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Pressure of fresh concrete on vertical formwork
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Pression de béton fraîchement malaxé sur des coffrages verticaux
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Contents

Foreword

This document has been prepared by Working Committee NA 005-07-11 AA *Bauausführungen* of the *Normenausschuss Bauwesen* (Building and Civil Engineering Standards Committee).

The new edition of the standard was published because of the need to incorporate concrete of consistency classes F5, F6 and self-compacting concrete (SCC), as no provisions covering these types of concrete existed up to this point in time. The specifications have been developed on the basis of scientific publications and the results of tests on the pressure of fresh concrete on vertical formwork.

Amendments

The standard differs from DIN 18218:1980-09 as follows:

a) the terms and definitions have been brought into line with technical developments, and the terminology has been adapted to correspond to that used in the reference standards;

b) loads are determined using the concept of partial safety factors;

c) the influence of fresh concrete temperatures is taken into account;

d) the influence of concrete compaction (vibration) is taken into account;

e) the method used to determine the pressure of fresh concrete has been amended, particularly with regard to consistency classes F5, F6 and SCC;

f) test methods to determine the end of setting of concrete have been specified.

Previous editions

DIN 18218: 1980-09

1 Scope

This standard is intended to be used to determine the fresh concrete pressure on vertical formwork by concrete according to DIN EN 206-1 and DIN 1045-2, and by self-compacting concrete (SCC) according to *DAfStb-Richtlinie "Selbstverdichtender Beton"* (SCC Code of practice issued by the German Reinforced Concrete Committee) with a maximum size of aggregate of 63 mm.

The fresh concrete pressure established according to this standard is the most important criterion governing the design of vertical formwork and formwork that deviates from the vertical by up to ± 5°.

Deviations from the specifications of this standard are permitted if a more precise verification is made on the basis of calculation and/or empirical testing.

2 Normative references

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

DIN 1045-2, *Concrete, reinforced and prestressed concrete structures — Part 2: Concrete — Specification, properties, production and conformity — Application rules for DIN EN 206-1*

DIN 4235-1:1978-12, *Compacting of concrete by vibrating — Vibrators and vibration mechanics*

DIN 4235-2:1978-12, *Compacting of concrete by vibrating — Compacting by internal vibrators*

DIN 4235-3, *Compacting of concrete by vibrating — Compacting by external vibrators during the manufacture of precast components*

DIN 4235-4, *Compacting of concrete by vibrating — Compacting of in-situ by formwork vibrators*

DIN EN 206-1:2001-07, *Concrete — Part 1: Specification, performance, production and conformity; German version EN 206-1:2000*

DIN EN 480-2, *Admixtures for concrete, mortar and grout — Test methods — Part 2: Determination of setting time*

DIN EN 12350-5, *Testing fresh concrete — Part 5: Flow table test*

DIN EN 12812, *Falsework — Performance requirements and general design*

DAfStb-Richtlinie — Selbstverdichtender Beton (SVB-Richtlinie) (DAfStb Code of practice on self-compacting concrete)[1)]

3 Terms, definitions and symbols

3.1 Terms and definitions

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

3.1.1
placing temperature
$T_{\text{c,placing}}$
temperature of the fresh concrete directly after placing (in the formwork)

1) Obtainable from *Beuth Verlag GmbH*, 10772 Berlin.

NOTE The placing temperature can be deduced from the temperature of the fresh concrete at the time of its handover on site and from the prevailing ambient conditions.

3.1.2
depth of penetration of internal vibrator
h_v
difference in height between the surface of the fresh concrete and the lower end of the internal vibrator

3.1.3
end of setting
t_E
time between the first addition of water for making the concrete and the point in time at which the concrete is fully set

NOTE The end of setting of the fresh concrete t_E can be determined by the Vicat penetration method specified in DIN EN 480-2 using mortar that is sieved from the concrete using a sieve of 4 mm aperture size. The end of setting may also be approximated to $t_E = 1{,}25 \cdot t_{E,knead}$, where $t_{E,knead}$ is the end of setting according to the “knead-bag test” (see Annex A).

3.1.4
fresh concrete
mixture of cement, aggregate and water (and, where required, admixtures and additions), that has not yet set or hardened and that still requires the support of formwork in order to retain its dimensional stability

3.1.5
lateral fresh concrete pressure
σ_h
lateral pressure caused by fresh concrete acting on the surface of formwork

3.1.6
fresh concrete density
γ_c
dead weight divided by the volume of the fresh concrete after compaction

3.1.7
hydrostatic pressure head
h_s
difference in height between the surface of the fresh concrete and the point at which the fresh concrete pressure reaches the value $\sigma_{hk,max}$

3.1.8
consistency
measure of the deformability and flowability of the fresh concrete

NOTE The consistency of fresh concrete is evaluated in accordance with DIN EN 206-1 or DIN 1045-2 by means of consistency classes or flow classes. The concrete is classified into classes F1, F2, F3, F4, F5 or F6 or as self-compacting concrete. The flow table test according to DIN EN 12350-5 is used.

3.1.9
reference temperature
$T_{c,Ref}$
fresh concrete temperature used to determine the end of setting t_E

3.1.10
placing rate
v
rise in level of the fresh concrete surface during pouring related to time

3.2 Symbols

d_s	diameter of reinforcement
h	height of concrete
h_E	height of concrete at end of setting t_E
h_s	hydrostatic pressure head
h_v	depth of penetration of internal vibrator
H	overall height of building part to be poured
t	time
t_E	end of setting
T	temperature
v	placing rate (pouring rate)
γ	density, partial safety factor
γ_c	density of fresh concrete
γ_F	partial safety factor of an action
σ	stress
σ_h	lateral fresh concrete pressure
σ_{hd}	design value of lateral fresh concrete pressure
σ_{hk}	characteristic value of lateral fresh concrete pressure

3.3 Subscripts

c	fresh concrete
d	design value
E	end of setting of fresh concrete
placing	moment in time at which the fresh concrete is placed in the formwork
F	action, force
h	lateral
hydr	hydrostatic pressure method taking into account the density of fresh concrete
knead	“knead bag” method
k	characteristic value
max	maximum value
Ref	reference value

4 Fresh concrete pressure

4.1 General

A distinction shall be made between the absolute value of fresh concrete pressure and the distribution of the fresh concrete pressure over the height of the formwork. In this standard, the fresh concrete pressure is stated as the characteristic value of the action σ_{hk}. When designing formwork constructions including their supports and anchoring, the fresh concrete pressure shall be taken to be a static load.

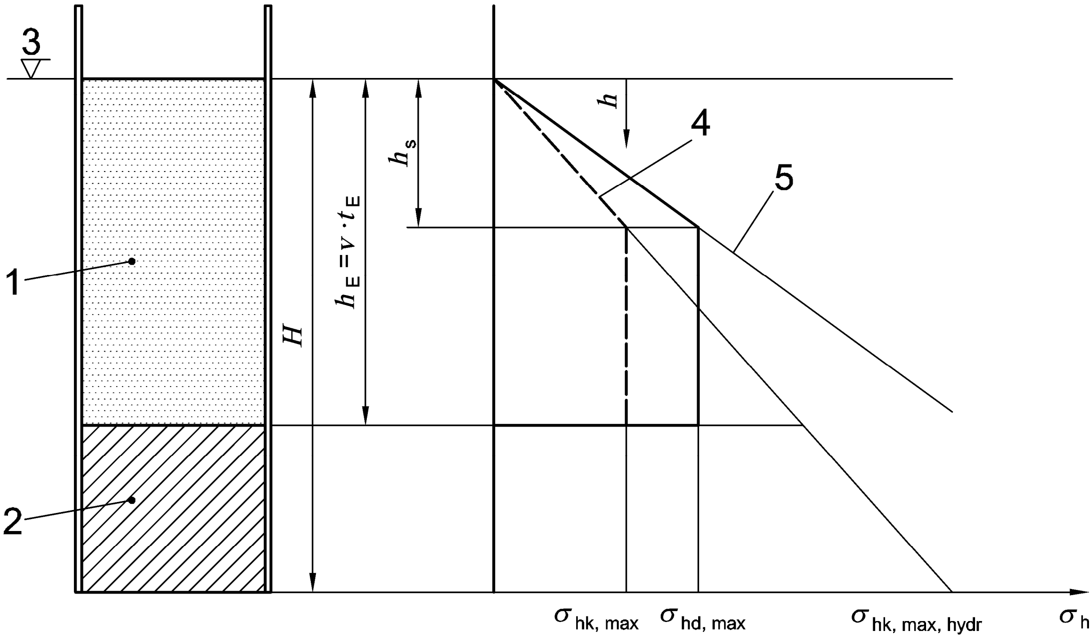
4.2 Design value of fresh concrete pressure

The design of formwork and falsework including anchoring shall be based on the design value of the fresh concrete pressure $\sigma_{hd} = \gamma_F \cdot \sigma_{hk}$. The partial safety factor γ_F can be taken from DIN EN 12812. For the analyses at ultimate limit state the factor is $\gamma_F = 1{,}5$ for unfavourable actions. A partial safety factor of $\gamma_F = 1{,}0$ shall be used in cases where the fresh concrete pressure is assumed to act favourably.

4.3 Distribution of fresh concrete pressure over the height of the formwork

In the ultimate limit state, the formwork of height H shall be designed assuming the most unfavourable load position in the pressure distribution diagram shown in Figure 1 as a function of the level of the concrete. The distribution of the fresh concrete pressure over the height $h_E = v \cdot t_E$ shall be taken to be as in Figure 1. Where the height H of the formwork is greater than h_E the fresh concrete pressure distribution in Figure 1 is a moving load that changes upwards over the height of the formwork.

A suitable load diagram shall be used for the analysis of formwork deformation at the serviceability limit state.



Key

1 fresh concrete
2 set (hardened) concrete
3 upper level of concrete
4 hydrostatic fresh concrete pressure
5 γ_F-times hydrostatic fresh concrete pressure

Figure 1 — Distribution of fresh concrete pressure over the height of the formwork

4.4 Determination of the characteristic value of the maximum fresh concrete pressure

Characteristic values of the maximum possible fresh concrete pressure $\sigma_{hk,max}$ for various placing rates and consistency classes can be calculated on the basis of the information given in Table 1.

In addition, the characteristic value of the maximum fresh concrete pressure can be taken from the diagrams in Figures B.1 to B.5. Each diagram is based on a specified end of setting t_E for the fresh concrete.

The equations in Table 1 and Figures B.1 to B.5 are based on the following conditions:

a) the fresh concrete density γ_c is 25 kN/m^3. Where it has a different value, 5.4 shall be taken into account;

b) the actual end of setting of the fresh concrete placed into the formwork does not exceed t_E.

c) fresh concrete of consistency classes F1, F2, F3, F4, F5 and F6 is compacted using internal vibrators;

d) the formwork is watertight (e.g. large-area formwork made of veneer plywood);

e) the mean placing rate v of concrete of consistency classes F1, F2, F3, F4 is not more than 7,0 m/h at any point;

f) the concrete is poured in opposite direction to the rise in level (i.e. it is placed from the top).

If the concrete is placed from the bottom (such as when pumps are used for placing SCC) $\sigma_{hk,max}$ shall be assumed to be at least the hydrostatic fresh concrete pressure at the feed location. The maximum difference in height between the feed location and the upper level of the concrete should at no time be more than 3,5 m. The concrete shall be placed at a steady rate until it reaches its maximum level. Placing of the entire building part should not take longer than 60 min, and any interruptions to the concreting process should not be longer than 10 min, except where there will be no significant changes in the rheological properties of the fresh concrete during placing, in which case longer interruptions and greater differences in height are possible.

Subclause 5.3.2 shall be taken into account in cases where the temperature at which the fresh concrete is placed, $T_{c,placing}$, deviates from the reference temperature $T_{c,Ref}$ according to 3.1.9 by more than 1 K.

The end of setting of the fresh concrete is determined on the basis of its composition (*w/c* value, cement type, additives, admixtures) and the temperature conditions (fresh concrete and ambient temperature combined with the type of formwork) at the time of placing, and is to be calculated during the initial testing (see 3.1.3, 5.2 and Annex A).

The following information regarding the end of setting can be used to indicate the expected values.

In the case of concrete with a strength development classified as “rapid” in accordance with DIN EN 206-1:2001-07, Table 12, at a temperature over +15 °C, or concrete classified as “medium” at a temperature over +20 °C, the end of setting can be assumed to be $t_E = 5$ h provided the mix does not contain any retarders. Where concrete is of “rapid” strength development at a temperature over +10 °C, “medium” at a temperature over +15 °C, or “slow” at a temperature over +20 °C, the end of setting may be assumed to be $t_E = 7$ h if the other conditions are the same. Subclause 5.3 shall be referred to for deviations between the reference temperature ($T_{c,Ref}$) and the temperature of the concrete during setting. The estimate of the setting time is based on concrete with a strength class of at least C20/25.

A reliable estimation of the end of setting cannot be made for concrete of “very slow” strength development, at lower concrete temperatures, or where retarding admixtures are used. It is to be noted that the addition of superplasticizers can considerably retard the setting procedure, particularly in the case of highly flowable concrete (i.e. concrete of consistency classes F5, F6, or SCC).

Table 1 — Characteristic values of maximum lateral fresh concrete pressure (where concrete is placed in opposite direction to the rise in level)

	1	2
1	Consistency class	Maximum lateral fresh concrete pressure when placed in opposite direction to the rise in level (from above) $\sigma_{hk,max}$ kN/m²
2	F1	$(5 \cdot v + 21) \cdot K1 \geq 25$
3	F2	$(10 \cdot v + 19) \cdot K1 \geq 25$
4	F3	$(14 \cdot v + 18) \cdot K1 \geq 25$
5	F4	$(17 \cdot v + 17) \cdot K1 \geq 25$
6	F5	$25 + 30 \cdot v \cdot K1 \geq 30$
7	F6	$25 + 38 \cdot v \cdot K1 \geq 30$
8	SCC	$25 + 33 \cdot v \cdot K1 \geq 30$

Where

v is the placing rate (pouring rate) in m/h;

$K1$ is the factor taking into account the setting behaviour according to Table 2.

Table 2 — Factors $K1$ for setting behaviour

	1	2	3	4	5
1	Consistency class	Factors $K1$			
2		End of setting t_E = 5 h	End of setting t_E = 10 h	End of setting t_E = 20 h	General [b]
3	F1 [a]	1,0	1,15	1,45	$1 + 0,03 \cdot (t_E - 5)$
4	F2 [a]	1,0	1,25	1,80	$1 + 0,053 \cdot (t_E - 5)$
5	F3 [a]	1,0	1,40	2,15	$1 + 0,077 \cdot (t_E - 5)$
6	F4 [a]	1,0	1,70	3,10	$1 + 0,14 \cdot (t_E - 5)$
7	F5, F6, SCC	1,0	2,00	4,00	$t_E / 5$

[a] Applies for concreting sections of a height H up to 10 m.

[b] Applies for 5 h ≤ t_E ≤ 20 h; t_E in h.

5 Parameters affecting the magnitude of fresh concrete pressure

5.1 General

Various factors can increase or decrease the pressure of the fresh concrete. When placed in opposite direction to the rise in level (from above), the hydrostatic fresh concrete pressure $\sigma_{hk,max,hydr} = \gamma_c \cdot H$ is the maximum possible characteristic value of the fresh concrete pressure. It is to be used as the upper limit value even where a higher value is obtained for the pressure as a result of one or more of the unfavourable parameters described in the following subclauses.

A different value of hydrostatic pressure $\sigma_{hk,max,hydr}$ can be assumed if it can be ensured that action is being taken to reduce the pressure (as described in the previous and following subclauses). In such cases, the permissible placing rate is mainly a result of the loadbearing capacity of the formwork and the end of setting of the concrete used.

5.2 End of setting

The end of setting t_E shall be used to take into account the influence of setting behaviour on fresh concrete pressure. When applying Table 1, the correction factor $K1$ from Table 2 shall be used. Intermediate values may be obtained by linear interpolation.

Alternatively, the diagrams in Figures B.1 to B.5, in which variations in setting behaviour are already taken into account, can be used. Intermediate values may be obtained by linear interpolation.

5.3 Temperature

5.3.1 General

The temperature influences the setting time of the fresh concrete as well as affecting its rheological behaviour and hence its pressure. The influence of the temperature of the fresh concrete and the outside temperature need to be taken into account.

5.3.2 Fresh concrete temperature

If, during placing, the temperature of the fresh concrete $T_{c,placing}$ is higher than the reference temperature $T_{c,Ref}$, the fresh concrete pressure may be reduced by 3 % $\sigma_{hk,max}$ for every 1 K of temperature difference, but by not more than 30 %, provided that the concrete production and/or the design of the formwork and/or protection measures ensure the temperature of the fresh concrete remains at this higher level until it has fully set.

If the temperature of the fresh concrete during placing, $T_{c,placing}$, is lower than the reference temperature $T_{c,Ref}$ or if a temperature higher than $T_{c,Ref}$ cannot be maintained, $\sigma_{hk,max}$ shall be increased by 3 % for every 1 K of temperature difference for concrete of consistency classes F1, F2, F3 and F4 and by 5 % for every 1 K temperature difference for concrete of consistency classes F5 and F6 and for SCC. The difference between $T_{c,Ref}$ and $T_{c,placing}$ shall be not more than 10 K for concrete of consistency classes F1, F2, F3 and F4 and not more than 5 K for concrete of consistency classes F5 and F6 and for SCC. Otherwise the end of setting shall be redetermined on the basis of a lower reference temperature $T_{c,Ref}$.

When using low-heat cement the lowest anticipated fresh concrete temperature shall not be less than the reference temperature $T_{c,Ref}$ even when the outside temperature is considered (see 5.3.3), when concrete of consistency classes F5 and F6 and SCC is used.

5.3.3 Outside temperature

The influence on the fresh concrete pressure of the outside temperature, though lower than the placing temperature, does not need to be taken into account if the concrete is thermally insulated while it sets and its temperature is thus maintained.

The influence of the outside temperature does need to be taken into account, however, if the temperature of the fresh concrete T_c goes below the placing temperature $T_{c,placing}$ while the concrete sets. In this case $\sigma_{hk,max}$ shall be increased by 3 % for every 1 K of temperature difference for concrete of consistency classes F1, F2, F3 and F4. For concrete of consistency classes F5 and F6 and for SCC, $\sigma_{hk,max}$ shall be increased by at least 5 % for each 1 K of temperature difference. The difference between $T_{c,Ref}$ and the lowest temperature of the concrete while it sets in the formwork shall be not more than 10 K for concrete of consistency classes F1, F2, F3 and F4, and not more than 5 K for concrete of consistency classes F5 and F6 and for SCC.

If outside temperatures are higher than $T_{c,placing}$ this fact shall not be taken into account.

5.3.4 Heating of formwork

Heating of formwork shall not generally be assumed to reduce the pressure of the concrete.

5.3.5 Cooling of concrete

Cooling of the fresh concrete by artificial means increases pressure, and this shall be taken into account in accordance with 5.3.3 if the temperature of the fresh concrete drops below the placing temperature $T_{\mathrm{c,placing}}$ while it sets.

5.4 Fresh concrete density

If the density of the fresh concrete γ_{c} deviates from the value 25 kN/m^3, the fresh concrete pressure $\sigma_{\mathrm{hk,max}}$ determined as specified in 4.4 shall be multiplied by the factor $K2 = \gamma_{\mathrm{c}}/25$ (γ_{c} in kN/m^3). The change in density does not affect the hydrostatic pressure head h_{s}.

5.5 Compaction

5.5.1 General

The equations in Table 1, column 2 and the diagrams in Figures B.1 to B.5 apply for concrete that is compacted using conventional internal vibrators from group 3 in accordance with DIN 4235-1:1978-12, Table 1. When using internal vibrators from vibrator groups 1 and 2, the fresh concrete pressure shall not be reduced to less than that given in the diagrams. When using particularly powerful internal vibrators (such as are frequently used for voluminous building parts) a higher concrete pressure shall be assumed.

Where the fresh concrete is compacted using external vibrators in accordance with DIN 4235-3 or formwork vibrators in accordance with DIN 4235-4, the part of the formwork subject to the action of these vibrators during compaction shall be calculated assuming the concrete to have a hydrostatic pressure of $\sigma_{\mathrm{hk,max}} = \gamma_{\mathrm{c}} \cdot v \cdot t_{\mathrm{E}}$ until the end of setting is reached, taking into account the minimum value specified in Table 1 and the provisions of 5.3.

5.5.2 Depth of penetration of the vibrators

The maximum value of lateral fresh concrete pressure calculated in accordance with 4.4 applies for a depth of penetration of the internal vibrator h_{v} up to the hydrostatic pressure head h_{s} for concrete of consistency classes F1 to F4. If the depth of penetration is intended to be greater than h_{s} the pressure of the fresh concrete shall be increased to $\sigma_{\mathrm{hk,max}} = \gamma_{\mathrm{c}} \cdot h_{\mathrm{v}}$ provided the other conditions specified in 4.4 prevail, taking into account the information in Clause 5.

If the internal vibrator is intended to penetrate concrete of consistency classes F5 and F6 to a depth greater than 1 m, then $\sigma_{\mathrm{hk,max}} = \gamma_{\mathrm{c}} \cdot v \cdot t_{\mathrm{E}}$ applies, taking into account the minimum value specified in Table 1 and the provisions of 5.3.

5.5.3 Vibration time

The maximum lateral fresh concrete pressure in accordance with 4.4 is based on the vibration time required to achieve normal compaction according to DIN 4235-2:1978-12, 5.2.

5.6 Admixtures and additives

Admixtures and additives have an effect on fresh concrete pressure, mainly by altering its consistency and by changing the end of setting. This shall be taken into account when specifying the design assumptions in Clause 4 regarding consistency class and end of setting t_{E}.

5.7 Vibrations

If the fresh concrete is liable to be subject to vibrations permanently or intermittently (but frequently), so that these have the same effect as external vibrators, then calculations shall assume $\sigma_{\text{hk,max}} = \gamma_{\text{c}} \cdot v \cdot t_{\text{E}}$, taking into account the minimum value in Table 1 and the provisions of 5.3.

5.8 Reinforcement

Where building parts are heavily reinforced, the lateral fresh concrete pressure can be significantly lower than when building parts are not reinforced.

When making reinforced columns using self-compacting concrete (SCC) that is placed in opposite direction to the rise in level in the entire building part, the characteristic value of the maximum fresh concrete pressure $\sigma_{\text{hk,max}}$ may be reduced by 20 % if the building part is not wider than b = 0,5 m at any point. In addition, the distance between the bars of the vertical reinforcement and between the bars of the horizontal reinforcement of such building parts in the concrete adjacent to the formwork shall be not more than 125 mm, with the bar diameter d_{s} satisfying the condition $d_{\text{s}} \geq 8$ mm. The vertical reinforcement shall extend over the entire height of the formwork and shall be continuous (i.e. without joints).

Annex A
(normative)

Determination of setting times by the “knead bag” method

A.1 General

The end of setting t_E required for calculating the pressure of the fresh concrete is equal to $t_E = 1{,}25 \cdot t_{E,knead}$. The value $t_{E,knead}$ is defined as the time from which water is added for the first time to make the concrete until the point at which the concrete reaches “set" consistency according to Table A.1, line 7.

A.2 Apparatus

The following apparatus and equipment are required for the test:

— a sealable plastic bag with a volume of at least 20 l;

— a scoop for fresh concrete;

— a vessel (bucket) with a volume of at least 10 l and an internal diameter of 25 cm to 30 cm;

— a thermometer with a maximum permissible error of 0,25 K;

— suitable compaction equipment for testing concrete of consistency classes F1 to F6.

A.3 Sampling and test procedure

Directly after mixing is completed, sampling is carried out as follows: A representative sample of fresh concrete approximately 8 l in volume is placed in the plastic bag which, in turn, is located in the bucket. The concrete of consistency classes F1 to F6 is then compacted by mechanical means using equipment suited to the consistency of the concrete. The bucket is placed on a thermally insulated base plate (e.g. a rigid foam slab).

Once the concrete has been placed in the bag and bucket, the temperature of the fresh concrete shall be determined, after which the plastic bag is sealed.

The concrete in the plastic bag shall be checked at intervals of approximately 30 min by scanning the surface of the bag. If the fresh concrete is of “plastic” to “stiff” consistency in accordance with Table A.1, the bag containing it is taken out of the bucket and placed on a thermally insulated base plate. The temperature of the fresh concrete shall then be measured.

Further tests of the setting behaviour are carried out at intervals of 30 min. These consist of pressing a thumb with medium force against the vertical outer sides of the bag, at approximately mid-height of the sample, to determine the extent to which the concrete can be indented (the force to be applied is approximately 50 N or 5 kg). The test shall be carried out in three places which have not yet been indented. Testing is completed when the fresh concrete is of “set” consistency in accordance with Table A.1, line 7.

Where the temperature of the fresh concrete (on completion of mixing) is 20 °C, the deviations between the temperature of the samples and the exposure temperature should be not greater than 4 K. The temperature difference should be not more than 3 K where the temperature of the sample is 15 °C and not more 2 K where the temperature of the sample is 5 °C.

Table A.1 — Description of the setting condition of concrete

	1	2
1	Consistency	Description
2	fluid	flows in the bag
3	soft	does not flow, oozes when pressed
4	plastic	kneadable
5	stiff	can be indented to a max. depth of 30 mm
6	semi-firm	can be indented to a max. depth of 10 mm
7	set	can be indented to a depth of less than 1,0 mm

A.4 Test report

The test report shall contain the following:

— designation of the fresh concrete sample;

— place of testing;

— date and time at which water was added;

— date and time at which the concrete reached “set” consistency;

— $t_{\mathrm{E,knead}}$;

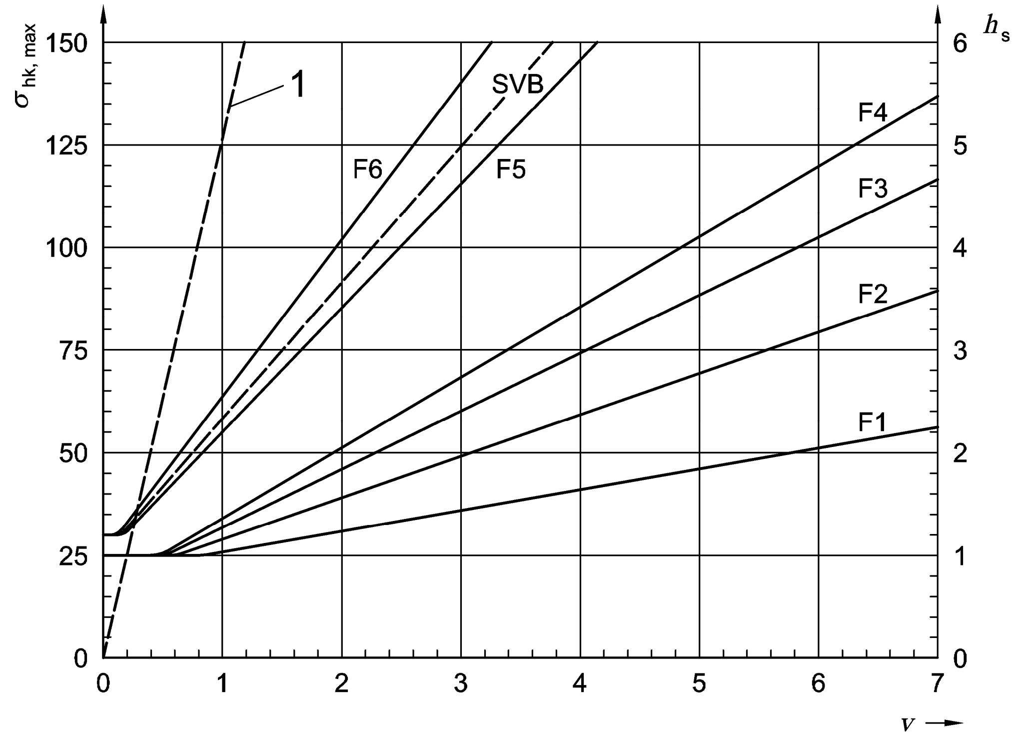
— temperature measurements of the fresh concrete, with the highest temperature measured being denoted $T_{\mathrm{c,Ref}}$;

— date and time, and signature of the person carrying out the test.

Annex B
(normative)

Diagrams to determine the maximum value of lateral fresh concrete pressure

The following diagrams can be used to read off the maximum value of the characteristic fresh concrete pressure to be assumed as a function of the placing rate for the various consistency classes and varying end of setting values. In some cases, consistency classes F5, F6 and SCC have lower values than the other consistency classes at placing rates $v < 0{,}5$ m/h. This is due to the fact that the determination of the fresh concrete pressure in flowable concrete is based on an improved calculation model.



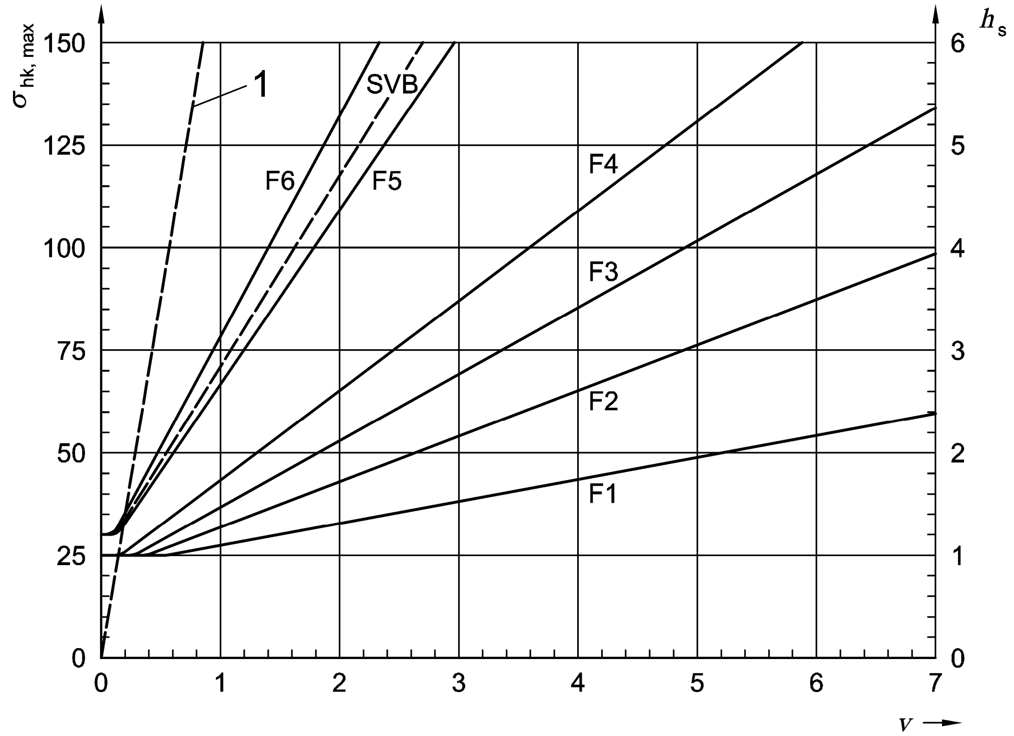
Key

1 hydrostatic up to t_E

SVB German abbreviation for SCC

$t_E = 5$ h
$\gamma_c = 25$ kN/m^3
maximum value of fresh concrete pressure $\sigma_{hk,max}$ in kN/m^2
placing rate v in m/h
hydrostatic pressure head h_s in m

Figure B.1 — Diagram to determine the fresh concrete pressure $\sigma_{hk,max}$ as a function of the placing rate v and the consistency class at an end of setting t_E of 5 h



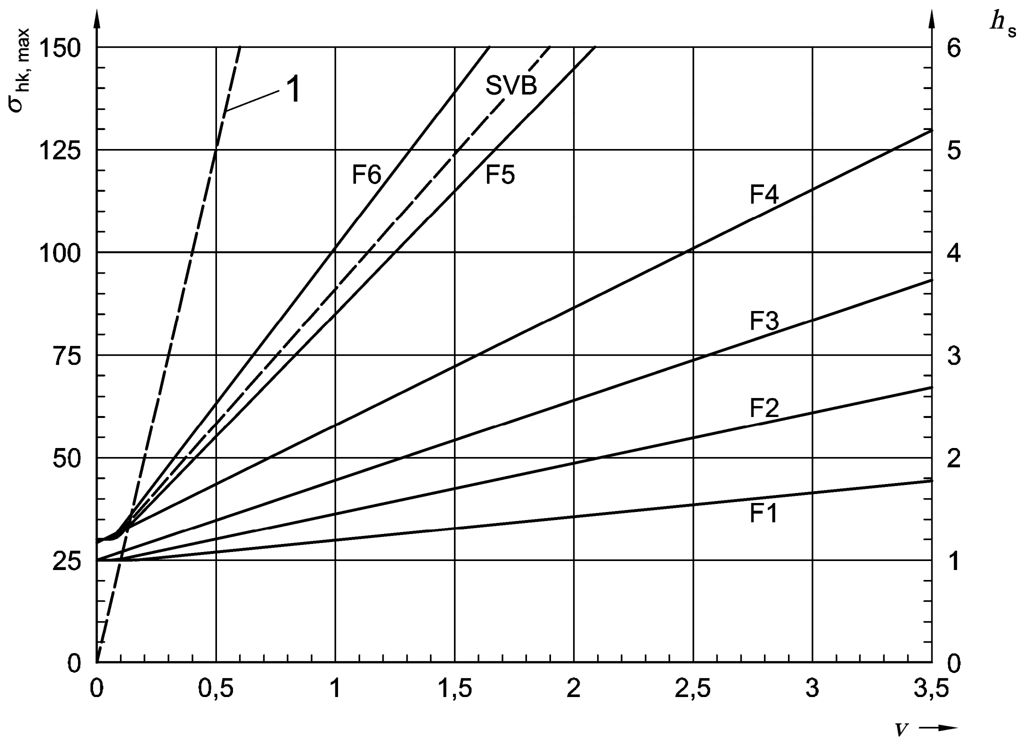
Key

1 hydrostatic up to t_E

SVB German abbreviation for SCC

$t_E = 7$ h
$\gamma_c = 25$ kN/m^3
maximum value of fresh concrete pressure $\sigma_{hk,max}$ in kN/m^2
placing rate v in m/h
hydrostatic pressure head h_s in m
Only applies up to a height of concrete section of 10 m, for consistency classes F1 and F4.

Figure B.2 — Diagram to determine the fresh concrete pressure $\sigma_{hk,max}$ as a function of the placing rate v and the consistency class for an end of setting t_E of 7 h



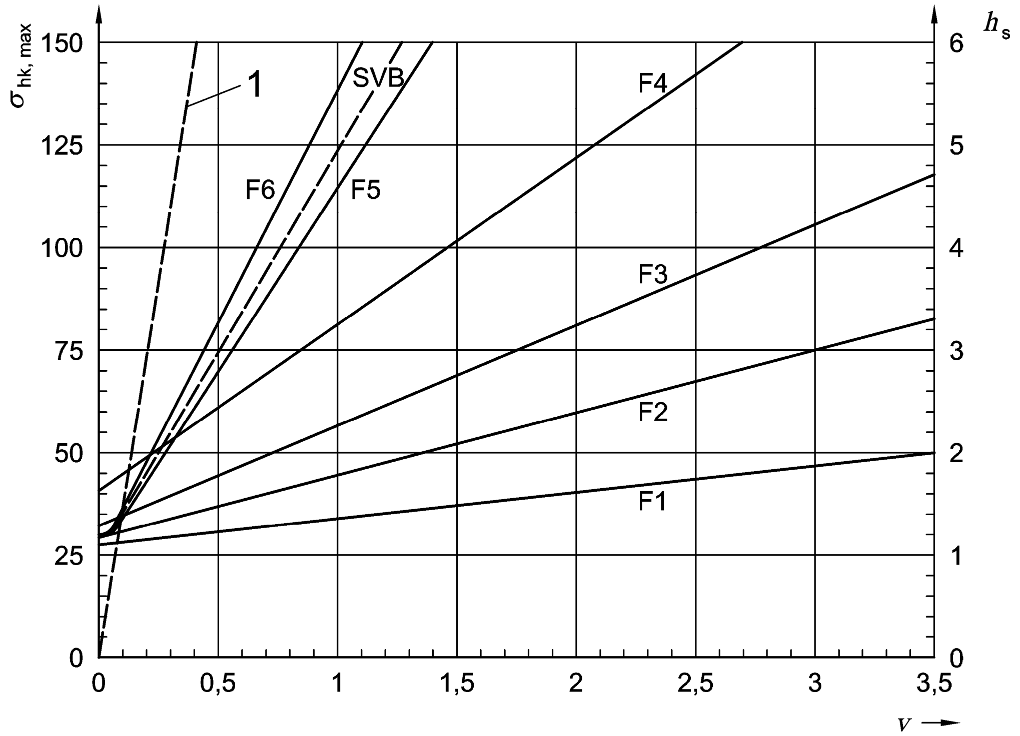
Key

1 hydrostatic up to t_E

SVB German abbreviation for SCC

$t_E = 10$ h
$\gamma_c = 25$ kN/m³
maximum value of fresh concrete pressure $\sigma_{hk,max}$ in kN/m²
placing rate v in m/h
hydrostatic pressure head h_s in m
Only applies up to a height of concrete section of 10 m, for consistency classes F1 and F4.

Figure B.3 — Diagram to determine the fresh concrete pressure $\sigma_{hk,max}$ as a function of the placing rate v and the consistency class for an end of setting t_E of 10 h



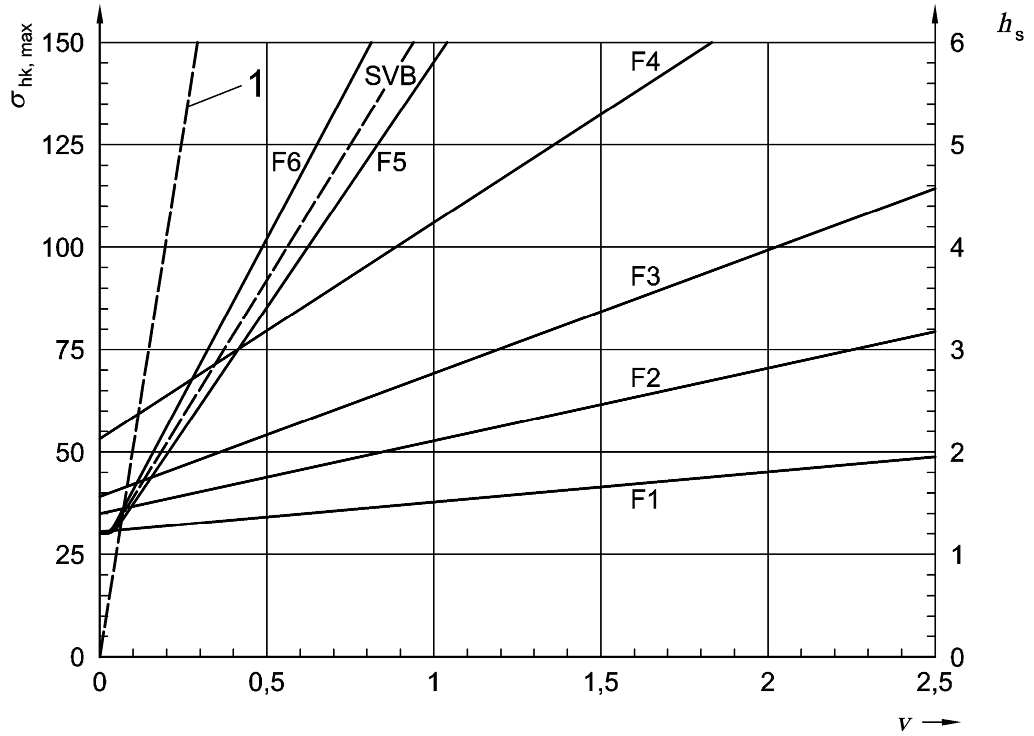
Key

1 hydrostatic up to t_E

SVB German abbreviation for SCC

$t_E = 15$ h
$\gamma_c = 25$ kN/m^3
maximum value of fresh concrete pressure $\sigma_{hk,max}$ in kN/m^2
placing rate v in m/h
hydrostatic pressure head h_s in m
Only applies up to a height of concrete section of 10 m, for consistency classes F1 and F4.

Figure B.4 — Diagram to determine the fresh concrete pressure $\sigma_{hk,max}$ as a function of the placing rate v and the consistency class for an end of setting t_E of 15 h



Key

1 hydrostatic up to t_E

SVB German abbreviation for SCC

$t_E = 20$ h
$\gamma_c = 25$ kN/m^3
maximum value of fresh concrete pressure $\sigma_{hk,max}$ in kN/m^2
placing rate v in m/h
hydrostatic pressure head h_s in m
Only applies up to a height of concrete section of 10 m, for consistency classes F1 and F4.

Figure B.5 — Diagram to determine the fresh concrete pressure $\sigma_{hk,max}$ as a function of the placing rate v and the consistency class for anend of setting t_E of 20 h