Part 6: Rocker bearings

AC1) – Vertical bearing resistance (AC1

– Horizontal bearing capacity due to friction

– Rotation capacity about one axis

Part 7: Spherical and cylindrical PTFE bearings

AC1) – Vertical bearing resistance (AC1

– Reaction moment(s) due to friction

– Rotation capacity about all (spherical) axes or one (cylindrical) axis

Part 8: Guided bearings and restraint bearings

– Restraint of movements in one or more directions

Part 9: Protection

Part 10: Inspection and maintenance

Part 11: Transport, Storage and installation

(2) For technical specifications for bearings including vertical and horizontal forces, translational and rotational movements and other geometrical and performance characteristics, see A.3.1 (3).

## A.2 Symbols

(1) Symbols for the most common types of bearings may be taken from EN 1337-1, Table 1.

## A.3 General

### A.3.1 Bearing layout

(1) The bearing layout should be designed to permit the specified movement of a structure with the minimum possible resistance to such movements.

(2) The arrangement of bearings for a structure should be considered in conjunction with the design of the structure as a whole. The forces and movements in bearings should be given to the bearing manufacturer to ensure that the bearings provided meet the requirements.

(3) A drawing showing the bearing layout should include the following:

a) a simplified general arrangement of the bridge showing the bearings in plan;

b) details at the bearing location (e.g. recess and reinforcement) ;

c) a clear indication of the type of bearing at each location;

d) a table giving the detailed requirements for each bearing;

e) bedding and fixing details.

(4) Bearings should not normally be expected to resist moments due to rotational movement. Where such rotational movement is present provision should be made to accommodate it by using the bearing itself or within the structure. Where bearings are required to resist rotational movement an analysis should be carried to ensure that the bearings will not be affected adversely, see A.3.2.

(5) Uplift may cause excessive wear in bearings if such conditions occur frequently. Where uplift is unavoidable prestressing may be used to provide the necessary additional vertical force.

(6) Bearings and supports should be designed in such a way that they can be inspected, maintained and replaced if necessary.

**NOTE 1:** For inspection purposes bearings should be provided with movement indicators with markings showing the maximum allowable movements.

**NOTE 2:** A clearance of not more than 10 mm should be provided for resetting or replacement of bearings or parts of bearings during jacking of the structure.

(7) If presetting is required it should be carried out at the factory wherever possible. If adjustment on site is unavoidable it should be carried out in accordance with the manufacturers' detailed instructions.

### A.3.2 Effects of continuity of deformation

(1) For line rocker and single roller bearings, the full implications of uneven pressure along the length of the roller or rocker should be taken into account in the design of the structure and the bearing. Particular care should be taken in the design of the following:

a) structures curved in plan;

b) structures with slender piers;

c) structures without transverse beams;

d) structures with transverse beams where the line rocker or single roller could effectively act as a built-in support for the transverse beam;

e) structures with a transverse temperature gradient.

### A.3.3 Anchorage of bearings

(1)P Anchorages of bridge bearings shall be designed at the ultimate limit state. Where the position of a bearing or part of a bearing is retained either completely or partially by friction its safety against sliding shall be checked in accordance with the following

$$V_{Ed} \leq V_{Rd} \tag{A.1}$$

where $V_{Ed}$ is the design value of the shear force acting at the bridge bearing

$$V_{Rd} = \frac{\mu_K}{\gamma_\mu} N_{Ed} + V_{pd}$$

$N_{Ed}$ is the minimum design force acting normal to the joint in conjunction with $V_{Ed}$;

$V_{pd}$ is the design value of shear resistance of any fixing device in accordance with the Eurocodes;

$\mu_K$ is the characteristic value of the friction coefficient, see Table A.1;

$\gamma_\mu$ is the partial factor for friction.

**NOTE:** The value for $\gamma_\mu$ may be given in the National Annex. The following values are recommended.

$\gamma_\mu = 2{,}0$ for steel on steel

$\gamma_\mu = 1{,}2$ for steel on concrete

**Table A.1: Characteristic values of the friction coefficient $\mu_K$**

| Surface treatment of steel components | Steel on steel | Steel on concrete |
|---|---|---|
| Uncoated and free from grease<br>Metal-sprayed<br>Coated with fully hardened zinc silicate | 0,4 | 0,6 |
| Other treatment | From test | From test |

(2) For dynamically loaded structures the value of $N_{Ed}$ should be determined taking into account any dynamic variations in traffic loads.

(3) For railway bridges and structures subjected to seismic situations friction should not be taken into account ($N_{Ed} = 0$).

(4) Where holding down bolts or other similar devices are used to provide some of the resistance to horizontal movement, it should be demonstrated that this resistance is provided before any movement can take place. If bolts are provided in holes with normal tolerances, movement will inevitably take place before the full resistance to movement is achieved. This is unacceptable in service conditions.

### A.3.4 Conditions of installation

(1) Conditions of installation taking into account the construction sequence and other time dependent effects should be determined and agreed with the manufacturer.

**NOTE:** In view of the difficulties of predicting conditions on site at the time of installation the design of bearings should be based on a number of alternative assumptions, see A.4.2.

### A.3.5 Bearing clearances

(1) Where the bearings are designed to resist horizontal forces, some movements will take place before clearances are taken up.

(2) The total clearance between extremes of movements may be up to 2 mm unless otherwise specified or agreed with the manufacturer.

(3) Clearance should not be taken into account when allowing for horizontal movements unless it can be shown that these movements will be permanently available in the correct direction.

(4) If more than one bearing is required to resist horizontal forces, the bearings and their supports should be designed to ensure that an adverse distribution of clearance will not prevent this happening. They should also be designed to accommodate the sharing of the load between the bearings caused by any distribution of clearance.

### A.3.6 Resistance of bearings to rolling and sliding

(1) The resistance to movement of the various types of bearings may be calculated in accordance with EN 1337.

**NOTE 1:** The calculation needs to allow for the most adverse combination of the permitted variation in material properties, environmental conditions and manufacturing and installation tolerances.

**NOTE 2:** The properties of some materials (e.g. wear or friction coefficient of PTFE or stress-strain behaviour of elastomers) are only valid for the specified temperature range and the movement speeds that normally occur in structures. They are only valid when the bearings are adequately maintained and protected from harmful substances.

**NOTE 3:** The actual resistance to movement is likely to be considerably less than the calculated maximum. Therefore, it should not be considered in the design when favourable except as given in (2) below.

(2) Where a number of bearings of equal type are arranged in such a way that the adverse forces, resulting from the resistance to movement by some bearings are partly relieved by the forces resulting from the resistance to movement by others, the respective coefficients of friction $\mu_a$ and $\mu_r$ should be calculated as follows:

$$\mu_a = 0,5\, \mu_{max}\, (1 + \alpha) \tag{A.2}$$

$$\mu_r = 0,5\, \mu_{max}\, (1 - \alpha) \tag{A.3}$$

where $\mu_a$ is the adverse coefficient of friction;

$\mu_r$ is the relieving coefficient of friction;

$\mu_{max}$ is the maximum coefficient of friction for the bearing as given in the relevant Parts of EN 1337;

$\alpha$ is a factor dependent on the type of bearing and the number of bearings which are exerting either an adverse or relieving force as appropriate.

**NOTE:** The value for $\alpha$ may be chosen in the National Annex. Recommended values are given in Table A.2.

**Table A.2: Factors $\alpha$**

| $n$ | $\alpha$ |
|---|---|
| $\leq 4$ | 1 |
| $4 < n < 10$ | $\frac{16-n}{12}$ |
| $\geq 10$ | 0,5 |

(3) Clause (2) may also be applied to elastomeric bearings which come from different manufacturers. In such a case the coefficients of friction in equation (A.2) and (A.3) may be substituted by the respective shear moduli.

## A.4 Preparation of the bearing schedule

### A.4.1 General

(1) The bearing schedule should ensure that bearings are designed and constructed in such a way that under the influence of all possible actions, unfavourable effects of the bearing on the structure are avoided.

(2) The bearing schedule should contain:

- a list of forces on the bearings from each action;
- a list of movements of the bearings from each action;
- other performance characteristics of the bearings.

**NOTE 1:** Forces and movements from the various actions during construction are to be appropriate to the construction and inspection scheme including time dependent effects.

**NOTE 2:** Forces and movements from variable actions are to be given extreme minimum and maximum values corresponding to the relevant load positions

**NOTE 3:** All forces and movements from actions other than temperature are to be given for a specified temperature $T_0$. The effects of temperature need to be determined in such a way that the effects of deviation from the specified temperature $T_0$ can be identified.

(3) For structures with elastic behaviour, all forces and movements should be based on characteristic values of actions. The relevant partial factors and combination rules should be applied at serviceability, ultimate or durability limit states.

**NOTE 1:** Guidance for a bearing schedule with characteristic values of bearing reactions and displacements is given in Table A.3. Design values representing the technical specifications for bearing are to be derived from this table.

**NOTE 2:** Normally the most adverse combination of action effects is sufficient for the design of bearings, see Table A.3. In special cases greater economy may be achieved by considering the actual coexistent values of action effects.

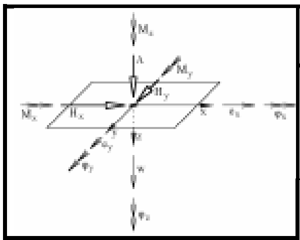
(4) For structures in which the deformations are significant for action effects second order analysis may be performed in two stages:

a) for the actions during the various construction phases up to the attainment of the final form of the structure that are required after construction for a specified temperature;

b) for all variable actions imposed on the final form of the structure.

**NOTE:** In general there is a requirement for the final geometrical form of the bridge (including its bearings) to be specified for a particular temperature after completion of construction. This is used as a reference for determining the necessary measures during construction and also for determining forces and movements from variable actions during service taking into account any uncertainties.

## Table A.3: Typical bearing schedule

|  | | | | **Bearing reactions and displacements** | | | | | | | | | **Bearing No.** | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | reaction *) | max $A$ | min $A$ | max $H_x$ | min $H_x$ | max $H_y$ | min $H_y$ | max $M_z$ | min $M_z$ | max $M_x$ | min $M_x$ | max $M_y$ | min $M_y$ |
| | | | | [kN] | [kN] | [kN] | [kN] | [kN] | [kN] | [kNm] | [kNm] | [kNm] | [kNm] | [kNm] | [kNm] |
| | | | displace-ment *) | max $w$ | min w | max $e_x$ | min $e_x$ | max $e_y$ | min $e_y$ | max $f_z$ | min $f_z$ | max $f_x$ | min $f_x$ | max $f_y$ | min $f_y$ |
| actions (characteristic values) | | | | [mm] | [mm] | [mm] | [mm] | [mm] | [mm] | [mrad] | [mrad] | [mrad] | [mrad] | [mrad] | [mrad] |
| 1.1 | perma-nent G, P | self weight | | | | | | | | | | | | | |
| 1.2 | | dead load | | | | | | | | | | | | | |
| 1.3 | | prestressing | | | | | | | | | | | | | |
| 1.4 | | creep and shrinkage | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| 2.1 | vari-able $Q$ | traffic loads | | | | | | | | | | | | | |
| 2.2 | | special vehicles | and/or 2.1 | | | | | | | | | | | | |
| 2.3 | | centrifugal force | | | | | | | | | | | | | |
| 2.4 | | braking and acceleration forces | | | | | | | | | | | | | |
| 2.5 | | nosing forces | | | | | | | | | | | | | |
| 2.6 | | footpath loading | | | | | | | | | | | | | |
| 2.7 | | wind on structure | w/o 2.1 to 2.6/or 2.8 | | | | | | | | | | | | |
| 2.8 | | wind on structure and traffic | or 2.7 | | | | | | | | | | | | |
| 2.9 | | temperature | | | | | | | | | | | | | |
| 2.10 | | vertical temperature gradient | | | | | | | | | | | | | |
| 2.11 | | horizontal temperature gradient | | | | | | | | | | | | | |
| 2.12 | | settlement substructure | | | | | | | | | | | | | |
| 2.13 | | restraint / friction force | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| 3.1 | seismic | non collapse rupture (ULS) | | | | | | | | | | | | | |
| 3.2 | | minimisation of damage (SLS) | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| 4.1 | acci-dental A | derailment | | | | | | | | | | | | | |
| 4.2 | | collision | | | | | | | | | | | | | |
| 4.3 | | rupture of overhead line | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| 5.1 | combi-nations | | | | | | | | | | | | | | |
| 5.2 | | | | | | | | | | | | | | | |
| 5.3 | | | | | | | | | | | | | | | |
| 5.4 | | | | | | | | | | | | | | | |
| 5.5 | | | | | | | | | | | | | | | |
| ... | | | | | | | | | | | | | | | |

*) delete if not applicable — light grey: given by the designer of the bridge — dark grey: given by the producer of the bearing

This list comprises all reactions and movements in the final stage. When the bearings are installed during erection, they should be readjusted after reaching the final stage and reactions and movements exceeding those of the final stage should be give separately.

## A.4.2 Determination of design values of actions on the bearings and movements of the bearings

### A.4.2.1 General

(1) In determining the actions on bearings and their movements the following reference situation should be recorded on the drawings:

a) Final geometrical form of the completed bridge for the reference temperature $T_0$;

b) The locations of the fixed bearings and the sliding bearings at the time of installation for the reference temperature $T_0$;

c) for elastomeric bearings, the position and movements of the bearings at their location should conform to the assumptions made for the reference temperature $T_0$;

d) any uncertainty of position of the bearings at the reference temperature $T_0$, that may give rise to enlarged movements or restraints to such movements, is included in the assumptions for the design values of the reference temperature $T_0$ and, consequently, for the design values of the temperature differences $\Delta T_d^*$.

(2) The uncertainty of position of the sliding bearings in relation to the position of the fixed bearings, or in case of elastomeric bearings in relation to the neutral point of movement for both permanent actions at the time of completion of the bridge, and the given reference temperature $T_0$ depends on:

a) the method of installing the bearings;

b) the mean temperature of the bridge when the bearing are installed;

c) the accuracy of measurement of the mean temperature of the bridge, see Figure A.1.

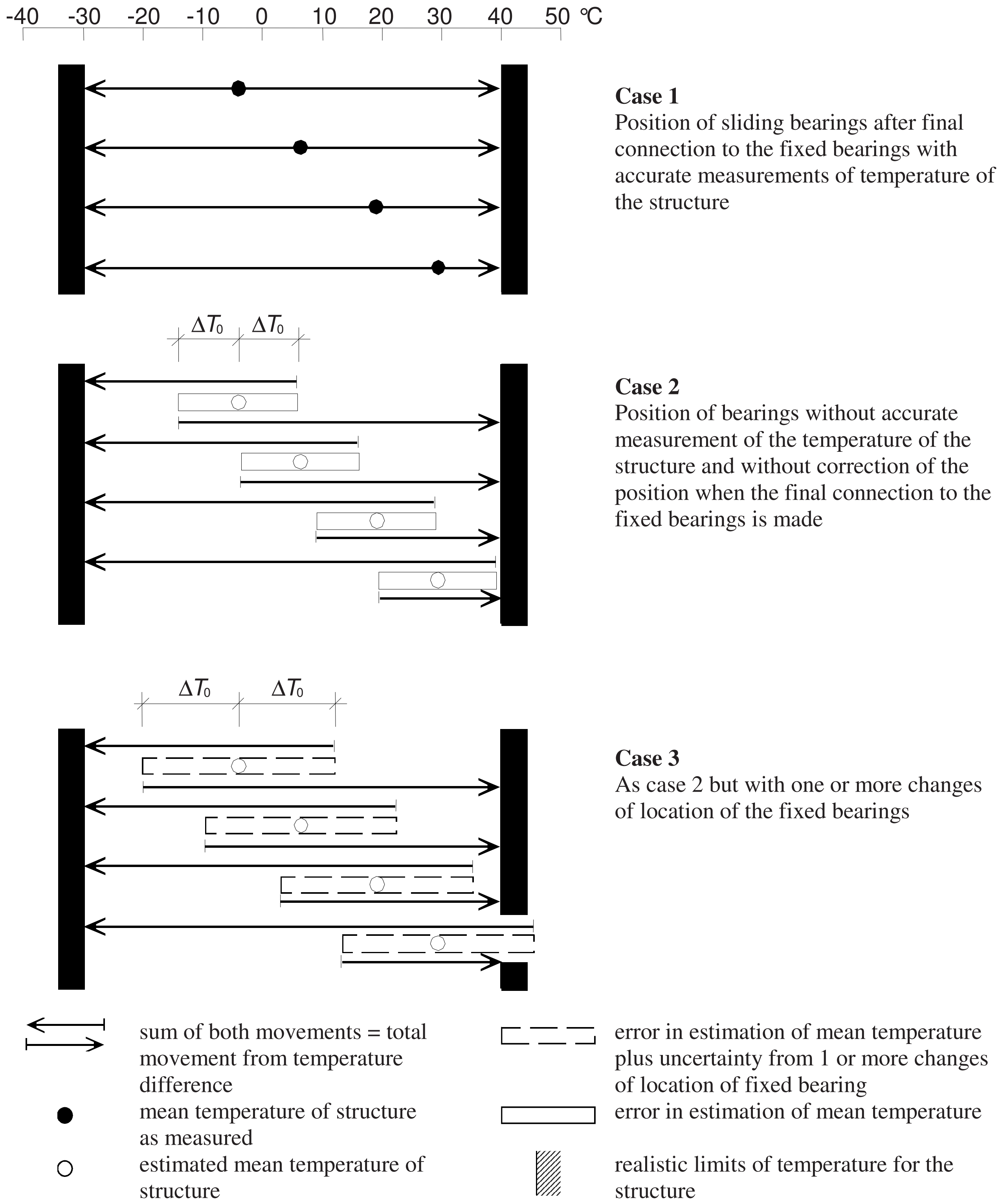



**Figure A.1: Determination of $\Delta T_0$ to take uncertainties of position of bearings into account**

**NOTE:** The National Annex may give guidance on temperature measurements.

(3) The uncertainty of the position of sliding bearings should be taken into account by taking an appropriate upper value $T_{0max}$ and a lower value $T_{0min}$ for the installation. These should be taken as:

$$T_{omax} = T_0 + \Delta T_0 \tag{A.4}$$

$$T_{omin} = T_0 - \Delta T_0 \tag{A.5}$$

**NOTE:** $\Delta T_0$ may be specified in the National Annex. Numerical values of $\Delta T_0$ for steel bridges as given in Table A.4 are recommended.

**Table A.4: Numerical values for $\Delta T_0$**

| Case | Installation of bearings | $\Delta T_0$ [°C] |
|---|---|---|
| 1 | Installation with measured temperature and with correction by resetting | 0 |
| 2 | Installation with estimated temperature and without correction by resetting with bridge set at $T_0 \pm 10$ °C | 15 |
| 3 | Installation with estimated temperature and without correction by resetting and also one or more changes in the position of the fixed bearing | 30 |

(4) The design values of the temperature difference $\Delta T_d^*$ including any uncertainty of the position of the bearings should be determined from

$$\Delta T_d^* = \Delta T_K + \Delta T_\gamma + \Delta T_0 \tag{A.6}$$

where $\Delta T_K$ is the characteristic value of the temperature difference in the bridge according to EN 1991-1-5 relative to the mid point of the temperature range;

$\Delta T_\gamma$ is the additional safety term to allow for the temperature difference in the bridge;

$\Delta T_0$ is the safety term to take into account the uncertainty of the position of the bearing at the reference temperature.

**NOTE 1:** The National Annex may specify $\Delta T_\gamma$ and $\Delta T_0$.

**NOTE 2:** A numerical example for determining $\Delta T_d^*$ for case 2 in Table A.4 is:

$T_{Kmin} = -25$°C

$T_{Kmax} = +45$°C

$\Delta T_K = \pm 35$ °C

$T_0 = +10$ °C

$\Delta T_0 = \pm 15$ °C

$\Delta T_\gamma = \pm 5$ °C

$\Delta T_d^* = 35 + 5 + 15 = \pm 55$ °C

**NOTE 3:** In using $\Delta T_d^*$ for bearings with sliding elements or rollers and for elastomeric bearings the design criteria should be appropriate to ultimate limit states and not to serviceability limit states.

(5) Where actions on bearings and their movements are obtained from a non linear global analysis of the structure (with the bearings being structural components) and incremental calculations are required, the design value of the temperature difference $\Delta T_d^*$ may be expressed in terms of:

$$\Delta T_d^* = \gamma_T \, \Delta T_K \tag{A.7}$$

where $\gamma_T$ is the partial factor for the temperature difference.

**NOTE:** In the case of the example given in NOTE 2 of A.4.2.1(4) $\gamma_T$ would take the following values:

case 1 in Table A.4 $\gamma_T = \frac{40}{35} = 1{,}15$

case 2 in Table A.4 $\gamma_T = \frac{55}{35} = 1{,}60$

case 3 in Table A.4 $\gamma_T = \frac{70}{35} = 2{,}00$

(6) For determining the design values of actions on bearings and their movements, the relevant loading combination for the persistent, transient and accidental load combinations should be taken into account.

### A.4.2.2 Actions for persistent design situations

(1) Persistent design situations should apply to the bridge after its construction with the required form under permanent actions at the reference temperature $T_0$.

**NOTE:** For construction see A.4.2.3.1

(2) Where time dependent actions have to be considered these should be applicable only after construction.

(3) The characteristic values of the actions may be taken from the Eurocodes listed in Table A.5, see also Table A.3.

**Table A.5: Characteristic values of actions**

| No. | Action | Eurocode |
|---|---|---|
| 01<br>02 | reference temperature $T_0$<br>temperature difference $\Delta T_0$ | EN 1991-1-5, Annex A |
| 1.4 | creep $\varepsilon_{K\phi_K}$ for $\phi_K = 1{,}35\ \phi_m$<br>shrinkage $\varepsilon_{SK} = 1{,}6\ \varepsilon_{sm}$ | EN 1992-1<br>EN 1992-1 |
| 2.1 | traffic loads | EN 1991-2 |
| 2.2 | special vehicles | EN 1991-2 |
| 2.3 | centrifugal forces | EN 1991-2 |
| 2.4 | brake and acceleration forces | EN 1991-2 |
| 2.5 | nosing forces | EN 1991-2 |
| 2.6 | foot path loading | EN 1991-2 |
| 2.7 | wind on structures | EN 1991-1-4 |
| 2.8 | wind on structures and traffic | EN 1991-2 |
| 2.9 | temperature | EN 1991-1-5 6.13 and 6.15 |
| 2.10 | vertical temperature gradient | EN 1991-1-5 6.14 and 6.15 |
| 2.11 | horizontal temperature gradient | EN 1991-1-5 6.14 and 6.2 |
| 2.12 | settlement of substructure | EN 1997-1 |
| 2.13 | restraint, friction forces | EN 1337 |

(4) For the combination of actions see A.4.2.7.