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European Recommendations for the Determination of Loads and Actions on Sandwich Panels

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PREFACE

This document intends to provide guidance on the application of loads and actions on sandwich panels. In general, loads and actions shall be taken from the relevant parts of EN 1991. Nevertheless the Joint Committee see's the need for some specific application rules and explanations to take into account the structural behaviour of sandwich panels, of panels both according to EN 14509 and structural sandwich panels.

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CONTENTS

1 INTRODUCTION AND APPLICATION RANGE

With the publication of the different parts of EN 1991, loads and actions on structures are consistently defined, irrespective of the materials and building products used. Nevertheless, some building products require additional information or even additional loads and actions to be taken into account. Furthermore, due to their load-bearing behaviour, simplifications in determining loads and actions are possible so long as they are in accordance with the design principles (see EN 1990, chapter 1.4). This also applies to sandwich panels, independent of the structural class defined in EN 1993-1-3[1]. Therefore, this document gives advice on actions and loads on sandwich panels within the scope of EN 14509 and on structural sandwich panels, focusing on specific aspects not considered by EN 1990 and EN 1991, amended with some explanatory remarks to EN 14509.
For some aspects, additional national provisions apply. These provisions will supersede the information given here.

[1] Structural Class I: Construction where sandwich panels are designed to contribute to the overall strength and stability of a structure (e.g. in stressed skin design)

Structural Class II: Construction where sandwich panels are designed to contribute to the strength and stability of individual structural elements (e.g. stabilisation of purlins)

Structural Class III: Construction where sandwich panels are used as elements that only transfer loads to the structure

2 DEFINITIONS

permanent action (G)	action that is likely to act throughout a given reference period and for which the variation in magnitude with time is negligible, or for which the variation is always in the same direction (monotonic) until the action attains a certain limit value. Typical examples are self-weight loads.
variable action (Q)	action for which the variation in magnitude with time is neither negligible nor monotonic
short-term	variable action with specified duration, but no specified time. Typical examples are wind loads and in most cases also temperature loads.
long-term	variable action with specified duration. Typical examples are snow loads.
accidental action (A)	action, usually of short duration but of significant magnitude, that is unlikely to occur on a given structure during the design working life
seismic action (A_E)	action that arises due to earthquake ground motions
static action	action that does not cause significant acceleration of the structure or sandwich panel
dynamic action	action that causes significant acceleration of the structure or sandwich panel, not covered by the ER at hand.
quasi-static action	dynamic action represented by an equivalent static action in a static model. Within the application range of the ER at hand, this definition refers only to wind loads which do not cause significant acceleration of the structure or sandwich panel

3 BASICS OF DESIGN

Load combinations are defined in EN 1990 and EN 14509, respectively. EN 14509 gives only combinations for the most relevant design situations:

- Persistent and transient design situations (ultimate limit state)
- Characteristic (rare) combination (serviceability limit state for resistance at intermediate supports)
- Frequent combination (serviceability limit state for deflections)

The frequent combination as defined in EN 14509 is not identical to the frequent combination as defined in EN 1990. The definition in EN 14509 takes account of the particular requirements for sandwich panels, leading to higher loads.

EN 14509 does not give combinations for the accidental and seismic design situation (both ultimate limit states). For these design situations, the combinations given in EN 1990 apply.

Load factors are given in EN 1990 and EN 14509, respectively. The values γ_G and γ_Q for actions and loads respectively, are identical. As EN 14509 also defines load factors γ_C for action effects due to creep, the combinations given in equations (E.7) to (E.9) of EN 14509 may be written as given in equations (3.1) to (3.3):

$$E_d = \gamma_G \cdot G_k + \gamma_{Q1} \cdot Q_{k1} + \sum_{i>1} \gamma_{Qi} \cdot \psi_{0i} \cdot Q_{ki} + \gamma_C \cdot \left(\Delta G_{k,c} + \Delta Q_{k1,c} + \sum_{i>1} \psi_{0i} \cdot \Delta Q_{ki,c} \right)$$

Eq. (3.1)

$$E_d = G_k + Q_{k1} + \sum_{i>1} \psi_{0i} \cdot Q_{ki} + \left(\Delta G_{k,c} + \Delta Q_{k1,c} + \sum_{i>1} \psi_{0i} \cdot \Delta Q_{ki,c} \right)$$

Eq. (3.2)

$$E_d = G_k + \psi_{11} \cdot Q_{k1} + \sum_{i>1} \psi_{0i} \cdot \psi_{1i} \cdot Q_{ki} + \left(\Delta G_{k,c} + \psi_{11} \cdot \Delta Q_{k1,c} + \sum_{i>1} \psi_{0i} \cdot \psi_{1i} \cdot \Delta Q_{ki,c} \right)$$

Eq. (3.3)

where

$\Delta G_{k,c}$ characteristic value of additional creep actions caused by permanent actions

$\Delta Q_{k1,c}$ characteristic value of additional creep actions caused by the dominant variable action, if long-term action. For variable short-term actions, $\Delta Q_{k1,c}$ = 0.0 applies.

$\Delta Q_{ki,c}$ characteristic value of additional creep actions caused by the non-dominant variable action, if long-term action. For variable short-term actions, $\Delta Q_{ki,c}$ =

0.0 applies.

For definition of the other symbols see EN 14509, equations (E.7) to (E.9). Annex A of this document gives a simplified example for combinations.

Values of the factors for combination ψ_0 and ψ_1 are defined in EN 1990 and EN 14509. Compared to the values stated in EN 1990, the factors of EN 14509 have been modified from the ψ-factors given in EN 1990 to take account of the particular requirements for sandwich panels, leading to higher ψ-factors, especially for temperature loads. These may be used in the absence of national regulations.

Values of the factor for combination ψ_2 (required for the accidental and seismic design situation) are defined in EN 1990.

On roofs (particularly for category H roofs according to EN 1991-1-1 – roofs not accessible except for normal maintenance and repair), imposed loads such as maintenance loads need not be applied in combination with either snow loads and/or wind actions, see EN 1991-1-1, chapter 3.3.2(1) and EN 1990, Table A.1. Actions during execution have to be applied in combination with other actions, see EN 1991-1-6, Annex A1.1.

4 GENERAL

Within this document, static actions and quasi-static actions (such as wind loads which do not cause significant acceleration) are covered. With the exception of seismic actions, dynamic actions are not covered, -. EN 1990, EN 1991 and EN 1998 remain applicable for actions and safety concepts. Unless otherwise specified in the following, the design actions to be used in the analysis at ultimate limit state and serviceability limit state shall be specified in accordance with EN 1991 and EN 1998. The following table gives an overview on actions and loads on sandwich panels.

Table 4.1: **Actions and loads on sandwich panels**

Load	Character	Reference
Self-weight	permanent	EN 14509
Self-weight of other components like PV modules or roof greening	permanent	EN 14509
Imposed loads	variable, short-term, long-term	EN 1991-1-1
Wind load Quasi static load	variable, short-term	EN 1991-1-4 EN 14509[1]
Snow load Uniform load Accumulation Effects of drifting and slipping	variable, short-term, long-term[2]	EN 1991-1-3 EN 14509[1]
Temperature Uniform temperature Temperature gradient	variable, short-term	EN 14509[3]
Water	variable, short-term	—[4]
Actions during execution and maintenance	variable, short-term	EN 1991-1-6 EN 1991-1-1
Loads caused by earthquake	seismic, short-term	EN 1998-1
Loads caused by fire	accidental, short-term	EN 1991-1-2
Stabilization of members	permanent or variable, short-term or long-term	EN 1993-1-1 EN 1993-1-3 ER on the Stabilization of Steel Structures by Sandwich Panels

1) EN 14509 gives additional information, especially on combination with temperature loads.
2) Creep under snow load shall be neglected in regions where snow does not regularly lie for more than a few days, see EN 14509, chapter E.7.6.
3) The temperature loads given in EN 1991-1-5 are not suitable for sandwich panels.
4) Water loads are outside the scope of EN 1991 and may be defined either in the National Annex or for the individual project, see EN 1990, chapter A2.2.1(2).

Both permanent and variable long-term loads might lead to creep effects (e.g. increase of deformation, additional action effects). For inclusion of creep effects see chapter 3.

The loads listed in table 4.1 cause mainly bending moments and shear forces but they may also cause axial loads and in-plane shear forces in sandwich panels. At the points of load introduction, fixings or supports, a complex setting of forces and stresses might occur. See also the European Recommendations for the Design of Sandwich Panels with Point or Line Loads and the Preliminary European Recommendations for the Testing and Design of Fastenings for Sandwich Panels.

5 SPECIFIC RULES

5.1 Self-weight from additional installations

If installations, illuminated advertising signs, claddings, sun blinds, scaffolding bolts or similar items are fixed to sandwich panels or their supporting structure, the resulting loads shall be taken into account in design. If these loads are introduced as point or line loads, special considerations have to be made in design, see the European Recommendations for the Design of Sandwich Panels with Point or Line Loads.

5.2 Water

The drainage shall be designed in accordance with the principles of EN 12056-1 and EN 12056-3.

If there is the risk of accumulation of water ponding (which can be generally assumed for roofs with a slope less than 2% and inappropriate positioned drainage systems), the roof should be designed for the water ponding.

The water load from the design head of the drainage system shall be taken to be a variable action in the dimensioning for persistent and transient design situations. The water load resulting from the maximum head of the emergency drainage system shall be considered to be an exceptional action in the accidental design situation. In principle, the additional load resulting from the total deflection of the sandwich panel shall be taken into account for all cases of water loading.

As there are no load and combination factors for water loads defined, the factors for snow loads may be adopted. Usually consideration of the combined effects of “water” and “snow” is not necessary.

5.3 Snow

Snow loads are given in EN 1991-1-3. The snow load may be assumed to act over the whole roof area, if applicable, taking accumulations resulting from slipping or drifting into account. A field-by-field rearrangement (partial area loading) is not necessary.

Exceptional snow loads may be treated as accidental actions depending on geographical location. If the analysis at the ultimate limit state for combinations with accidental actions according to EN 1991-1-3, chapter 3.3 is carried out using plastic analysis, there is no need to carry out an additional serviceability limit state design for accidental actions.

5.4 Wind

Wind loads are given in EN 1991-1-4. The use of increased suction loads in the roof zones F, G and J and in the wall zone A may only be necessary for structural

analysis of the fasteners (see note). In this case zone H shall be representative for dimensioning the roof elements in the areas F, G, H and J[1]. Zone B shall be representative for dimensioning the wall elements in the zones A and B. The $c_{pe,10}$-values are generally used for the design of the sandwich panel, assuming a load transfer via the longitudinal joint. For the design of the fasteners the $c_{pe,1}$-values or the interpolated values apply.
EN 1991-1-4, 7.4.1 together with figure 7.19 defines the wind loads for parapets.

Note: These simplifications are justified by the ductile behaviour of the metallic faces of sandwich panels: For roof and wall panels the higher wind loads at the corners of a building may not be taken into account. High local stresses can be transferred to other areas of the panel and a ductile damage of the faces does not result in a safety relevant failure of the outer skin of a building. On the other hand, re-distribution of forces from one fastener to another is not possible and failure of the fasteners results in a safety relevant separation of the building skin and supporting structure which may lead to the collapse of sandwich panels. For the static calculation at the corners, the wind actions from the zone next to the corner zone may be taken. But in either case, the higher loads have to be used for the design of the fasteners. The area of influence of the fasteners corresponds to the area of influence of a 1.0 m line of support.

5.5 Temperature

Temperature is an important load case for sandwich panels. Aside from its normal inclusion in the analysis for the design life of the panel, temperature and temperature changes also have to be to be taken into account during installation.
The temperature of the outer face of the panel, T_1, mainly depends on alignment to the sun, colour and type of the coating. The largest changes in temperature of wall panels can be observed in spring and probably autumn. In northern Europe this is typically in the months of February and March, when the sun is at a low angle. The largest changes in temperature of roof panels occur between night and day, when the sky is clear. Due to radiation of the panel surface, the temperature of the roof panel outer face at night can be significantly lower than the air temperature. The temperature of the inner face of the panel, T_2, mainly depends on the service temperature of the building.
EN 14509 gives minimum and maximum values for temperature T_1 of the outer face. For the determination of the minimum temperature, EN 14509 uses four different minimum winter temperature levels (T_1) of 0°C, -10°C, -20°C and -30°C. The assumption in EN 14509 that the temperature of the outer face of a roof panel with

[1] For zone J, also wind pressure has to be checked.

an over layer of snow is 0 °C is not always valid, especially for Scandinavia.
To determine the maximum temperature of the outer face, EN 14509 adopts a simplified approach, referencing three colour groups. Differentiation between colours is based on the degree of reflection R_G, using magnesium oxide as a reference value (Burkhardt, 2010). The table in Annex B of the document at hand gives more specific values for colours and coatings according to the RAL system than EN 14509. The values were determined for polyester coatings, but can also be used as guidance for other coating systems. These values can be taken for both the ultimate limit state and the serviceability limit state. Colours and coatings according to other systems, such as the NCS and BS-system, can be deduced from similar RAL colours or determined by tests. It should be noted that recently special coatings, so called reflection coatings, have been developed. With these coatings lower temperatures occur because part of the solar radiation is reflected. This effect is achieved by a modification of the colour pigments. Since the use of such reflective coatings is still in an early stage, currently reduced surface temperature values are not available, unless demonstrated through testing.
Laboratory tests for the determination of colour and coating specific temperatures can be performed according to SFS 7030, Annex B (2013) for example: Total Solar Reflectance (TSR) and Thermal Emittance (TE) of a colour are measured according to laboratory methods based on ASTM E 903-12 and ASTM C 1371-04a (2010) respectively. Every coating type and colour must be measured separately. Then Solar Reflective Index (SRI) is calculated according to ASTM E 1980-11. Finally the estimated Steady State Surface (exterior) temperature is calculated according to ASTM E 1980-11. Recommended wind speed in calculations is 2 to 6 m/s (medium wind speed), giving a convective coefficient of 12 W/(m²K), which is taken into account in the calculation.
EN 14509 also gives values for the temperature T_2 of the inner face: In general, 20°C in winter and 25°C in summer should be assumed for the interiour face. In some special applications (climate-controlled buildings such as chill or ripe rooms and chill-storage or cold-storage buildings) the service temperature of the application shall be taken for design.

5.6 Actions during execution and maintenance

EN 1991-1-6, table 4.1 does not apply to sandwich panels.
For construction load Q_{ca} caused by personal and hand tools (roof traffic and walkability) see EN 14509, A.9.
Setting-down places on the roof for the non-permanent storage of construction materials (construction load Q_{cb}, e.g. bundles of sandwich panels) shall be taken into account in design and defined in the layout drawings. They shall be positioned in the areas of support of the sandwich panels.

Accumulation of waste materials (construction loads Q_{ce}, e.g. foils, surplus sandwich panels) shall be taken into account, see EN 1991-1-6.
Construction loads Q_{cc} to Q_{cd} and Q_{cf} usually do not apply to sandwich panels.
Maintenance loads are considered as imposed load caused by a set of activities performed during the working life of the structure, in order to enable it to fulfil the requirements for reliability, for example cleaning and repair. They are often also referred to as access load. Activities to restore the structure after an accidental or seismic event are normally outside the scope of maintenance. For maintenance loads caused by personal and hand tools (roof traffic and walkability) see EN 14509, A.9.

5.7 Seismic loads

Sandwich panels are usually not designed as bracing elements for seismic actions according to EN 1998-1. Under seismic actions, the panels are regarded as non-structural building components according to structural class III. But proof has to be made that they remain fixed to the supporting structure. The load acting on the panels (seismic action) is calculated using a behaviour factor of q = 2.0, see EN 1998-1, 4.3.5.4 and eCahier 3725 (2013).

5.8 Fire

Fire classification of sandwich panels according to EN 13501-2 is based on resistance tests. EN 15254-5 and EN 15254-7 give rules for the extended applications not tested. Usual characteristics tested with sandwich panels are:

- Integrity - E: Ability of a sandwich panel to prevent transmission of fire by passage of flames or hot gases.
- Insulation - I: Ability of a sandwich panel to prevent transmission of fire by transfer of heat.
- Radiation - R: Ability of a sandwich panel to prevent transmission of fire by transfer of radiant heat.

To maintain these characteristics while exposed to fire, the sandwich panel's fasteners have to be designed accordingly. The whole self-weight of a wall panel must be fixed by fasteners to the non-exposed side because of the possible reduction of the load-bearing capacity on the fire exposed side.

The same applies for the fasteners used in the fire resistance test. If the fasteners used in tests are designed accordingly, the fire classification depends on the material of the fastener, not the type of fastener: For end-use the fasteners on each panel side can be specified based of a static calculation considering the self-weight of the panel.

5.9 Explosions, impact and comparable "shock loads"

Sandwich panels are usually not designed for accidental actions such as loads from explosions, impacts and comparable "shock loads" according to EN 1991-1-7. Under these actions, the panels are regarded as non-structural building components according to structural class III. But proof has to be made that they remain fixed to the supporting structure. For special cases (e.g. blast resistance), see ASCE (2010).

Note: In some special applications, failure of the fixing is desirable to reduce the internal pressure after an explosion.

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ANNEX

ANNEX

ANNEX A: EXAMPLE FOR COMBINATIONS OF ACTIONS

This example shows combinations of the action effects from self-weight and other permanent loads, from snow and winds loads and loads caused by temperature difference. The combinations in the tables are based on EN 14509 for the ultimate limit state in persistent and transient design situations and for the serviceability limit state. For the ultimate limit state in accidental design situations and seismic design situations, combinations are based on EN 1990. No numerical values for load factors γ_F and combination coefficients ψ are given here to allow for national regulations.

The combinations are typical for sandwich panels in roof applications, but they can easily be adopted for sandwich panels in wall applications, by neglecting the effects from self-weight (usually neglected in the design of wall panels), snow and creep. Combinations given here cover several ultimate limit states and serviceability limit states. Thus, some of those may not become decisive and may be not applicable in design of a particular roof.

The following symbols apply:

G_k characteristic value of permanent actions
$\Delta G_{k,c}$ characteristic value of additional creep actions caused by permanent actions
W_k characteristic value of wind actions
S_k characteristic value of snow loads
$\Delta S_{k,c}$ characteristic value of additional creep actions caused by snow loads
T_k characteristic value of temperature (difference)
S_{Ad} exceptional load, here caused by exceptional snow loads
A_{Ed} seismic action

For definition of the other symbols see EN 14509, equations (E.7) to (E.9).

Notes:

- Depending on the direction of loading, load factors γ_G = 1.35 or γ_G = 1.00 for self-weight loading become decisive. So both values should be checked (especially in combinations including wind suction and temperature).
- Combination coefficients may differ depending on type and number of variable actions included in the combination, see EN 14509, table E.6.
- Wind loads may act as wind pressure or wind suction. If both apply, both have to be checked independently with each combination including wind.
- Temperature loads may act as summer or winter temperatures. Value of winter temperature may depend on the combination: If snow is included in the combination, reduced winter temperatures may apply, see EN 14509, chapter E.3.3.

- According to EN 1991-1-6, the rules for the combination of snow load and wind action with construction loads Q_c should be defined in the National Annex or for the individual project. This might lead to combinations deviating from the ones given here for the transient design situation in construction.
- An exceptional snow load $A_d = S_{Ad}$ was assumed in this example. If other exceptional loads have to be taken into account, combinations must be arranged accordingly.
- Combination coefficient ψ_{2i} is often equal to zero, thus further simplifying the combinations given here.
- The sign + in the following tables implies "to be combined with".

Table A|1: **Combinations for ultimate limit state (ULS, persistent design situations)**

self-weight only (including creep)	
$E_d = \gamma_G \cdot G_k$	Eq. (A.1a)
$E_d = \gamma_G \cdot G_k + \gamma_C \cdot \Delta G_{k,C}$	Eq. (A.1b)
self-weight and one variable action (including creep)	
$E_d = \gamma_G \cdot G_k + \gamma_W \cdot W_k$	Eq. (A.1c)
$E_d = \gamma_G \cdot G_k + \gamma_W \cdot W_k + \gamma_C \cdot \Delta G_{k,C}$	Eq. (A.1d)
$E_d = \gamma_G \cdot G_k + \gamma_S \cdot S_k$	Eq. (A.1e)
$E_d = \gamma_G \cdot G_k + \gamma_S \cdot S_k + \gamma_C \cdot \Delta G_{k,C} + \gamma_C \cdot \Delta S_{k,C}$	Eq. (A.1f)
$E_d = \gamma_G \cdot G_k + \gamma_T \cdot T_k$	Eq. (A.1g)
$E_d = \gamma_G \cdot G_k + \gamma_T \cdot T_k + \gamma_C \cdot \Delta G_{k,C}$	Eq. (A.1h)
table continued on next page	

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self-weight and two variable actions (including creep)	
$E_d = \gamma_G \cdot G_k + \gamma_W \cdot W_k + \gamma_S \cdot \psi_{0S} \cdot S_k$	Eq. (A.1i)
$E_d = \gamma_G \cdot G_k + \gamma_W \cdot W_k + \gamma_S \cdot \psi_{0S} \cdot S_k + \gamma_C \cdot \Delta G_{k,C} + \gamma_C \cdot \psi_{0S} \cdot \Delta S_{k,C}$	Eq. (A.1j)
$E_d = \gamma_G \cdot G_k + \gamma_W \cdot W_k + \gamma_T \cdot \psi_{0T} \cdot T_k$	Eq. (A.1k)
$E_d = \gamma_G \cdot G_k + \gamma_W \cdot W_k + \gamma_T \cdot \psi_{0T} \cdot T_k + \gamma_C \cdot \Delta G_{k,C}$	Eq. (A.1l)
$E_d = \gamma_G \cdot G_k + \gamma_S \cdot S_k + \gamma_W \cdot \psi_{0W} \cdot W_k$	Eq. (A.1m)
$E_d = \gamma_G \cdot G_k + \gamma_S \cdot S_k + \gamma_W \cdot \psi_{0W} \cdot W_k + \gamma_C \cdot \Delta G_{k,C} + \gamma_C \cdot \Delta S_{k,C}$	Eq. (A.1n)
$E_d = \gamma_G \cdot G_k + \gamma_S \cdot S_k + \gamma_T \cdot \psi_{0T} \cdot T_k$	Eq. (A.1o)
$E_d = \gamma_G \cdot G_k + \gamma_S \cdot S_k + \gamma_T \cdot \psi_{0T} \cdot T_k + \gamma_C \cdot \Delta G_{k,C} + \gamma_C \cdot \Delta S_{k,C}$	Eq. (A.1p)
$E_d = \gamma_G \cdot G_k + \gamma_T \cdot T_k + \gamma_W \cdot \psi_{0W} \cdot W_k$	Eq. (A.1q)
$E_d = \gamma_G \cdot G_k + \gamma_T \cdot T_k + \gamma_W \cdot \psi_{0W} \cdot W_k + \gamma_C \cdot \Delta G_{k,C}$	Eq. (A.1r)
$E_d = \gamma_G \cdot G_k + \gamma_T \cdot T_k + \gamma_S \cdot \psi_{0S} \cdot S_k$	Eq. (A.1s)
$E_d = \gamma_G \cdot G_k + \gamma_T \cdot T_k + \gamma_S \cdot \psi_{0S} \cdot S_k + \gamma_C \cdot \Delta G_{k,C} + \gamma_C \cdot \psi_{0S} \cdot \Delta S_{k,C}$	Eq. (A.1t)
self-weight and three variable actions (including creep)	
$E_d = \gamma_G \cdot G_k + \gamma_W \cdot W_k + \gamma_S \cdot \psi_{0S} \cdot S_k + \gamma_T \cdot \psi_{0T} \cdot T_k$	Eq. (A.1u)
$E_d = \gamma_G \cdot G_k + \gamma_W \cdot W_k + \gamma_S \cdot \psi_{0S} \cdot S_k + \gamma_T \cdot \psi_{0T} \cdot T_k + \gamma_C \cdot \Delta G_{k,C} + \gamma_C \cdot \psi_{0S} \cdot \Delta S_{k,C}$	Eq. (A.1v)
$E_d = \gamma_G \cdot G_k + \gamma_S \cdot S_k + \gamma_W \cdot \psi_{0W} \cdot W_k + \gamma_T \cdot \psi_{0T} \cdot T_k$	Eq. (A.1w)
$E_d = \gamma_G \cdot G_k + \gamma_S \cdot S_k + \gamma_W \cdot \psi_{0W} \cdot W_k + \gamma_T \cdot \psi_{0T} \cdot T_k + \gamma_C \cdot \Delta G_{k,C} + \gamma_C \cdot \Delta S_{k,C}$	Eq. (A.1x)
$E_d = \gamma_G \cdot G_k + \gamma_T \cdot T_k + \gamma_W \cdot \psi_{0W} \cdot W_k + \gamma_S \cdot \psi_{0S} \cdot S_k$	Eq. (A.1y)
$E_d = \gamma_G \cdot G_k + \gamma_T \cdot T_k + \gamma_W \cdot \psi_{0W} \cdot W_k + \gamma_S \cdot \psi_{0S} \cdot S_k + \gamma_C \cdot \Delta G_{k,C} + \gamma_C \cdot \psi_{0S} \cdot \Delta S_{k,C}$	Eq. (A.1z)

Table A|2: **Combinations for ultimate limit state (ULS, transient design situations)**

self-weight and one variable action (including creep)	
$E_d = \gamma_G \cdot G_k + \gamma_Q \cdot Q_{cb,k}$	Eq. (A.2a)
$E_d = \gamma_G \cdot G_k + \gamma_Q \cdot Q_{cb,k} + \gamma_C \cdot \Delta G_{k,C}$	Eq. (A.2b)
$E_d = \gamma_G \cdot G_k + \gamma_Q \cdot Q_{cc,k}$	Eq. (A.2c)
$E_d = \gamma_G \cdot G_k + \gamma_Q \cdot Q_{cc,k} + \gamma_C \cdot \Delta G_{k,C}$	Eq. (A.2d)
For construction load Q_{ca} caused by personal and hand tools (roof traffic and walkability) see EN 14509, A.9.	

Table A|3: **Combinations for ultimate limit state (ULS, accidental design situations)**

self-weight and exceptional snow load (including creep)	
$E_d = G_k + S_{Ad}$	Eq. (A.3a)
$E_d = G_k + S_{Ad} + \Delta G_{k,C} + \Delta S_{Ad,C}$	Eq. (A.3b)
self-weight, exceptional snow load and one variable action (including creep)	
$E_d = G_k + S_{Ad} + \psi_{1W} \cdot W_k$	Eq. (A.3c)
$E_d = G_k + S_{Ad} + \psi_{1W} \cdot W_k + \Delta G_{k,C} + \Delta S_{Ad,C}$	Eq. (A.3d)
$E_d = G_k + S_{Ad} + \psi_{1T} \cdot T_k$	Eq. (A.3e)
$E_d = G_k + S_{Ad} + \psi_{1T} \cdot T_k + \Delta G_{k,C} + \Delta S_{Ad,C}$	Eq. (A.3f)
self-weight, exceptional snow load and two variable actions (including creep)	
$E_d = G_k + S_{Ad} + \psi_{1W} \cdot W_k + \psi_{2T} \cdot T_k$	Eq. (A.3g)
$E_d = G_k + S_{Ad} + \psi_{1W} \cdot W_k + \psi_{2T} \cdot T_k + \Delta G_{k,C} + \Delta S_{Ad,C}$	Eq. (A.3h)
$E_d = G_k + S_{Ad} + \psi_{1T} \cdot T_k + \psi_{2W} \cdot W_k$	Eq. (A.3i)
$E_d = G_k + S_{Ad} + \psi_{1T} \cdot T_k + \psi_{2W} \cdot W_k + \Delta G_{k,C} + \Delta S_{Ad,C}$	Eq. (A.3j)

Table A|4: **Combinations for ultimate limit state (ULS, seismic design situations)**

self-weight and seismic load (including creep)	
$E_d = G_k + A_{Ed}$	Eq. (A.4a)
$E_d = G_k + A_{Ed} + \Delta G_{k,C}$	Eq. (A.4b)
self-weight, seismic load and one variable action (including creep)	
$E_d = G_k + A_{Ed} + \psi_{2W} \cdot W_k$	Eq. (A.4c)
$E_d = G_k + A_{Ed} + \psi_{2S} \cdot S_k$	Eq. (A.4d)
$E_d = G_k + A_{Ed} + \psi_{2S} \cdot S_k + \Delta G_{k,C} + \psi_{2S} \cdot \Delta S_{k,C}$	Eq. (A.4e)
$E_d = G_k + A_{Ed} + \psi_{2T} \cdot T_k$	Eq. (A.4f)
self-weight, seismic load and two variable actions (including creep)	
$E_d = G_k + A_{Ed} + \psi_{2W} \cdot W_k + \psi_{2S} \cdot S_k$	Eq. (A.4g)
$E_d = G_k + A_{Ed} + \psi_{2W} \cdot W_k + \psi_{2S} \cdot S_k + \Delta G_{k,C} + \psi_{2S} \cdot \Delta S_{k,C}$	Eq. (A.4h)
$E_d = G_k + A_{Ed} + \psi_{2W} \cdot W_k + \psi_{2T} \cdot T_k$	Eq. (A.4i)
$E_d = G_k + A_{Ed} + \psi_{2W} \cdot W_k + \psi_{2T} \cdot T_k + \Delta G_{k,C}$	Eq. (A.4j)
$E_d = G_k + A_{Ed} + \psi_{2S} \cdot S_k + \psi_{2T} \cdot T_k$	Eq. (A.4k)
$E_d = G_k + A_{Ed} + \psi_{2S} \cdot S_k + \psi_{2T} \cdot T_k + \Delta G_{k,C} + \psi_{2S} \cdot \Delta S_{k,C}$	Eq. (A.4l)
self-weight, seismic load and three variable actions (including creep)	
$E_d = G_k + A_{Ed} + \psi_{2W} \cdot W_k + \psi_{2S} \cdot S_k + \psi_{2T} \cdot T_k$	Eq. (A.4m)
$E_d = G_k + A_{Ed} + \psi_{2W} \cdot W_k + \psi_{2S} \cdot S_k + \psi_{2T} \cdot T_k + \Delta G_{k,C} + \psi_{2S} \cdot \Delta S_{k,C}$	Eq. (A.4n)

Table A|5: **Combinations for serviceability limit state (SLS, rare combination)**

self-weight only (including creep)	
$E_d = G_k$	Eq. (A.5a)
$E_d = G_k + \Delta G_{k,C}$	Eq. (A.5b)
self-weight and one variable action (including creep)	
$E_d = G_k + W_k$	Eq. (A.5c)
$E_d = G_k + S_k$	Eq. (A.5d)
$E_d = G_k + S_k + \Delta G_{k,C} + \Delta S_{k,C}$	Eq. (A.5e)
$E_d = G_k + T_k$	Eq. (A.5f)
self-weight and two variable actions (including creep)	
$E_d = G_k + W_k + \psi_{0S} \cdot S_k$	Eq. (A.5g)
$E_d = G_k + W_k + \psi_{0S} \cdot S_k + \Delta G_{k,C} + \psi_{0S} \cdot \Delta S_{k,C}$	Eq. (A.5h)
$E_d = G_k + W_k + \psi_{0T} \cdot T_k$	Eq. (A.5i)
$E_d = G_k + W_k + \psi_{0T} \cdot T_k + \Delta G_{k,C}$	Eq. (A.5j)
$E_d = G_k + S_k + \psi_{0W} \cdot W_k$	Eq. (A.5k)
$E_d = G_k + S_k + \psi_{0W} \cdot W_k + \Delta G_{k,C} + \Delta S_{k,C}$	Eq. (A.5l)
$E_d = G_k + S_k + \psi_{0T} \cdot T_k$	Eq. (A.5m)
$E_d = G_k + S_k + \psi_{0T} \cdot T_k + \Delta G_{k,C} + \Delta S_{k,C}$	Eq. (A.5n)
$E_d = G_k + T_k + \psi_{0W} \cdot W_k$	Eq. (A.5o)
$E_d = G_k + T_k + \psi_{0W} \cdot W_k + \Delta G_{k,C}$	Eq. (A.5p)
$E_d = G_k + T_k + \psi_{0S} \cdot S_k$	Eq. (A.5q)
$E_d = G_k + T_k + \psi_{0S} \cdot S_k + \Delta G_{k,C} + \psi_{0S} \cdot \Delta S_{k,C}$	Eq. (A.5r)
self-weight and three variable actions (including creep)	
$E_d = G_k + W_k + \psi_{0S} \cdot S_k + \psi_{0T} \cdot T_k$	Eq. (A.5s)
$E_d = G_k + W_k + \psi_{0S} \cdot S_k + \psi_{0T} \cdot T_k + \Delta G_{k,C} + \psi_{0S} \cdot \Delta S_{k,C}$	Eq. (A.5t)
$E_d = G_k + S_k + \psi_{0W} \cdot W_k + \psi_{0T} \cdot T_k$	Eq. (A.5u)
$E_d = G_k + S_k + \psi_{0W} \cdot W_k + \psi_{0T} \cdot T_k + \Delta G_{k,C} + \Delta S_{k,C}$	Eq. (A.5v)
$E_d = G_k + T_k + \psi_{0W} \cdot W_k + \psi_{0S} \cdot S_k$	Eq. (A.5w)
$E_d = G_k + T_k + \psi_{0W} \cdot W_k + \psi_{0S} \cdot S_k + \Delta G_{k,C} + \psi_{0S} \cdot \Delta S_{k,C}$	Eq. (A.5x)

Table A|6: **Combinations for serviceability limit state (SLS, frequent combination)**

self-weight only (including creep)	
$E_d = G_k$	Eq. (A.6a)
$E_d = G_k + \Delta G_{k,C}$	Eq. (A.6b)
self-weight and one variable action (including creep)	
$E_d = G_k + \psi_{1W} \cdot W_k$	Eq. (A.6c)
$E_d = G_k + \psi_{1S} \cdot S_k$	Eq. (A.6d)
$E_d = G_k + \psi_{1S} \cdot S_k + \Delta G_{k,C} + \psi_{1S} \cdot \Delta S_{k,C}$	Eq. (A.6e)
$E_d = G_k + \psi_{1T} \cdot T_k$	Eq. (A.6f)
self-weight and two variable actions (including creep)	
$E_d = G_k + \psi_{1W} \cdot W_k + \psi_{0S} \cdot \psi_{1S} \cdot S_k$	Eq. (A.6g)
$E_d = G_k + \psi_{1W} \cdot W_k + \psi_{0S} \cdot \psi_{1S} \cdot S_k + \Delta G_{k,C} + \psi_{0S} \cdot \psi_{1S} \cdot \Delta S_{k,C}$	Eq. (A.6h)
$E_d = G_k + \psi_{1W} \cdot W_k + \psi_{0T} \cdot \psi_{1T} \cdot T_k$	Eq. (A.6i)
$E_d = G_k + \psi_{1W} \cdot W_k + \psi_{0T} \cdot \psi_{1T} \cdot T_k + \Delta G_{k,C}$	Eq. (A.6j)
$E_d = G_k + \psi_{1S} \cdot S_k + \psi_{0W} \cdot \psi_{1W} \cdot W_k$	Eq. (A.6k)
$E_d = G_k + \psi_{1S} \cdot S_k + \psi_{0W} \cdot \psi_{1W} \cdot W_k + \Delta G_{k,C} + \psi_{1S} \cdot \Delta S_{k,C}$	Eq. (A.6l)
$E_d = G_k + \psi_{1S} \cdot S_k + \psi_{0T} \cdot \psi_{1T} \cdot T_k$	Eq. (A.6m)
$E_d = G_k + \psi_{1S} \cdot S_k + \psi_{0T} \cdot \psi_{1T} \cdot T_k + \Delta G_{k,C} + \psi_{1S} \cdot \Delta S_{k,C}$	Eq. (A.6n)
$E_d = G_k + \psi_{1T} \cdot T_k + \psi_{0W} \cdot \psi_{1W} \cdot W_k$	Eq. (A.6o)
$E_d = G_k + \psi_{1T} \cdot T_k + \psi_{0W} \cdot \psi_{1W} \cdot W_k + \Delta G_{k,C}$	Eq. (A.6p)
$E_d = G_k + \psi_{1T} \cdot T_k + \psi_{0S} \cdot \psi_{1S} \cdot S_k$	Eq. (A.6q)
$E_d = G_k + \psi_{1T} \cdot T_k + \psi_{0S} \cdot \psi_{1S} \cdot S_k + \Delta G_{k,C} + \psi_{0S} \cdot \psi_{1S} \cdot \Delta S_{k,C}$	Eq. (A.6r)
self-weight and three variable actions (including creep)	
$E_d = G_k + \psi_{1W} \cdot W_k + \psi_{0S} \cdot \psi_{1S} \cdot S_k + \psi_{0T} \cdot \psi_{1T} \cdot T_k$	Eq. (A.6s)
$E_d = G_k + \psi_{1W} \cdot W_k + \psi_{0S} \cdot \psi_{1S} \cdot S_k + \psi_{0T} \cdot \psi_{1T} \cdot T_k + \Delta G_{k,C} + \psi_{0S} \cdot \psi_{1S} \cdot \Delta S_{k,C}$	Eq. (A.6t)
$E_d = G_k + \psi_{1S} \cdot S_k + \psi_{0W} \cdot \psi_{1W} \cdot W_k + \psi_{0T} \cdot \psi_{1T} \cdot T_k$	Eq. (A.6u)
$E_d = G_k + \psi_{1S} \cdot S_k + \psi_{0W} \cdot \psi_{1W} \cdot W_k + \psi_{0T} \cdot \psi_{1T} \cdot T_k + \Delta G_{k,C} + \psi_{1S} \cdot \Delta S_{k,C}$	Eq. (A.6v)
$E_d = G_k + \psi_{1T} \cdot T_k + \psi_{0W} \cdot \psi_{1W} \cdot W_k + \psi_{0S} \cdot \psi_{1S} \cdot S_k$	Eq. (A.6w)
$E_d = G_k + \psi_{1T} \cdot T_k + \psi_{0W} \cdot \psi_{1W} \cdot W_k + \psi_{0S} \cdot \psi_{1S} \cdot S_k + \Delta G_{k,C} + \psi_{0S} \cdot \psi_{1S} \cdot \Delta S_{k,C}$	Eq. (A.6x)

ANNEX B: EXAMPLES FOR TEMPERATURE LOADS

Table B|1: **Temperatures T_1**

RAL No.	name			colour group	R_G	T_1 [°C]
	English	French	German			
1000	Green beige	Beige vert	Grünbeige	2	72	56
1001	Beige	Beige	Beige	2	68	57
1002	Sand yellow	Jaune sable	Sandgelb	2	67	57
1003	Signal yellow	Jaune de sécurité	Signalgelb	2	70	57
1004	Golden yellow	Jaune or	Goldgelb	2	64	58
1005	Honey yellow	Jaune miel	Honiggelb	2	57	60
1006	Maize yellow	Jaune maïs	Maisgelb	2	63	58
1007	Daffodil yellow	Jaune narcisse	Narzissengelb	2	57	59
1011	Brown beige	Beige brun	Braunbeige	2	50	62
1012	Lemon yellow	Jaune citron	Zitronengelb	2	69	57
1013	Oyster white	Blanc perlé	Perlweiß	1	85	54
1014	Ivory	Ivoire	Elfenbein	2	76	55
1015	Light ivory	Ivoire clair	Hellelfenbein	1	82	54
1016	Sulfur yellow	Jaune soufre	Schwefelgelb	1	78	55
1017	Saffron yellow	Jaune safran	Safrangelb	2	70	57
1018	Zinc yellow	Jaune zinc	Zinkgelb	1	80	54
1019	Grey beige	Beige gris	Graubeige	2	54	61
1020	Olive yellow	Jaune olive	Olivgelb	2	53	61
1021	Rape yellow	Jaune colza	Rapsgelb	2	73	56
1023	Traffic yellow	Jaune signalisa-tion	Verkehrsgelb	2	72	56
1024	Ochre yellow	Jaune ocre	Ockergelb	2	57	59
1026	Luminous yellow	Jaune brillant	Leuchtgelb	1	99	50
1027	Curry	Jaune curry	Currygelb	2	47	63
1028	Melon yellow	Jaune melon	Melonengelb	2	68	57
1032	Broom yellow	Jaune genêt	Ginstergelb	2	65	58
1033	Dahlia yellow	Jaune dahlia	Dahliengelb	2	67	58

Table B|1: **Temperatures T_1 (continuation)**

RAL No.	name			colour group	R_G	T_1 [°C]
	English	French	German			
1034	Pastel yellow	Jaune pastel	Pastellgelb	2	68	58
2000	Yellow orange	Orangé jaune	Gelborange	2	51	61
2001	Red orange	Orangé rouge	Rotorange	2	40	65
2002	Vermilion	Orangé sang	Blutorange	3	37	67
2003	Pastel orange	Orangé pastel	Pastellorange	2	55	60
2004	Pure orange	Orangé pur	Reinorange	2	43	64
2005	Luminous orange	Orangé brillant	Leuchtorange	2	63	58
2007	Luminous bright orange	Orangé clair brillant	Leuchthellor-ange	1	84	53
2008	Bright red orange	Orangé rouge clair	Hellrotorange	2	53	61
2009	Traffic orange	Orangé signal-isation	Verkehrsorange	2	44	64
2010	Signal orange	Orangé de sécurité	Signalorange	2	45	63
2011	Deep orange	Orangé foncé	Tieforange	2	53	61
2012	Salmon range	Orangé saumon	Lachsorange	2	48	63
3000	Flame red	Rouge feu	Feuerrot	3	31	70
3001	Signal red	Rouge de sécurité	Signalrot	3	28	71
3002	Carmine red	Rouge carmin	Karminrot	3	28	71
3003	Ruby red	Rouge rubis	Rubinrot	3	23	74
3004	Purple red	Rouge pourpre	Purpurrot	3	20	76
3005	Wine red	Rouge vin	Weinrot	3	20	76
3007	Black red	Rouge noir	Schwarzrot	3	18	80
3009	Oxide red	Rouge oxyde	Oxidrot	3	28	71
3011	Brown red	Rouge brun	Braunrot	3	23	74
3012	Beige red	Rouge beige	Beigerot	2	55	61
3013	Tomato red	Rouge tomate	Tomatenrot	3	27	71
3014	Antique pink	Vieux rose	Altrosa	2	51	62
3015	Light pink	Rose clair	Hellrosa	2	66	58
3016	Coral red	Rouge corail	Korallenrot	3	32	68
3017	Rose	Rosé	Rosé	2	43	64

Table B|1: **Temperatures T_1 (continuation)**

RAL No.	name			colour group	R_G	T_1 [°C]
	English	French	German			
3018	Strawberry red	Rouge fraise	Erdbeerrot	2	40	65
3020	Traffic red	Rouge signalisation	Verkehrsrot	3	32	69
3022	Salmon pink	Rouge saumon	Lachsrot	2	48	62
3024	Luminous red	Rouge brillant	Leuchtrot	2	48	63
3026	Luminous bright red	Rouge clair brillant	Leuchthellrot	2	54	61
3027	Raspberry red	Rouge framboise	Himbeerrot	3	31	69
3031	Orient red	Rouge oriental	Orientrot	3	31	69
4001	Red lilac	Lilas rouge	Rotlila	3	37	66
4002	Red violet	Violet rouge	Rotviolett	3	29	70
4003	Heather violet	Violet bruyère	Erikaviolett	2	46	63
4004	Claret violet	Violet bordeaux	Bordeauxviolett	3	20	76
4005	Blue lilac	Lilas bleu	Blaulila	2	39	65
4006	Traffic purple	Pourpre signal-isation	Verkehrspurpur	3	30	69
4007	Purple violet	Violet pourpre	Purpurviolett	3	18	79
4008	Signal violet	Violet de sécurité	Signalviolett	3	33	68
4009	Pastel violet	Violet pastel	Pastellviolett	2	51	62
4010	Telemagenta	Telemagenta	Telemagenta	3	36	67
5000	Violet blue	Bleu violet	Violettblau	3	26	72
5001	Green blue	Bleu vert	Grünblau	3	23	74
5002	Ultramarine blue	Bleu outremer	Ultramarinblau	3	20	76
5003	Saphire blue	Bleu saphir	Saphirblau	3	19	78
5004	Black blue	Bleu noir	Schwarzblau	3	15	86
5005	Signal blue	Bleu de sécurité	Signalblau	3	26	72
5007	Brillant blue	Bleu brillant	Brillantblau	3	33	69
5008	Grey blue	Bleu gris	Graublau	3	21	76
5009	Azure blue	Bleu azur	Azurblau	3	28	71
5010	Gentian blue	Bleu gentiane	Enzianblau	3	22	75
5011	Steel blue	Bleu acier	Stahlblau	3	18	80

Table B|1: **Temperatures T_1 (continuation)**

RAL No.	name			colour group	R_G	T_1 [°C]
	English	French	German			
5012	Light blue	Bleu clair	Lichtblau	2	43	64
5013	Cobalt blue	Bleu cobalt	Kobaltblau	3	15	80
5014	Pigeon blue	Bleu pigeon	Taubenblau	2	40	65
5015	Sky blue	Bleu ciel	Himmelblau	2	40	65
5017	Traffic blue	Bleu signalisation	Verkehrsblau	3	28	71
5018	Turquoise blue	Bleu turquoise	Türkisblau	2	44	64
5019	Capri blue	Bleu capri	Capriblau	3	28	71
5020	Ocean blue	Bleu océan	Ozeanblau	3	19	78
5021	Water blue	Bleu d'eau	Wasserblau	3	36	67
5022	Night blue	Bleu nocturne	Nachtblau	3	19	78
5023	Distant blue	Bleu distant	Fernblau	3	36	67
5024	Pastel blue	Bleu pastel	Pastellblau	2	52	61
6000	Patina green	Vert patine	Patinagrün	3	37	66
6001	Emerald green	Vert émeraude	Smaragdgrün	3	32	70
6002	Leaf green	Vert feuillage	Laubgrün	3	29	71
6003	Olive green	Vert olive	Olivgrün	3	28	71
6004	Blue green	Vert bleu	Blaugrün	3	21	76
6005	Moss green	Vert mousse	Moosgrün	3	21	76
6006	Grey olive	Olive gris	Grauoliv	3	20	77
6007	Bottle green	Vert bouteille	Flaschengrün	3	18	79
6008	Brown green	Vert brun	Braungrün	3	16	79
6010	Grass green	Vert herbe	Grasgrün	3	37	67
6011	Reseda green	Vert réséda	Resedagrün	2	43	64
6012	Black green	Vert noir	Schwarzgrün	3	21	76
6013	Reed green	Vert jonc	Schilfgrün	2	41	65
6014	Yellow olive	Olive jaune	Gelboliv	3	23	74
6015	Black olive	Olive noir	Schwarzoliv	3	22	75
6016	Turquoise green	Vert turquoise	Türkisgrün	3	31	69

Table B|1: **Temperatures T_1 (continuation)**

RAL No.	name			colour group	R_G	T_1 [°C]
	English	French	German			
6017	May green	Vert mai	Maigrün	2	41	65
6018	Yellow green	Vert jaune	Gelbgrün	2	50	62
6019	Pastel green	Vert blanc	Weißgrün	1	76	55
6020	Chrome green	Vert oxyde chromique	Chromoxidgrün	3	23	75
6021	Pale green	Vert pâle	Blassgrün	2	55	60
6022	Olive drab	Olive brun	Braunoliv	3	20	77
6024	Traffic green	Vert signalisation	Verkehrsgrün	3	39	66
6025	Fern green	Vert fougère	Farngrün	3	36	67
6026	Opal green	Vert opale	Opalgrün	3	26	72
6027	Light green	Vert clair	Lichtgrün	2	66	58
6028	Pine green	Vert pin	Kieferngrün	3	26	72
6029	Mint green	Vert menthe	Minzgrün	3	32	69
6032	Signal green	Vert de sécurité	Signalgrün	3	37	66
6033	Mint turquoise	Turquoise menthe	Minttürkis	2	44	64
6034	Pastel turquoise	Turquoise pastel	Pastelltürkis	2	62	59
7000	Squirrel grey	Gris petit-gris	Fehgrau	2	48	62
7001	Silver grey	Gris argent	Silbergrau	2	52	61
7002	Olive grey	Gris olive	Olivgrau	2	44	64
7003	Moss grey	Gris mousse	Moosgrau	2	41	65
7004	Signal grey	Gris de sécurité	Signalgrau	2	57	60
7005	Mouse grey	Gris souris	Mausgrau	3	38	66
7006	Beige grey	Gris beige	Beigegrau	3	37	66
7008	Khaki grey	Gris kaki	Khakigrau	3	34	68
7009	Green grey	Gris vert	Grüngrau	3	30	70
7010	Tarpaulin grey	Gris tente	Zeltgrau	3	30	69
7011	Iron grey	Gris fer	Eisengrau	3	30	70
7012	Basalt grey	Gris basalte	Basaltgrau	3	31	69
7013	Brown grey	Gris brun	Braungrau	3	27	72

Table B|1: **Temperatures T_1 (continuation)**

RAL No.	name			colour group	R_G	T_1 [°C]
	English	French	German			
7015	Slate grey	Gris ardoise	Schiefergrau	3	28	71
7016	Anthracite grey	Gris anthracite	Anthrazitgrau	3	21	76
7021	Black grey	Gris noir	Schwarzgrau	3	19	78
7022	Umbra grey	Gris terre d'ombre	Umbragrau	3	26	72
7023	Concrete grey	Gris béton	Betongrau	2	45	63
7024	Graphite grey	Gris graphite	Graphitgrau	3	25	73
7026	Granite grey	Gris granit	Granitgrau	3	23	74
7030	Stone grey	Gris pierre	Steingrau	2	52	61
7031	Blue grey	Gris bleu	Blaugrau	3	36	67
7032	Pebble grey	Gris silex	Kieselgrau	2	67	57
7033	Cement grey	Gris ciment	Zementgrau	2	46	63
7034	Yellow grey	Gris jaune	Gelbgrau	2	50	62
7035	Light grey	Gris clair	Lichtgrau	1	75	55
7036	Platinum grey	Gris platine	Platingrau	2	55	61
7037	Dusty grey	Gris poussière	Staubgrau	2	45	63
7038	Agate grey	Gris agate	Achatgrau	2	67	57
7039	Quartz grey	Gris quartz	Quarzgrau	3	35	67
7040	Window grey	Gris fenêtre	Fenstergrau	2	59	60
7042	Traffic grey A	Gris signalisation A	Verkehrsgrau A	2	54	61
7043	Traffic grey B	Gris signalisation B	Verkehrsgrau B	3	27	71
7044	Silk grey	Gris soie	Seidengrau	2	69	57
7045	Telegrey 1	Telegris 1	Telegrau 1	2	54	61
7046	Telegrey 2	Telegris 2	Telegrau 2	2	47	63
7047	Telegrey 4	Telegris 4	Telegrau 4	2	75	55
8000	Green brown	Brun vert	Grünbraun	3	39	66
8001	Ochre brown	Brun terre de Sienne	Ockerbraun	2	39	65
8002	Signal brown	Brun de sécurité	Signalbraun	3	30	70
8003	Clay brown	Brun argile	Lehmbraun	2	40	65

Table B|1: **Temperatures T_1 (continuation)**

RAL No.	name			colour group	R_G	T_1 [°C]
	English	French	German			
8004	Copper brown	Brun cuivré	Kupferbraun	3	33	69
8007	Fawn brown	Brun fauve	Rehbraun	3	27	72
8008	Olive brown	Brun olive	Olivbraun	3	28	70
8011	Nut brown	Brun noisette	Nussbraun	3	22	75
8012	Red brown	Brun rouge	Rotbraun	3	21	76
8014	Sepia brown	Brun sépia	Sepiabraun	3	19	77
8015	Chestnut brown	Marron	Kastanienbraun	3	23	74
8016	Mahogany brown	Brun acajou	Mahagonibraun	3	18	78
8017	Chocolate brown	Brun chocolat	Schokoladen-braun	3	18	79
8019	Grey brown	Brun gris	Graubraun	3	22	75
8022	Black brown	Brun noir	Schwarzbraun	3	14	88
8023	Orange brown	Brun orangé	Orangebraun	2	40	65
8024	Beige brown	Brun beige	Beigebraun	3	30	69
8025	Pale brown	Brun pâle	Blassbraun	3	34	68
8028	Terra brown	Brun terre	Terrabraun	3	22	75
9001	Cream	Blanc crème	Cremeweiß	1	84	53
9002	Grey white	Blanc gris	Grauweiß	1	83	54
9003	Signal white	Blanc de sécurité	Signalweiß	1	89	52
9004	Signal black	Noir de sécurité	Signalschwarz	3	14	89
9005	Jet black	Noir foncé	Tiefschwarz	3	13	95
9006	White aluminium	Aluminium blanc	Weißaluminium	2	66	57[1)]
9007	Grey aluminium	Aluminium gris	Graualuminium	2	48	63[1)]
9010	Pure white	Blanc pur	Reinweiß	1	90	52
9011	Graphite black	Noir graphite	Graphitschwarz	3	15	84
9016	Traffic white	Blanc signalisation	Verkehrsweiß	1	88	52
9017	Traffic black	Noir signalisation	Verkehrs-schwarz	3	13	95
9018	Papyrus white	Blanc papyrus	Papyrusweiß	2	76	55

1) Indicative values only. The temperature depends much on the reflectivity and/or on the glimmer particles.

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