, when inviting tenders:
- The principal will define the requirements for the quality-relevant categories of work and activities in the special conditions (in particular the construction inspection plan)
- The principal will define the minimum requirements regarding the contractor's QM plan (in particular the test plan) in the special conditions.

1.4.4 The following provisions regarding QM must be made, as a priority, during the execution:
- The contractor will control the quality of the services to be performed by him and by their subcontractors by means of documented procedures as part of their object-specific QM plan
- The principal will monitor the success of the quality control by the contractor and will if necessary initiate corrective measures.

1.4.5 The following applies to payment for the work performed by the contractor in relation to QM:
- Quality control measures count as being included in the prices for the individual activities
- Tests additionally ordered by the principal will be paid for separately if they exceed the general conditions for the method of construction.

1.4.6 If the contractor fails to carry out the quality assurance measures which he is contractually obliged to perform, at no fault on the part of the principal, then the principal will set him an appropriate deadline for remedying this. After this deadline has expired without result, the principal is entitled either to carry out the measures in question himself or have them carried out by third parties at the cost and risk of the contractor.

1.4.7 If errors or defects are repeated which clearly arise from the same or similar causes, the principal is entitled, to a reasonable extent, to have the work in question suspended, at the cost and risk of the contractor,

until the causes have been identified and remedied. The principal reserves the right to proceed in accordance with Art. 366 para. 2 of the Swiss law on obligations (OR) if the relevant preconditions are fulfilled.

1.5 Resolution of disputes

In the event of disputes, a procedure for arriving at an amicable resolution should be followed (construction site decision procedure in accordance with SN 641 510 *Resolution of Disputes*, mediation, etc.)

If the parties to the contract cannot agree on a procedure, the construction site decision procedure is recommended, which comprises three levels for discussions:
– Contact between site management/site foremen
– Contact between senior construction management/technical management
– Discussion between directors.

2 PAYMENT FOR WORKS PERFORMED BY THE CONTRACTOR

2.1 Provisions regarding payment

2.1.1 The principal will stipulate in the tender documents which tests of construction materials are to be calculated into the price and which will be paid for separately.

2.1.2 The draining of surface water will not be paid for separately unless it requires special measures (pumps, chemical treatment, soakaways, etc).

2.1.3 Some bills of quantities contain, in contrast to Art. 43 of SIA 118, items showing provision of equipment throughout the duration of construction work as being charged for on a global or flat-rate basis. In calculating the value of the work performed for stage payments, Art. 146 of SIA 118 will also be applied to these items.

2.1.4 If new or amended legal regulations or technical codes come into force following the bid deadline, the principal and contractor will agree on additional or reduced payment.

2.2 Determination of quantities

2.2.1 In the case of services tendered on the basis of graduated ranges, the entire quantity will be measured with the item, within the range of which the performed work falls. Examples of such services are trench depth 0–1.00 m, 1.01–1.50 m, 1.51–2.00 m, etc. or transport distance 0–100 m, 101–200 m, 201–500 m, etc. Regarding this rule, see also NPK leaflet no. 4 *Measurement Ranges* published by the Swiss Central Office for Building Rationalisation (CRB).

2.2.2 In the case of items, in particular those relating to site equipment and installations, which are tendered on a per-month or per-week basis, the following applies:
– for part months, $^1/_{30}$ of the agreed unit price for the month will be paid per calendar day
– for part weeks, $^1/_7$ of the agreed unit price for the week will be paid per calendar day.

5 FURNISHING OF SECURITIES

5.1 Unless otherwise agreed, SIA 118 applies to the furnishing of securities by the contractor.

5.2 The furnishing of special securities necessitated by significant technical risks (variants, special designs, new methods) or by financial risks (creditworthiness of the contractor) is to be regulated separately in the works contract, preferably on the basis of the leaflet SIA 2020 *Furnishing of securities by the contractor in the works contract*.

8 UNDERGROUND CONSTRUCTION WORK, GENERAL

8.0 Scope of application and technical terms

8.0.1 Limitation

This code SIA 118/198 relates to works in underground construction, to which the SIA 198 *Underground Construction Work – Execution* is applicable.

This code applies analogously to services to which the SIA 195 *Pipe Jacking* is applicable; see Appendix F in particular.

8.0.2 Technical terms

Actual construction time *Ist-Bauzeit*	Time actually required for construction.
Advance sealing *Vorabdichtung*	Measure for conducting away penetrating water such as half shells, dimpled sheeting, etc.
Anchor *Anker*	Construction element which transmits force into the ground through a tensile member or (in the case of grouted anchors) increases the shear resistance within the ground.
Annular space *Ringspalt*	Gap between the outer surface of the installed segments and the excavated surface.
Arch *Gewölbe*	Development of the theoretical excavated surface except invert.
Auxiliary construction measure *Bauhilfsmassnahme*	Advance measure as part of the tunnel driving to ensure working safety and the stability of the cavity.
Blade shield *Messerschild*	Shield skin consisting of individual steel planks (blades, spiles) which lie on several moveable steel ribs and can be advanced individually.
Bored diameter D_b *Bohrdurchmesser* D_b	Diameter of the cavity created with worn gauge cutters (in TBM tunnelling).
Bored diameter/nominal diameter D_n *Bohrdurchmesser/Nenndurchmesser* D_n	Diameter of the cavity created with new gauge cutters (in TBM tunnelling).
Cavern *Kaverne*	Underground structure with a large cross-section and relatively short length.
Collapse *Niederbruch*	Sudden collapse of disturbed, jointed and/or broken rock mass, rockburst and spalling or breaking out caused by stress.
Compressed air method (compressed-air support) *Druckluftverfahren (Druckluftstützung)*	Construction method in which the groundwater pressure at the tunnel face is compensated using compressed air.
Compressed air shield *Schild mit Druckluftunterstützung*	Shield with bulkhead in which the groundwater pressure at the tunnel face is compensated by means of compressed air within the excavation space.

Construction time *Bauzeit*	Total time required to carry out the construction work.
Construction time for valuation purposes *Abrechnungs-Bauzeit*	Duration of construction work valid for valuation purposes, calculated from the applicable quantities in the final measurement and the performance data of the contractor as set forth in the works contracts taking into account variations and interruptions recognised in the works contract.
Cuttability *Abbaubarkeit*	Possibility of excavating rock or soft ground using mechanical means (equipment, machines).
Cuttability class *Abbauklasse*	Classification of the rock mass according to the work involved in excavating a certain distance using mechanical means.
Cutting area *Schneidbereich*	Area which can be cut from one location with the cutting head.
Dewatering *Entwässerung*	Measures for collecting and draining off water and fluids.
Dewatering *Wasserhaltung*	Construction measures during execution for draining away the formation and process water to a discharge point
Drainage *Drainage*	Drainage of the rock mass by means of boreholes, drain pipes, surface elements, soakaway packings, invert ballast, etc.
Duration of shift *Schichtdauer*	Working time per shift at working location.
Earth pressure balance machine *Schildmaschine mit Erddruckunterstützung*	Tunnelling machine inside a shield and equipped with a bulkhead. The tunnel face is supported by the excavated soil, which collects between cutterhead and bulkhead. The pressure is maintained through the removal of the excavated spoil with a screw conveyor, or by variable discharge openings.
Excavation class *Ausbruchart*	Way of dividing the excavated cross-section into individual excavation stages (full-face excavation or partial excavation).
Face support *Bruststützung*	Temporary support of an unstable tunnel face using rock wedges, anchor bolts, etc.
Ground freezing *Gefrierverfahren*	Construction method in which the ground is solidified and rendered impermeable by means of artificial freezing.
Heading *Stollen*	Underground structure with a small cross-section; referred to in this code as a tunnel.
Jacked pipe *Pressrohre*	Prefabricated pipe element for underground pipelines created using trenchless methods.
Jet grouting *Jetting (Düsenstrahlverfahren)*	Ground solidification technique in which the soft ground is broken up with high-pressure jets and solidified into columns with a cement suspension.
Lining *Ausbau*	Measures for ensuring the stability and restricting the deformation of the excavated cavity during the construction and use phases; comprises the support and the permanent lining.
Overbreak *Überprofil*	Additional excavation resulting from the method of working or collapse due to geological conditions or additional excavation in the invert area (outside the design profile).
Permanent lining *Verkleidung*	Measures carried out to supplement the excavation support or separately in order to provide the supporting structure (vault) with the necessary properties (load-bearing capacity, form, appearance, etc).

Pipe umbrella *Rohrschirm*	Steel pipes driven outside of the excavation cross-section to secure the subsequent excavation work.
Planned construction schedule *Soll-Bauprogramm*	Construction schedule based on the planned construction time and the intended times required for installation work and relocation.
Planned construction time *Soll-Bauzeit*	Construction time based on the works contract, calculated from the applicable quantities in the bill of quantities (at the time the contract was concluded) and the performance data stated by the contractor in the works contract as well as the planned interruptions to work.
Profile type *Profiltyp*	Representation of the excavated cross-section, the support, any auxiliary constructional measures and the permanent lining.
Ring closure length *Ringschlusslänge*	Maximum distance between tunnel face and support closed to form a ring. A distinction is made between the ring closure of partial areas in partial excavation and the ring closure of the entire excavated cross-section.
Roadheader (TSM) *Teilschnittmaschine (TSM)*	Machine used for the mechanical excavation of the rock mass with a cutting head which only excavates one part of the tunnel face at any time (road heading).
Round length *Abschlaglänge*	Length of tunnel excavated with one blasting operation in full-face and top heading excavation, excavation of crown and side headings as well as shafts excavated upwards.
Scrubber *Entstaubung*	Equipment for filtering the dust out of the air.
Sealing *Abdichtung*	Measures for keeping out water (to protect components or cavities) or to prevent loss of fluids from the cavity.
Shaft, inclined shaft *Schacht, Schrägschacht*	Underground construction with a gradient of over 20%.
Shield *Schild*	Steel construction installed for the temporary support of the rock mass or for the purposes of working safety.
Slurry shield machine *Schildmaschine mit Flüssigkeitsstützung*	Tunnelling machine inside a shield and equipped with a bulkhead. The tunnel face is supported with a mixture of excavated soil and supporting fluid. The pressure is regulated by means of an air cushion behind the bulkhead or by pumping the supporting fluid, which also serves as a transport medium.
Spiles, spile umbrella *Spiesse, Spiessschirm*	Steel rods or pipes driven outside of the excavated cross-section to secure the subsequent excavation work.
Standard profile *Normalprofil*	Representation of the typical cross-section with information on support, sealing, dewatering, permanent lining and inner lining as well as the usable spaces and operating equipment.
Support *Ausbruchsicherung*	Measures for maintaining working safety and stability and for restricting deformation of the rock mass in the area of the excavated cavity during the construction phase.
Support class *Sicherungsklasse*	Classification of the support according to the type, quantity and installation area of the measures.
Tunnel *Tunnel*	Underground structure of great length and with a maximum gradient of 20%.
Tunnel boring machine (TBM) *Tunnelbohrmaschine (TBM)*	Machine used for the mechanical excavation of the rock mass with a cutter head which cuts the entire tunnel face with each revolution (full-face tunnelling).

Tunnelling *Vortrieb*	Work required in order to create a cavity in the rock mass. This includes excavation and support as well as any auxiliary constructional measures.
Tunnelling class *Bohrklasse*	Classification of the rock mass according to the work required in order to drive a certain length of tunnel.
Tunnelling equipment *Vortriebseinrichtung*	Machinery and equipment for tunnelling.
Tunnelling machine *Tunnelvortriebsmaschine*	Tunnelling machines excavate the entire excavated cross-section using a cutter head or a cutter wheel over the full face or partial areas, using suitable excavation equipment. A distinction is made between tunnel boring machines (TBMs), tunnel reamers (TBE) used in rock, and shield machines (SM) used in soft ground with or without groundwater.
Tunnelling method *Vortriebsverfahren*	Type and method of tunnelling.
Undercut *Unterschnitt*	Cutting depth of the road header below its own standing surface.
Working area *Arbeitsbereich*	Location where the different support measures are installed. A distinction is made between: L1: face area; L2: driving area; L3: rearward area
Working day (WD) *Arbeitstag (AT)*	A working day comprises the working hours in a calendar day, the number of which results from the number of shifts and duration of a shift.
Working zone *Arbeitszone*	Section of the working areas L1*, L2*, L3* in mechanical tunnelling, in which support work is carried out (specified by the contractor).

8.1 Invitation to tender

8.1.1 Information regarding the rock mass

8.1.1.1 The principal provides information about the rock mass (ground). He determines its properties in good time by means of investigations. The scope of investigations depends on the rock mass and the local conditions to be taken into account (e.g. groundwater) as well as the construction methods, which are conceivable from a technical viewpoint.

8.1.1.2 Knowledge of the geological, geotechnical and hydrogeological circumstances is an essential basis for an efficient project as well as for the invitation to tender and the bid.

Correct interpretation and its appropriate implementation with the construction methods, which are practical for a particular project, represent a prerequisite for limiting the geological risk.

8.1.1.3 The principal makes the documentation concerning the ground conditions available to the contractor completely and in an appropriate form.

8.1.2 Information regarding the project and construction

8.1.2.1 In the tender documents, the principal communicates:
- the underlying considerations which resulted in the design, for which tenders are invited
- the requirements for the individual components in terms of load-bearing capacity and serviceability
- the function of the excavation support as a temporary or permanent measure (e.g. load-bearing part of the permanent lining).

8.1.2.2 The principal states the values for errors in construction which are to be taken into account in the project:
- Deformations of the rock mass for the tendered tunnelling method
- Inaccuracies in construction or space to accommodate inaccuracies in construction
- Axis deviations (surveying errors).

8.1.2.3 The principal specifies the limits for inaccuracies in construction, e.g. for the:
- thickness of the excavation support and the permanent lining
- deviation of the inner side wall from the theoretical position (e.g. angle, kinks)
- size and type of offsets (e.g. joints in formwork, joints between segments)
- position and shape of parts of the inner lining.

8.1.2.4 The principal specifies any special measures resulting from the properties of the rock mass, e.g. for:
- underground transport roads, if construction site traffic can have adverse effects on the rock mass.

8.1.2.5 The principal announces the conditions for:
- the areas for construction site setup and installations
- the supply connections and waste disposal arrangements for the construction site (transport, water, electrical energy, waste water)
- material management and tipping possibilities
- the protection of neighbouring structures and installations
- limitation of the effects on the environment as well as any securing of evidence.

8.1.2.6 The principal supplies the necessary information for the design of the construction ventilation, e.g.:
- Types of rock and their quartz contents; occurrence of rock containing asbestos
- Occurrence of gas and of radioactive rock as well as the resulting ventilation measures and monitoring equipment
- Forecast of rock temperature (deep overburden) and the resulting ventilation and cooling measures
- Conditions for the use of shafts, tunnels etc. to implement an air circulation system
- Possibilities (permits) for sinking additional ventilation shafts during the construction phase.

8.1.2.7 The principal notifies the imposed permit conditions, such as:
- conditions arising from the environmental impact study
- conditions attached to the construction permit.

8.1.3 Information regarding the invitation to tender

8.1.3.1 The principal can define framework conditions for contractor's alternative proposals, such as:
- permissibility of project variants
- exclusion of certain tunnelling methods
- deadlines which must be met
- properties of the project design, which must be complied with.

8.1.3.2 The specification and bill of quantities are broken down according to certain criteria.

The main criteria are:
- The type of structure (Section 8.1.4)
- Tunnelling method (Section 8.1.5).

With regard to tunnelling, the following criteria are decisive, depending on the tunnelling method:
- Excavation class (Section 8.1.6)
- Support class (Sections 8.1.7 and 8.1.8)
- Cuttability of the rock mass (Section 8.1.9)
- Stability of the tunnel face (type and quantity of the face support).

The auxiliary constructional measures and measures in the event of water inflow, occurrence of gas or high rock temperatures are dealt with separately. The same applies to the work following tunnelling, such as sealing, permanent lining and inner lining.

8.1.4 Type of structure

8.1.4.1 A distinction is made between the following types of structure:
- Tunnel (in this context, galleries are also classed as tunnels)
- Shaft (vertical or inclined shaft)
- Cavern (the distinction between a cavern and a short tunnel with a large cross-section is based on the excavation class).

8.1.4.2 Several objects of the same type of structure can be found in one project. They are referred to by different project-specific terms.

8.1.5 Tunnelling method

8.1.5.1 A distinction is made between the following tunnelling methods (Table 1):
- Drill & blast tunnelling in rock (D&B)
- TBM tunnelling in rock, i.e. tunnelling using a tunnel boring machine (TBM) with or without shield or a tunnel reamer (TBE)
- Mechanically-assisted tunnelling in rock (MR)
- Mechanically-assisted tunnelling in soft ground (MSG)
- Shield tunnelling in soft ground (SM).

Table 1: Overview of tunnelling methods

	Rock			Loose rock	
Tunnelling method	D&B	TBM TBE	MR	MSG	SM
Excavation of the ground by	drilling and blasting	cutterhead	rock breaker, drag pick, roadheader/, cutting head perhaps supported by blasting to loosen rock	rock breaker, excavator bucket, drag pcick, roadheader/ cutting head perhaps supported by blasting to loosen rock	cutterhead, rock breaker[1)], excavator bucket[1)], drag pick[1)], roadheader/ cutting head
[1)] Fixed excavation devices					

8.1.6 **Excavation classes**

8.1.6.1 The excavation class defines in which partial cross-sections and in what sequence the profile is excavated.

8.1.6.2 For tunnels, a distinction is made between the following excavation classes:
A: full-face excavation
B: top heading and subsequent excavation of bench and invert
C: divided top heading and subsequent excavation of bench and invert
D: side headings and subsequent excavation of top heading, core and invert
E: other partial excavation classes defined by the principal on an project-specific basis.

8.1.6.3 For vertical and inclined shafts, a distinction is made between the following excavation types:
– Full-face excavation
– Construction process involving a pilot shaft and subsequent enlargement. Both excavation phases count as full-face excavation.

8.1.6.4 In general, caverns are excavated in partial cross-sections. The excavated cross-section and the sequence of partial excavations are to be stipulated in the tender documents.

8.1.7 **Support classes and support types**

8.1.7.1 The support class takes into account the hindrance to tunnelling caused by the installation of the support.

8.1.7.2 A distinction is made between the following support classes:
SC 1: the support causes insignificant hindrance to tunnelling operations
SC 2: the support causes slight hindrance to tunnelling operations
SC 3: the support causes considerable hindrance to tunnelling operations
SC 4: the support causes severe hindrance to tunnelling operations (immediate support following each round)
SC 5: the support causes extremely severe hindrance and may necessitate immediate support of the face or auxiliary constructional measures
SC T: the support is installed in the form of segments, installed inside the shield skin (TBM or SM).

8.1.7.3 A particular support class can if required be divided through the determination of more than one support type.

8.1.7.4 The type, quantity and installation location of the support measures are decisive for the classification into support classes or support types.

8.1.7.5 The support classes or the support types are defined in the tender documents. The guide values shown in the Tables 4, 6, 7, 9, 11, 13 and 14 count as being contractually agreed, unless otherwise stipulated.

If several support measures are listed in one table field of a support class, each measure on its own is sufficient for classification.

Support measures outside of the identified working areas have no influence on the classification.

8.1.7.6 Measures for working safety which consist of the same measures as used for support of the cavity are also taken into account in determining the support class or the support type.

8.1.7.7 The choice and use of construction equipment are the responsibility of the contractor and have no influence on the support class.

8.1.7.8 If necessary, the principal will stipulate in the tender documents the location of the ring closure for each partial excavation and the full cross-section.

8.1.7.9 Local widenings and niches are assigned the support class or the support type of the main tunnel, irrespective of whether they are created at the same time the tunnel is driven or subsequently.

8.1.8 Working areas

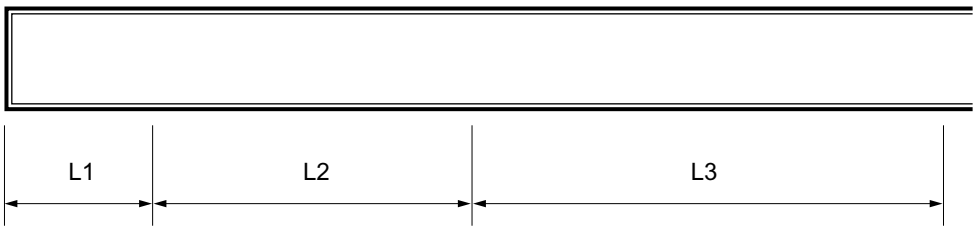
8.1.8.1 The excavation and the installation of the support measures hinder one another. The type, quantity and location of installation of the support measures influence the advance rates. A distinction is therefore made between different working areas in the tunnel starting from the tunnel face.

The following working areas apply to the tunnelling method used in rock.

8.1.8.2 The working areas for tunnels are designated as follows:
L1: face area or machine area in TBM tunnelling
L2: unsupported advance area or back-up area in TBM tunnelling
L3: rearward area; in TBM tunnelling up to 200 m behind the back-up.

8.1.8.3 The working area L1 is measures from the tunnel face, the areas L2 and L3 are measured after one another as shown in Figure 3.

Figure 3: Working areas for tunnelling in rock



8.1.8.4 The working areas are defined in the tender documents. The guide values shown in Tables 5 and 12 count as being contractually agreed, unless otherwise stipulated.

8.1.9 Cuttability of the rock mass

8.1.9.1 The variable cuttability of the rock mass can be taken into account in TBM tunnelling by means of the tunnelling classes according to Section 12.1.3 and in MR and SM tunnelling by means of the cuttability classes according to Section 13.1.5.

8.1.9.2 Stretches of tunnel which lie in the same geological formations or rock types, or ones which are comparable in terms of excavability, are combined into sections with the same cuttability (tunnelling or cuttability class).

8.1.9.3 Different classification criteria can occur over a certain distance at a transition between one rock type and another. If this is not specially regulated in the tender documents, then the classification is determined on the basis of the ground encountered at the apex line of the tunnel or at the excavation cross-section.

8.2 Contractor's bid

8.2.1 General addenda accompanying the bid

8.2.1.1 Generally, the addenda comprise the documents or information listed below.

8.2.1.2 Explanations regarding the bid:
- fundamental considerations on the part of the contractor, which form the basis for his bid.

8.2.1.3 Organisation of the contractor or the consortium:
- Composition of the consortium
- Lead company, technical and business management
- Assignment of work within the consortium and participation shares
- Construction site organisation, organisational chart showing site management
- CVs of the managing personnel on the construction site
- Quality management concept according to Section 1.4.1
- Concept of the measures for occupational health and safety protection
- References for the proposed construction methods
- Proposed subcontractors
- Most important proposed suppliers and sources.

8.2.1.4 Description of the general site setup and equipment:
- Measures for accommodation and catering
- Workshops and stores
- Description of additionally required areas.

8.2.1.5 Description of the special site equipment and installations including a list of the most important equipment with the services involved as well as the proposed periods for which equipment will be made available, in particular:
- tunnelling equipment
- plant for concrete production
- formwork (mobile formwork).

8.2.1.6 Description of the transport installations including loading and unloading facilities as well as the crushing equipment listed in Appendix B.

8.2.1.7 Description of the site ventilation:
- Necessary fresh air requirement for the proposed construction methods
- Ventilation scheme for the proposed construction methods and possible events (e.g. fire)
- Diameter and quality class of air ducts
- Delivery quantities of the fans and energy consumption
- Proposed dust extraction systems with characteristic data and locations
- Space required for the largest items of equipment, layout of ducts
- Noise reduction measures
- Structural measures for controlling the air flow in air circulation systems.

8.2.1.8 Statement of the average energy consumption per month and the necessary transformer output in kVA.

8.2.1.9 Statement of the average water consumption per month and the maximum consumption in m^3/min.

8.2.1.10 Description of the measures for the implementation of disposal arrangements for the construction site, material management, water conservation and noise reduction.

8.2.1.11 Information on any tips operated by the contractor.

8.2.1.12 Description of the construction processes for the drive including auxiliary construction measures, permanent lining and the internal fitting out.

8.2.1.13 Construction schedule and performance data:
- Diagrammatical construction schedule for the most important quantities in the bill of quantities as planned construction schedule stating personnel requirements
- Analytical calculation of the planned construction time for the most important working phases (example in Appendix C)
- Critical path.

8.2.1.14 Plans, where the description does not provide sufficient information, e.g.:
- location of the site setup installations
- tunnelling equipment
- construction operations
- auxiliary constructional measures.

8.2.2 Special addenda to the bid

8.2.2.1 Additional information is required depending on the construction method.

8.2.2.2 Information about drill & blast tunnelling in rock:
- Drilling equipment
- Blasting plan
- Back-up.

8.2.2.3 Information on TBM tunnelling and TBE tunnelling in rock:
- Location and length of the working areas L1, L2, L3 and working zones L1*, L2* and L3*
- Type of possible support work in each working area
- Necessary quantity of water required for dust suppression, cooling of motors and tools etc.
- Technical data on machines according to Appendix B.

8.2.2.4 Information on mechanically assisted tunnelling:
- Information on excavating equipment according to Appendix B
- Proposed measures for dust extraction in the working areas
- Any other machines and equipment planned for use
- Information on shield according to Appendix B
- Information on blade shield according to Appendix B.

8.2.2.5 Information on SM tunnelling in loose rock.

8.2.2.6 Information on segment production and handling:
- Dimensions of the segments including manufacturing tolerances
- Manufacture, storage and curing
- Transport equipment and installation equipment
- Actions on the segments during manufacture, storage, transport and installation
- Actions on the segments or the segment ring caused by the tunnelling equipment.

8.2.2.7 Information about ground freezing:
- Thermal calculations corresponding to the sequence of construction operations, dimensioning of the frozen ground mass
- Drilling work (drilling technique, arrangement and diameter of the drillholes, positioning of the drillholes, drilling accuracy)
- Measures to counteract water pressure
- Freezing pipes (installation of the freezing pipes, grouting of annular space)
- Refrigerating system (refrigerating units, refrigerants, coolants, power used in producing and maintaining the frozen ground mass, etc.)
- Measuring and monitoring systems (measures to counteract coolant losses, temperature measurements, determination of the existing frozen ground mass, measurements on the surface, convergence measurements)
- Proposed measures for rectifying defective locations in the frozen ground mass.

8.3 Resposibilities of the contract partners during the execution

8.3.1 Principal and contractor, jointly

8.3.1.1 On the basis of the assessment of the ground conditions, the principal and contractor will mutually agree the necessary excavation support.

8.3.1.2 If support measures are used other than those identified in the definition of the support classes, they will be assigned to the support class by the principal and contractor jointly.

8.3.1.3 If, despite the support being installed properly and in good time, the cavity is deformed beyond the permissible degree by ground pressure, then the principal and contractor will decide jointly which additional measures need to be taken.

8.3.1.4 If, as a result of other ground conditions, changes in relation to the project in terms of excavation type, support or auxiliary constructional measures become necessary, then the principal and contractor will decide jointly on the measures to be applied.

The technical and deadline-related aspects should be taken into account to a reasonable degree. Frequent changes should be avoided.

8.3.1.5 If it is not possible to drive the tunnel using the proposed method, the principal and contractor will jointly define the measures to be taken.

8.3.1.6 If more water is encountered than provided for in the works contract, the principal and contractor will jointly define the measures to be taken.

8.3.1.7 In the case of tunnelling with compressed-air face support or with slurry face support, the principal and contractor will jointly define concept for limiting damage in the event of a blow-out before work is commenced.

8.3.2 Contractor

8.3.2.1 The contractor will prepare a health and safety plan on the basis of the existing documents and will determine the necessary measures.

8.3.2.2 The contractor will obtain in good time at least the quantities of the necessary materials as periodically agreed with the principal and keep them available on the construction site.

8.3.2.3 If there is a danger during tunnelling of collapses, outflow of soil, heaving of the invert, water ingress, structural damage or other dangers, the contractor will immediately take the necessary measures to prevent or limit damage and will notify the principal straight away.

Damage, which has already occurred, must be reported to the principal immediately.

Further measures will be decided on by the principal and contractor jointly according to Section 8.3.1.4 or 8.3.1.5.

8.3.2.4 The contractor will decide on the method for the manufacture, handling (storage, transport) and installation of the segments and will submit their concept to the principal.

8.3.2.5 The contractor can suggest a change in or maintenance of the excavation type and submit this to the principal for approval, even if there are no geotechnical or hydrogeological grounds for doing so.

The approval of the principal does not count as a variation (payment and deadlines remain unchanged).

8.3.2.6 The contractor can provide additional excavation for operational reasons (e.g. by-pass points, turning or assembly and dismantling spaces) and submit these to the principal for approval.

The approval of the principal does not count as a variation (payment and deadlines remain unchanged).

With their approval, the principal specifies the construction measures to be carried out to achieve the final condition of the tunnel.

8.4 Provisions regarding payment

8.4.1 General

8.4.1.1 The cost of tunnelling (excavation and support) is principally influenced by the:
- type of the structure (tunnel, shaft, cavern)
- tunnelling method
- excavation class
- support class (type, area and quantity of the support measures)
- cuttability of the rock mass (tunnelling or cuttability class)
- stability of the tunnel face (type and quantity of the face support)
- auxiliary constructional measures (type, scope, location of installation).

In addition there are other circumstances which, depending on requirements, influence tunnelling, such as advance investigation measures, measurements for monitoring during the construction phase and special measures in the event of inflow of water, the presence of gas or high temperatures.

8.4.1.2 This leads to the classification of excavation items according to Table 2.

Table 2: Overview of the classification of excavation items

	Rock			Loose rock		
Tunnelling method	D&B	TBM	MR	MSG	SM	
Excavation class	A, B, C, D, E	A	A, B, C, D, E	A bis E	A	
Support class SC	1, 2, 3, 4, 5	1, 2, 3, 4, 5, T	1, 2, 3, 4, 5	–	T	
Cuttability	–	tunnelling class X, Y, Z	cuttability class X, Y, Z	–	cuttability class X, Y, Z	
Face inclination				I, n		
Face support				a, b, c	a, b, c	
Auxiliary constr. measure				measure Δ	if nec.	
Examples for the desicription of the excavation items	B 2 D 4 E 5	3 X 2 Z 1 Y	A 3 X B 2 Y C 4 Z	I – – n b Δ n c –	X – Y a Y b	X X Y

8.4.1.3 The influence of the chosen tunnelling method, the systematic auxiliary constructional measures and the support on the advance rate as well as the wear on the excavating tools and tool holders (drill bits, round shank cutter bits, disc cutters, soft ground tools, etc.) are included in the excavation prices.

8.4.1.4 If the project provides for a pilot tunnel or pilot shaft, it will be classified and paid for separately. This has no influence on the classification of the subsequent enlargement to an excavation class.

8.4.1.5 The removal and disposal of a temporary support with anchors, reinforced shotcrete (reinforcing fibres or mesh) or steel ribs is paid for separately.

8.4.1.6 The subsequent excavation of an invert arch in the excavation types A, B, C and D is paid for separately.

8.4.1.7 Changing from one excavation class to another is paid for separately.

8.4.1.8 The costs arising from geologically caused interruptions to tunnelling, so far as these lie in the sphere of risk of the principal, or stoppages ordained by the principal will be paid for separately. The payment is dependant on the duration of the interruption and the number of employees, who could not be employed elsewhere to cover costs.

The costs will be paid with the unit prices intended for this eventuality; if there are no such unit prices, as daywork.

8.4.1.9 The transporting of muck to the specified temporary tip in the vicinity of the portal is included in the excavation price.

8.4.1.10 Further transport of the muck as well as its further use is paid for separately.

8.4.1.11 Hindrances caused by water ingress, gas emissions or the carrying-out of special measures (sporadic auxiliary constructional measures or exploratory boring) are paid for separately.

8.4.1.12 The construction and maintenance of the underground transport roads are paid for separately.

8.4.1.13 In the case of additional excavation, which the contractor carries out for operational reasons, all resulting additional quantities of each type (excavation, excavation support, backfilling, permanent lining, etc.) count as an included service and are not paid for separately.

8.4.1.14 The taking-back or further use of the quantities of materials stocked in agreement with the principal, which remain at the end of construction work, will be paid for separately.

8.4.1.15 Monitoring on the surface and of adjacent structures is to be arranged and paid for separately.

8.5 Determination of quantities

8.5.1 General

8.5.1.1 Unless otherwise stipulated in the works contract, the excavation is paid for according to the theoretical quantities involved.

8.5.1.2 The face surface area is the exposed surface area of the tunnel face following excavation. This applies to full-face or partial excavation.

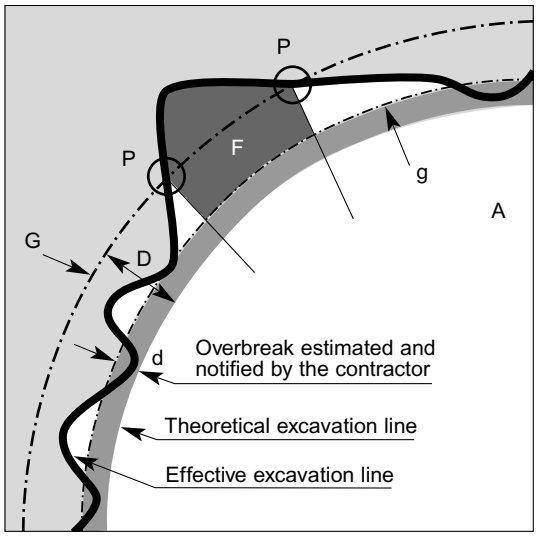
8.5.2 Overbreak

8.5.2.1 The overbreak d according to Figure 4 resulting from working methods is included in the unit prices for excavation and removal. This estimated overbreak is to be stated by the contractor in the bid.

8.5.2.2 An overbreak resulting from geological conditions is defined as a local collapse not caused by carelessness on the part of the contractor (e.g. through overcharging or incorrect placement of charges, defective excavation support or support installed too late, setting out errors), as well as the overbreak in the invert which has to be excavated for geological-geotechnical reasons.

8.5.2.3 In the case of overbreak for geological reasons, loading and transporting of muck to the temporary tip as well as the measures necessary for grouting of the cavity and for support are paid for the entire profile area F. The surface area F is determined at the point where the collapse extends beyond the boundary line G and counts from the boundary line g. The remaining surface areas within the boundary line G are included in the excavation prices.

Figure 4: Limitation of the geological overbreak in drill & blast tunnelling and mechanically-assisted tunnelling in rock and in loose rock



A: Theoretical excavated surface area

D: Distance between the theoretical excavation line and the boundary line G

d: Distance between the theoretical excavation line and the boundary line g

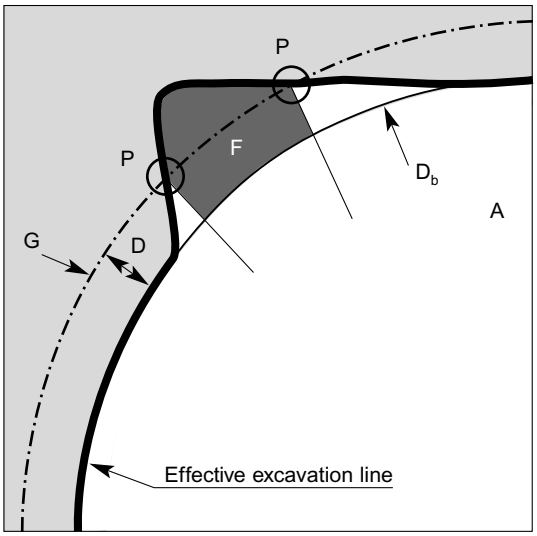
g: Up to this line, the overbreak is calculated into the excavation price

G: Boundary line, dependent on D

F: Surface area for which the geological overbreak will be paid for

P: Point of intersection between the boundary line G and the effective excavation line

Figure 5: Limitation of the geological overbreak in TBM tunnelling with or without shield



A: Theoretical excavated surface area

D: Distance between the effective excavation line and the boundary line G

D_b: Bore diameter with worn tool

G: Boundary line, dependent on D

F: Surface area for which the geological overbreak will be paid for

P: Point of intersection between the boundary line G and the effective excavation line

8.5.2.4 Unless otherwise stipulated in the works contract, the value D for vault and invert is determined according the following formulas:

- Drill & blast tunnelling: $D = 0.07 \cdot \sqrt{A}$, but $D_{min} = 0.40$ m
- Mechanically-assisted tunnelling in rock or in loose rock $D = 0.05 \cdot \sqrt{A}$, but $D_{min} = 0.40$ m
- Tunnelling with systematic auxiliary constructional measures, shield or blade shield: $D = 0.03 \cdot \sqrt{A}$, but $D_{min} = 0.25$ m
- Tunnelling with TBM or shield tunnelling machine: $D = 0.03 \cdot \sqrt{A}$, but $D_{min} = 0.20$ m.

The surface area of the partial excavation in m^2 counts as the theoretical excavated surface area A.

8.6 Variations, adjustment of deadlines

8.6.1 General

8.6.1.1 In underground construction work, the construction schedule forms the basis for the definition and adjustment of deadlines. The rules stipulated below apply in supplementation and amendment of SIA 118.

8.6.1.2 The definitive deadlines are shown in the contractual construction schedule, which is based on the planned construction time. The necessary basis for this (proposed daily working hours, works holidays, intended performance, decisive quantities, etc.) is to be set forth in the contract.

8.6.1.3 In order to determine the deadlines, the critical path is to be defined in the construction schedule. The following should be noted:
- Construction times independent of the length (e.g. installation phase)
- Construction times dependent on the length (e.g. permanent lining)
- Construction times dependent on performance and length (e.g. tunnelling).

8.6.1.4 In determining the planned construction time, the following working phases or interruptions to work must always be handled separately:
- Preliminary work
- Tunnelling
- Sealing and permanent lining
- Inner lining
- Interruptions to tunnelling operations and other down times.

The procedure to be followed in the case of working phases proceeding simultaneously is to be decided individually.

8.6.1.5 Changes to the deadlines and the periods for which equipment is made available are determined separately for each working phase, taking into account the effective quantities.

8.6.1.6 The decisive quantities in the bill of quantities (provisionally estimated quantities and final quantities) are:
- Tunnelling, taking into account support class, tunnelling or cuttability class, face support or systematic auxiliary constructional measures
- The sealing, the permanent lining and the inner lining
- The corresponding number of days taken into account for dewatering measures, advance investigations, sporadic auxiliary constructional measures and for branching tunnels and cross-headings
- The corresponding number of days taken into account for interruptions to working ordered by the principal.

8.6.1.7 The changes in the decisive quantities in the final quantities (valuation) in relation to the provisionally estimated quantities (contract) count as variations.

8.6.2 Adjustment of deadlines

8.6.2.1 The adjustment of the deadlines is determined on the basis of the difference between the planned construction time and the construction time for valuation purposes.

8.6.2.2 The construction time for valuation purposes is determined according to the same rules as the planned construction time on the basis of the decisive quantities in the final measurement of quantities (for examples see appendixes C and D).

8.6.2.3 The date for the completion of the work changes in line with the resulting deadlines.

8.6.3 Variations

8.6.3.1 In the event of variations, the unit prices (rates) remain unchanged if the bill of quantities includes special items for the site equipment and installations.

8.6.3.2 Variations have effect on the deadlines and on the payments for making equipment available for longer or shorter periods.

8.6.3.3 In the event that equipment is made available for longer or shorter periods (difference between planned construction time and construction time for valuation purposes), only the site equipment and installations required during the working phase in question are taken into account.

8.6.3.4 Making the site equipment and installations available for longer or shorter periods is only taken into account in terms of payment if the corresponding construction time for valuation purposes changes by more than 1 month. If the change amounts to less than 1 month, the payment remains unchanged. The first month is neither offset nor credited.

8.6.3.5 If, as a result of changed ground conditions, work needs to be carried out, for which no provision is made in the works contract, this work counts as a variation, for which the due payment is to be agreed.

8.6.3.6 If more water is encountered than provided for in the works contract, the measures which need to be taken in terms of water drainage and construction operations count as a variation, for which the due payment is to be agreed.

8.6.3.7 The effects on deadlines and the site equipment and installations of variations other than those defined in Section 8.6.1.7 must be agreed on before the work is commenced.

8.7 Allocation of risks

8.7.1 Risks in underground construction work

8.7.1.1 Special risks exist in connection with tunnelling resulting from the properties of the rock mass, irrespective of a fault on the part of the contractor. It is therefore recommended that these risks be allocated in the works contract.

8.7.1.2 Unless otherwise agreed, the following allocation of risks to the principal or to the contractor applies. The principal risks, which can exist in tunnelling depending on the individual case, are listed.

8.7.2 General risks

8.7.2.1 The following belong to the risk sphere of the principal:
- Rock characteristics different from the tender documents, to the extent that the deviation lies outside the contractual limits
- Presence of gas
- Encountering contaminated ground
- Effects on existing structures within the area of influence of the cavity which occur despite proper execution of the work
- Major collapses due to geological conditions and exceptional inflow of water
- Encountering archaeological remains.

8.7.2.2 The following belong to the risk sphere of the contractor:
- Rock characteristics different from the tender documents, to the extent that the deviation lies within the contractual limits
- Contractually defined services.

8.7.3 Drill & blast tunnelling in rock (D&B)

8.7.3.1 The following belong to the risk sphere of the principal:
- Deformations of the cross-section of the cavity greater than contractually provided for, and their consequences: reworking of the profile, modifying the formwork to reduced cross-section.

8.7.3.2 The following belong to the risk sphere of the contractor:
- Problems with the operation of the drilling, loading or conveying system, e.g. as a result of the adhesiveness of the excavated material or large blocks of material.
- Hindrance caused through the inflow of water into blasting holes.

8.7.4 Tunnelling with tunnel boring machine in rock (TBM)

8.7.4.1 The following belong to the risk sphere of the principal:
- Deformations of the cross-section of the cavity greater than contractually provided for, and their consequences: jamming in place of the tunnelling machine, sinking of invert segments which have already been installed, modifying the formwork to reduced diameter, widening of tunnel cross-sections, which have already been bored, rebuilding the tunnelling machine to a larger diameter

– Rock characteristics lying outside of the limit values stated in the works contract and the consequences of this: significantly less favourable cuttability, rock fails to provide the necessary grip for the gripper pads, load-bearing capacity of the invert inadequate (tunnelling machine cannot maintain its intended position without exceptional measures)
– More difficult tunnelling in loose rock or in rock broken into loose material (e.g. locally unstable face).

8.7.4.2 The following belong to the risk sphere of the contractor:
– Poor cuttability due to very different hard and soft sections of rock in the same excavated cross-section
– Problems with the operation of the boring, loading or conveying system, e.g. as a result of the adhesiveness of the excavated materials or large blocks of material.

8.7.5 Mechanically assisted tunnelling in rock (MR)

8.7.5.1 The following belong to the risk sphere of the principal:
– Rock characteristics outside the limit values stated in the works contract and their consequences: cuttability significantly less favourable
– Deformations of the cross-section of the cavity greater than contractually provided for, and their consequences: reworking of the profile, reassembling the formwork to reduced cross-section.

8.7.5.2 The following belong to the risk sphere of the contractor:
– Excavation made more difficult due to very different hard and soft sections of rock in the same excavated cross-section
– Problems with the operation of the excavating, loading or conveying system, e.g. as a result of the adhesiveness of the excavated materials or large blocks of material.

8.7.6 Mechanically assisted tunnelling in soft ground (MSG)

8.7.6.1 The following belong to the risk sphere of the principal:
– Deformations of the cross-section of the cavity greater than contractually provided for, and their consequences: reworking of the profile, modifying the formwork to reduced cross-section
– Tunnelling made more difficult due to foreign bodies such as masonry, pipes, ground anchors, piles made of timber, reinforced concrete or steel within the excavated cross-section (incl. salvage)
– Interference with tunnelling due to pipelines of all kinds within the area of influence of the tunnelling
– Extraordinary measures where the load-bearing capacity of the invert is inadequate.

8.7.6.2 The following belong to the risk sphere of the contractor:
– Excavation made more difficult due to different hard and soft sections of rock in the same excavated cross-section
– Problems with the operation of the excavating, loading or conveying system, e.g. as a result of the adhesiveness of the excavated materials or large blocks of material.

8.7.7 Tunnelling using shield tunnelling machine in soft ground (SM)

8.7.7.1 The following belong to the risk sphere of the principal:
– Tunnelling made more difficult due to foreign bodies such as masonry, pipes, ground anchors, piles made of timber or steel within the excavated cross-section (incl. salvage)
– Interference with tunnelling due to pipelines of all kinds within the area of influence of the tunnelling
– Extraordinary measures where the load-bearing capacity of the invert is inadequate (for example, the shield cannot maintain its theoretical position).

8.7.7.2 The following belong to the risk sphere of the contractor:
– Problems with the operation of the loading or conveying system, e.g. as a result of the adhesiveness of the excavated materials or large blocks of material.

9 CONSTRUCTION SITE EQUIPMENT AND INSTALLATIONS

9.1 Invitation to tender

9.1.1 The specification and bill of quantities contains separate items for the site equipment and installations.

9.1.2 The specification and bill of quantities contains separate items for making the site equipment and installations available for longer or shorter periods.

9.1.3 The site ventilation is to be put out to tender as a special group of items; generally, divided into:
- equipment for ventilation in the different sections and construction phases (installation, provision, operation and maintenance, any reconfiguration and dismantling)
- equipment for dust extraction
- equipment for cooling
- measuring equipment
- additional equipment and measures for an air circulation system
- consumption of electrical energy.

9.1.4 If site equipment and installations, for example site ventilation, lighting, etc., are used for works provided by third-party companies, this is to be specified in the tender documents.

9.1.5 Before work is commenced and after the site equipment and installations have been removed, the principal and contractor jointly take samples from the construction site in order to record any contamination of the soil. Measures are to be agreed if necessary.

9.2 Provisions regarding payment and determination of quantities

9.2.1 If the contractor makes no statement in the item “Special equipment required in the view of the contractor”, all equipment required for the requested services or construction methods count as being included in the prices.

9.2.2 If site equipment and installations are divided into items for erection, provision and dismantling, at variance with Section 2.1.3 of this code, the performance value for the item “Erection” amounts to 100% following complete delivery and readiness for operation; the provision of the equipment is paid for pro rata (depending on quantity or duration of provision).

9.2.3 The following services count as being included in the bid for the ventilation:
- Detailed calculation of the ventilation system (a concept for the ventilation examined by the SUVA is to be submitted to the principal prior to execution)
- Necessary adjustments to the ventilation system due to repositioning of the loading, conveying and transport equipment as well as the crushing equipment, where the contractor is responsible for these
- Noise reduction measures in accordance with the works contract.

If the ventilation system requires construction measures (excavation, support and concreting work), which are not part of the project, these costs (where not mentioned separately in the contractor’s bid) are included in the global items.

9.2.4 If orders issued by the principal or circumstances, for which the principal is responsible, lead to the suspension of tunnelling, then the provision of the tunnelling equipment will be paid with the appropriate unit prices.

10 EXPLORATORY MEASURES

10.1 Invitation to tender

10.1.1 The conditions according to Sections 17.1 and 17.7 apply to investigation boreholes, boreholes for taking samples, boreholes drilled for the purpose of tests and in-situ measurements.

10.1.2 Special equipment for these boreholes or tests are to be tendered separately

10.1.3 Advance investigation measures involving geophysical or similar methods are to be tendered separately.

10.1.4 Investigation headings are independent underground structures and are not counted as advance investigation in the sense of Section 10 of this code.

Investigation headings to be driven in the course of tunnelling will be tendered as part of the tunnelling works.

11 DRILL & BLAST TUNNELLING IN ROCK (D&B)

11.1 Invitation to tender

11.1.1 General

The costs of excavation depend on the excavation class and support class. These are determined by means of a classification of the excavation items in accordance with Table 3.

Table 3: Drill & blast tunnelling in rock (D&B); classification of the excavation items

	Support class				
Excavation class	SC 1	SC 2	SC 3	SC 4	SC 5
A: Full-face excavation	A 1	A 2	A 3	A 4	A 5
B: Top heading	B 1	B 2	B 3	B 4	B 5
C: Roadheading, divided			C 3	C 4	C 5
D: Side headings				D 4	D 5
E: Partial excavation (specific to project)				E 4	E 5

11.1.2 **Support classes for tunnels**

11.1.2.1 The support classes used are defined in Table 4.

Table 4: Support classes for tunnels (D&B)

	Face area L1	Advance area L2	Rearward area L3
SC 1	– possibly head protection acc. to EKAS-Richtlinie 6514	– mesh fixed in place with anchors or bolts	
SC 2	– ≤ 0,4 anchors per m^2 in arch – shotcrete with or without mesh or shotcrete with fibre reinforcement in the crown area over ≤ $^2/_3$ the width of the excavation [1)] – shotcrete on ≤ $^1/_2$ of the face surface	– ≤ 1,0 anchors per m^2 in arch	– > 1,0 anchors per m^2 in arch)
SC 3	– > 0,4 anchors per m^2 in arch – ≤ 0,4 anchors per m^2 in face – shotcrete with or without mesh or shotcrete with fibre reinforcement in the crown area over > $^2/_3$ the width of the excavation [1)] – shotcrete on > $^1/_2$ of the face surface	– > 1,0 anchors per m^2 in arch – steel ribs in series (at least 3 ribs) with or without lagging	– not decisive
SC 4	– Complete support provided in L1 after each round up to the face – steel ribs with or without lagging – > 0,4 anchors per m^2 in face	– not decisive	– not decisive
SC 5	– shotcrete applied continuously during excavation with or without anchors and mesh and with steel ribs – face support over > $^1/_4$ of the face surcface	– not decisive	– not decisive
[1)] the width of the excavated cross-section applies			

11.1.2.2 The length of the working areas depends on the size of the excavated profile or the width of the excavation and is defined as a guide value in Table 5.

Table 5: Working areas for tunnels (D&B)

Lengths of the working areas			
Width of the excavation [1)]	Face area L1	Advance area L2	Rearward area L3
3 m	2 m	15 m	150 m
6 m	4 m	20 m	200 m
12 m	5 m	25 m	250 m
15 m	5 m	35 m	300 m
[1)] the width of the excavated cross-section applies			

11.1.2.3 If special measures are necessary, such as
– reduction of the round length
– reduction of the charge quantities per firing stage,
– use of special explosives and firing systems,
these are put out to tender separately.

11.1.3 Support classes for shafts

11.1.3.1 The completed support in the working area determines the definition of the support classes for shafts excavated upwards. Guide values for the round length, which is identical to the working area, are given in Table 6.

Table 6: Support classes for ascending shafts (D&B)

Support class	Support work in the working area	Round length
SC 1	– mesh fixed with anchors or bolts	max. 3 m
SC 2	– ≤ 0,4 anchors per m^2 around circumference and shotcrete with or without mesh or shotcrete with fibre reinforcement	max. 2 m
SC 3	– anchor in the face over at least 2 excavation steps – > 0,4 anchors per m^2 around circumference and shotcrete with or without mesh or shotcrete with fibre reinforcement	max. 1,5 m
SC 4	– steel ribs with or without lagging	max. 1 m

11.1.3.2 The completed excavation support which is to be applied after each excavation step determines the support classes for shafts which are sunk vertically or at an angle. The permissible height of the excavation step depends on the stability of the shaft wall and is to be laid down in the tender documents. Guide values for the height are stated in Table 7.

Table 7: Support classes for shafts, which are sunk or widened from top to bottom (D&B)

Support class	Support work following each excavation step	Step (height)
SC 1	– mesh fixed with anchors or bolts	max. 5 m
SC 2	– ≤ 0,4 anchors per m^2 around circumference and shotcrete with or without mesh or shotcrete with fibre reinforcement; but not after each round	max. 4 m
SC 3	– > 0,4 anchors per m^2 around circumference and shotcrete with or without mesh or shotcrete with fibre reinforcement after each round	max. 3 m
SC 4	– steel ribs with or without lagging	max. 1 m

11.1.3.3 If the permanent lining follows the excavation directly at a maximum distance defined in the tender documents, only one support class need to be defined.

11.1.3.4 If the permanent lining is first constructed after the completion of the drive or periodically in sections of defied length, the support classes apply according to Table 6 or Table 7 as appropriate.

11.1.4 Support classes for caverns

Partial excavations of the cavern are treated like tunnels (Table 4).

11.2 Provisions regarding payment and determination of quantities

11.2.1 Tunnels

11.2.1.1 Unless otherwise stipulated in the works contract, the quantities are determined according to the following rules:
- Starting out from a point defined in the design, the length of the tunnel is divided into sections of 5 m in length or a multiple thereof.
- In the case of the support classes 1, 2 and 3 each sections is assessed as a whole and assigned a support class or a support type, for example in that an average value for the number of anchors is derived for the entire length of the section.
- In the case of the support classes 4 and 5 or the appropriate support types, the classification is based on the effective length of the section.
- In the case of steel ribs, the length of the section extends to the length with steel ribs installed plus two times half the standard distance between the individual installation frames.

11.2.1.2 In the case of partial excavation, the classification of the overall tunnel profile is based on the support in the completely excavated top heading.

Only one excavation price will be paid for the entire profile.

11.2.1.3 Unless otherwise stipulated in the tender documents, the following values for the permissible round length in the individual support classes counts as being contractually agreed:
- Support classes 1 and 2: no restriction
- Support class 3: maximum 4.00 m
- Support class 4: maximum 2.00 m
- Support class 5: the length is determined by the support necessary.

11.2.2 Shafts

11.2.2.1 Unless otherwise stipulated in the tender documents, the same principles apply to the determination of quantities as for tunnels (Section 11.2.1.1).

11.2.2.2 If, in the case of raised shafts, the permanent lining is not installed immediately following excavation, a distinction is made between support classes.

11.2.3 Caverns

Each individual partial cross-section is paid for on the basis of the support class.

12 TUNNELLING IN ROCK USING A TUNNEL BORING MACHINE (TBM)

12.1 Invitation to tender

12.1.1 General

The cost of excavation depend on the support class and tunnelling class. This is determined through a classification of the excavation items in accordance with Table 8.

Table 8: TBM tunnelling in rock; classification of the excavation items

Support class	Tunnelling class		
	X	Y	Z
SC 1	1 X	1 Y	1 Z
SC 2	2 X	2 Y	2 Z
SC 3	3 X	3 Y	3 Z
SC 4	4 X	4 Y	4 Z
SC 5	5 X	5 Y	5 Z
SC T	T X	T Y	T Z

12.1.2 **Support classes for tunnels and shafts**

12.1.2.1 The support classes used are defined in Table 9.

Table 9: Support classes for tunnels and shafts (TBM)

	Machine area L1	Back-up area L2	Rearward area L3
SC 1	– possibly head protection in accordance with EKAS-Richtlinie 6514	– mesh fixed in place with anchors or bolts or equivalent measures – invert segments, if provided for all support classes in the project	The support in L3 is irrelevant in terms of the classification into support classes. If such support is planned, down-time items should be planned.
SC 2	– mesh around ≤ $^1/_3$ of the circumference fixe in place with ≤ 0,4 anchors and/or bolts per m^2	– > 0,4 anchors per m^2 with sectional ribs around > $^1/_4$ of the circumference – mesh and shotcrete or shotcrete with fibre reinforcement around ≤ $^1/_2$ of the circumference	
SC 3	– mesh around > $^1/_3$ of the circumference fixe in place with > 0,4 anchors per m^2 and individual lagging plates – sectional ribs around ≤ $^3/_4$ of the circumference [1)]	– mesh with > 0,4 anchors per m^2 and shotcrete or shotcrete with fibre reinforcement around the entire circumference excl. the invert – sectional ribs around ≤ $^3/_4$ of the circumference [2)]	
SC 4	– closed ring of steel ribs with mesh or individual lagging plates [1)] – lattice girders around ≥ $^3/_4$ of the circumference with mesh and anchors [1)] – shotcrete as sealing around > $^1/_4$ of the circumference – pressure-distributing elements in the area of the gripper pads	– invert support with shotcrete or in-situ concrete, if no invert segments are planned – closed ring of steel ribs, possibly supported on invert segments [2)] – lattice girders around ≥ $^3/_4$ of the circumference with mesh and anchors [2)]	
SC 5	– closed ring of steel ribs with lagging – full-face steel elements	– not decisive	
SC T	– closed segment lining	– not decisive	

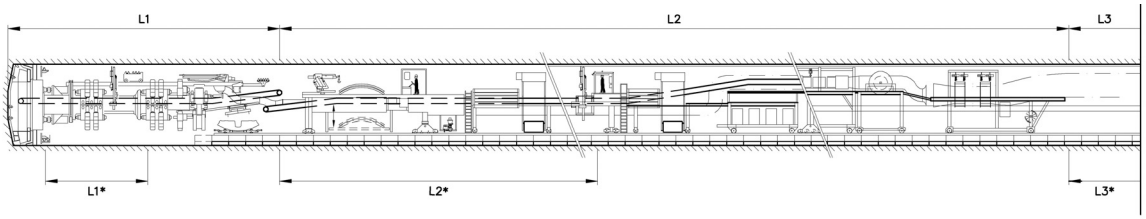
[1)] in the case of tunnels with Ø > 6 m
[2)] in the case of tunnels with Ø ≤ 6 m

12.1.2.2 If the support consists of an immediately installed and continuous closed ring of segments, support class T applies.

12.1.2.3 Within the areas L1, L2, L3, the working zones L1*, L2*, L3*, in which the excavation support can be installed on the basis of the requirements of the project and the possibilities allowed by the type of machine, are distinguished (Figure 6).

12.1.2.4 The contractor shows in his bid, in a plan of the proposed tunnel boring machine, the length of the working areas L1, L2, L3 and the working zones L1*, L2*, L3* and states what support work is possible in these areas given the specified works. This takes into account the conditions regarding the installation location of the excavation support stipulated in the tender documents.

Figure 6: Working areas and working zones in TBM tunnelling



Representation of a TBM without shield

Designation of working areas and zones:
– L1 Machine area
– L1* Working zone for support in the machine area
– L2 Back-up area
– L2* Working zone for support in the back-up area
– L3 Rearward area up to 200 m behind back-up train
– L3* Working zone for support in the rearward area

12.1.2.5 Tunnels and inclined shafts will be treated equally for the determination of the support classes.

12.1.2.6 For vertical shafts enlarged from the bottom, no support classes are differentiated.

12.1.2.7 For vertical shafts enlarged from the top, Section 11.1.3.2 applies correspondingly.

12.1.2.8 If the permanent lining of a vertical shaft follows immediately behind the driving at a maximum spacing specified in the specification, only one support class is to be determined.

12.1.2.9 If the permanent lining is constructed after the completion of the drive or periodically in sections of a predefined length, the support classes according to Table 9 apply.

12.1.3 Tunnelling classes

12.1.3.1 The classification into tunnelling classes is based on the amount of work required in order to excavate the rock using a tunnel boring machine.

12.1.3.2 The tunnelling classes are defined in the tender documents on the basis of the decisive rock characteristics.

12.1.3.3 Sections of tunnel of the same tunnelling class should be characterised as accurately as possible by means of the geological and ground characteristics affecting penetration and wear of the boring tools and their spreads.

12.1.3.4 The procedure for determining the tunnelling classes in-situ and the necessary tests (type and number) are to be defined in the tender documents. For example, the tunnelling class can be defined by determining the penetration in a test advance. If no other agreement is made, this method counts as being agreed (see Section 12.2.5).

12.2 Provisions regarding payment and determination of quantities

12.2.1 The following conditions apply in the same way to tunnels, inclined shafts and vertical shafts.

12.2.2 The excavation is paid for per running metre of tunnel.

12.2.3 Unless otherwise stipulated in the works contract, the quantities are measured in accordance with the rules in Section 11.2.1.1.

12.2.4 The situation of the unstable tunnel face and of the cavity above the cutter head is to be regarded as a special case. The work involved in stabilisation and the removal of collapsed material is to be paid for separately and taken into account in the construction time for valuation purposes.

If the material can be cleared mechanically, the items for geological overbreak apply.

If this is not possible, or is only partially possible, payment is based on the cost involved.

If the excavation support, comprising the stipulated support measures, can be installed from working zone L1*, payment is based on the items in the bill of quantities.

If this is not possible, payment is based on the cost of work involved.

12.2.5 If it is agreed that the tunnelling class should be determined by means of a test advance (penetration), this will be done periodically, e.g. daily, at approximately the same time of day. The framework conditions for the test advance must be contractually agreed, e.g. the length of the test advance, the average gross thrust, the condition of the boring tools and their degree of wear, as well as the section of tunnel for which the tunnelling class determined in this way applies. For example, in the case of daily test advances, the classification applies for the whole day.

12.2.6 If it has been agreed that the tunnelling class should be determined on the basis of the geological description, the evaluation at the crown line of the tunnel applies.

12.2.7 In the case of extremely abrasive rock, provision can be made for an additional payment for increased tool wear. It becomes due when the abrasiveness exceeds a limit value specified in advance (e.g. Cerchar, LCPC).

12.2.8 Additional quantities for the excavation and the permanent lining which arise in TBM tunnelling for technical reasons relating to the equipment (effective excavated profile greater than specified), are included in the unit prices. However, the support will be charged for according to the effective measurement.

13 MECHANICALLY ASSISTED TUNNELLING IN ROCK (MR)

13.1 Invitation to tender

13.1.1 General

The work involved in excavation depends on the excavation type, the support class and the cuttability class. This situation is taken into account by means of a classification of the excavation items in accordance with Table 10.

Table 10: Mechanically-assisted tunnelling in rock (MR); classification of excavation items

Excavation type	Support class	Cuttability class		
		X	Y	Z
A Full-face excavation B Top heading C Roadheading, divided D Side headings E Partial excavation (project-specific)	SC 1	A 1 X B 1 X	A 1 Y B 1 Y	A 1 Z B 1 Z
	SC 2	A 2 X B 2 X	A 2 Y B 2 Y	A 2 Z B 2 Z
	SC 3	A 3 X to C 3 X	A 3 Y to C 3 Y	A 3 Z to C 3 Z
	SC 4	A 4 X to C 4 X	A 4 Y to C 4 Y	A 4 Z to C 4 Z
	SC 5	A 5 X to C 5 X	A 5 Y to C 5 Y	A 5 Z to C 5 Z

13.1.2 **Support classes for tunnels**

13.1.2.1 The support classes to be applied are defined in Table 11.

Table 11: Support classes for tunnels (MR)

	Face area L1	Advance area L2	Rearward area L3
SC 1	– possibly head protection acc. to EKAS-Richtlinie 6514	– mesh fixed in place with anchors or bolts	
SC 2	– ≤ 0,4 anchors per m^2 in arch – shotcrete with or without mesh or shotcrete with fibre reinforcement in the crown area over ≤ $^2/_3$ the width of the excavation [1)] – shotcrete on ≤ $^1/_2$ of the face surface	– ≤ 1,0 anchors per m^2 in arch	– > 1,0 anchors per m^2 in arch
SC 3	– > 0,4 anchors per m^2 in arch – ≤ 0,4 anchors per m^2 in face – shotcrete with or without mesh or shotcrete with fibre reinforcement in the crown area over > $^2/_3$ the width of the excavation [1)] – shotcrete on > $^1/_2$ of the face surface	– > 1,0 anchors per m^2 in arch – steel ribs in series (at least 3 ribs) with or without lagging	– not decisive
SC 4	– Complete support provided in L1 after each round up to the face – steel ribs with or without lagging – > 0,4 anchors per m^2 in face	– not decisive	– not decisive
SC 5	– shotcrete applied continuously during excavation with or without anchors and mesh, possibly steel ribs – face support over > $^1/_4$ of the face surcface	– not decisive	– not decisive
[1)] the width of the excavated cross-section applies			

13.1.2.2 The lengths of the working areas depends on the size of the excavated profile or the width of the excavation and is defined as a guide value in Table 12.

Table 12: Working areas for tunnels (MR)

Lengths of the working areas			
Width of the excavation [1)]	Face area L1	Advance area L2	Rearward area L3
3 m	2 m	15 m	150 m
6 m	4 m	20 m	200 m
12 m	5 m	25 m	250 m
15 m	5 m	35 m	300 m
[1)] the width of the excavated cross-section applies			

13.1.3 Support classes for shafts

13.1.3.1 The definition of the support classes for shafts which are sunk vertically or at an angle is the completed support which is to be applied after each excavation stage. The permissible height of the excavation step depends on the stability of the shaft wall and is to be stipulated in the tender documents. Guide values for the height are stated in Table 13.

Table 13: Support classes for shafts (MR)

Support class	Support work following each excavation step	Height of step
SC 1	– mesh fixed with anchors or bolts	max. 5 m
SC 2	– ≤ 0,4 anchors per m^2 and shotcrete with or without without mesh or shotcrete with fibre reinforcement	max. 4 m
SC 3	– > 0,4 anchors per m^2 and shotcrete with or without mesh or shotcrete with fibre reinforcement	max. 3 m
SC 4	– steel ribs with or without lagging, but not driven as Marciavanti	max. 1 m

13.1.3.2 If the permanent lining follows the excavation directly at a maximum distance defined in the tender documents, then only one support class is to be defined. If the permanent lining is only installed following completion of the excavation or in sections of predetermined length, this has no influence on the support classes.

13.1.4 Support classes for caverns

The partial cross-sections of the cavern are treated like tunnels (Table 11).

13.1.5 Cuttability classes

13.1.5.1 The classification into cuttability classes is based on the work involved in mechanically excavating the rock, whether by cutting, ripping, picks or splitting. The critical geological characteristics for each cuttability class are defined in the tender documents.

13.1.5.2 The stratification and jointing of the rock mass influence the amount of work involved in the mechanical excavation of rock; these are to be taken into account in defining the cuttability classes.

13.1.5.3 The number of cuttability classes depends on the different geological formations and their differing geological characteristics and is to be stipulated on an project-specific basic in the tender documents.

13.1.5.4 The procedure for determining the cuttability classes in-situ and the necessary tests (type and number) are to be defined in the tender documents.

13.2 Provisions regarding payment and determination of quantities

13.2.1 General

13.2.1.1 In the case of partial excavations, the different partial cross-sections can be assigned different cuttability classes where they clearly differ in terms of cuttability (e.g. cuttability class Y in the top heading, cuttability class Z for the bench).

13.2.1.2 In determining the cuttability classes, individual measured values may lie outside of the stipulated ranges for the geological characteristics, unless otherwise stipulated in the works contract.

13.2.2 Tunnels

13.2.2.1 Unless otherwise stipulated in the tender documents, the quantities are determined according to the provisions in Section 11.2.1.1.

13.2.2.2 In the case of partial excavation, the classification of the entire tunnel profile is based on the support in the completed excavated top heading.

Only one excavation price is paid for the entire profile.

13.2.2.3 Unless otherwise stipulated in the tender documents, the following values for the permitted length of advance in the individual support classes count as being contractually agreed:

Support class 1 and 2:	no restriction
Support class 3:	maximum 4.00 m
Support class 4:	maximum 2.00 m
Support class 5:	the length is determined by the necessary support.

13.2.2.4 If special measures are necessary, e.g. shortening of the length of advance, blasting to loosen the rock, these will be paid for separately.

13.2.3 Shafts

Unless otherwise stipulated in the tender documents, the quantities are determined according to the provisions in Section 11.2.1.1.

13.2.4 Caverns

Each individual partial cross-section is paid for on the basis of the support and cuttability classes.

14 MECHANICALLY ASSISTED TUNNELLING IN SOFT GROUND (MSG)

14.1 Invitation to tender

14.1.1 In mechanically-assisted tunnelling in soft ground, a distinction is made between the following tunnelling methods:
- Tunnelling without or with walking blades (walking blade shield)
- Tunnelling with or without auxiliary constructional measures
- Tunnelling with systematic auxiliary constructional measures.

14.1.2 The provisions in Section 15 apply to mechanically-assisted tunnelling with shield.

14.1.3 In general, the variation of the support within a particular tunnel is very slight, so no distinction is made between support classes.

14.1.4 The cuttability (e.g. the degree of natural or artificial cementation) does not represent an additional criterion for the classification of the excavation items. Any additional work resulting from reduced cuttability is not paid for separately.

14.1.5 The work involved in excavation depends on the excavation type, the auxiliary constructional measures and the type and quantity of the face support (soil wedge, face anchors, etc.) and also the systematic auxiliary construction measures. This fact is taken into account by means of a classification of the excavation items in accordance with Table 14.

This classification applies separately to each systematic auxiliary constructional measures employed (Section 17.1.6).

Table 14: Mechanically-assisted tunnelling in soft ground (MSG); classification of the excavation items

Excavation type	Inclination	Type and quantity of face support			
		without face support	a	b	c
Excavation type A to E	vertical l	l	l a	l b	l c
	inclination n	n	n a	n b	n c
Auxiliary constructional measure (Δ):					

14.1.6 The specified inclination of the face (vertical or inclination n) is to be specified in the tender documents.

14.1.7 The type and quantity of face support (grade a, b and c) are to be to be specified in the tender documents.

14.1.8 The intended auxiliary construction measures are to be to be described in the tender documents.

14.2 Provisions regarding payment and determination of quantities

14.2.1 For excavation types A to E, each individual partial cross-section counts as a full excavation and is separately paid based on the inclination of the face, the type and quantity of face support as well as the auxiliary construction measures.

14.2.2 Separate additional payments are made for the hindrances encountered in excavating boulders and rock within the excavated cross-section or on the haunch.

14.2.3 These provisions apply accordingly to shafts and caverns.

14.2.4 The conditions in Section 17 apply to the auxiliary constructional measures.

15 TUNNELLING USING A SHIELD TUNNELLING MACHINE IN SOFT GROUND (SM)

15.1 General

15.1.1 Invitation to tender

15.1.1.1 For tunnelling using a shield machine in soft ground, a distinction is made between:
- Shield with partial-face excavation by means of permanently-fitted excavating equipment, without or with mechanical face support (open shield)
- Shield with full-face excavation and support (cutterhead, mechanical face support, compressed-air, slurry or earth pressure balanced face support).

15.1.1.2 Generally, there is no variation of the excavation support within a particular tunnel, so no distinction is made between support classes in SM tunnelling.

15.1.1.3 The cost of excavation depends on the type of shield and the cuttability (cuttability class), and for open shields also on the type and quantity of the face support. This circumstance is dealt with by a classification of the excavation items according to Table 15 or Table 16 as appropriate.

Table 15: Tunnelling with open shield in soft ground (SM); classification of the excavation items

Shield type	Type and quantity of face support	Cuttability class		
Open shield with or without mechanical face support	without face support	X	Y	Z
	Grade a	X a	Y a	Z a
	Grade b	X b	Y b	Z b
	Grade c	X c	Y c	Z c

Table 16: Tunnelling with shield tunnelling machines in soft ground (SM); classification of the excavation items

Shield type	Cuttability class		
Shield with mechanical face support	X	Y	Z
Shield with compressed-air support	X	Y	Z
Shield with slurry face support	X	Y	Z
Shield with earth pressure balanced face support	X	Y	Z

15.1.1.4 The division into cuttability classes (X, Y, Z) is based on the nature of the ground (geological and hydrogeological conditions, geotechnical characteristics etc) and is defined project-specifically in the tender documents.

15.1.1.5 The type and quantity of the face support (grade a, b and c) is to be given in the tender documents.

15.1.1.6 The principal makes known in the tender documents the properties of the ground to be tunnelled through, which are decisive for the selection of the process, like:
- Petrographic composition
- Grading curve
- In-situ density
- Plasticity properties, adhesiveness, swelling capability
- Water content
- Location of the groundwater table
- Upper and lower limits of hydraulic pressure in the invert.

15.1.1.7 The principal specifies in the tender documents:
- The nature of the daily reports to be produced (control factors etc.)
- Requirements for the documentation of completed work (results).

15.1.1.8 The contractor prepares the project for the implementation of compressed air, slurry or earth pressure support on the basis of the geological, geotechnical and hydrogeological conditions.

15.1.1.9 Unless otherwise laid down in the tender documents, the contractor is responsible for:
- Uninterrupted operation of the entire plant in order to be able to constantly guarantee the required support pressure
- Monitoring and maintaining of the support pressure
- Maintenance of the entire plant including replacement devices (he is liable for all damage due to the plant not working or working incorrectly).

15.1.2 Provisions regarding payment and determination of quantities

15.1.2.1 The excavation is paid per running metre of tunnel.

15.1.2.2 Additional quantities for the excavation and the permanent lining which arise in SM tunnelling for technical reasons relating to the equipment (effective excavated profile greater than specified), are included in the unit prices.

15.1.2.3 The cost of the planning of the construction and the production of the necessary construction instructions is covered by a global item according to Section 15.1.1.8.

15.1.2.4 The production and delivery of the daily reports and the documentation of the completed work is included in the unit prices.

15.2 Shield tunnelling machine with compressed-air support

15.2.1 Invitation to tender

The contractor describes in the bid:
- The determination of the necessary positive pressure and the probable air requirement (incl. reserve for the compressed air)
- Measures to reduce air losses
- Measures to prevent blow-outs
- Measures for the grouting of the annular gap (shield tail).

15.2.2 Provisions regarding payment and determination of quantities

15.2.2.1 The following services are paid for separately:
- Assembly, dismantling and provision of the special equipment (equipment for generating the compressed air and maintaining the pressure, personnel and material air-locks)
- Operation of the compressed air equipment
- Monitoring of the entire system.

15.2.2.2 The following measures are paid for separately:
- Provision of back-up devices in the event of a device failure
- Provision of emergency power generators in the event of a power failure.

15.2.2.3 The work resulting from down times in the event of a blow-out, which arises despite measures having been taken, will be paid for separately.

15.3 Shield tunnelling machine with slurry or earth pressure balanced support

15.3.1 Invitation to tender

15.3.1.1 In general, only one cuttability class is defined in the case of shield tunnelling with slurry or earth pressure balanced face support. Exceptions may arise in the case of transitions between solid and soft ground.

15.3.1.2 Improvements in the ground do not result in changes in the cuttability class.

15.3.1.3 In the tender documents, the size of block is laid down, the breaking up of which is included in the unit prices.

15.3.1.4 The ground is mixed with additive materials depending on the construction method or the type of face support. It is stipulated in the tender documents how the muck is to be treated, what degree of separation is to be aimed at and how it is to be disposed of.

15.3.1.5 The contractor describes in the bid:
- Concept for the production of the support slurry and for the conditioning of the excavated material
- Equipment for the breaking up of blocks
- Concept for the transport system including the transfer stations
- Concept of the separation plant
- Measures for the sealing of the shield tail and the grouting of the annular gap.

15.3.2 Provisions regarding payment and determination of quantities

15.3.2.1 Additional payments are paid for the hindrances encountered in breaking up and removing blocks, the mass of which exceeds the agreed limit value.

15.3.2.2 The removal of foreign components (anchors, parts of basement excavation support or foundations) in front of the face will be paid for separately.

15.3.2.3 The work involved in the treatment of muck mixed with additive materials is included in the excavation price.

15.3.2.4 The disposal of the muck mixed with additive materials will be paid for separately.

16 SUPPORT MEASURES

16.1 Anchors

16.1.1 Invitation to tender

16.1.1.1 In the tender documents, the principal specifies:
- The properties of the anchor
- The properties of the embedding material
- Requirements regarding the surface protection of the anchor.

16.1.1.2 In the tender documents, the principal stipulates the number of site tests.

16.1.2 Provisions regarding payment and determination of quantities

16.1.2.1 The anchors, classified according to anchor type and dimensions (length, diameter), are paid according to the number used. The unit price includes the drilling of the hole and the installation of the anchor including embedding material.

16.1.2.2 The additional cost of washer plates with special requirements (e.g. in terms of dimensions or deformability) will be paid for separately according to the number.

16.1.2.3 The work involved in for the site tests (anchoring force) is included in the unit price for the anchors.

16.1.2.4 Other types of test (e.g. overdrilling, pull-out tests, ultrasound measurements) will be paid for separately.

16.2 Reinforcing mesh

16.2.1 Invitation to tender

In the tender documents, the principal specifies:
- The properties of the reinforcement (ductility class, yield strength)
- Minimum necessary overlap
- Mesh types including fixing.

16.2.2 Vergütungsregelungen und Ausmassbestimmungen

16.2.2.1 The mesh, classified according to installation type (mesh with or without anchors, mesh with lattice girders, etc.) and mesh types (mesh spacing, wire diameter), is charged for per m^2 or by weight.

16.2.2.2 An additional payment is made for the bending and folding of the mesh at the factory.

16.2.2.3 The quantity is determined as the surface area of the installed mesh. Cutting of mesh on the construction site is included in the price for the mesh.

16.2.2.4 The fixings, except for the anchors required for the support, are included in the unit price for the mesh.

16.3 Shotcrete without or with fibres

16.3.1 Invitation to tender

16.3.1.1 In the tender documents, the principal specifies:
- The proposed shotcrete classes
- Tolerances for the thickness
- Necessary preliminary tests (suitability tests) for shotcrete of the shotcrete classes SC 2 to SC 7.

16.3.1.2 The principal specifies the requirements regarding the surface of the shotcrete (e.g. as base layer for the sealing).

16.3.2 Provisions regarding payment and determination of quantities

16.3.2.1 The following methods of valuation apply for shotcrete work:
- Quantities determined on the basis of the processed volume of the starting mixture
  This method of charging is suitable in most cases.
- Quantities determined according to theoretical surface area and specified thickness
  This method of charging is suitable in particular for standard surfaces (e.g. TBM tunnelling).
- Quantities determined on the basis of the processed volume of the starting mixture with a price reduction for the overbreak shotcrete according to Section 21.2.3
  This method of charging is particularly suitable if a regular surface has to be achieved with the shotcrete in drill & blast tunnelling (for example see Appendix E).

16.3.2.2 The unit of measurement for the starting mixture is:
- For dry-mix shotcrete, 1 m^3 dry mix (loose) consisting of aggregates and cement
- For wet-mix shotcrete, 1 m^3 of compacted finished concrete cast in formwork.

16.3.2.3 Generally, the work involved for the following services is included in the unit price for shotcrete:
- Determination of volumes, achieved by means of regular yield tests
- Loading and removal of the rebound as well as the repositioning of the scaffolding and the installations for the shotcreting work.

16.3.2.4 The unit price for shotcrete according to properties includes additives and added materials, which are necessary in order to achieve the specified requirements.

This also applies for shotcrete with fibres; but in this case, separate bill items are provided.

16.3.2.5 Where the unit price for shotcrete according to composition, additives and added materials as well as additional or reduced amounts of cement are charged separately.

The addition of fibres is paid for as an additional payment by weight. The quantities are determined on the basis of the quantity of shotcrete and the specified amount of fibres added to the starting mixture.

16.3.2.6 The work involved in the addition of the fibres as well as any additional wear on the equipment is included in the additional payment for the fibres.

16.3.2.7 The work involved in the preliminary tests according to Section 16.3.1.1 will be paid for separately.

16.4 Steel ribs and lagging

16.4.1 Invitation to tender

In the tender documents, the principal specifies:
- The type of the steel ribs (rolled steel section, lattice girders), the steel quality, the geometry, the profile data for the steel ribs and the type of connection
- The type of lagging elements (lagging plates, Marciavanti, formwork and reinforcement mesh, liner plates)
- The means of filling the cavity between the lagging and the excavated surface.

16.4.2 **Provisions regarding payment and determination of quantities**

16.4.2.1 The delivery of the steel ribs, classified according to types (rolled steel section, lattice girders) and sizes is paid for according to theoretical weight (without rolling tolerance) including the foot and head plates, fish-plates, bolts and spacers.

16.4.2.2 The delivery of lagging elements, classified according to type (material, purpose) and dimension, is paid for by weight.

16.4.2.3 Repositioning as well as any removal and disposal will be paid for separately.

16.4.2.4 The filling of the cavities between the excavated surface and lagging elements will be paid for separately.

16.5 Segments

16.5.1 **Invitation to tender**

16.5.1.1 The principal specifies the following criteria in the tender documents:
- Compressive strength which the concrete of the segments must achieve at the time of installation. The segments must be stored until the demanded compressive strength has been achieved
- Dimensional tolerances of the segments
- Requirements regarding waterproofing quality, surface, etc.

16.5.1.2 In the case of double-shell lining, the maximum permissible size of chipped corners and edges and offset of segment joints are also defined, taking into account the requirements for the sealing base.

16.5.2 **Provisions regarding payment and determination of quantities**

16.5.2.1 The following services will be paid for separately:
- Delivery, i.e. manufacture, transport and storage on the construction site (per running metre of tunnel)
- Delivery and fixing of segment reinforcement (by weight)
- Transport to the location of installation and installation of the segments including any connections and joint seals (per running metre of tunnel).

16.5.2.2 The filling of the annular space is paid for separately according to construction material, per running metre of tunnel.

16.5.2.3 The necessary levelling of misalignments as well as the repair of corners and edges to receive the sealing are not paid for separately.

17 AUXILIARY CONSTRUCTION MEASURES

17.1 General

17.1.1 In the tender documents, the principal specifies which auxiliary constructional measures are used, individually or in combination:
- Spiles, spile umbrella
- Pipe umbrella
- Jet grouting, jet grouting umbrella
- Grouting
- Ground freezing
- Long face anchors
- Drainage (drillholes).

17.1.2 Measures which are carried out before tunnelling begins, from the surface or from construction trenches, and which do not cause any hindrance to tunnelling are not classed as auxiliary constructional measures in terms of the following conditions.

17.1.3 In the case of auxiliary constructional measures, a distinction is made between:
- Systematic auxiliary constructional measures, which form part of the tunnelling method, e.g. pipe umbrella, spile umbrella, jet grouting, ground freezing
- Periodic auxiliary constructional measures, which do not form part of the tunnelling method, as a result of which the excavation and support work is interrupted in individual cases, e.g. spiles, local grouting, long face anchors, dewatering drillholes.

17.1.4 Where the auxiliary constructional measures are not defined in the tender documents, the principal will stipulate the necessary measures following consultation with the contractor.

17.1.5 The various auxiliary constructional measures will be paid for separately.

17.1.6 In the case of systematic auxiliary constructional measures which form part of the tunnelling method, the hindrance (obstruction and interruption of tunnelling operations) caused by the systematic procedure and the quantities for the measures are determined per running metre of tunnel. The work involved is included in the unit prices for excavation.

17.1.7 The performance data for the tunnel drive take into account the time required for the systematic auxiliary constructional measures and form the basis for calculation of the planned construction time and the construction time for valuation purposes.

17.1.8 Periodic auxiliary constructional measures, which do not form part of the tunnelling method, can result in interruption of tunnelling operations. The resulting costs (wage costs for lost working time, operation of site equipment and installations during interruption of tunnelling operations, etc.) are paid for according to group hours and graduated according to the duration of the interruption.

17.1.9 The tunnelling down time caused by the periodic measures is also taken into account in the construction time for valuation purposes.

17.1.10 Independent measures not related to tunnelling do not result in any adjustment of the contractual deadline.

17.2 Spiles, spile umbrella/pipe umbrella

17.2.1 Invitation to tender

17.2.1.1 The principal specifies in the tender documents the requirements according to SIA 198, 2004 issue, Sections 3.5.2 and 3.5.3.

17.2.1.2 The principal specifies in the tender documents:
- The type of reports to be delivered daily
- Requirements regarding the documentation of the services performed (results).

17.2.2 **Provisions regarding payment and determination of quantities**

17.2.2.1 In the case of pipe umbrellas, the following services are paid for:
- Installation, dismantling and provision of the special equipment (drilling equipment, grouting equipment) including cleaning of the workplace
- Delivery and placing of the steel pipes incl. drilling work
- Grouting of the steel pipes including closure and sealing of the drillholes.

17.2.2.2 In the case of spile umbrellas, the following services are paid for:
- Delivery and placing of the steel pipes incl. drilling work
- Grouting of the steel pipes or anchors including closure and sealing of the drillholes.

17.2.2.3 The preparation and delivery of the daily reports and the documentation of the services performed is included in the unit prices.

17.3 Jet grouting, jet grouting umbrella

17.3.1 The principal specifies in the tender documents the requirements according to SIA 198, 2004 issue, Section 3.5.4.

17.3.2 The principal specifies in the tender documents:
- The type of reports to be delivered daily
- Requirements regarding the documentation of the services performed (results).

17.3.3 Where nothing is specified in the tender documents, the following data are to be recorded in the reports:
- Length of drillholes, angle of drillholes
- Jet velocity (revolutions per minute, retraction speed)
- Jet quantity and pressures (cement suspension, compressed air, water)
- Flowback quantity (in % of the jet quantity)
- Special events or occurrences.

17.3.4 Otherwise, SIA 118/267, Section 9 applies to jet grouting.

17.4 Grouting

17.4.1 **Invitation to tender**

17.4.1.1 The principal specifies in the tender documents the requirements according to SIA 198, 2004 issue, Section 3.5.5.

17.4.1.2 The principal describes in the tender documents the purpose of the grouting which is to be carried out and the proposed preliminary tests.

17.4.1.3 The position and length of the boreholes, the grouting pressure and the injected quantity per unit of time as well as the grout are, in general, defined on the basis of the preliminary tests.

17.4.1.4 The principal specifies in the tender documents:
- The type of reports to be delivered daily
- Requirements regarding the documentation of the services performed (results).

17.4.1.5 Where nothing is specified in the tender documents, the following data are to be recorded in the reports:
- Position of the grouting hole
- Depth of hole or depth of the grouted section
- Composition of the grout
- Quantity and injection pressure of the injected grout per unit of time and packer
- Identification of communicating holes
- Special occurrences.

17.4.2 Provisions regarding payment and determination of quantities

17.4.2.1 The payment is based on the:
- Type and length of the boreholes
- Type and quantity of the grout
- Location and time at which the work was carried out.

17.4.2.2 Section 17.7.2 applies analogously with respect to the drillholes.

17.4.2.3 In the case of grouting, the following services are paid for:
- Installation, dismantling and provision of the grouting equipment
- Delivery and placing of the grouting pipes and lances including packers and accessories
- Delivery of the grout
- Injection of the grout per unit of time (equipment group hours).

17.4.2.4 The closure and sealing of the boreholes as well as the covering and cleaning of the workplaces are included in the unit prices.

17.4.2.5 The removal of leaked grout, cleaning of blocked pipes and the removal of soiling are included in the unit prices.

17.4.2.6 The visual monitoring of the rock mass, the support and the permanent lining and the drainage pipes is included in the unit prices.

17.5 Ground freezing

17.5.1 Invitation to tender

17.5.1.1 Depending on the rock and groundwater conditions, tunnels and shafts driven using the excavation types A or B can use the ground freezing method.

17.5.1.2 The principal specifies in the tender documents the requirements according to SIA 198, 2004 issue, Section 3.5.6.

17.5.1.3 The principal also defines:
- The dimension of the necessary frozen ground mass at a particular temperature
- Compressive strength of the frozen ground mass (average value)
- Overlap of the freezing stages.

17.5.1.4 The principal specifies in the tender documents:
- The type of reports to be delivered daily
- Requirements regarding the documentation of the services performed (results).

17.5.1.5 The contractor prepares the project for construction on the basis of the information provided about hydrogeology. He submits proposals for boring work, freezing installations, thermal engineering calculations, calculation and dimensioning of the frozen ground mass, creation and maintenance of the frozen ground mass, monitoring and measuring systems, rectification of defective locations, etc. The proposals are to be sorted out with the principal.

17.5.2 **Provisions regarding payment and determination of quantities**

17.5.2.1 In the case of ground freezing the following services are paid for separately:
- Installation, dismantling and provision of all equipment and scaffolding for the creation of the frozen ground mass
- Installation, dismantling and provision of the refrigeration system
- Operation of the refrigeration system
- Creation and removal of the frozen ground mass (depending on type) per running metre of tunnel (only useful length) including work involved in creating any drilling niches, etc.
- Installation, dismantling and provision of all measuring and monitoring equipment.

17.5.2.2 The work involved in planning construction and the necessary regulations for construction are compensated with a global price.

17.5.2.3 The work involved for all measurements which are necessary for the creation and maintenance of the frozen ground mass is included in the unit prices.

17.5.2.4 No additional payment is paid for the excavation of the frozen rock mass.

17.5.2.5 The preparation and delivery of the daily reports and the documentation of the services performed are included in the unit prices.

17.6 Long face anchors

17.6.1 **Invitation to tender**

17.6.1.1 Face anchors count as an auxiliary constructional measures if they are longer than the width of the excavation.

17.6.1.2 The principal specifies in the tender documents the requirements according to SIA 198, 2004 issue, Section 3.5.7.

17.6.2 **Provisions regarding payment and determination of quantities**

17.6.2.1 The anchors, classified according to anchor type and dimensions (length, diameter), are paid for according to the number used. The unit price includes the drilling of the hole, whereby a distinction is made between cased and uncased, the installation of the anchor including embedding material and cutting off the anchor in stages.

17.6.2.2 The transport to and from site, setting-up and provision of a periodically required drill is paid for separately.

17.7 Drainage (drillholes)

17.7.1 **Invitation to tender**

17.7.1.1 The principal specifies in the tender documents the requirements according to SIA 198, 2004 issue, Section 3.5.8.

17.7.1.2 The principal also specifies whether these measures are to be carried out systematically or periodically.

17.7.1.3 The principal specifies in the tender documents:
- The length, diameter and number of drilling stages
- The type of reports to be delivered daily
- Requirements regarding the documentation of the works (results).

17.7.2 **Provisions regarding payment and determination of quantities**

17.7.2.1 The payment for the boreholes is based on:
- The boring method (cased/uncased)
- Rotary hammer drilling using drilling equipment used in tunnelling
- Rotary hammer drilling using special drilling equipment
- Rotary core drilling using special drilling equipment
- The position, diameter and length stages of the boreholes.

17.7.2.2 Transport to and from site, setting-up and provision of periodically required drilling equipment is paid for separately.

17.7.2.3 The preparation and delivery of the daily reports and the documentation of the services performed are included in the unit prices.

18 SEALING

SIA 118/270 applies to sealing.

19 DEWATERING MEASURES

19.1 Water drainage measures during the construction time

19.1.1 Invitation to tender

Special measures for draining off water are specified in the tender documents.

19.1.2 Provisions regarding payment and determination of quantities

19.1.2.1 The collection, diversion and conducting away of the water in the excavation, including process water, is, in general, paid for separately.

19.1.2.2 If the use of pumps is necessary, then their delivery, provision, installation, relocation and dismantling are paid for separately according to the nominal delivery rate and delivery head. Operation is paid for according to hours of operation.

19.1.2.3 The provision period begins with the arrival of the ordered equipment on the construction site and ends with release by the principal.

19.1.2.4 No payment is only made if the water can drain away by force of gravity and the capacity of the existing, cleaned dewatering facilities (french drain, pipe) is sufficient.

19.1.2.5 The contractor of a construction contract section at a higher level must retain the dirt and slurry from the overflowing water at the section boundary. The corresponding measures will be paid for separately.

19.1.2.6 If the existing dewatering facilities are sufficient, the contractor of a construction contract section at a lower level must take on the additional water encountered following breakthrough without payment.

19.1.2.7 If, according to the construction schedule, work remains to be carried out in the lower construction contract section, which necessitates a diversion of the water from the upper construction contract section, the corresponding measures will be paid for.

19.1.2.8 The cleaning of the settling basin, the conducting away of the water and the disposal of slurry will be paid for separately.

19.2 Hindrances resulting from water for tunnelling in rock

19.2.1 Invitation to tender

19.2.1.1 The group hours provided for in the bill of quantities for hindrances resulting from water are to be taken into account, pro rata, in the construction schedule.

19.2.1.2 The number of planned and valuation schedule days taken up by hindrances resulting from water is determined taking into account reduction factors applicable to group hours.

19.2.1.3 The reduction factors applicable to group hours in determining the planned construction time and the one for valuation purposes are to be defined project-specifically on the basis of the hydrogeological conditions. If nothing is stipulated in the tender documents, the values in Table 17 count as being contractually agreed.

Table 17: Reduction factors for group hours in the event of water ingress (excluding process water) within the section of tunnel in question

Tunnels with theoretical excavated surface area $A \leq 25\ m^2$ or $Ø \leq 5$ m		Tunnels with theoretical excavated surface area $A > 25\ m^2$ or $Ø > 5$ m		Shafts		Reduction factor for group hours
ascending [l/s]	descending [l/s]	ascending [l/s]	descending [l/s]	ascending [l/s]	descending [l/s]	
10–20	5–10	10–20	5–10	2–5	1–2	0,2
>20–30	>10–20	>20–40	>10–20	>5–10	>2–5	0,4
>30–40		>40–60	>20–30			0,6

19.2.1.4 Arrangements for the measurement of water in caverns and shafts are to be specified on an object-related basis in the tender documents.

19.2.2 **Provisions regarding payment and determination of quantities**

19.2.2.1 The inflow of water results in a reduction in the progress of work (working in water and slurry or additional work required for boring as well as repairs to site equipment and installations). These reductions in performance (hindrances) are paid for according to group hours.

19.2.2.2 The payment for hindrances is dependent on the inclination of tunnelling (ascending or descending), on the excavated cross-section and on the volume of water, excluding process water, which flows in over at least eight hours within the relevant section of tunnel measured from the tunnel face.

19.2.2.3 Hindrances resulting from volumes of water, which lie below the lower values named in Table 17, are included in the excavation prices.

19.2.2.4 The inflow of water is measured by the principal and contractor using suitable measuring equipment and at suitable points. The measuring equipment is to be regularly maintained and periodically calibrated.

19.2.2.5 The relevant length of tunnel behind the tunnel face, in terms of measuring the volume of inflowing water, is 100 metres.

19.2.2.6 In the case of partial-face excavations carried out in immediate succession, this length is measured from the face of the rearmost widened section rather than the tunnel face.

19.2.2.7 In the case of partial-face excavations, which lie more than 100 m apart, the relevant length of tunnel in terms of measuring the volume of inflowing water is measured in each case from the tunnel face of the individual partial excavation.

19.2.2.8 The difference between the effective schedule and theoretical schedule, expressed in schedule days, is applied in adjusting the contractual deadlines as a result of changed quantities in comparison with the group hours provided for in the bill of quantities (for example see Appendix D).

19.2.2.9 The payment for hindrances to tunnelling operations resulting from water is based on group hours. The wage costs for the delay are included in the price for the group hour. Installations and equipment costs are covered through extended provision.

19.2.2.10 The hindrances begin when the lower limit value is exceeded and end when this value is no longer reached.

19.2.2.11 The beginning of the hindrances is to be recorded in writing immediately by the contractor and principal, jointly.

19.2.2.12 Regular water measurements are to be carried out throughout the duration of the payment.

19.2.2.13 The work involved in the setting-up, the operation and maintenance of the measuring equipment is paid for. The assistance of the contractor in carrying out water measurements is not paid for separately.

19.2.2.14 Hindrances encountered during concreting work on the invert or when installing the invert segments are not paid for separately.

19.2.2.15 Measures for transferring the water will be paid for separately.

19.3 Hindrances resulting from water for tunnelling in loose rock

The procedure for tunnelling in loose rock is to be specified in the tender documents for each occurrence.

20 DEWATERING

20.1 Invitation to tender

20.1.1 The principal specifies in the tender documents:
- The material of the pipes
- The shape and type of the pipes
- The type of pipe connection.

20.1.2 For earthworks involved with dewatering, the standard CRB V118/903 applies.

20.2 Provisions regarding payment and determination of quantities

20.2.1 Advance sealing (drain or surface sealing) is paid for according to effective quantities. Fixing in place is included in the unit price.

20.2.2 Dewatering pipes are paid for according to their theoretical length (from inner wall of shaft).

20.2.3 Pipe fittings are paid for additionally according to quantity.

20.2.4 Shafts are to be paid for separately.

20.2.5 Pipes and shafts are to be regularly cleaned of sinter and soiling until acceptance. If not necessitated by soiling caused by the contractor, this cleaning is paid for separately.

21 PERMANENT LINING

21.1 Invitation to tender

21.1.1 The composition of the starting mixture determined on the basis of preliminary tests and the origin of the individual concrete components may not be changed during the execution of work without the approval of the principal.

21.1.2 Following completion of the grouting of the crown gap, the principal can order control tests between the grouted holes. If these fail to satisfy the requirements, further grouting must take place.

21.1.3 The formwork (mobile formwork) for standard profiles is tendered as a separate item of the construction site installations.

21.1.4 The principal specifies the requirements for curing. In case he requires special measures, any equipment required and its operation are tendered as separate bill items.

21.2 Provisions regarding payment and determination of quantities

21.2.1 **Concrete**

21.2.1.1 For concrete, a distinction is made between the following methods of charging:
- Quantities determined according to actual quantity with price reduction for the overbreak concrete (according to Section 21.2.3)
  This method of charging is suitable for general cases.
- Quantities per running metre according to theoretical profile
  This method of charging is suitable for regular surfaces (e.g. TBM tunnel-driving).
- Quantities determined according to quantity, including the overbreak concrete
  This method of charging is suitable for individual components, e.g. foundations, niches.
- Quantities determined according to theoretical quantity, overbreak concrete according to the theoretical contact surface of the concrete with the rock face or the support.
  This method of charging is suitable for smooth or regular surface areas, e.g. underlay concrete or smoothing concrete.

21.2.1.2 Concrete for geological overbreak will be paid for separately.

21.2.1.3 Unless otherwise stipulated, the necessary concrete additives required in order to achieve the specified quality of concrete paid for according to properties, are included in the unit price.

21.2.1.4 For cavity grouting, the following payment types are differentiated:
- The grouting of the crown gap is measured per running metre.
- The grouting of any cavities between the lining and the waterproofing or temporary support is measured according to the theoretical contact surface.

21.2.1.5 Profile checks to guarantee the design position and thickness of the permanent lining are included in the unit prices.

21.2.2 **Shotcrete**

The provisions in Section 16.3.2 apply to shotcrete.

21.2.3 **Determination of the deduction from the overbreak quantity (shotcrete and concrete)**

21.2.3.1 The following conditions apply for the first method of charging according to Section 21.2.1.1 (for example see Appendix E).

21.2.3.2 The theoretical quantities and the estimated overbreak quantity of shotcrete and concrete are shown separately in the bill of quantities. The deduction from the overbreak is specified as a negative amount on the basis of the estimated overbreak quantity applying the factor *a* defined in the bill of quantities.

The contractor calculates the expected deduction into the price for the overbreak concrete or overbreak shotcrete.

21.2.3.3 Valuation is based on the effectively applied quantity of concrete (shotcrete and concrete). The quantity is determined jointly by the principal and contractor, e.g. on the basis of the quantity delivered.

21.2.3.4 If shotcrete is applied before concreting of the permanent lining, then the applied quantity of solid shotcrete is included in the determination of the average thickness or the quantity of the overbreak. The applied quantity of shotcrete is calculated as being 0.5 times the delivered quantity of the dry mixture or 0.8 times the quantity of the delivered starting mixture in the case of wet-mix shotcrete.

21.2.3.5 The concrete for the geological overbreak according to Section 8.5.2 is included in the theoretical quantity of concrete.

21.2.3.6 The average overbreak thickness d_m is determined by combining the relevant lengths following completion of a structure (tunnel, shaft, cavern) or of an independent component (access tunnel, connecting tunnel, etc.).

21.2.3.7 The average overbreak thickness amounts to:

$$d_m = \frac{\text{concrete}_{ob}\ (= \text{concrete}_{eff} - \text{concrete}_{theor})}{\text{external surface area of the theoretical profile}} \quad \text{in m}$$

concrete_{eff}	effective concrete quantity (in-situ concrete and shotcrete) in m^3
concrete_{theor}	theoretical concrete quantity (in-situ concrete- and shotcrete) in m^3
concrete_{ob}	overbreak concrete quantity (in-situ concrete and shotcrete) in m^3
External surface area of the theoretical profile	product of the theoretical development (line of excavated surface area) and the considered length of the structure or component.

21.2.3.8 The deduction from the overbreak is dependent on the overbreak quantity, the average overbreak thickness and the factor *a*.

21.2.3.9 The factor *a* is to be defined in the tender documents (specification). It is recommended that it be defined in the order of 1% of a usual concrete price [CHF/m^3].

The deduction increases with increasing overbreak, but may not exceed the tender price for the overbreak concrete.

21.2.3.10 The deduction from the overbreak amounts to:

Overbreak quantity $\cdot\ d_m \cdot a$ in m^3

d_m = average thickness of the overbreak in cm
a = factor dependent on an average concrete price in CHF/m^3 per cm

21.2.4 Formwork

21.2.4.1 In the case of the formwork for the permanent lining, a distinction is made between the following methods of valuation:
- Quantity according to running metres of tunnel and global installation price for formwork construction
  This method of charging is suitable for a constant theoretical profile (inner haunch of the permanent lining)
- Quantity according to the actual surface area of formwork
  This method of charging is, for example, suitable in the case of changeable theoretical profiles (inner haunch of the permanent lining).

21.2.4.2 Recesses, inserts and special forms such as grooves or bosses and joint profile strips, which are part of the formwork, are not charged for separately if the formwork is paid for as an item under the construction site setup.

21.2.4.3 The formwork for niches will be paid for separately.

21.2.4.4 In the case of formwork elements for front and joint faces, the theoretical surface area is paid for.

21.2.4.5 All striking of formwork carried out for practical reasons but not required by the design is included in the unit prices.

21.2.5 Cable protection ducts

Spacers for cable protection ducts will be paid for separately.

21.2.6 Reinforcement

SIA 118/262 applies to reinforcement.

21.2.7 Curing

21.2.7.1 Curing, like the protection of the concrete against rapid drying or cooling, is not paid separately unless special measures are required.

21.2.7.2 If a special finished concrete surface treatment is required for the inner vault, this will be paid for separately (e.g. global installation prices for mobile treatment units and treatment per running metre of tunnel).

22 INNER LINING

SIA 118/262 applies to all concrete structures within the permanent lining, e.g. kerbs, walkways, carriageway slabs, intermediate ceilings, permanent lining panels, cable ducts, control centre or cavern installations.

APPENDIX A STRUCTURE OF THE PROJECT-RELATED SPECIAL PROVISIONS

(according to Section 1.1.4)

The special provisions applying to a particular construction project can be drawn up with the aid of Normpositionen-Katalog 102, published by the Schweizerische Zentralstelle für Baurationalisierung (CRB, Swiss Central Office for Building Rationalisation). NPK 102 is a checklist for the drafting of special provisions, provides text modules for this purpose and is structured as follows:

100	Principal's organisation, location, purpose of the project, scope of works
200	Invitation to tender, pre-qualification and award criteria, addenda to be enclosed with bid
300	Building ground, local conditions
400	Use of land, rights of use, supply and disposal of pipes and drains
500	Protection of persons, property, construction site, surrounding area
600	Schedule of construction work, deadlines, bonuses, contract penalties
700	Standards and other regulations, special requirements
800	Construction work, construction operations
900	Insurance, administration, supervisory checks on construction work.

APPENDIX B ADDENDUM TO BID; TECHNICAL SPECIFICATIONS OF MACHINERY AND EQUIPMENT

B.1 **Specifications of the tunnel boring machine (TBM)**

- Manufacturer, model, year of construction and excavation principle
- Nominal diameter D_n and bore diameter D_b
- Weight
- Revolutions per minute
- Total installed electrical power of the tunnelling machine
- Drive power of the cutter head (kW) and drive type
- Revolutions per minute of the cutter head
- Torque of the cutter head (at nominal power as well as at start-up torque and breakdown torque)
- Maximum start-up current of the tunnelling machine at corresponding voltage
- Thrust (gross)
- Gripping force and number and size of gripper pads
- Cutting tools (number, type and diameter)
- Track separation (spacing)
- Average thrust per cutting tool (gross)
- Stroke of thrust cylinders
- Possibilities for changing the bore diameter
- Equipment for the initial attack (start) of the tunnelling machine
- Back-up installations
- Surveying equipment and description of the machine guidance.

B.2 **Specifications of the excavation equipment**

For mechanical hammers, excavators, rippers, etc.:

- Manufacturer, model, year of construction
- Dimensions
- Weight.

For road headers (TSM):

- Type of cutter head (longitudinal or transverse cutter head)
- Dimensions of the cutting head
- Spray jet equipment of the cutting head
- Cutting range
- Dimension of the undercut
- Ejection height of the conveyer
- Maximum climbing capacity
- Net cutting rate in the main geological formations (m^3/h effective cutting)
- Installed overall power.

B.3 **Specifications for a shield tunnelling machine with compressed-air, slurry, or earth-pressure-balanced face support (in addition to the information listed in section B.1)**

- Compressed air lock
- Cutter head type, excavating tools, cutter head equipment
- Delivery system, delivery pumps
- Tunnel face support components incl. information on supporting medium
- Auxiliary equipment (rock crusher, spraying equipment, pipes)
- Grouting of annular space (number, type and position of the grouting pipes)
- Rearward installations (mixing and separating equipment, etc.)
- Support pressure calculation
- Recovery of boulders.

B.4 **Specifications of the shield (open shield, shield for TBM, shield tunnelling machine)**

- Manufacturer, year of construction
- Outer diameter of the cutter, shield skin
- Thickness of the tail skin, tail seal
- Length of the shield
- Weight of the shield without/with excavating equipment
- Number of thrust jacks (distribution round the circumference)
- Maximum thrust
- Application of the thrust forces (pressure ring, gripper shoes)
- Advance length
- Static load assumption for the shield.

B.5 **Type of face support for open-face shield**

- Number of working platforms
- Number and size of face plates
- Possibilities for grouting through the shield skin (number, location, maximum diameter of the spiles).

B.6 **Specifications of the blade shield**

- Description of the design
- Manufacturer, year of construction
- External diameter the cutters (depending on the position of the blade cutters)
- Number of blades, width of blades, connection of the blades
- Thickness of the tail skin construction
- Length of the entire blade construction
- Length of the concreting stage
- Guide ribs and their support
- Type and location of annular space filling
- Type and number of thrust devices for the individual blades
- Possibilities for temporarily increasing the thrust
- Thrust per blade
- Structural load assumptions for shield
- Design check of transmission of force into the ground beneath the guide ribs
- Formwork design
- Guidance of the blade shield.

B.7 **Specifications of operation of vehicles with pneumatic tyres**

- Type, number of vehicles
- Vehicle type
- Transport volume per vehicle.

B.8 **Specifications of the rail operations**

- Track width, number of tracks
- Traction type
- Rails and sleeper type
- Specifications: locomotives, composition of train
- Number of trains
- Special vehicles.

B.9 **Specifications of the conveyor belt system**

- Belt width
- Belt speed
- Drive, drive power
- Conveying rate: tonnes per hour (t/h)

– Belt storage facility
– Noise reduction and anti-dust measures.

B.10 **Specifications of the crusher plant**

– Type of crusher the
– Crushing capacity in tonnes per hour (t/h)
– Block size (dimensions)
– Loading hopper in m^3
– Installed power
– Weight of the installation.

APPENDIX C PLANNED CONSTRUCTION TIME, CONSTRUCTION TIME FOR VALUATION PURPOSES, DEADLINES

(for information)

Table 18: Example for determining the planned construction time and the construction time for valuation purposes in tunnelling. The entered values are intended as examples and must be agreed for each project.
Normal script = to be filled in as part of the works contract,
Italic script = to be filled in as part of the valuation

Planned constr. time/for valuation purposes, deadlines			Works contract		**Example 1**	
Component: tunnel			Monthly production time			21
Working phase: drill & blast tunnelling, ascending			Interruptions to production time			
Working time: shifts/WD		2	Christmas/New Year			15
hours/shift		8.5	Summer holiday			10
			Works contract		Valuation	
Work category	Unit	Unit per WD	Planned construction time Quantity	WD	Valuation constr. time Quantity	in WD
Tunnelling SC 1 15 m²	m	5.50	200	36.4	*100*	***18.2***
SC 2 15 m²	m	4.50	350	77.8	*500*	***111.1***
SC 3 16 m²	m	2.50	400	160.0	*330*	***132.0***
SC 4 17 m²	m	1.00	50	50.0	*70*	***70.0***
Total	m	3.09	1000	324.2	*1000*	***331.3***
Interruption of tunnelling						
Drillings				4.0		***6.0***
Grouting				3.0		***1.5***
Change of tunnelling equipment	item		1	1.0		***1.0***
Change of excavation type	item		1	2.0		***2.0***
Hindrances rseulting from water						
Full-face excavation, 10…20 l/s	group hours		1250	14.7	*1800*	***21.1***
ascending 20…40 l/s			940	22.1	*800*	***18.8***
40…60 l/s			310	10.9	*400*	***14.1***
Other interruptions						
Sundry down times				5.0		***10.0***
Collapse Tm 250						***14.0***
support work (subsequent)						***6.0***
Total working phase				386.9		***425.8***
Interruptions to production time						
Christmas/New Year 2002/2003				15.0		***15.0***
Summer holiday 2003				10.0		***10.0***
Christmas/New Year 2003/2004						***15.0***
Total construction time		in WD		411.8		***465.8***
		in Mt		19.6		***22.2***
Difference between construction time for valuation purposes and planned time		in WD				***54.0***
		in Mt				***2.6***
Deduction according to Section 8.6.10						***– 1.0***
Extended provision of quipment		**in Mt**				***1.6***
Deadlines start of work, tunnelling phase				15.04.02		*15.04.02*
completion date, tunnelling phase				04.12.03		*26.02.04*

APPENDIX D ADJUSTMENT OF DEADLINES AS A RESULT OF INFLOW OF WATER

(for information)

D.1 Planned construction time in relation to hindrances resulting from water

D.1.1 Water working days are calculated from the missed group hours divided by the daily working hours (e.g. 2 x 8.5 hrs in two shifts).

D.1.2 The resulting water working days for the corresponding water inflow (excluding process water), multiplied by the reduction factor according to Table 19, directly produces the allowable working days attributable to hindrances resulting from water.

Table 19: Example of the determination of the planned construction time in working days for hindrances resulting from water; example: estimated group hours

Water quantity	Group hours	Water working days	Reduction factor	Working days
10…20 l/s	1250	73.5	0.2	14.7
20…30 l/s	940	55.3	0.4	22.1
40…60 l/s	310	18.2	0.6	10.9
Total	2500	147		47.7

D.2 Construction time for valuation purposes relating to hindrances resulting from water

D.2.1 Water working days are calculated from the actual group hours divided by the daily working hours (e.g. 2 x 8.5 hrs in two shifts).

D.2.2 The working days for hindrances resulting from water (excluding process water) are calculated analogously to D.1.2.

Table 20: Example of the determination of the construction time for valuation purposes in working days for hindrances resulting from water; example: measured group hours

Water inflow	Group hours	Water working days	Reduction factor	Working days
10…20 l/s	1800	105.5	0.2	21.1
20…30 l/s	800	47.1	0.4	18.8
40…60 l/s	400	23.5	0.6	14.1
Total	3000	176.1		54.0

Details:
- 2-lane road tunnel
- Support (support class 3): 20 cm wet-mix shotcrete with steel fibres
- Inner vault: 30 cm concrete
- Factor *a*: for shotcrete *a* = 3.0, for concrete *a* = 2.0

Assumptions for the example calculation:
- Length of tunnel under consideration: 100 m
- Development of the theoretical excavation line: 20 m

Table 21: Example of invitation to tender and bid

Example of bill of quantities (principal)			**Example of price formation (contractor)**	
Assumptions	– rebound shotcrete – overbreak	20% 10 cm shotcrete vault 15 cm in-situ concrete inner vault 25 cm total overbreak	Assumptions – rebound shotcrete 20% – overbreak 8 cm shotcrete vault 12 cm in-situ concrete inner vault 20 cm total overbreak	
Item		**Provisional measurement**	**Price**	**Amount**
Wet-mix shotcrete	theoretical quantity	100 m x 20 m x 0,20 m = 400 m^3 400 m^3 : 0.8 = 500 m^3	CHF 300.–	CHF 150 000.–
	overbreak shotcrete	100 m x 20 m x 0,10 m = 200 m^3 200 m^3 : 0.8 = 250 m^3	overbreak volume: 100 m x 20 m x 0.08 m = 160 m^3 160 m^3 : 0.8 = 200 m^3 deduction for overbreak: 200 m^3 x (20 cm x 3) = CHF 12 000.– price for overbreak shotcrete: 200 m^3 x CHF 300.– + CHF 12 000.– = CHF 72 000.– : 200 m^3 = CHF 360.–	CHF 90 000.–
	deduction for overbreak shotcrete	250 m^3 x (25 cm x 3) = –18 750 UP	UP = CHF 1.–	CHF –18 750.–
Concrete	theoretical quantity	100 m x 20 m x 0.30 m = 600 m^3	CHF 200.–	CHF 120 000.–
	overbreak concrete	100 m x 20 m x 0.15 m = 300 m^3	overbreak volume: 100 m x 20 m x 0,12 m = 240 m^3 deduction for overbreak: 240 m^3 x (20 cm x 2) = CHF 9600.– price for overbreak concrete: 240 m^3 x CHF 200.– + CHF 9600.– = CHF 57 600.– : 240 m^3 = CHF 240.–	CHF 72 000.–
	deduction for overbreak concrete	300 m^3 x (25 cm x 2) = –15 000 UP	UP = CHF 1.–	CHF –15 000.–
			Total	**CHF 398 250.–**

Valuation:

Determination of the thickness of the overbreak:

Measured rebound of the shotcrete: 20%

Theor. quantity of concrete:	– shotcrete:			500 m^3 (incl. rebound)
	– concrete:			600 m^3
Effective quantity of concrete:	– shotcrete:	delivered quantity:		725 m^3 (incl. rebound)
		applied quantity:		725 m^3 x 0.8 = 580 m^3
	– concrete:			840 m^3
Overbreak concrete:	– shotcrete:	delivered quantity:		725 m^3 – 500 m^3 = 225 m^3
		applied quantity:		225 m^3 x 0.8 = 180 m^3
	– concrete:			840 m^3 – 600 m^3 = 240 m^3

Overbreak thickness: 180 m^3 + 240 m^3 = 420 m^3 : (100 m x 20 m) = 0.21 m
(9 cm shotcrete and 12 cm concrete)

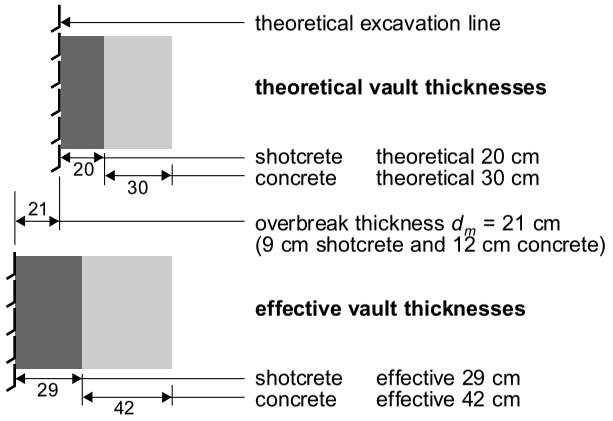


Table 22: Beispiel Abrechnung

Item		Measurement (Quantity?)	Price	Amount
Wet-mix concrete	theoretical quantity	100 m x 20 m x 0.20 m = 400 m^3 400 m^3 : 0.8 = 500 m^3	CHF 300.–	CHF 150 000.–
	overbreak shotcrete	100 m x 20 m x 0.09 m = 180 m^3 180 m^3 : 0.8 = 225 m^3	CHF 360.–	CHF 81 000.–
	deduction for overbreak shotcrete	225 m^3 x (21 cm x 3) = –14 175 UP	CHF 1.–	CHF –14 175.–
Concrete	theoretical quantity	100 m x 20 m x 0.30 m = 600 m^3	CHF 200.–	CHF 120 000.–
	overbreak concrete	100 m x 20 m x 0.12 m = 240 m^3	CHF 240.–	CHF 57 600.–
	deduction for overbreak concrete	240 m^3 x (21 cm x 2) = –10 080 UP	CHF 1.–	CHF –10 080.–
			Total	**CHF 384 345.–**

APPENDIX F GENERAL CONDITIONS FOR PIPE JACKING

F.0 **Scope**

The following provisions only apply to pipe jacking. The categorisation corresponds to Section 8 of this code, which applies accordingly to pipe jacking.

F.1 **Invitation to tender**

The invitation to tender includes the following information about the construction:
- Location of the drive centreline and the permissible deviations (corridor of the route)
- Dimensions of the starting and target shafts
- Shape, material, nominal diameter and wall thickness of the jacking pipe (elements)
- Suggestion for the length of the jacking pipe
- Requirements for the waterproofing of joints (internal and external pressure)
- Suggestions for joint details
- Suggestion for ventilation
- Suggestion for dewatering
- Known obstructions
- Relocation of underground pipes and cables
- Buildings and plant, which will be passed under, and also the permissible settlements.

F.2 **Contractor's bid**

The bid normally includes the following information:
- Description of the driving process
- Main and intermediate press forces
- Excavation and transport equipment for the drive
- Intended length of the jacking pipes (elements)
- Manufacture and handling of the jacking pipes analogous to Section 8.2.2.6
- Detail of the joints including sealing
- Size of the annular gap (gap between the external wall of the jacking pipe and the excavated surface)
- Composition of the intended lubricant
- Description of the construction ventilation
- Deviating dimensions (plan and elevation) of the starting and target shafts
- Installation plan including the required quantity of electricity and water.

F.3 **Duties of the contract parties during execution**

No additional provisions.

F.4 **Provisions regarding payment**

F.4.1 The delivery of the jacking pipes (elements) including storage on the construction site is paid for separately.

F.4.2 The installation of the jacking pipes is included in the prices for driving.

F.4.3 The laying of jacking pipes, which are not driven, is paid separately.

F.4.4 The following applies for the delivery and installation of the pipe connections including the joint sealing:
- For jacking pipes of nominal diameter ≥ 1000 mm, this work is paid separately
- For jacking pipes of nominal diameter < 1000 mm, it is included in the unit prices.

F.4.5 The cutting of the jacking pipes is paid separately.

F.4.6 Passing through or removing obstructions is paid separately.

F.4.7 The disposal of silted or dirty material is paid separately.

F.4.8 For grouting work, the following are differentiated:
- Injection of lubricant during the drive; payment per running metre of driven route
- Consolidation grouting with interruption or after the completion of the drive; payment according to group hours (effective time required between interruption and restarting of the drive).

F.5 Provisions regarding determination of quantities

F.5.1 The driven route is the total length of the driven jacking pipes (elements).

F.5.2 The measurement of the jacking pipes, which are not driven (laid open in the shaft) is determined as effective length.

F.6 Variations, variation of deadlines

If the same rules are to apply as in underground construction (see Section 8.6), the necessary preconditions have to be created in the tender documents:
- Basis for the determination of the planned construction time and the construction time for purposes of payment
- Separate items for longer and shorter provision of the construction site facilities.

F.7 Assignment of risks

No additional provisions.

Abbreviations for the organisations represented in the commission of code SIA 197

ASTRA Bundesamt für Strassen (Federal Department of Roads)
BAV Bundesamt für Verkehr (Federal Department of Transport)

Working group SIA 118/198

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Supervisory commission "Tunnel codes"

President	Pierre Michel, dipl. Ing. ETH, Sion	Consultant engineer
Members	Ede Andraskay, dipl. Bauing. ETH, Zurich	Consultant engineer
	Erwin Beusch, dipl. Ing. ETH, Ennetbaden	Principal
	Alain Jeanneret, ing. civ. EPF, St-Blaise	ASTRA
	Martin Känzig, dipl. Ing. ETH, Berne	BAV
	Willy Ritz, dipl. Bauing. HTL, Kastanienbaum	Contractor
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Acceptance and coming into force

The central committee for codes and regulations accepted the present code SIA 118/198 in September 2007.

It comes into force on 1 November 2007 and replaces from that date the code SIA 198 *Underground Construction Work* of 1993 and the organisational part of the code SIA 195.