b) snow loads;

c) wind loads;

d) temperature loads; and

e) specific loads.

A.2.2 User loads

The loads resulting from users of playground equipment shall be based on the following load system:

a) total mass

$$G_n = n \times m + 1{,}64 \times \sigma \sqrt{n} \quad \text{(A.1)}$$

where

G_n is the total mass of n children, in kilograms;

n is the number of children on the equipment or part thereof, as given in A.3;

m is the mean mass of a child in a specified age group;

σ is the standard deviation of the age group concerned.

For open public and private playgrounds the following values can be used:

m = 53,8 kg

σ = 9,6 kg

These values are based on data for children of 14 years of age. However the calculated loads include safety factors, which ensure structures may also be used by adults.

For playgrounds with supervision open to well-defined age groups only (e.g. day-care centres), the following values can be used:

— age up to 4 years: m = 16,7 kg σ = 2,1 kg;

— age up to 8 years: m = 27,9 kg σ = 5,0 kg;

— age up to 12 years: m = 41,5 kg σ = 7,9 kg.

NOTE 1 The mass of children up to 14 years is based on the anthropometric data of age group 13,5 to 14,5 years, including 2 kg for clothing. For the other age groups, the mass includes 0,5 kg, 1 kg and 1,5 kg for clothing for 4, 8 and 12 years respectively.

b) dynamic factor

$$C_{dyn} = 1 + 1/n \quad \text{(A.2)}$$

where

C_{dyn} is a factor representing the load caused by movement (running, playing, etc.) of the users, including material behaviour under impact loading;

n is as given in a).

c) total vertical user load

$$F_{tot;v} = g \times G_n \times C_{dyn} \tag{A.3}$$

where

$F_{tot;v}$ is the total vertical user load on the equipment caused by n children, in Newtons;

g is the acceleration due to gravity (10 m/s²);

G_n is as given in a);

C_{dyn} is as given in b).

NOTE 2 Calculated examples are given in Table A.1 for information.

Table A.1 — Total vertical load for playground intended for use by children of all ages

Number of users n	Mass of n users G_n kg	Dynamic factor C_{dyn}	Total vertical user load $F_{tot;v}$ N	Vertical load per users $F_{1;v}$ N
1	69,5	2,00	1 391	1 391
2	130	1,50	1 948	974
3	189	1,33	2 516	839
5	304	1,20	3 648	730
10	588	1,10	6 468	647
15	868	1,07	9 259	617
20	1 146	1,05	12 033	602
25	1 424	1,04	14 810	592
30	1 700	1,03	17 567	586
40	2 252	1,025	23 083	577
50	2 801	1,02	28 570	571
60	3 350	1,017	34 058	568
∞		1,00		538
NOTE At infinity the vertical load per user equals the average mass.				

d) total horizontal user load

The total horizontal user load is 10 % of the total vertical user load in accordance with A.2.2 c) and acts on the same level, together with the vertical load:

$$F_{tot;h} = 0{,}1F_{tot;v} \tag{A.4}$$

NOTE 3 This load allows for movement of children playing and inaccuracies in the structure.

e) distribution of user loads

The user loads are uniformly distributed over the element considered as follows:

1) point loads

$F = F_{tot}$ in Newtons; (A.5)

F is acting on an area of 0,1 m × 0,1 m;

2) line loads:

$q = F_{tot}/L$ in Newtons per metre; (A.6)

where: L is in accordance with A.3.3;

3) area loads:

$p = F_{tot}/A$ in Newtons per metre squared; (A.7)

where: A is in accordance with A.3.4;

4) volume loads:

$q = F_{tot}/L$ in Newtons per metre (A.8)

or

$p = F_{tot}/A$ in Newtons per metre squared. (A.9)

NOTE 4 Volume loads are expressed either in line loads or area loads, depending on the type of elements that form the structure.

A.2.3 Snow loads

Snow loads shall be taken from EN 1991-1-3, allowing for a reference period of 10 years.

A.2.4 Wind loads

Wind loads shall be taken from EN 1991-1-4, allowing for a reference period of 10 years.

A.2.5 Temperature loads

Temperature loads shall be taken from EN 1991-1-2, allowing for a reference period of 10 years.

A.2.6 Specific loads

A.2.6.1 Swing seats

The number of users n on a swing seat in motion shall be calculated from the following:

a) for a traditional swing $n = 2$;

b) for a gondola, n shall be calculated as given in A.3;

c) for a single point swing $n = L/0,6$ with $n \geq 2$;

where

L is the total length of the outer edge of the swinging platform in metres.

The forces caused by motion of swings shall be considered for all the most onerous positions relevant for the element being considered.

The user loads in accordance with A.2.2 c) and d) need not be considered.

NOTE 1 In the case of swings, the mass can be considered as being uniformly distributed on the equipment between the points of support.

The maximum swing angle $\alpha_{max.}$ considered for swing seats suspended from ropes or chains is 80° from the vertical position.

NOTE 2 In Annex B the method to be used for calculating the forces resulting from the motion of a swing is included. A worked example is also given.

A.2.6.2 Carousels

The number of users on a carousel shall be the highest number calculated from:

a) number of seats, as given in A.3.3 where L_{pr} is the total length of the seats; or

b) platform dimensions, as given in A.3.4 where A_{pr} is the area of the platform.

For carousels, two load cases shall be considered for the user loads:

c) the load F_{tot} is evenly distributed over the entire carousel;

d) the load F_{tot} (1/2 L_{pr} or 1/2 A_{pr}) is evenly distributed over one half of the carousel.

NOTE Vertical and horizontal user loads act at the same time. Centrifugal forces need not be considered additionally, as they are covered by the horizontal user load.

A.2.6.3 Cableways

The maximum tension in the cable of a cableway shall be calculated for the situation where the users are swinging in a vertical direction in the middle of the cable.

The user loads as given in A.2.2 c) and d) need not be considered.

The maximum forces in the foundation of the cableway can be based on the static situation with the users in the middle of the cable.

The number of users n on a traditional cableway is $n = 2$.

NOTE In Annex B, a method that can be used for calculating the forces resulting from the motion of users suspended from a cableway is included. A worked example is also given.

A.2.6.4 Spatial networks

The number of users in a spatial network shall be calculated in accordance with A.3.5 on the basis of the volume V defined by the periphery of the spatial network.

For spatial networks two load cases shall be considered for the user loads as follows:

a) load F_{tot} (V) is equally distributed over the entire structure;

b) load F_{tot} (1/2 V) is equally distributed over one half of the structure.

A.2.6.5 Access ladders and stairs

The number of users on an access ladder or stair shall be calculated in accordance with A.3.3 on the basis of the sum of the length of all rungs or treads.

A.2.6.6 Barriers and guard rails

The horizontal load on barriers and guard rails is 750 N/m acting in a horizontal direction on the top rail.

A.2.6.7 Seats

The number of users on a seat is the highest value of the following:

a) one user, the load to be treated as a point load;

b) number specified in this standard for specific equipment; the load to be treated as a distributed load; or

c) number calculated as given in A.3.2.

A.2.6.8 Lateral protection of slides

The vertical and horizontal loads applied to the lateral protections of slides are given in A.2.2.

A.3 Number of users on the equipment

A.3.1 General

Calculate the number of users for each structural element likely to be loaded by users.

The calculated number shall be rounded up to the next whole number.

NOTE Rounding up in this context means that 3,13 becomes 4,0, for example.

A.3.2 Number of users on a point

Unless stated differently elsewhere in this part of EN 1176, the number of users, n, on a point is as follows:

$$n = 1$$

Every single point of playground equipment for standing, walking or climbing upon, or a flat surface greater than 0,1 m wide and which has less than a 30° angle from the horizontal, shall be able to carry the load caused by one user.

NOTE This also applies to rungs or steps for supporting the user's feet.

A.3.3 Number of users on line type elements

The number of users, n, on a line shall be calculated from the following:

a) line elements with an inclination up to and including 60°:

$$n = L_{pr}/0,6; \quad \text{(A.10)}$$

b) line elements with an inclination greater than 60°:

$$n = L/1,20 \quad \text{(A.11)}$$

where

L is the length of the element in metres;

L_{pr} is the length of the element projected down to a horizontal plane, in metres.

Line type elements are rungs in ladders and in climbing frames, poles and ropes.

A.3.4 Number of users on an area

The number of users, n, on a surface area shall be calculated from the following:

a) planes with inclination up to and including 60°:

$$n = A_{pr}/0{,}36; \quad (A.12)$$

b) planes with inclination greater than 60°:

$$n = A/0{,}72 \quad (A.13)$$

where

A is the area, in metres squared;

A_{pr} is the area projected down to a horizontal plane, in metres squared.

Area type elements are platforms, lattice type platforms, ramps and nets.

The width of the plane shall be greater than 0,6 m. Planes having a smaller width shall be treated as line type elements.

Where these types of element can be used from both sides, e.g. nets or grids, the number of children, n, shall be based on the area of one side only. These types of element will not be loaded as densely as platforms.

A.3.5 Number of users in a volume

The number of users, n, in a volume shall be calculated from the following:

— for volumes $V \le 4{,}3\text{m}^3 : n = V/0{,}43$; (A.14)

— for volumes $4{,}3\text{m}^3 < V \le 12{,}8\text{m}^3 : n = (V - 4{,}3)/0{,}85$; (A.15)

— for volumes $V > 12{,}8\text{m}^3 : n = 20 + (V - 12{,}8)/1{,}46$. (A.16)

where

V is the volume defined by the periphery of the playground equipment in cubic metres.

The volume is used to determine the maximum number of users on playground equipment, e.g. climbing frames, spatial networks.

NOTE The volumes mentioned are based on the following dimensions:

a) 0,60 m × 0,60 m × 1,20 m = 0,43 m^3;

b) 0,75 m × 0,75 m × 1,50 m = 0,85 m^3;

c) 0,90 m × 0,90 m × 1,80 m = 1,46 m^3.

Annex B
(normative)

Method of calculation of structural integrity

B.1 General principles: Limit state

B.1.1 Limit state

Each structure and structural element, e.g. connections, foundations, supports, shall be calculated taking into account the load combinations of B.2.

The preferred method of calculation shall be based on the general principles and definitions for limit states as specified in the appropriate structural Eurocodes.

Well-established technical rules and methods of construction practice, other than this method, may be used provided that the level of safety is at least the same.

NOTE Limit states are states beyond which the structure no longer conforms to this part of EN 1176.

In symbolic form, a limit state can be written as:

$$\gamma_F \times S \leq R/\gamma_M \tag{B.1}$$

where

γ_F is a partial safety factor for loads;

γ_M is a partial safety factor for materials;

S is load effect;

R is the resistance of the structure.

To allow for uncertainties in the actual loads and in the model used for determining loads, loads are multiplied by a partial safety factor for loads (γ_F).

To allow for uncertainties in the actual material properties and in the models used for determining forces in the structure, the strength of the structure is divided by a partial safety factor for materials (γ_M).

In most cases, the symbolic representation given here cannot be used to represent the limit state because the actual formulation is often nonlinear, e.g. in cases where loads have to be combined.

B.1.2 Ultimate limit state

Ultimate limit states requiring consideration include:

a) loss of equilibrium of the structure or any part of it, considered as a rigid body;

b) failure by excessive deformation, rupture, or loss of stability of the structure or any part of it.

NOTE Ultimate limit states are those associated with collapse, or with other forms of structural failure, which can endanger the safety of people.

B.1.3 Serviceability limit state

Where serviceability requirements are made, the preferred method of calculation shall be based on the principles for serviceability limit state as specified in the appropriate structural Eurocodes.

The deflection criteria for serviceability limit states mentioned in the appropriate Eurocodes do not apply to playground equipment.

NOTE Serviceability limit states correspond to states which do not conform to specified service criteria.

B.2 Load combinations for static analysis

The following load combinations shall be used for verification:

$$\gamma_{G;c} \times Q_p + \gamma_{Q;c} \times Q_i \tag{B.2}$$

where

Q_p is the permanent load as given in A.1;

Q_i is one of the variable loads as given in A.2.2 to A.2.6;

$\gamma_{G;c}$ is a partial safety factor for permanent loads to be used in calculations;

$\gamma_{Q;c}$ is a partial safety factor for variable loads to be used in calculations.

The following partial safety factors for loads shall be used:

$\gamma_{G;c}$ = 1,0 for favourable effects;

$\gamma_{G;c}$ = 1,35 for unfavourable effects;

$\gamma_{Q;c}$ = 0 for favourable effects;

$\gamma_{Q;c}$ = 1,35 for unfavourable effects.

NOTE 1 It is not necessary to combine independent variable loads such as wind and user loads. Related loads acting in different directions, such as vertical and horizontal user loads, are combined.

NOTE 2 In the following examples only the forces (F or T) created by the loads Q are calculated. For static analysis in elements of equipment, the safety factors given above need to be included.

B.3 Worked example of the calculation of user loads (without safety factors)

B.3.1 General

The application of the load system based on the number of users is demonstrated for a platform with ladder access, see Figure B.1.

Data:

Platform:

dimensions: 1 000 mm × 1 000 mm

Ladder:

length:	1 770 mm
number of rungs:	6
external width:	388 mm
internal width:	350 mm
angle:	76°

Barrier:

length:	4 × 1 000 mm

Dimensions in millimetres

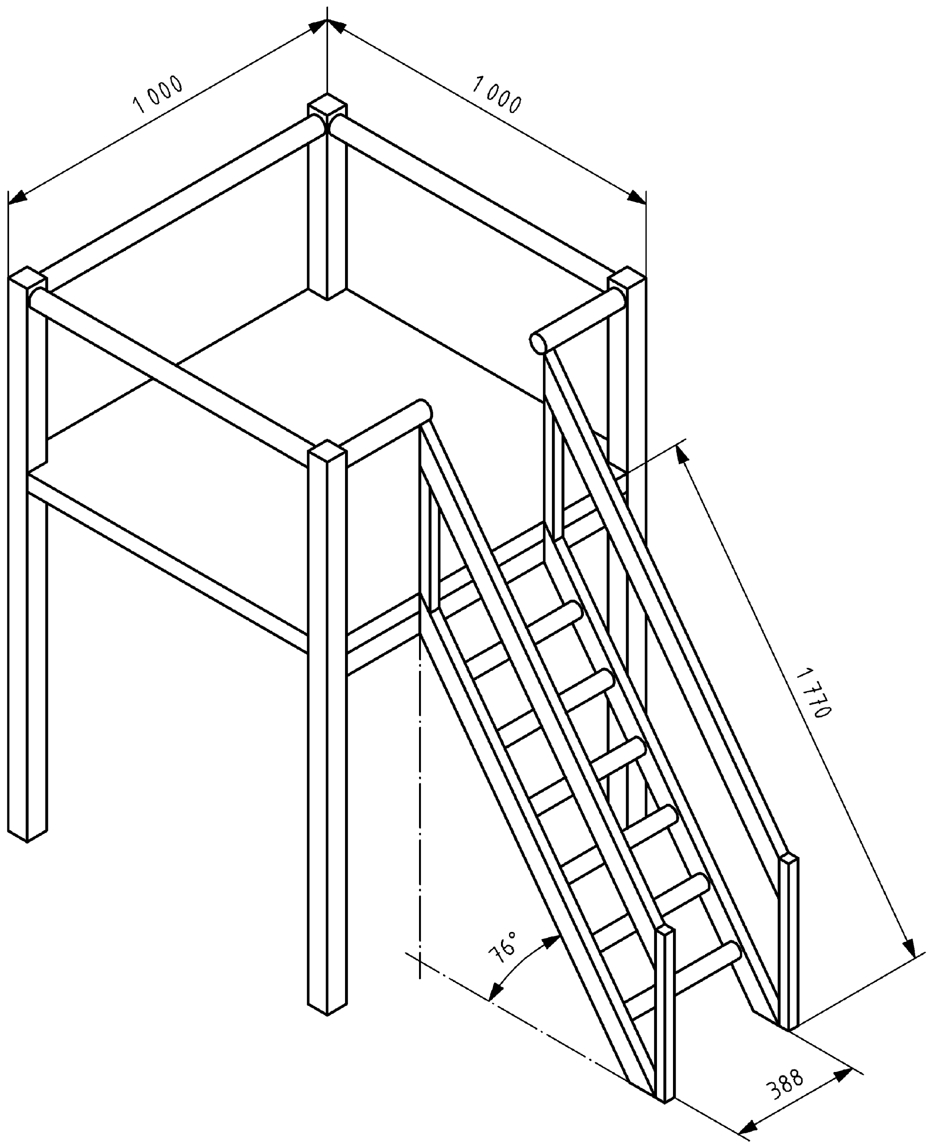

Figure B.1 — Platform with ladder

B.3.2 Platform

The number of users on the platform is calculated from A.3.4 (Formula A.12):

$n = A_{pr}/0{,}36 = 1{,}0/0{,}36 = 2{,}77$ rounded off upwards to $n = 3$

The total vertical load on the platform follows from Table A.1:

$F_{tot;v} = 2\ 516\ N$

The horizontal user load on the platform (calculated from Formula A.4) is:

$F_{tot;h} = 0{,}1\ F_{tot;v} = 252\ N$

B.3.3 Barrier

For the barrier, a line type element, two load cases are considered: the user load and the barrier load. The number of users on one barrier (calculated from Formula A.10) is:

$n = L_{pr}/0{,}6 = 1{,}0/0{,}6 = 1{,}67$ rounded off upwards to $n = 2$

The total vertical load (taken from Table A.1) is $F_{tot;v} = 1\ 948$ N.

The line load on the barrier is:

$q_v = F_{tot;v}/L_{pr} = 1\ 948$ N/m

The horizontal load on the barrier is:

$q_h = 0{,}1 q_v = 195$ N/m

NOTE This load is overruled by the barrier load and need not be considered further.

In accordance with A.2.6.6, the horizontal barrier load is 750 N/m.

B.3.4 Ladder

In accordance with A.3.2, each rung shall be able to carry one user:

$F_{tot;v} = 1\ 391$ N

The ladder in this example is an access ladder. In accordance with A.2.6.5, the number of users shall be calculated on the basis of the sum of the length of all rungs.

The total length of all rungs is: 6 × 0,35 m = 2,1 m.

The number of users is calculated in accordance with A.3.3 (Formula A.10):

$n = L_{pr}/0{,}6 = 2,\ 1/0{,}6 = 3{,}5$ rounded off upwards to $n = 4$

The ladder shall be able to carry a load of four users (see A.2.2 c)):

$F_{tot;v} = 10 \times (4 \times 53{,}8 + 1{,}64 \times 9{,}6\ \sqrt{4}) \times (1 + 1/4) = 3\ 084$ N

For convenience, Table A.1 may also be used:

$F_{tot;v} = 4 \times 839 = 3\ 356$ N

B.3.5 Complete structure

The load on the complete structure may be taken as the sum of the individual elements. However, it is permissible to take into account the reducing effect on the load of the increased number of users.

Platform:	$n = 2{,}77$
Barriers (4):	$n = 4 \times 1{,}67 = 6{,}68$
Ladder:	$n = 3{,}5$