〈AC〉 Table A1.2(C) – Design values of actions (STR/GEO) (Set C)

Persistent and transient design situation	Permanent actions		Leading variable action (*)	Accompanying variable actions (*)	
	Unfavourable	Favourable		Main (if any)	Others
(Eq. 6.10)	$\gamma_{G,j,sup} G_{k,j,sup}$	$\gamma_{G,j,inf} G_{k,j,inf}$	$\gamma_{Q,1}\ Q_{k,1}$		$\gamma_{Q,i}\,\psi_{0,i} Q_{k,i}$

(*) Variable actions are those considered in Table A1.1

NOTE The γ values may be set by the National annex. The recommended set of values for γ are:
$\gamma_{G,j,sup} = 1{,}00$
$\gamma_{G,j,inf} = 1{,}00$
$\gamma_{Q,1} = 1{,}30$ where unfavourable (0 where favourable)
$\gamma_{Q,i} = 1{,}30$ where unfavourable (0 where favourable)

〈AC〉

A1.3.2 Design values of actions in the accidental and seismic design situations

(1) The partial factors for actions for the ultimate limit states in the accidental and seismic design situations (expressions 6.11a to 6.12b) should be 1,0. ψ values are given in Table A1.1.

NOTE For the seismic design situation see also EN 1998.

Table A1.3 – Design values of actions for use in accidental and seismic combinations of actions

〈AC〉

Design situation	Permanent actions		Leading accidental or seismic action	Accompanying variable actions (**)	
	Unfavourable	Favourable		Main (if any)	Others
Accidental (*) (Eq. 6.11a/b)	$G_{k,j,sup}$	$G_{k,j,inf}$	A_d	$\psi_{1,1}$ or $\psi_{2,1} Q_{k,1}$	$\psi_{2,i}\ Q_{k,i}$
Seismic (Eq. 6.12a/b)	$G_{k,j,sup}$	$G_{k,j,inf}$	$A_{Ed} = \gamma_I A_{Ek}$		$\psi_{2,i}\ Q_{k,i}$

(*) In the case of accidental design situations, the main variable action may be taken with its frequent or, as in seismic combinations of actions, its quasi-permanent values. The choice will be in the National annex, depending on the accidental action under consideration. See also EN 1991-1-2.

(**) Variable actions are those considered in Table A1.1.

〈AC〉

A1.4 Serviceability limit states

A1.4.1 Partial factors for actions

(1) For serviceability limit states the partial factors for actions should be taken as 1,0 except if differently specified in EN 1991 to EN 1999.

Table A1.4 – Design values of actions for use in the combination of actions

AC

Combination	Permanent actions G_d		Variable actions Q_d	
	Unfavourable	Favourable	Leading	Others
Characteristic	$G_{k,j,sup}$	$G_{k,j,inf}$	$Q_{k,1}$	$\psi_{0,i}Q_{k,i}$
Frequent	$G_{k,j,sup}$	$G_{k,j,inf}$	$\psi_{1,1}Q_{k,1}$	$\psi_{2,i}Q_{k,i}$
Quasi-permanent	$G_{k,j,sup}$	$G_{k,j,inf}$	$\psi_{2,1}Q_{k,1}$	$\psi_{2,i}Q_{k,i}$

AC

A1.4.2 Serviceability criteria

(1) Serviceability limit states in buildings should take into account criteria related, for example, to floor stiffness, differential floor levels, storey sway or/and building sway and roof stiffness. Stiffness criteria may be expressed in terms of limits for vertical deflections and for vibrations. Sway criteria may be expressed in terms of limits for horizontal displacements.

(2) The serviceability criteria should be specified for each project and agreed with the client.

NOTE The serviceability criteria may be defined in the National annex.

(3)P The serviceability criteria for deformations and vibrations shall be defined:

– depending on the intended use;
– in relation to the serviceability requirements in accordance with 3.4;
– independently of the materials used for supporting structural member.

A1.4.3 Deformations and horizontal displacements

(1) Vertical and horizontal deformations should be calculated in accordance with EN 1992 to EN 1999, by using the appropriate combinations of actions according to expressions (6.14a) to (6.16b) taking into account the serviceability requirements given in 3.4(1). Special attention should be given to the distinction between reversible and irreversible limit states.

(2) Vertical deflections are represented schematically in Figure. A1.1.

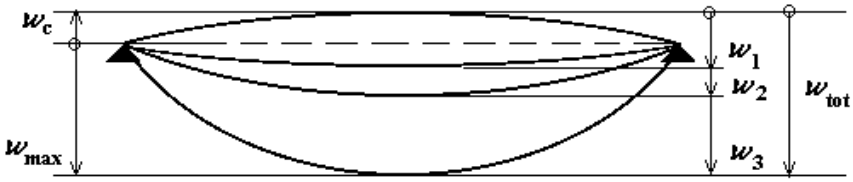

Figure A1.1 – Definitions of vertical deflections

Key:

w_c Precamber in the unloaded structural member

w_1 Initial part of the deflection under permanent loads of the relevant combination of actions according to expressions (6.14a) to (6.16b)

w_2 Long-term part of the deflection under permanent loads

w_3 Additional part of the deflection due to the variable actions of the relevant combination of actions according to expressions (6.14a) to (6.16b)

w_{tot} Total deflection as sum of w_1 , w_2 , w_3

w_{max} Remaining total deflection taking into account the precamber

(3) If the functioning or damage of the structure or to finishes, or to non-structural members (*e.g.* partition walls, claddings) is being considered, the verification for deflection should take account of those effects of permanent and variable actions that occur after the execution of the member or finish concerned.

NOTE Guidance on which expression (6.14a) to (6.16b) to use is given in 6.5.3 and EN 1992 to EN 1999.

(4) If the appearance of the structure is being considered, the quasi-permanent combination (expression 6.16b) should be used.

(5) If the comfort of the user, or the functioning of machinery are being considered, the verification should take account of the effects of the relevant variable actions.

(6) Long term deformations due to shrinkage, relaxation or creep should be considered where relevant, and calculated by using the effects of the permanent actions and quasi-permanent values of the variable actions.

(7) Horizontal displacements are represented schematically in Figure A1.2.

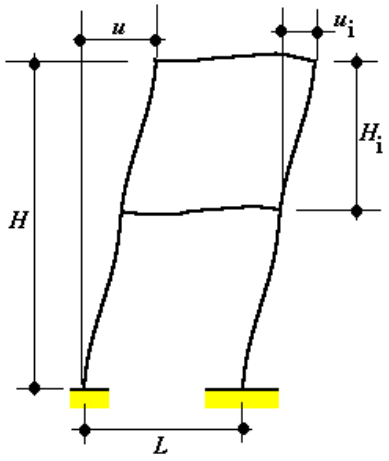

Figure A1.2 – Definition of horizontal displacements

Key:

u Overall horizontal displacement over the building height H

u_i Horizontal displacement over a storey height H_i

A1.4.4 Vibrations

(1) To achieve satisfactory vibration behaviour of buildings and their structural members under serviceability conditions, the following aspects, amongst others, should be considered:

a) the comfort of the user;

b) the functioning of the structure or its structural members (*e.g.* cracks in partitions, damage to cladding, sensitivity of building contents to vibrations).

Other aspects should be considered for each project and agreed with the client.

(2) For the serviceability limit state of a structure or a structural member not to be exceeded when subjected to vibrations, the natural frequency of vibrations of the structure or structural member should be kept above appropriate values which depend upon the function of the building and the source of the vibration, and agreed with the client and/or the relevant authority.

(3) If the natural frequency of vibrations of the structure is lower than the appropriate value, a more refined analysis of the dynamic response of the structure, including the consideration of damping, should be performed.

NOTE For further guidance, see EN 1991-1-1, EN 1991-1-4 and ISO 10137.

(4) Possible sources of vibration that should be considered include walking, synchronised movements of people, machinery, ground borne vibrations from traffic, and wind actions. These, and other sources, should be specified for each project and agreed with the client.

Annex A2
(normative)
Application for bridges

A1 National Annex for EN 1990 Annex A2

National choice is allowed in EN 1990 Annex A2 through the following clauses:

General clauses

Clause	Item
A2.1 (1) NOTE 3	Use of Table 2.1: Design working life
A2.2.1(2) NOTE 1	Combinations involving actions which are outside the scope of EN 1991
A2.2.6(1) NOTE 1	Values of ψ factors
A2.3.1(1)	Alteration of design values of actions for ultimate limit states
A2.3.1(5)	Choice of Approach 1, 2 or 3
A2.3.1(7)	Definition of forces due to ice pressure
A2.3.1(8)	Values of γ_P factors for prestressing actions where not specified in the relevant design Eurocodes
A2.3.1 Table A2.4(A) NOTES 1 and 2	Values of γ factors
A2.3.1 Table A2.4(B)	- NOTE 1: choice between 6.10 and 6.10a/b - NOTE 2: Values of γ and ξ factors - NOTE 4: Values of γ_{Sd}
A2.3.1 Table A2.4 (C)	Values of γ factors
A2.3.2(1)	Design values in Table A2.5 for accidental design situations, design values of accompanying variable actions and seismic design situations
A2.3.2 Table A2.5 NOTE	Design values of actions
A2.4.1(1) NOTE 1 (Table A2.6) NOTE 2	Alternative γ values for traffic actions for the serviceability limit state Infrequent combination of actions
A2.4.1(2)	Serviceability requirements and criteria for the calculation of deformations

Clauses specific for road bridges

Clause	Item
A2.2.2 (1)	Reference to the infrequent combination of actions
A2.2.2(3)	Combination rules for special vehicles
A2.2.2(4)	Combination rules for snow loads and traffic loads
A2.2.2(6)	Combination rules for wind and thermal actions
A2.2.6(1) NOTE 2	Values of $\psi_{1,infq}$ factors
A2.2.6(1) NOTE 3	Values of water forces

Clauses specific for footbridges

Clause	Item
A2.2.3(2)	Combination rules for wind and thermal actions
A2.2.3(3)	Combination rules for snow loads and traffic loads
A2.2.3(4)	Combination rules for footbridges protected from bad weather
A2.4.3.2(1)	Comfort criteria for footbridges

Clauses specific for railway bridges

Clause	Item
A2.2.4(1)	Combination rules for snow loading on railway bridges
A2.2.4(4)	Maximum wind speed compatible with rail traffic
A2.4.4.1(1) NOTE 3	Deformation and vibration requirements for temporary railway bridges
A2.4.4.2.1(4)P	Peak values of deck acceleration for railway bridges and associated frequency range
A2.4.4.2.2 – Table A2.7 NOTE	Limiting values of deck twist for railway bridges
A2.4.4.2.2(3)P	Limiting values of the total deck twist for railway bridges
A2.4.4.2.3(1)	Vertical deformation of ballasted and non ballasted railway bridges
A2.4.4.2.3(2)	Limitations on the rotations of non ballasted bridge deck ends for railway bridges
A2.4.4.2.3(3)	Additional limits of angular rotations at the end of decks
A2.4.4.2.4(2) – Table A2.8 NOTE 3	Values of α_i and r_i factors
A2.4.4.2.4(3)	Minimum lateral frequency for railway bridges
A2.4.4.3.2(6)	Requirements for passenger comfort for temporary bridges

A2.1 Field of application

〖AC〗 *deleted text* 〖AC〗

(1) This Annex A2 to EN 1990 gives rules and methods for establishing combinations of actions for serviceability and ultimate limit state verifications (except fatigue verifications) with the recommended design values of permanent, variable and accidental actions and ψ factors to be used in the design of road bridges, footbridges and railway bridges. It also applies to actions during execution. Methods and rules for verifications relating to some material-independent serviceability limit states are also given.

NOTE 1 Symbols, notations, Load Models and groups of loads are those used or defined in the relevant section of EN 1991-2.

NOTE 2 Symbols, notations and models of construction loads are those defined in EN 1991-1-6.

NOTE 3 Guidance may be given in the National Annex with regard to the use of Table 2.1 (design working life).

NOTE 4 Most of the combination rules defined in clauses A2.2.2 to A2.2.5 are simplifications intended to avoid needlessly complicated calculations. They may be changed in the National Annex or for the individual project as described in A2.2.1 to A2.2.5.

NOTE 5 This Annex A2 to EN 1990 does not include rules for the determination of actions on structural bearings (forces and moments) and associated movements of bearings or give rules for the analysis of bridges involving ground-structure interaction that may depend on movements or deformations of structural bearings.

(2) The rules given in this Annex A2 to EN 1990 may not be sufficient for:
– bridges that are not covered by EN 1991-2 (for example bridges under an airport runway, mechanically-moveable bridges, roofed bridges, bridges carrying water, etc.),
– bridges carrying both road and rail traffic, and
– other civil engineering structures carrying traffic loads (for example backfill behind a retaining wall).

〖AC〗 *deleted text* 〖AC〗

A2.2 Combinations of actions

A2.2.1 General

(1) Effects of actions that cannot occur simultaneously due to physical or functional reasons need not be considered together in combinations of actions.

(2) Combinations involving actions which are outside the scope of EN 1991 (e.g. due to mining subsidence, particular wind effects, water, floating debris, flooding, mud slides, avalanches, fire and ice pressure) should be defined in accordance with EN 1990, 1.1(3).

NOTE 1 Combinations involving actions that are outside the scope of EN 1991 may be defined either in the National Annex or for the individual project.

NOTE 2 For seismic actions, see EN 1998.

NOTE 3 For water actions exerted by currents and debris effects, see also EN 1991-1-6.

(3) The combinations of actions given in expressions 6.9a to 6.12b should be used when verifying ultimate limit states.

NOTE Expressions 6.9a to 6.12b are not for the verification of the limit states due to fatigue. For fatigue verifications, see EN 1991 to EN 1999.

(4) The combinations of actions given in expressions 6.14a to 6.16b should be used when verifying serviceability limit states. Additional rules are given in A2.4 for verifications regarding deformations and vibrations.

(5) Where relevant, variable traffic actions should be taken into account simultaneously with each other in accordance with the relevant sections of EN 1991-2.

(6)P During execution the relevant design situations shall be taken into account.

(7)P The relevant design situations shall be taken into account where a bridge is brought into use in stages.

(8) Where relevant, particular construction loads should be taken into account simultaneously in the appropriate combinations of actions.

NOTE Where construction loads cannot occur simultaneously due to the implementation of control measures they need not be taken into account in the relevant combinations of actions.

(9)P For any combination of variable traffic actions with other variable actions specified in other parts of EN 1991, any group of loads, as defined in EN 1991-2, shall be taken into account as one variable action.

(10) Snow loads and wind actions need not be considered simultaneously with loads arising from construction activity Q_{ca} (i.e. loads due to working personnel).

NOTE For an individual project it may be necessary to agree the requirements for snow loads and wind actions to be taken into account simultaneously with other construction loads (e.g. actions due to heavy equipment or cranes) during some transient design situations. See also EN 1991-1-3, 1-4 and 1-6.

(11) Where relevant, thermal and water actions should be considered simultaneously with construction loads. Where relevant the various parameters governing water actions and components of thermal actions should be taken into account when identifying appropriate combinations with construction loads.

(12) The inclusion of prestressing actions in combinations of actions should be in accordance with A2.3.1(8) and EN 1992 to EN 1999.

(13) Effects of uneven settlements should be taken into account if they are considered significant compared to the effects from direct actions.

NOTE The individual project may specify limits on total settlement and differential settlement.

(14) Where the structure is very sensitive to uneven settlements, uncertainty in the assessment of these settlements should be taken into account.

(15) Uneven settlements on the structure due to soil subsidence should be classified as a permanent action, G_{set}, and included in combinations of actions for ultimate and serviceability limit state verifications of the structure. G_{set} should be represented by a set of values corresponding to differences (compared to a reference level) of settlements between individual foundations or parts of foundations, $d_{set,i}$ (i is the number of the individual foundation or part of foundation).

NOTE 1 Settlements are mainly caused by permanent loads and backfill. Variable actions may have to be taken into account for some individual projects.

NOTE 2 Settlements vary monotonically (in the same direction) with time and need to be taken into account from the time they give rise to effects in the structure (i.e. after the structure, or a part of it, becomes statically indeterminate). In addition, in the case of a concrete structure or a structure with concrete elements, there may be an interaction between the development of settlements and creep of concrete members.

(16) The differences of settlements of individual foundations or parts of foundations, $d_{set,i}$, should be taken into account as best-estimate predicted values in accordance with EN 1997 with due regard for the construction process of the structure.

NOTE Methods for the assessment of settlements are given in EN 1997

(17) In the absence of control measures, the permanent action representing settlements should be determined as follows:

– the best-estimate predicted values $d_{set,i}$ are assigned to all individual foundations or parts of foundations,
– two individual foundations or parts of an individual foundation, selected in order to obtain the most unfavourable effect, are subject to a settlement $d_{set,i} \pm \Delta d_{set,i}$, where $\Delta d_{set,i}$ takes account of uncertainties attached to the assessment of settlements.

A2.2.2 Combination rules for road bridges

(1) The infrequent values of variable actions may be used for certain serviceability limit states of concrete bridges.

NOTE The National Annex may refer to the infrequent combination of actions. The expression of this combination of actions is:

$$E_d = E\left\{G_{k,j}\,;\,P\,;\,\psi_{1,\text{infq}}Q_{k,1}\,;\,\psi_{1,i}Q_{k,i}\right\} \quad j \geq 1\,;\,i > 1 \tag{A2.1a}$$

in which the combination of actions in brackets { } may be expressed as:

$$\sum_{j\geq 1} G_{k,j}\text{"+"}P\text{"+"}\psi_{1,\text{infq}}Q_{\text{k,1}}\text{"+"}\sum_{i>1}\psi_{1,i}Q_{\text{k,i}} \tag{A2.1b}$$

(2) Load Model 2 (or associated group of loads gr1b) and the concentrated load Q_{fwk} (see 5.3.2.2 in EN 1991-2) on footways need not be combined with any other variable non traffic action.

(3) Neither snow loads nor wind actions need be combined with:

– braking and acceleration forces or the centrifugal forces or the associated group of loads gr2,

– loads on footways and cycle tracks or with the associated group of loads gr3,
– crowd loading (Load Model 4) or the associated group of loads gr4.

NOTE The combination rules for special vehicles (see EN 1991-2, Annex A, Informative) with normal traffic (covered by LM1 and LM2) and other variable actions may be referenced as appropriate in the National Annex or agreed for the individual project.

(4) Snow loads need not be combined with Load Models 1 and 2 or with the associated groups of loads gr1a and gr1b unless otherwise specified for particular geographical areas.

NOTE Geographical areas where snow loads may have to be combined with groups of loads gr1a and gr1b in combinations of actions may be specified in the National Annex.

(5) No wind action greater than the smaller of F_W^* and $\psi_0 F_{Wk}$ should be combined with Load Model 1 or with the associated group of loads gr1a.

NOTE For wind actions, see EN 1991-1-4.

(6) Wind actions and thermal actions need not be taken into account simultaneously unless otherwise specified for local climatic conditions.

NOTE Depending upon the local climatic conditions a different simultaneity rule for wind and thermal actions may be defined either in the National Annex or for the individual project.

A2.2.3 Combination rules for footbridges

(1) The concentrated load Q_{fwk} need not be combined with any other variable actions that are not due to traffic.

(2) Wind actions and thermal actions need not be taken into account simultaneously unless otherwise specified for local climatic conditions.

NOTE Depending upon the local climatic conditions a different simultaneity rule for wind and thermal actions may be defined either in the National Annex or for the individual project.

(3) Snow loads need not be combined with groups of loads gr1 and gr2 for footbridges unless otherwise specified for particular geographical areas and certain types of footbridges.

NOTE Geographical areas, and certain types of footbridges, where snow loads may have to be combined with groups of loads gr1 and gr2 in combinations of actions may be specified in the National Annex.

(4) For footbridges on which pedestrian and cycle traffic is fully protected from all types of bad weather, specific combinations of actions should be defined.

NOTE Such combinations of actions may be given as appropriate in the National Annex or agreed for the individual project. Combinations of actions similar to those for buildings (see Annex A1), the imposed loads being replaced by the relevant group of loads and the ψ factors for traffic actions being in accordance with Table A2.2, are recommended.