

Figure A1.1 - Definitions of vertical deflections

Key :

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|-----------|--|
| 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.

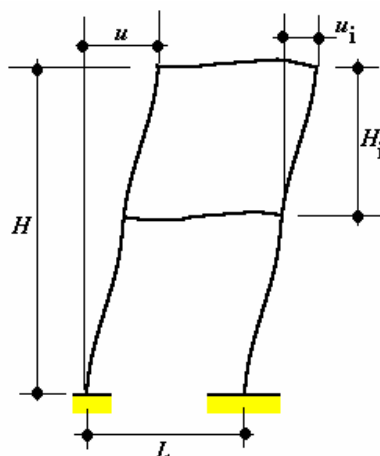


Figure A1.2 - Definition of horizontal displacements

Key :

- u Overall horizontal displacement over the building height H
- u_1 Horizontal displacement over a storey height H_1

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.

18) Modification to the Annexes

At the end of Annex A1 and before Annex B, add the following Annex A2: **Annex A2**

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Annex A2 (normative) Application for bridges

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 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 |

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| A2.4.3.2(1) | Comfort criteria for footbridges |
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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

AC2 *Text deleted* **AC2**

(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). **A1**

AC2 *Text deleted* **AC2**



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.



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(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

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(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:

$$E_d = E\{G_{k,j}; P; \psi_{1,inf} Q_{k,1}; \psi_{1,i} Q_{k,i}\} \quad j \geq 1; i > 1 \quad (A2.1a)$$

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

$$\sum_{j \geq 1} G_{k,j} + P + \psi_{1,inf} Q_{k,1} + \sum_{i > 1} \psi_{1,i} Q_{k,i} \quad (A2.1b)$$

(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 EN1991-1-4.

(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.

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A2.2.3 Combination rules for footbridges

(1) The concentrated load Q_{fwh} 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.

A2.2.4 Combination rules for railway bridges

(1) Snow loads need not be taken into account in any combination for persistent design situations nor for any transient design situation after the completion of the bridge unless otherwise specified for particular geographical areas and certain types of railway bridges.

NOTE Geographical areas, and certain types of railway bridges, where snow loads may have to be taken into account in combinations of actions are to be specified in the National Annex.

(2) The combinations of actions to be taken into account when traffic actions and wind actions act simultaneously should include:

- vertical rail traffic actions including dynamic factor, horizontal rail traffic actions and wind forces with each action being considered as the leading action of the combination of actions one at a time;
- AC2** - vertical rail traffic actions excluding dynamic factor and lateral rail traffic actions from the “unloaded train” defined in EN 1991-2 (6.3.4 and 6.5) with wind forces for checking stability.” **AC2**

(3) Wind action need not be combined with:

- groups of loads gr 13 or gr 23;
- groups of loads gr 16, gr 17, gr 26, gr 27 and Load Model SW/2 (see EN 1991-2, 6.3.3).

(4) No wind action greater than the smaller of F_w^{**} and $\psi_0 F_{wk}$ should be combined with traffic actions.

NOTE The National Annex may give the limits of the maximum wind speed(s) compatible with rail traffic for determining F_w^{**} . See also EN 1991-1-4.



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(5) Actions due to aerodynamic effects of rail traffic (see EN 1991-2, 6.6) and wind actions should be combined together. Each action should be considered individually as a leading variable action.

(6) If a structural member is not directly exposed to wind, the action q_{ik} due to aerodynamic effects should be determined for train speeds enhanced by the speed of the wind.

(7) Where groups of loads are not used for rail traffic loading, rail traffic loading should be considered as a single multi-directional variable action with individual components of rail traffic actions to be taken as the maximum unfavourable and minimum favourable values as appropriate.

A2.2.5 Combinations of actions for accidental (non seismic) design situations

(1) Where an action for an accidental design situation needs to be taken into account, no other accidental action or wind action or snow load need be taken into account in the same combination.

(2) For an accidental design situation concerning impact from traffic (road or rail traffic) under the bridge, the loads due to the traffic on the bridge should be taken into account in the combinations as accompanying actions with their frequent value.

AC2 NOTE 1 For actions due to impact from traffic, see EN 1991-1-7. **AC2**

NOTE 2 Additional combinations of actions for other accidental design situations (e.g. combination of road or rail traffic actions with avalanche, flood or scour effects) may be agreed for the individual project.

NOTE 3 Also see 1) in Table A2.1.

(3) For railway bridges, for an accidental design situation concerning actions caused by a derailed train on the bridge, rail traffic actions on the other tracks should be taken into account as accompanying actions in the combinations with their combination value.

AC2 NOTE 1 For actions due to impact from traffic, see EN 1991-1-7. **AC2**

NOTE 2 Actions for accidental design situations due to impact from rail traffic running on the bridge including derailment actions are specified in EN1991-2, 6.7.1.

(4) Accidental design situations involving ship collisions against bridges should be identified.

NOTE For ship impact, see EN1991-1-7. Additional requirements may be specified for the individual project.

A2.2.6 Values of ψ factors

(1) Values of ψ factors should be specified.

NOTE 1 The ψ values may be set by the National Annex. Recommended values of ψ factors for the groups of traffic loads and the more common other actions are given in:

Table A2.1 for road bridges,

Table A2.2 for footbridges, and

Table A2.3 for railway bridges, both for groups of loads and individual components of traffic actions.

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