PAGEL®
SPEZIAL-BETON GMBH & CO KG

PROCESSING OF GROUT
Application of the PAGEL-GROUT and PAGEL-ANCHORAGE materials

1. Basis

The cement-bound PAGEL-GROUTS capable of expansion are applied with preference in the combination range of the constructive construction, i.e. steel-girder construction, railway construction, and mechanical engineering to ensure the taking-up and conduction of high dynamical and structural loads.

In order to reach the maximum use efficiency for the respective application case some basic knowledge and practice regarding the application are to be taken into account – these you will find in the following summary:

1.1 Compounds

PAGEL-GROUTS consist of high-quality source materials only for which the following standardization is decisive:

Cement:	Portland cement according to DIN 1164 and/or EN 196
Surcharge:	Quartz sand and quartz gravel of different selected grain fractions, washed and fire-dried according to DIN 4226
Concrete additive:	PAGEL NV-CONCENTRATE (BV) as concrete additive according to DIN 1045 with "Allgemeiner bauaufsichtlicher Zulassung“ and „Übereinstimmungszertifikat“ DIBt (Deutsches Institut für Bautechnik, Berlin) (“General construction supervision-like admission” and “Accordance certificate”)
Concrete additional materials:	With “Allgemeiner bauaufsichlicher Zulassung” and “Übereinstimmungszertifikat” from DIBt (Deutsches Institut für Bautechnik, Berlin („General construction supervision-like admission“ and „Accordance certificate“)

1.2 Basis for tests and admissions

Basis for the test, supervision and foreign supervision of the Grouts is the editorial leaflet for the application for work-mixed grouts (edition September, 1990, revised 1996) published by the study group main-committee, concrete technology of the German Betonverein e.V. Bonn and/or from the German Beton and Bautechnikverein, Berlin.
(Merkblatt für die Anwendung von werksgemischtem Vergussmörtel (Fassung September 1990, redaktionell überarbeitet 1996), herausgegeben vom Arbeitskreis – Hauptausschuss, Betontechnologie des Deutschen Betonvereins e.V. Bonn bzw. vom Deutschen Beton und Bautechnikverein, Berlin.)

Regarding the application field “drinking water” the following admission certificates are available for some products on enquiry:

- recommendation of the team "drinking water matters “of the Plastic-Commission of the Federal Public Health Department
- DVGW, technical rules, work sheet W270
- DVGW, technical rules, work sheet W347

2. Fields of Application

- grouting below machines
- grouting of fortification bolts
- grouting below crane rails and bridge bearings
- grouting of steel fittings in concrete
- grouting of joints between prefabricated parts
- grouting of joints between prefabricated parts and place concrete
- closing of openings and cavities in the concrete
- production of tension anchoring
- repairing grout (with connection reinforcement only)

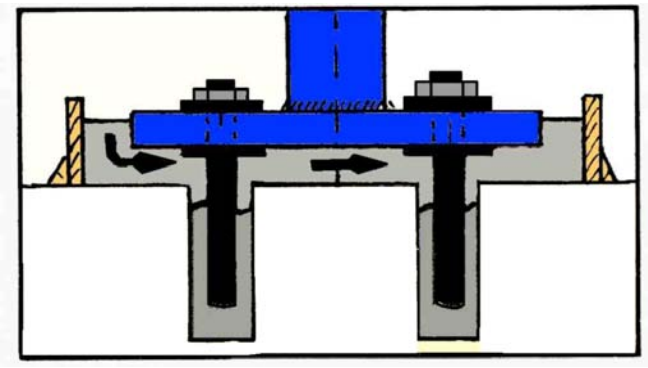
For the field of application regarding the production of additional tension anchoring the calculation procedures of DIN 1045, especially the comparative tensions of table 19 may be applied, this as an agreement with the demands of DIN 1045 and special anchor tension qualifying tests of PAGEL-Grouts can be submitted on enquiry.

The calculation proof must be proved by the responsible designer on the basis of the measuring results of the respective product.

2.1 Grouting of Machines

When grouting machines, the machine elements are either adjusted to levels, fixator or to lining plates. In any case the machine elements are fixed via anchors to the concrete base. Grouting of the machine can only take place after grouting of the anchoring has been finished and the air existing in the anchoring has escaped.

Under no circumstances should this grouting of anchors be allowed to take place at the same time as grouting the support plates, as the included air can not escape.

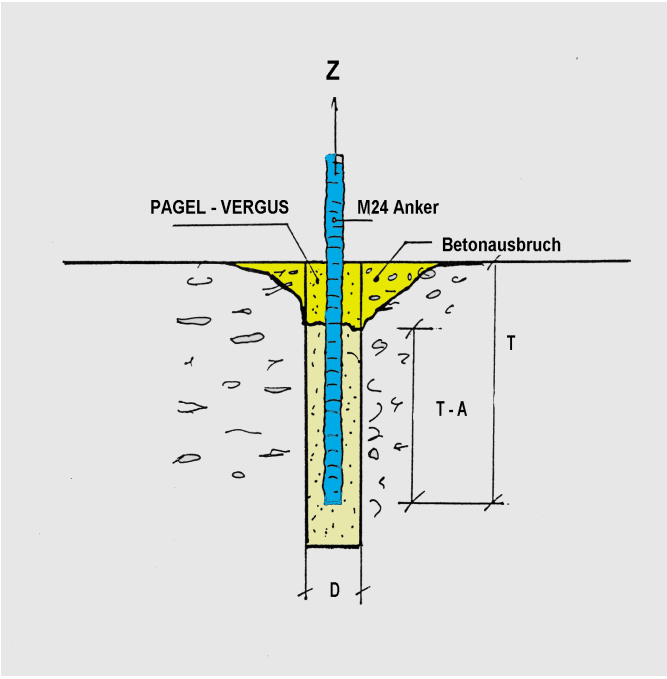


Picture 1: examples of sub-grouting showing basis plate and anchor bar

2.2 Tension Anchorages

Tension anchorages must frequently be produced on the building site. Either when the use of a building has to meet new requirements, or when a factory is switching over to other products. This is connected with the construction of new production plants.

For the anchorage of new machine plants the producing of core drillings has proved itself as this is a gentle productive technology. The concrete structure within the surrounding area of the core drillings remains practically undisturbed. With wet-drilling diamond drill bits the needed diameter and the necessary depth can be reached with a sufficient drilling speed. Also the drilling-through of an existing reinforcement is possible, when having the suitable drilling equipment.



PAGEL-GROUT - M24 anchor - concrete break-off
Graphic 1: diagram of an anchor bar anchorage

When exceeding the concrete bond stress a circular crater – this as a sign of a rupture – breaks off within the upper area of the concrete.

As the drill core normally breaks off through jamming and for this reason the break-off of the core does not take place at its deepest place some additional cm regarding the anchoring length are to be drilled.

Picture 2: The upper anchorage area must be deducted mathematically from the anchorage length.

In the upper area of the drilling however – depending on the diameter of the core - at least 5 cm of the plug-in depth of the anchorage length must be deducted, this is because, in the upper concrete area the cleavage strength of the surrounding concrete is lower compared to the bigger plug-in depth.

For the calculation of the bond stress between grout and concrete the basic values of the permissable bond stress are taken from the DIN 1045 – this according to the existing comparible concrete strength.

	1	2	3	4	5	6
	bond area	permissable basic values of the bond stress permissable τ_1 in N/mm2 for strength classes of the concrete				
		B15	B25	B35	B45	B55
1	1	1.4	1.8	2.2	2.6	3.0
2	2	0.7	0.9	1.1	1.3	1.5

Table 1: DIN 1045, table 19 permissable basic values of the bond stress, permissable τ_1 in N/mm2

2.3 Steps to grouting repairs

In the field of concrete repair repairs using grouts are carried out in nearly all West European states.

In Germany this field is still reserved for PCC- and SPCC-mortars.
The background of these rules is simply said to be found in the fact that for repairs in the constructive engineering special protection functions are assigned to the repair mortars.

The origin of the ZTV-SIB goes back in time 20 years. At that time no standard building materials where known which could meet the requirements of the ZTV-SIB.

As modern grouts with their material-specific qualities have been clearly improved grouts of today meet the main requirements of the ZTV-SIB.

Shrinkage was clearly reduced.
With the products

V1/50 PAGEL-GROUT and
V1/160 PAGEL-GROUT

Shrinkage values less than 1.0 0/00 are reached, the limit value of the ZTV-SIB falls below.

Less E-modules are to be found in the field of the ZTV-SIB – taking the a.m. PAGEL-products between B 35 and 45 - this is achieved by using agents and additives. Therefore, seen from this side of the test values a concrete repair is possible.

	1	2	3	4	5	6	7
1	strength class of the concrete	*B10*	*B 15*	*B25*	B35	B45	B55
2	elasticity module E_b in N/mm²	22000	26000	30000	34000	37000	39000

Table 2: Elasticity modules for the various concrete strength classes according to DIN 1045 (1988) table 11.

The following qualifications are applicable with regard to the concrete repair:

The quality of the concrete base must at least correspond to a BII-concrete, i.e. at least a concrete of a comparative concrete-strength class B35.

For the repair grout a projecting reinforcement must exist and/or is to be produced (corresponds to concrete according to DIN 1045).

The layer thickness must amount to at least 50mm, (then this measure can (must) also be seen on the grounds of the admission bases of the ZTV-SIB).

The composition of the grouts must correspond to DIN 1045 (only base materials being admitted according to DIN 1045)

Only grouts are allowed (applies to V1/50 and V1/160)

Production must be covered by self-control as well as foreign supervision.

Typical repair grouting at a balcony ledge using V160 (B45). In principle these works are carried out only when having a projected reinforcement to the balcony plate and a clip basket for balcony ledge.

3. Preparation of the Concrete Basis

Practically every standard formula concrete sediment on the surface is cement slurry for reasons of its admixture and cement values.

The cement is enriched with a lot of water and has only got low compressive strengths and also low tension strength.

Unprepared concrete surfaces do normally have a surface tension strength less than 0,5 N/mm^2 and are **not** suitable for the absorption of high-solid mortars (grouts).
All less adhesive surface components as well as all impurities are to be removed until the tension-proves mass-concrete is reached.

Besides the conventional procedures like

- blasting with solid basting equipment
- milling
- shot blasting
- pressing and bush hammering

it is also possible to apply hand milling tools when having defined and small surfaces.

Within the grouting area the less adhesive components are to be removed. The aggregate grain must be exposed in order to reach a surface adhesion strength which corresponds to the adhesion strength of the existing concrete ($\geq$ 1.5 N/mm^2) and an adhesion is achieved between the grout and the concrete base (attention is to be paid to pre-wetting and curing).

3.1 Minimum demands to the concrete base

Minimum quality:	comparable concrete compressive strength $\geq$ B25
Cement slurry:	completely to be removed until the aggregate grain is exposed
Adhesive strength:	at least 1.5 N/mm^2
Cracks:	to refill, to inject, to impregnate
Capillary absorbency:	before grouting pre-wet sufficiently

4. Selection of products

4.1 Selection of products on the grounds of the grouting height

Product	Product type	Grain size	Grouting height
		mm	mm
V1/10	Standard Grout	0.1 – 1.0	5 – 30
V1/50	Standard Grout	0.1 – 5.0	20 – 100
V1/160	Standard Grout	0.1 – 16.0	> 100
V2/10	Fast Setting Grout	0.1 – 1.0	10 – 20
V2/40	Fast Setting Grout	0.1 – 4.0	20 – 60
V2/80	Fast Setting Grout	0.1 – 8.0	50 – 100
V2/160	Fast Setting Grout	0.1 – 16.0	> 100

4.2 Selection of products on the grounds of the flow route

Product	Product type	Grain size	Grouting height	hand processing	Mechanical processing
		mm	mm	M	m
V1/10	Standard Grout	0.1 – 1.0	5 – 30	4.00	> 30
V1/50	Standard Grout	0.1 – 5.0	20 – 100	4.00	> 20
V1/160	Standard Grout	0.1 – 16.0	> 100	2.00	> 10
V2/10	Standard Grout	0.1 – 1.0	10 – 20	1.00	> 10
V2/40	Fast Setting Grout	0.1 – 4.0	20 – 60	1.00	> 10
V2/80	Fast Setting Grout	0.1 – 8.0	50 – 100	1.00	> 5
V2/160	Fast Setting Grout	0.1 – 16.0	> 100	1.00	> 5

PAGEL-GROUTS do have the ability to flow under continuous material supply very well. If, however, – when hand mixings – the process is interrupted "again and again" and resulting from this the product stops again and again, it can on reaching a certain mass not be "pushed forward" any longer from the later poured product. Even more problematic is that layers (floes) form themselves as a result from the later pouring. This should be avoided.

The flow ability of the product depends directly on the supply of the mixed material. Using mono pumps (spindle drag pumps) and ensuring a continuous adding of material the grout is constantly kept moved and therefore it can be pushed forward far away.

PABEC I and PABEC II are supposed to be the best possible machines. They in the meantime are equipped with a Vario-transmission as well as a continuous water filling-system. They are able to grant an equally mixed basis product, i.e. from cement glue (E1F PAGEL ANCHOR- and INJECTION GROUT) to grout (V1/160 PAGEL GROUT) for a longer period of time.

4.3 Selection of products for tension anchorings

For the production of additional tension anchorings PAGEL GROUTS are preferred for the vertical anchorings as they correspond to the computation handicap of DIN 1045 table 19.

Regarding the selection of the product the ring split around the anchor is to be treated equivalent to the layer thickness given in the technical leaflets.

Product	Product type	Grain size	Ring split	Hand processing	Mechanical processing
		mm	mm	m	m
V1/10	Standard Grout	0.1 – 1.0	5 – 30	≤ 4.00	> 30
V1/50	Standard Grout	0.1 – 5.0	20 – 100	≤ 4.00	> 20
V1/160	Standard Grout	0.1 – 16.0	> 100	≤ 2.00	> 10
V2/10	Fast Setting Grout	0.1 – 1.0	10 – 20	≤ 1.00	> 10
V2/40	Fast Setting Grout	0.1 – 4.0	20 – 60	≤ 1.00	> 10
V2/80	Fast Setting Grout	0.1 – 8.0	50 – 100	≤ 1.00	> 5
V2/160	Fast Setting Grout	0.1 – 16.0	> 100	≤ 1.00	> 5
V14/10	Soft Plastic Tamping Mortar	0.1 – 1.0	5 – 30	≤ 1.00	≥ 1.00

For the dimensioning of the anchorings certificates regarding the suitability of anchor bars - and from which the computation of the necessary bond stress comparible values can also be taken - are available to the customer on enquiry.

4.4 Selection of products according to the strength development

Depending on the demand of the construction the using of grout might be necessary after a short and/or very short setting time.

Taking a 24 hour setting-time the compressive strengths of the products regarding the V1/.. PAGEL.GROUT line are normally sufficient (depending on the demand of the building site).

In case a loading after a few hours is demanded the products of the V2/..PAGEL-GROUT line should be used. They also react relatively insensitively to low temperatures when applying.

4.5 Development of strengths regarding the PAGEL standard products

Product	Product type	Grain size	Compressive strength development at 20°C - after days in N/mm²		
		mm	1	7	28
V1/10	Standard Grout	0.1 – 1.0	37	72	96
V1/50	Standard Grout	0.1 – 5.0	44	77	98
V1/160	Standard Grout	0.1 – 16.0	46	75	83

4.6 Development of strength regarding the PAGEL fast setting mortars

Product	Product type	Grain size	Compressive strength development at 20°C - after hours as well as days in N/mm²					
		mm	2 h	4 h	8 h	24 d	7 d	28 d
V2/10	Fast Setting Mortar	0.1 – 1.0	14	20	32	40	62	78
V2/40	Fast Setting Mortar	0.1 – 4.0	14	22	32	39	62	78
V2/80	Fast Setting Mortar	0.1 – 8.0	12	18	28	40	56	75
V2/160	Fast Setting Mortar	0.1 – 16.0	12	21	31	38	56	84

4.7 Development of strength when having low application temperatures

When having low application temperatures the rate of hydration of cement-bound building materials clearly slows down.

The example of V1/50 PAGEL-GROUT shows the various rates of hydration for different application temperatures.

Product	Product type	Grain size	with	Compressive strength development after days in N/mm²			
		mm	°C	1	3	7	28
V1/50	Standard Grout	0.1 – 5.0	5	2,2	48	68	87
			10	18	66	74	87
			25	58	75	84	104

The products of the V2 /.. PAGEL-FAST-SETTING-MORTARS line are clearly more insensitively to low application temperatures and show a very positive compressive strength development (basis materials not being pre-warmed).

Product	Product type	Grain size	with	Compressive strength development after hours and days in N/mm²						
		mm	°C	2 h	4 h	6 h	8 h	24 h	7d	28 d
V2/10	Fast Setting Mortar	0.1–1.0	5	18.8	25.0	28.1	34.2	43.8	50.0	62.5
V2/40	Fast Setting Mortar	0.1–4.0	5	12.0	15.0	21.5	23.4	36.0	58.0	74.0
V2/80	Fast Setting Mortar	0.1–8.0	5	10.0	13.3	15.6	17.5	28.1	43.0	53.1
V2/160	Fast Setting Mortar	0,1–16,0	5	3.1	11.8	12.5	13.8	28.1	44.5	65.2

4.8 Basis of the compressive strength development when having low application temperature

Cement-bound building materials are not allowed to be applied when having weather temperatures and/or temperatures of parts of building components below + 5 °C. As the hydration is retarded when having low application temperatures and also in case of a sinking of the temperatures down to frost, frost damages are to be feared. However, frost damages can only develop in case the compressive strengths are less than 5 N/mm^2.

Therefore care is to be taken when applying cement-bound building materials that the temperature of + 5 °C regarding building components and/or material is kept for the time until the compressive strength of 5 N/mm^2 is reached.

Taking V1/50 PAGEL-GROUT a period of at least 36 hours with at least +5°C must be allowed in order to reach for sure a frost compressive strength of 5 N/mm^2.
When this compressive strength been reached a further increase of the compressive strength takes place relatively quickly.

V2 PAGEL-FAST-SETTING-MORTAR

Also when having fast setting mortars there is the danger of frost damages given in case frost effects the compressive strength under 5 N/mm^2.

V2 PAGEL-FAST-SETTING-MORTARS have, however, the big advantage that even when having low application temperatures the compressive strength is retarded insignificantly.

Therefore, using

V2 PAGEL-FAST-SETTING-MORTARS

means that awkward heat treatment measures are not necessary if at the time of application + 5 °C are reached (temperature of weather and parts of building components).

5. Production of mixtures

Wetting of the cement particles with water when having low temperatures is carried out much slower as for example when having 20 °C. Also the chemical used for the deflocculating (high capacity agent) is dissolved more slowly when having low temperatures.

Way out:

- Allow to mix for a longer period of time.
  It is necessary to use a compulsory mixer using 2/3 – 3/4 of the water amount, pre-mix tenaciously, add the remaining water slowly.

- A better mixing is reached when the **mixing water** is not too cold (**at least 15 °C**) (to achieve the effect of the agent).
- The total amount of water to be added is within the given tolerance range. A reduction of the maximum water quantity in case of low temperatures is not necessary.

5.1 Fundamental contemplations

With regard to the non-shrinking PAGEL-GROUTS the flow behaviour is caused by the dry pre-mixed high-capacity agent and not via water. For the basis mixture approx. 2/3 of the water are given into a compulsory mixer and mixed for about 3 minutes. Then the remaining water is added and mixed until the necessary mortar consistency is reached. Generally two minutes are enough for the additional mixing.

5.2 Free-fall mixers

Free-fall mixers can only mix "rough" mortars and/or mass building materials containing a low amount of cement sufficiently. They are not suited for the mixing of grouts. Especially when having fine mortars with a low grain the mortar powder sticks to the walls of the mixer. About a sufficient mixing effect cannot be talked when using free-fall mixers for mixing grouts.

5.3 Compulsory mixers

In case of compulsory mixers agitating arms rotate in a fixed agatation vessel. These mixers (compulsory mixers) force the mixture via a massive shear force to be mixed thoroughly and by this a good and equal mixing quality is reached. These types of mixers are often combined with mortar pumps.

5.4 Hand-mixing equipment

Using hand-mixing equipment attention has to be paid to the compulsory mixing effect when mixing. Drilling machines with an inserted mixing agigator are completely unsuitable for the mixing of grouts, this because a shearing of the mixture is not possible.

The shearing of the mixture is only possible when using a double agigator mixer with a low rotational speed.

BEBA - double agigator mixers

The mixing of grout when using a double agigator is to be executed the same way as when using a compulsory mixer. After filling 2/3 of the total amount of water into a mixing vessel the dry mortar is added and mixed for approx. 3 minutes. Then the remaining water is added and mixed till the necessary consistency of the mortar is reached. For a further mixing about 2 minutes are necessary.

The total mixing time amounts to at least 10 minutes.
In case the mixed grout remains in the mixing vessel for a longer period of time the material should before applying be mixed again for a short time.

6. Conveying

For conveying the mixed mortar screw conveyors and piston pumps are suitable. Screw conveyors should be preferred as by this kind of conveying a uniform mortar flow can be guaranteed.

Because of the compact and homogeneous consistency of the mortar conveying distances of more than 100 m are possible even when having very low heads. The diameter of the conveying hose is only depending on the biggest grain of the product and the needed amount to be conveyed.

6.1 Conveying technique

PFT N2 Vario spindle drag pump

The spindle drag pump may be used for the conveying of mortars up to a biggest grain of 4 mm and/or 5 mm. The conveying speed can be regulated via the Vario transmission from 0 – 14 l/min.

The mortar itself must be mixed in a separate mixer.

S5 Putzmeister spindle drag pump with a compulsory mixer put on top

This machine equipment allows mixing and conveying at the same time. With the corresponding conveying speed an always sufficiently mixed product is available, i.e. the conveying must not be interrupted.

6.2 Mixing- and conveying technique

Using the mixing and conveying technique the mortar powder is being filled into a storage tank. From there it is conveyed into a mixing unit and via the rotation speed of the conveyor shaft it is supplied in a certain volume to the mixing unit. This makes it possible to inject the mixing water under a constant and steady pressure, the amount of water to be added is carried out by means of a scale value in the proportion l/h.
The grout consistency is checked via the given expansion and/or slump at the end of the spindle, this before the conveying hose is connected. Before connecting the conveying hose the same should be rinsed with water (this applies to all conveying pumps and conveying systems) in order to reduce the side friction in the hose. Additionally cement slurry in an amount for approx. 5 l is filled in the hose before connecting in order to reduce the side friction clearly when "starting". In case no pre-wetting takes place and no slurry is used material blockades can occur in the dry hose.

May mixing- and conveying pump

PABEC II Vario mixing- and conveying pump

The mixing- and conveying unit of the May mixing- and conveying pump is situated underneath the storage tank, therefore, a very constant powder proportion within the mixing unit is guaranteed.

Taking the PABEC II Vario mixing- and conveying pump the mixing tube stands vertically and the dry powder is conveyed by means of a steel helix into the mixing tube. The rotating and conveying speeds can be "led" (automatically) in dependence of the amount of water to be added.

7. Grouting

PAGEL-GROUTS have a consistency reminding of a "honey-like" flowability. The product flows slowly, however much more constant and homogeneous as this is the case with most of the other grouts. This has the advantage that a constant flow over very long ways is achieved without showing any segregation.

Unimportant whether manual or mechanical application is carried through enough basis material must be available for the grouting object in order to allow a grouting without interruption.

The basis mixture usually is given into a compulsory mixer, 2/3 of the water is added and the mixture is mixed for approx. 3 minutes. In this dry form the chemical flow agents react very well. The necessary remaining amount of water is then added and mixed until the necessary mortar consistency is reached. Generally a time of 2 minutes is sufficient for the final mixing.

7.1 Continuous grouting

For the grouting of small separate supports or individual machine supports the necessary amount of grouting is produced separately and then poured without interruptions (caused by rests when mixing). Grouting preferably is carried out from one corner of the not-sucking formwork without changing the position until leaving on the opposite side without air entrainment. Rodding is to be avoided as this trafs air under the support plate which cannot escape.

7.2 Grouting of extensive machine supporting surfaces

In case of either extensive or big groutings to be carried out a continuous mixing cannot be guaranteed when mixing the grout separately or manually.

The use of mixing- and conveying pumps instead is sensible.

If a receiving hopper was positioned at the grouting side the grouting can take place by using a mixing- or conveying pump.

Mixing- and conveying pumps, however, do not only convey the mortar mixture but also mix-in air.

When Grouting grouts via hose connections at the formwork only mono pumps should be used in order to avoid air entrainment underneath the support plate.

A combination of mixing- and conveying pumps with mono pumps is sensible.

8. Curing

The curing of a cement-bound building material comprises the following technical background:

Preventation of cracks and separation from the (concrete) basis

The tension strength of the cement-bound products must be higher than the shrinkage stress resulting from the shrinking if the curing is broken off.

Logically the curing takes longer if through low temperatures the development of the compressive strengths is reduced significantly.

Practically this time factor can be defined:

The building material must at least have reached 60 % of its final compressive strengths so that the tension strength is higher than the shrinkage stress.

Consequently, when having low application temperatures the evaporation of the water from the mortar must be prevented.

Having low application temperatures the covering with "thermo foils has proved itself to be good practice.

In order to gain all technical handicap values grout must be cured consequently for 5 days.