NEDCON

EN 15512:2020

Modifications to 2009 version

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0 | INTRODUCTION

During the revision of the 2009 version of the EN 15512 several technical items are modified to comply to the target reliability as defined in EN 1990.

1 | MODIFICATIONS

1.1 | 6.3.3.6 EFFECTS OF RACK-GUIDED EQUIPMENT

EN 15512:2009

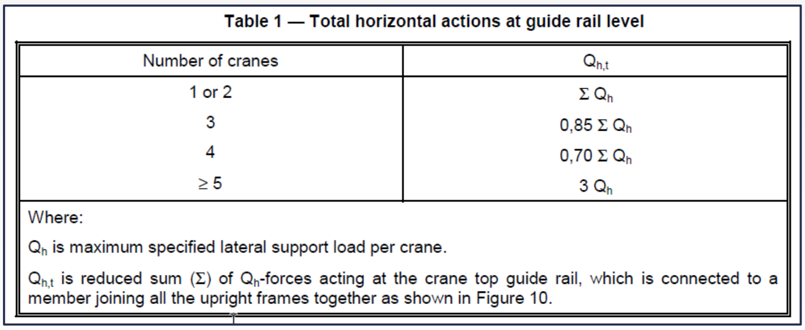


Table 1 — Total horizontal actions at guide rail level

Number of cranes	$Q_{h,t}$
1 or 2	ΣQ_h
3	$0{,}85\ \Sigma Q_h$
4	$0{,}70\ \Sigma Q_h$
≥ 5	$3\ Q_h$

Where:

Q_h is maximum specified lateral support load per crane.

$Q_{h,t}$ is reduced sum (Σ) of Q_h-forces acting at the crane top guide rail, which is connected to a member joining all the upright frames together as shown in Figure 10.

Table 1 – Horizontal crane load – EN 15512:2009

EN 15512:2020

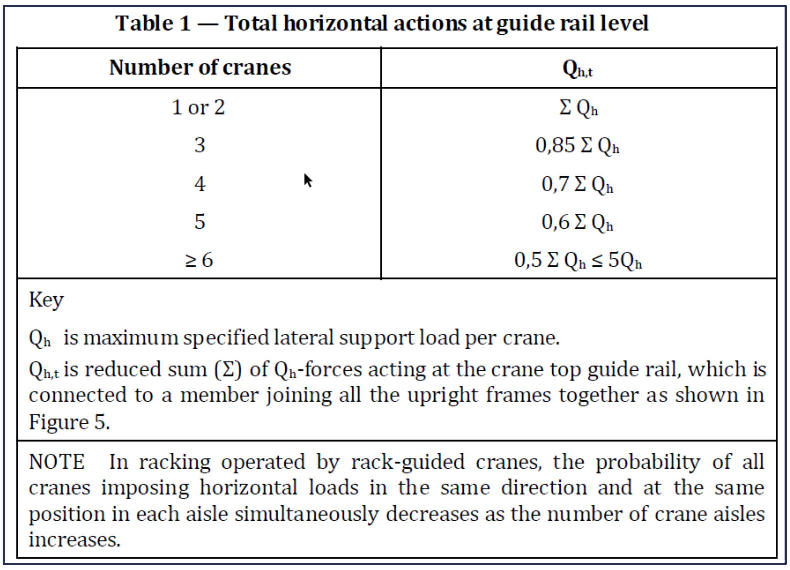


Table 1 — Total horizontal actions at guide rail level

Number of cranes	$Q_{h,t}$
1 or 2	ΣQ_h
3	$0{,}85\ \Sigma Q_h$
4	$0{,}7\ \Sigma Q_h$
5	$0{,}6\ \Sigma Q_h$
≥ 6	$0{,}5\ \Sigma Q_h \leq 5Q_h$

Key

Q_h is maximum specified lateral support load per crane.

$Q_{h,t}$ is reduced sum (Σ) of Q_h-forces acting at the crane top guide rail, which is connected to a member joining all the upright frames together as shown in Figure 5.

NOTE In racking operated by rack-guided cranes, the probability of all cranes imposing horizontal loads in the same direction and at the same position in each aisle simultaneously decreases as the number of crane aisles increases.

Table 2 – Horizontal crane load – EN 15512:2020

1.2 | 6.5.2 MATERIAL FACTORS

EN 15512:2009

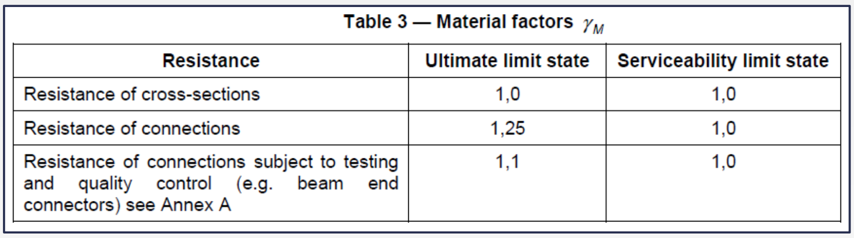


Table 3 — Material factors γ_M

Resistance	Ultimate limit state	Serviceability limit state
Resistance of cross-sections	1,0	1,0
Resistance of connections	1,25	1,0
Resistance of connections subject to testing and quality control (e.g. beam end connectors) see Annex A	1,1	1,0

Table 3 – Material factors EN 15512:2009

EN 15512:2020

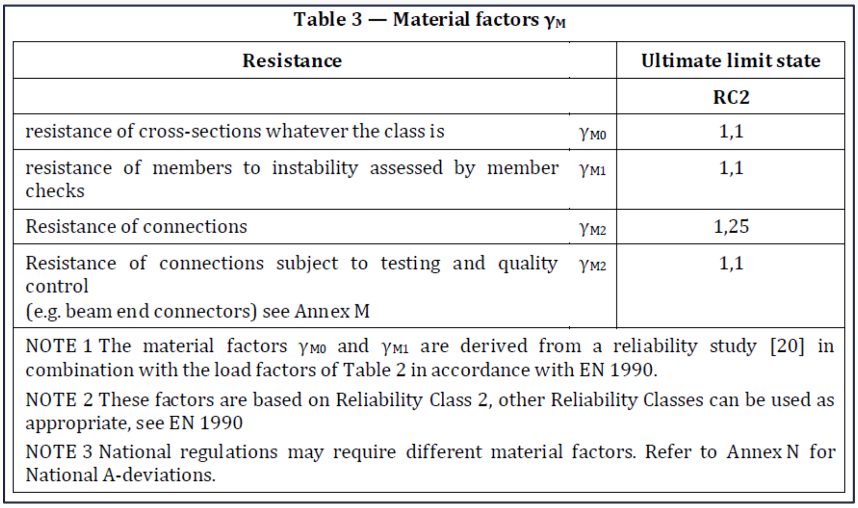


Table 3 — Material factors γ_M

Resistance		Ultimate limit state
		RC2
resistance of cross-sections whatever the class is	γ_{M0}	1,1
resistance of members to instability assessed by member checks	γ_{M1}	1,1
Resistance of connections	γ_{M2}	1,25
Resistance of connections subject to testing and quality control (e.g. beam end connectors) see Annex M	γ_{M2}	1,1

NOTE 1 The material factors γ_{M0} and γ_{M1} are derived from a reliability study [20] in combination with the load factors of Table 2 in accordance with EN 1990.

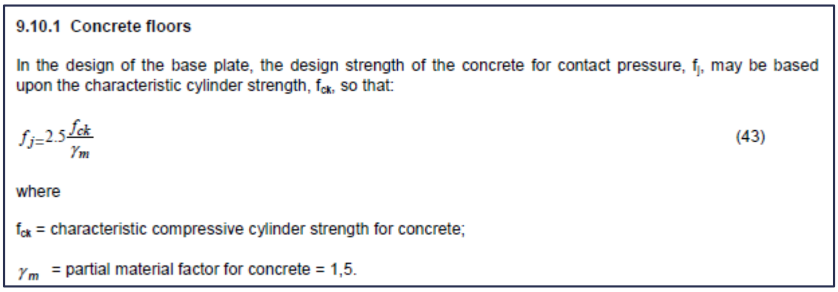
NOTE 2 These factors are based on Reliability Class 2, other Reliability Classes can be used as appropriate, see EN 1990

NOTE 3 National regulations may require different material factors. Refer to Annex N for National A-deviations.

Table 4 – Material factors EN 15512:2020

1.3 | 7.2.1 CONCRETE FLOORS

EN 15512:2009



9.10.1 Concrete floors

In the design of the base plate, the design strength of the concrete for contact pressure, f_j, may be based upon the characteristic cylinder strength, f_{ck}, so that:

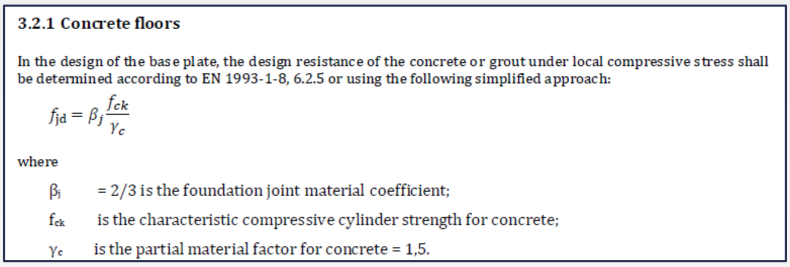
$$f_j = 2.5 \frac{f_{ck}}{\gamma_m} \quad (43)$$

where

f_{ck} = characteristic compressive cylinder strength for concrete;

γ_m = partial material factor for concrete = 1,5.

EN 15512:2020



3.2.1 Concrete floors

In the design of the base plate, the design resistance of the concrete or grout under local compressive stress shall be determined according to EN 1993-1-8, 6.2.5 or using the following simplified approach:

$$f_{jd} = \beta_j \frac{f_{ck}}{\gamma_c}$$

where

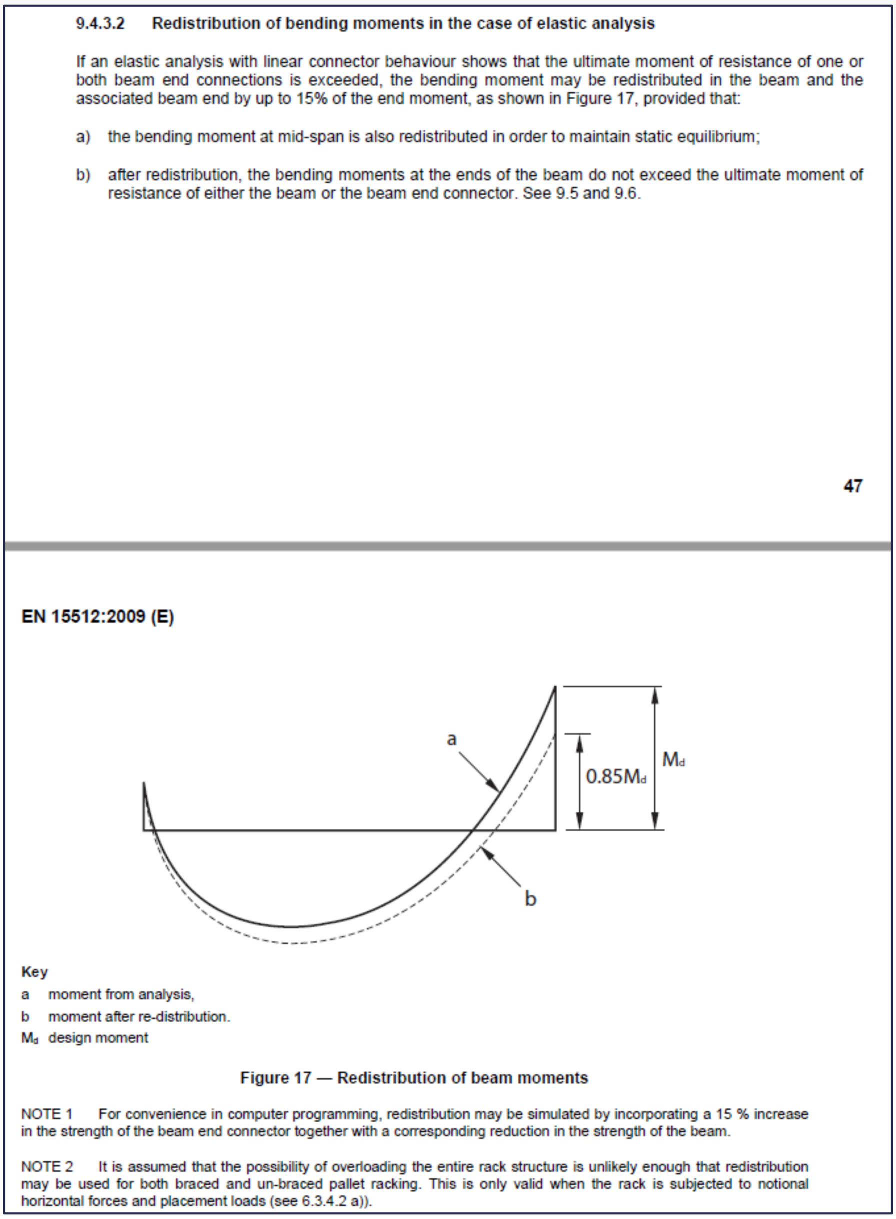
β_j = 2/3 is the foundation joint material coefficient;

f_{ck} is the characteristic compressive cylinder strength for concrete;

γ_c is the partial material factor for concrete = 1,5.

1.4 | 9.1.2 JOINT MODELLING

EN 15512:2009



9.4.3.2 Redistribution of bending moments in the case of elastic analysis

If an elastic analysis with linear connector behaviour shows that the ultimate moment of resistance of one or both beam end connections is exceeded, the bending moment may be redistributed in the beam and the associated beam end by up to 15% of the end moment, as shown in Figure 17, provided that:

a) the bending moment at mid-span is also redistributed in order to maintain static equilibrium;

b) after redistribution, the bending moments at the ends of the beam do not exceed the ultimate moment of resistance of either the beam or the beam end connector. See 9.5 and 9.6.

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EN 15512:2009 (E)

Key

a moment from analysis,

b moment after re-distribution.

M_d design moment

Figure 17 — Redistribution of beam moments

NOTE 1 For convenience in computer programming, redistribution may be simulated by incorporating a 15 % increase in the strength of the beam end connector together with a corresponding reduction in the strength of the beam.

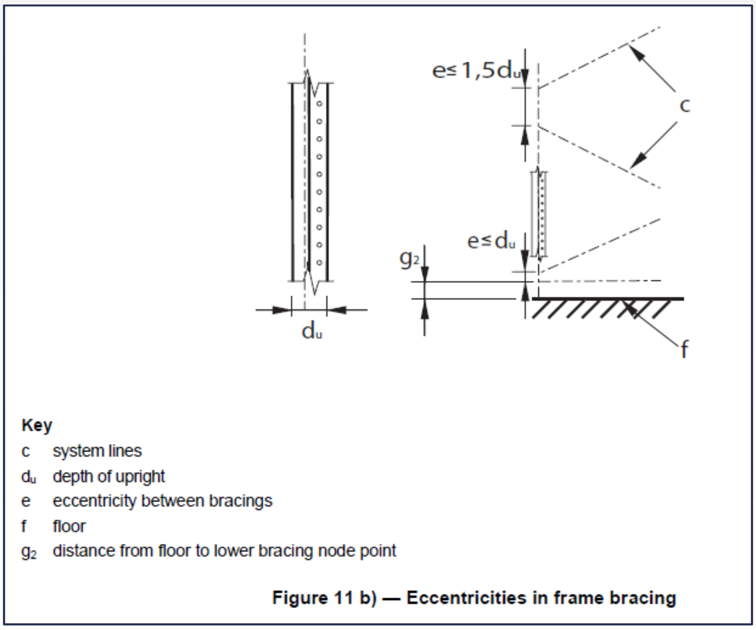
NOTE 2 It is assumed that the possibility of overloading the entire rack structure is unlikely enough that redistribution may be used for both braced and un-braced pallet racking. This is only valid when the rack is subjected to notional horizontal forces and placement loads (see 6.3.4.2 a)).

EN 15512:2020

The redistribution option is removed.

1.5 | 9.1.2.4 BRACING ECCENTRICITIES

EN 15512:2009



Key

c system lines

d_u depth of upright

e eccentricity between bracings

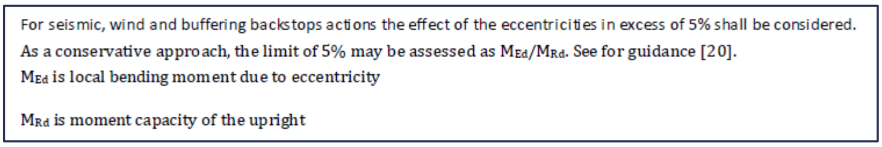
f floor

g_2 distance from floor to lower bracing node point

Figure 11 b) — Eccentricities in frame bracing

When $e \leq 1.5\ d_u$ and $g_2 \leq 1.5\ d_u$, the joint may be modelled without eccentricities

EN 15512:2020



For seismic, wind and buffering backstops actions the effect of the eccentricities in excess of 5% shall be considered. As a conservative approach, the limit of 5% may be assessed as M_{Ed}/M_{Rd}. See for guidance [20].

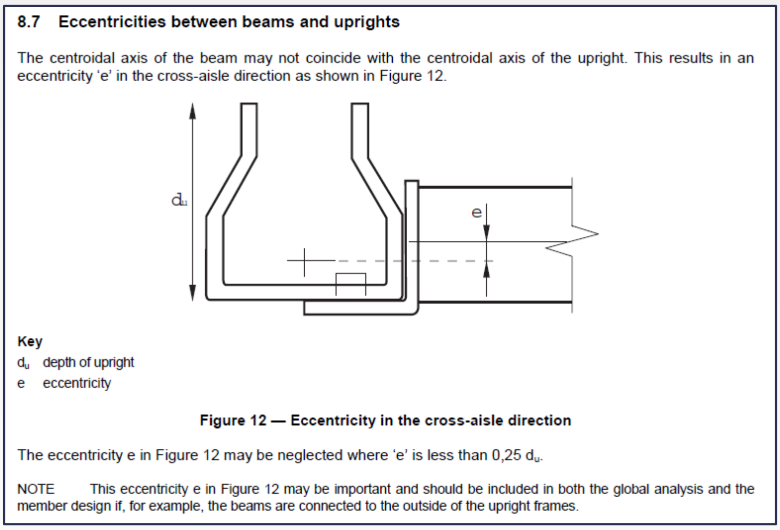
M_{Ed} is local bending moment due to eccentricity

M_{Rd} is moment capacity of the upright

A limitation for the stress effect of 5% is added.

1.6 | BEAM TO UPRIGHT ECCENTRICITIES

EN 15512:2009



8.7 Eccentricities between beams and uprights

The centroidal axis of the beam may not coincide with the centroidal axis of the upright. This results in an eccentricity 'e' in the cross-aisle direction as shown in Figure 12.

Key

d_u depth of upright

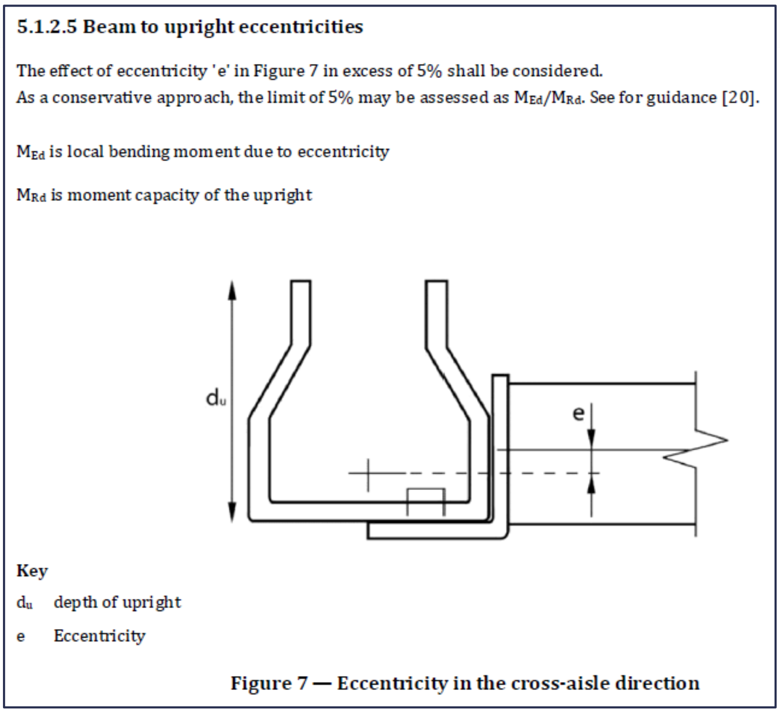
e eccentricity

Figure 12 — Eccentricity in the cross-aisle direction

The eccentricity e in Figure 12 may be neglected where 'e' is less than 0,25 d_u.

NOTE This eccentricity e in Figure 12 may be important and should be included in both the global analysis and the member design if, for example, the beams are connected to the outside of the upright frames.

EN 15512:2020



5.1.2.5 Beam to upright eccentricities

The effect of eccentricity 'e' in Figure 7 in excess of 5% shall be considered.
As a conservative approach, the limit of 5% may be assessed as M_{Ed}/M_{Rd}. See for guidance [20].

M_{Ed} is local bending moment due to eccentricity

M_{Rd} is moment capacity of the upright

Key

d_u depth of upright

e Eccentricity

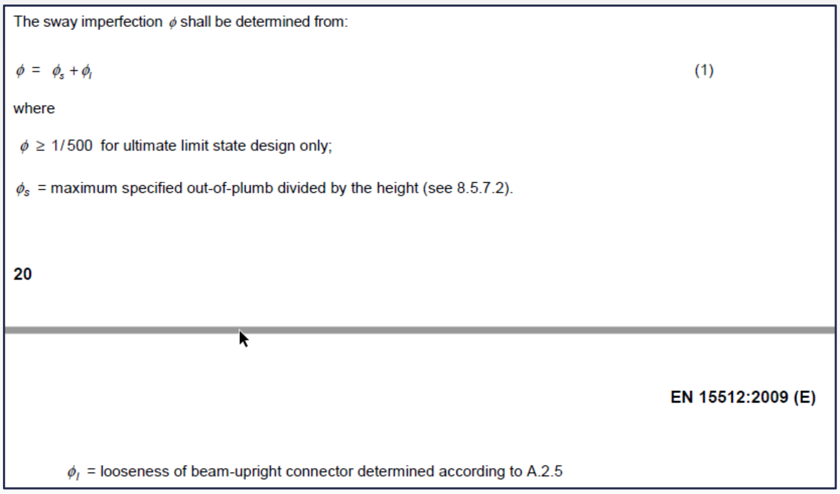
Figure 7 — Eccentricity in the cross-aisle direction

A limitation for the stress effect of 5% is added

1.7 | 9.3 IMPERFECTIONS

EN 15512:2009

Sway frame



The sway imperfection ϕ shall be determined from:

$$\phi = \phi_s + \phi_l \qquad (1)$$

where

$\phi \geq 1/500$ for ultimate limit state design only;

ϕ_s = maximum specified out-of-plumb divided by the height (see 8.5.7.2).

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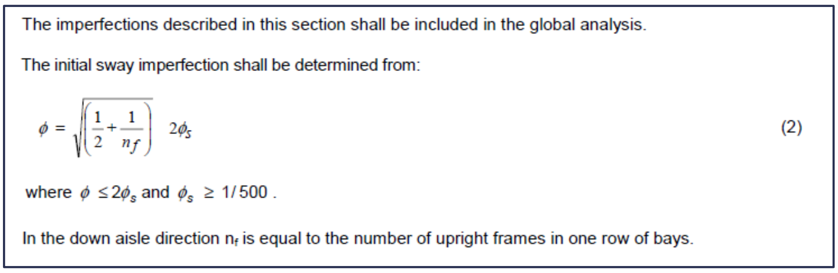
EN 15512:2009 (E)

ϕ_l = looseness of beam-upright connector determined according to A.2.5

Braced frame



The imperfections described in this section shall be included in the global analysis.

The initial sway imperfection shall be determined from:

$$\phi = \sqrt{\left(\frac{1}{2}+\frac{1}{n_f}\right)}\ 2\phi_s \qquad (2)$$

where $\phi \leq 2\phi_s$ and $\phi_s \geq 1/500$.

In the down aisle direction n_f is equal to the number of upright frames in one row of bays.

EN 15512:2020

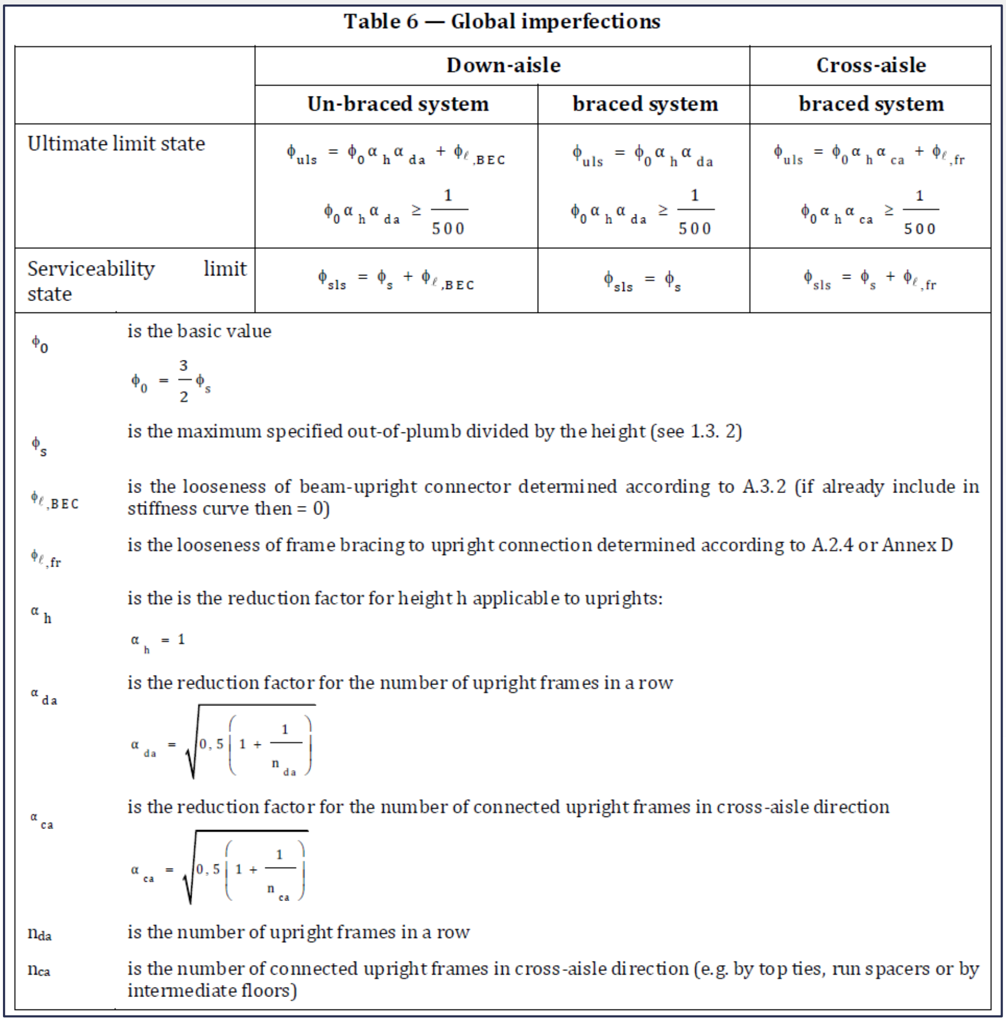


Table 6 — Global imperfections

	Down-aisle		Cross-aisle
	Un-braced system	**braced system**	**braced system**
Ultimate limit state	$\phi_{uls} = \phi_0 \alpha_h \alpha_{da} + \phi_{\ell,BEC}$ $\phi_0 \alpha_h \alpha_{da} \geq \frac{1}{500}$	$\phi_{uls} = \phi_0 \alpha_h \alpha_{da}$ $\phi_0 \alpha_h \alpha_{da} \geq \frac{1}{500}$	$\phi_{uls} = \phi_0 \alpha_h \alpha_{ca} + \phi_{\ell,fr}$ $\phi_0 \alpha_h \alpha_{ca} \geq \frac{1}{500}$
Serviceability limit state	$\phi_{sls} = \phi_s + \phi_{\ell,BEC}$	$\phi_{sls} = \phi_s$	$\phi_{sls} = \phi_s + \phi_{\ell,fr}$

ϕ_0	is the basic value $\phi_0 = \frac{3}{2}\phi_s$
ϕ_s	is the maximum specified out-of-plumb divided by the height (see 1.3. 2)
$\phi_{\ell,BEC}$	is the looseness of beam-upright connector determined according to A.3.2 (if already include in stiffness curve then = 0)
$\phi_{\ell,fr}$	is the looseness of frame bracing to upright connection determined according to A.2.4 or Annex D
α_h	is the is the reduction factor for height h applicable to uprights: $\alpha_h = 1$
α_{da}	is the reduction factor for the number of upright frames in a row $\alpha_{da} = \sqrt{0,5\left(1 + \frac{1}{n_{da}}\right)}$
α_{ca}	is the reduction factor for the number of connected upright frames in cross-aisle direction $\alpha_{ca} = \sqrt{0,5\left(1 + \frac{1}{n_{ca}}\right)}$
n_{da}	is the number of upright frames in a row
n_{ca}	is the number of connected upright frames in cross-aisle direction (e.g. by top ties, run spacers or by intermediate floors)

1.8 | 10.1.2.2 STIFFNESS

EN 15512:2009

Gross section properties are properties of the gross section without any reduction for perforations or local buckling. Gross section properties are generally used in global calculations for internal forces and deflections.

EN 15512:2020

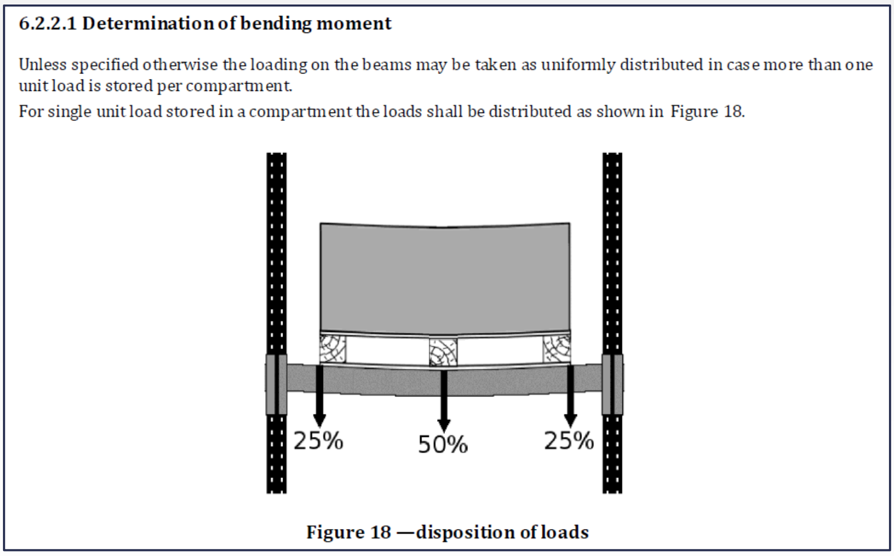
Equivalent section properties shall be used for global analysis.

1.9 | 10.2.2.1 DETERMINATION OF BENDING MOMENT

EN 15512:2009

It is usual to consider the loading on the beams to be uniformly distributed unless specified otherwise.

EN 15512:2020



6.2.2.1 Determination of bending moment

Unless specified otherwise the loading on the beams may be taken as uniformly distributed in case more than one unit load is stored per compartment.

For single unit load stored in a compartment the loads shall be distributed as shown in Figure 18.

Figure 18 —disposition of loads

1.10 | 10.3.4 TORSIONAL BUCKLING LENGTH

EN 15512:2009

No method specified to consider different system lengths for flexural and torsional buckling in relation to the calculation of the critical load for torsional flexural buckling.

EN 15512:2020

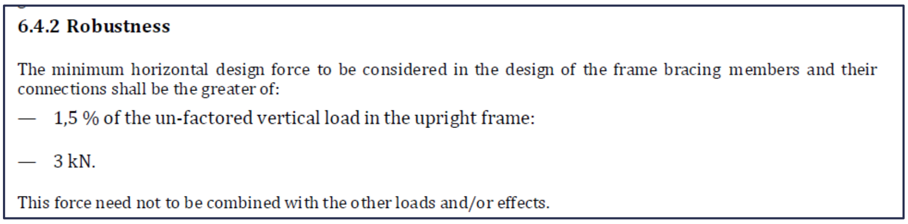
Method of NEN 5056:2011 included

1.11 |10.4.2 ROBUSTNESS (OF FRAME BRACING)

EN 15512:2009

No requirement.

EN 15512:2020



6.4.2 Robustness

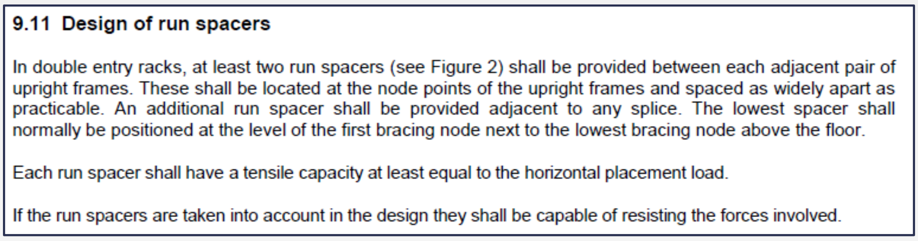
The minimum horizontal design force to be considered in the design of the frame bracing members and their connections shall be the greater of:

- 1,5 % of the un-factored vertical load in the upright frame:
- 3 kN.

This force need not to be combined with the other loads and/or effects.

1.12 | 10.5 DESIGN OF RUN SPACES

EN 15512:2009



9.11 Design of run spacers

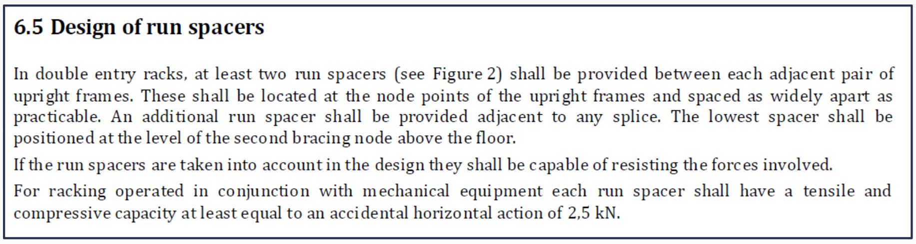
In double entry racks, at least two run spacers (see Figure 2) shall be provided between each adjacent pair of upright frames. These shall be located at the node points of the upright frames and spaced as widely apart as practicable. An additional run spacer shall be provided adjacent to any splice. The lowest spacer shall normally be positioned at the level of the first bracing node next to the lowest bracing node above the floor.

Each run spacer shall have a tensile capacity at least equal to the horizontal placement load.

If the run spacers are taken into account in the design they shall be capable of resisting the forces involved.

The design load is connected to the horizontal placement load. The minimum horizontal placement load is 250 N.

EN 15512:2020



6.5 Design of run spacers

In double entry racks, at least two run spacers (see Figure 2) shall be provided between each adjacent pair of upright frames. These shall be located at the node points of the upright frames and spaced as widely apart as practicable. An additional run spacer shall be provided adjacent to any splice. The lowest spacer shall be positioned at the level of the second bracing node above the floor.

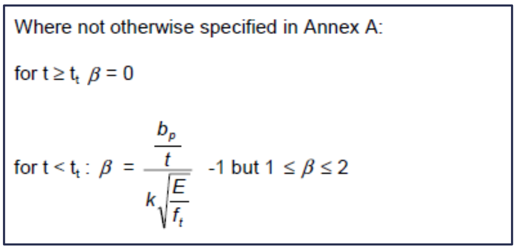
If the run spacers are taken into account in the design they shall be capable of resisting the forces involved.

For racking operated in conjunction with mechanical equipment each run spacer shall have a tensile and compressive capacity at least equal to an accidental horizontal action of 2,5 kN.

Capacity at least 2.5 kN

1.13 | 13.3.2.2 CORRECTION FACTOR C

EN 15512:2009

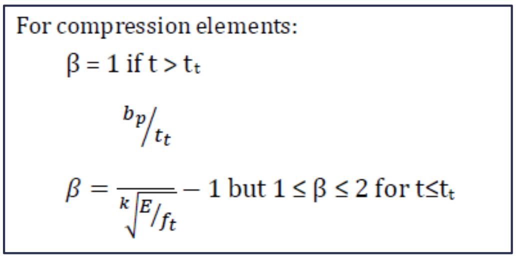


Where not otherwise specified in Annex A:

for $t \ge t_t$ $\beta = 0$

for $t < t_t$: $\beta = \dfrac{\dfrac{b_p}{t}}{k\sqrt{\dfrac{E}{f_t}}}$ -1 but $1 \le \beta \le 2$

EN 15512: 2020



For compression elements:

$\beta = 1$ if $t > t_t$

$$\beta = \frac{b_p/t_t}{k\sqrt{E/f_t}} - 1 \text{ but } 1 \le \beta \le 2 \text{ for } t \le t_t$$

1.14 | A3.1 BENDING TESTS ON BEAM END CONNECTORS

EN 15512:2009

Yield strength deviations (actual compared to nominal) smaller than 15% may be ignored

EN 15512:2020

Yield strength deviations (actual compared to nominal) shall be corrected.

If it can be done,
consider it done