

# Package ‘civilR’

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**Description** Civil Engineering R package

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all_member_sizes	<i>Extract a vector of all member sizes</i>
------------------	---

---

## Description

Extract a vector of all member sizes for specified steel grade (S355/S275) and member type (UC/UB)

## Usage

```
all_member_sizes(steel_grade, member_type, list_reference_tables)
```

## Arguments

steel_grade	steel_grade [ $N/mm^2$ ], categorical: 'S355' or 'S275'
member_type	member_type, categorical: 'UC' or 'UB'
list_reference_tables	List of reference tables

## Value

Vector of all member sizes [ height (mm) x width (mm) x mass (kg/m) ]

---

axial\_compression\_force

*Calculate the axial compression force*


---

### Description

Compute Axial Compression Force,  $N_{ed}$  [kN], for member without including Temperature effect. Used as trial for the top level strut where temperature changes could not be neglected. As well can be used to calculate final  $N_{ed}$  for struts from low levels of excavation, where temperature effect could be neglected.

### Usage

```
axial_compression_force(isTopLevel = T, DL = 1, LL = 1, L = 12.5,
    P = 247, theta = 90, spacing = 6, Lcry = 12.7, Lcrz = 1,
    steel_grade = "S355", member_type = "UB", alpha_T = 1.2e-05,
    delta_T = 10, k_T = 0.8, E = 210, IL = 50, gamma = 1.35,
    list_reference_tables)
```

### Arguments

isTopLevel	Is member located at top level? [boolean]
DL	Dead load / self-weight of member [kN/m]
LL	Live load / imposed load [kN/m]
L	Total length of member [m]
P	Axial compression force of member per meter [kN/m]
theta	Angle to wall [deg]
spacing	spacing [m]
Lcry	critical length major axis [m]
Lcrz	critical length minor axis [m]
steel_grade	steel_grade [N/mm <sup>2</sup> ], categorical: 'S355' or 'S275'
member_type	member_type, categorical: 'UC' or 'UB'
alpha_T	Thermal coef. of expansion [degC]
delta_T	Change in temperature from the Installation temperature [degC]
k_T	Coefficient Of Temperature Effect [dimensionless]
E	Young's Modulus of Elasticity [GPa]
IL	Accidental Impact Load [kN/m]
gamma	Partial factor for action [dimensionless], as per EN 1990:2002 standard
list_reference_tables	List of reference tables

### Details

First of all function check which combination govern in ULS (Ultimate Limit State) without including Temperature load, TL [kN]. Then include TL calculations for Load Combinations applying partial factors based on the Table A1.2(B), EN1990-2002, p53 Compare maximum from ULS and ALS to define which mistake could govern.

**Value**

$N_{ed}$  Axial compression force [ $kN$ ],  $TL$  Temperature Load [ $kN$ ]

---

axial\_compression\_force\_given\_member

*Calculate the axial compression force for a given member size*

---

**Description**

Compute Axial Compression Force,  $N_{ed}$  [ $kN$ ], for member without including Temperature effect. Used as trial for the top level strut where temperature changes could not be neglected. As well can be used to calculate final  $N_{ed}$  for struts from low levels of excavation, where temperature effect could be neglected.

**Usage**

```
axial_compression_force_given_member(isTopLevel = T, Ned_no_TL = 6987,
    member_size, alpha_T = 1.2e-05, delta_T = 10, k_T = 0.8, E = 210,
    list_reference_tables)
```

**Arguments**

isTopLevel	Is member located at top level? [boolean]
alpha_T	Thermal coef. of expansion [ $degC$ ]
delta_T	Change in temperature from the Installation temperature [ $degC$ ]
k_T	Coefficient Of Temperature Effect [dimensionless]
E	Young's Modulus of Elasticity [ $GPa$ ]
list_reference_tables	List of reference tables

**Details**

First of all function check which combination govern in ULS (Ultimate Limit State) without including Temperature load,  $TL$  [ $kN$ ]. Then include  $TL$  calculations for Load Combinations applying partial factors based on the Table A1.2(B), EN1990-2002, p53 Compare maximum from ULS and ALS to define which mistake could govern.

**Value**

$N_{ed}$  Axial compression force [ $kN$ ],  $TL$  Temperature Load [ $kN$ ]

---

calculated_NEd	<i>Generate calculated NEd</i>
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---

**Description**

Generate calculated  $N_{Ed}$ ,  $N_{Edc}$  [ $kN$ ].

**Usage**

calculated\_NEd(N\_b\_Rd, Ieff, MEd, h0, A)

**Arguments**

N_b_Rd	Overall buckling resistance of the struts about the axis [ $kN$ ]
Ieff	Effective second moment of area [ $mm^4$ ]
MEd	Second order moment [ $kN.m$ ]
h0	Distance between centroids of chords [ $m$ ]
A	Cross-section area of strut [ $cm^2$ ]

**Value**

$N_{Edc}$  Calculated  $N_{Ed}$  [ $kN$ ]

---

check_all_member_sizes	<i>Generate a table with all member sizes and apply all checks on each of them</i>
------------------------	--

---

**Description**

Generate a table with all member sizes and apply all checks on each of them

**Usage**

```
check_all_member_sizes(steel_grade = "S355", member_type = "UB",
  k = 0.8, L = 12.5, E = 210, h0 = 1000, Lch = 1000, Ad = 1140,
  n = 2, isTopLevel = T, alpha_T = 1.2e-05, delta_T = 10,
  k_T = 0.8, Ned_no_TL = 6987,
  file_name = "tables/input/all_member_sizes_checked.xlsx",
  export_xlsx = T)
```

**Arguments**

steel_grade	steel_grade [ $N/mm^2$ ], categorical: 'S355' or 'S275'
member_type	member_type, categorical: 'UC' or 'UB'
k	Coefficient [dimensionless]
L	Total length of member [ $m$ ]
E	Young's Modulus of Elasticity [ $GPa$ ]
h0	Distance between centroids of chords [ $mm$ ]

Lch	Length of chord [mm]
Ad	Section area of diagonal (lacing), [cm <sup>2</sup> ]
n	Number of planes of lacing, default [n = 2]
isTopLevel	Is member located at top level? [boolean]
alpha_T	Thermal coef. of expansion [degC]
delta_T	Change in temperature from the Installation temperature [degC]
k_T	Coefficient Of Temperature Effect [dimensionless]
Ned_no_TL	Axial Compressional Force without Temperature Load [kN]
file_name	Path and file name of the output table
export_xlsx	Boolean to export Excel spreadsheet or not [T/F]

### Value

Dataframe containing relevant input and all computed data

---

check\_local\_buckling\_resistance\_about\_zz\_axis

*Perform check #3, calculating the local buckling resistance of struts about minor z - z axis*

---

### Description

Calculate the local buckling resistance of member about minor z - z axis, based on EC3 Approach.

$$L_e = kL_{ch}$$

[mm] where  $L$  is the critical length for buckling about minor axis z - z Steps of the check performed for laced struts:

1. Plastic resistance of the cross-section to compression [kN]

$$N_{pl,Rd,ch} = 2(A f_y)$$

2. The Euler buckling load [kN]

$$N_{cr,ch} = \frac{\pi^2 E I_{zz}}{L_e^2}$$

3. Relative slenderness [dimensionless]

$$\lambda_{ch}^- = \sqrt{\frac{N_{pl,Rd,ch}}{N_{cr,ch}}}$$

4. Calculate  $\Phi_{ch}$  parameter for slenderness reduction factor

$$\Phi_{ch} = 0.5 \left[ 1 + \alpha (\lambda_{ch}^- - 0.2) + \lambda_{ch}^{-2} \right]$$

5. Slenderness reduction factor [dimensionless]

$$X_{ch} = \frac{1}{\Phi_{ch} + \sqrt{\Phi_{ch}^2 - \lambda_{ch}^{-2}}}$$

6. Output overall buckling resistance of the struts about z - z minor axis [kN]

$$N_{b,Rd,ch} = X_{ch} N_{pl,Rd,ch}$$

The partial factors  $\gamma_M$  that are applied to resistance of members to instability:  $\gamma_{M1} = 1$

**Usage**

```
check_local_buckling_resistance_about_zz_axis(trial_member_size,
      member_type, steel_grade, k, Lch, E, list_reference_tables)
```

**Arguments**

trial_member_size	Trial member size
member_type	member_type, categorical: 'UC' or 'UB'
steel_grade	steel_grade [ $N/mm^2$ ], categorical: 'S355' or 'S275'
k	Coefficient [dimensionless]
Lch	Length of chord [ $mm$ ]
E	Young's Modulus of Elasticity [ $GPa$ ]
list_reference_tables	List of reference tables

**Value**

$N_{b,Rd,X}$  Local buckling resistance of struts about  $z - z$  axis [ $kN$ ],  $f_y$ ,  $N_{pl,Rd}$ ,  $N_{cr}$ ,  $\bar{\lambda}$ ,  $\alpha_{yy}$ ,  $X$

---

check\_overall\_buckling\_resistance\_about\_yy\_axis

*Perform check #1, calculating the overall buckling resistance of member about major  $y - y$  axis*

---

**Description**

Calculate the overall buckling resistance of member about  $y - y$  axis, based on EC3 Approach.

$$L_e = kL$$

[ $mm$ ] where  $L$  is the critical length for buckling about major axis  $y - y$  Steps of the check performed for laced struts:

1. Plastic resistance of the cross-section to compression [ $kN$ ]

$$N_{pl,Rd} = 2(A f_y)$$

2. The Euler buckling load [ $kN$ ]

$$N_{cr,X} = \frac{\pi^2 E I_{yy}}{L_e^2}$$

3. Relative slenderness [dimensionless]

$$\bar{\lambda}_X = \sqrt{\frac{N_{pl,Rd}}{N_{cr,X}}}$$

4. Calculate  $\Phi_X$  parameter for slenderness reduction factor

$$\Phi_X = 0.5 \left[ 1 + \alpha (\bar{\lambda}_X - 0.2) + \bar{\lambda}_X^2 \right]$$

5. Slenderness reduction factor [dimensionless]

$$X_x = \frac{1}{\Phi_X + \sqrt{\Phi_X^2 - \bar{\lambda}_X^2}}$$

6. Output overall buckling resistance of the struts about  $y - y$  axis  $[kN]$

$$N_{b,R_d,X} = X_X N_{pl,R_d}$$

The partial factors  $\gamma_M$  that are applied to resistance of members to instability:  $\gamma_{M_1} = 1$

### Usage

```
check_overall_buckling_resistance_about_yy_axis(trial_member_size,
        member_type, steel_grade, k, L, E, list_reference_tables)
```

### Arguments

trial_member_size	Trial member size
member_type	member_type, categorical: 'UC' or 'UB'
steel_grade	steel_grade $[N/mm^2]$ , categorical: 'S355' or 'S275'
k	Coefficient [dimensionless]
L	Total length of member $[m]$
E	Young's Modulus of Elasticity $[GPa]$
list_reference_tables	List of reference tables

### Value

$N_{b,R_d,X}$  Overall buckling resistance of struts about major y-y axis  $[kN]$ ,  $N_{b,R_d,X}$ ,  $f_y$ ,  $N_{pl,R_d}$ ,  $N_{cr,X}$ ,  $\bar{\lambda}_X$ ,  $\alpha_{yy}$ ,  $X$

---

check\_overall\_buckling\_resistance\_about\_zz\_axis

*Perform check #2, calculating the overall buckling resistance of struts about major z - z axis*

---



### Description

Calculate the overall buckling resistance of member about  $z - z$  axis, based on EC3 Approach.

$$L_e = k L$$

[mm] where  $L$  is the critical length for buckling about major axis  $z - z$  Steps of the check performed for laced struts:

1. Plastic resistance of the cross-section to compression [ $kN$ ]

$$N_{pl,Rd} = 2(A f_y)$$

2. The Euler buckling load [ $kN$ ]

$$N_{cr,Y} = \frac{\pi^2 E I_{eff}}{L_e^2}$$

3. Relative slenderness [dimensionless]

$$\bar{\lambda}_Y = \sqrt{\frac{N_{pl,Rd}}{N_{cr,Y}}}$$

4. Calculate  $\Phi_Y$  parameter for slenderness reduction factor

$$\Phi_Y = 0.5 \left[ 1 + \alpha (\bar{\lambda}_Y - 0.2) + \bar{\lambda}_Y^2 \right]$$

5. Slenderness reduction factor [dimensionless]

$$X_Y = \frac{1}{\Phi_Y + \sqrt{\Phi_Y^2 - \bar{\lambda}_Y^2}}$$

6. Output overall buckling resistance of the struts about  $z - z$  axis [ $kN$ ]

$$N_{b,Rd,Y} = X_Y N_{pl,Rd}$$

The partial factors  $\gamma_M$  that are applied to resistance of members to instability:  $\gamma_{M_1} = 1$

### Usage

```
check_overall_buckling_resistance_about_zz_axis(trial_member_size,
member_type, steel_grade, k, L, E, h0, list_reference_tables)
```

### Arguments

trial_member_size	Trial member size
member_type	member_type, categorical: 'UC' or 'UB'
steel_grade	steel_grade [ $N/mm^2$ ], categorical: 'S355' or 'S275'
k	Coefficient [dimensionless]
L	Total length of member [ $m$ ]
E	Young's Modulus of Elasticity [ $GPa$ ]
h0	Distance between centroids of chords [ $mm$ ]
list_reference_tables	List of reference tables

**Value**

$N_{b,Rd,Y}$  Overall buckling resistance of struts about z-z axis  $[kN]$ ,  $N_{b,Rd,Y}$ ,  $f_y$ ,  $N_{pl,Rd}$ ,  $I_{eff}$ ,  $N_{cr,Y}$ ,  $\bar{\lambda}_Y$ ,  $\alpha_{yy}$ ,  $X$

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civilR	<i>Package civilR</i>
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**Description**

Civil Engineering package.

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compute_output_table	<i>Export output table to Excel file</i>
----------------------	--

---

**Description**

Export output table to Excel file.

**Usage**

```
compute_output_table(file_name = "tables/input/output_processed_table.xlsx")
```

**Arguments**

file_name	Path and file name of the output table
-----------	--

**Value**

None

---

convert_member_dimensions_string_to_elements	<i>Convert individual member dimensions to a string</i>
--	---

---

**Description**

Convert individual member dimensions to a string.

**Usage**

```
convert_member_dimensions_string_to_elements(s)
```

**Arguments**

s	String of the member dimensions
---	---------------------------------

**Value**

- $h$  Member height  $[mm]$
- $b$  Member width  $[mm]$
- $m$  Member weight  $[kg/m]$

---

 convert\_member\_dimensions\_to\_string

*Convert the member size individual dimensions to a standard string*

---

### Description

Generate a combined string from given three individual elements, separated by "x".

### Usage

convert\_member\_dimensions\_to\_string(h, b, m)

### Arguments

h	Member height [mm]
b	Member width [mm]
m	Member mass [kg/m]

### Value

String of the member dimensions

---

 effective\_length\_of\_member

*Calculate the effective length of member*

---

### Description

Calculate the effective length of member,  $L_e$  [m].

### Usage

effective\_length\_of\_member(k, L)

### Arguments

k	Effective length coefficient [dimensionless]
L	Length of strut between restraints [m]

### Value

$L_e$  Effective length of strut [m]

---

effective\_second\_moment\_of\_area

*Calculate the effective second moment of area*

---

### Description

Compute the effective second moment of area [ $mm^4$ ].  $I_{eff}$  is a function of the distance between the centroids of the chords and the section area of a chord, calculated as  $I_{eff} = 0.5 h_0^2 A$ .

### Usage

effective\_second\_moment\_of\_area(h0, A)

### Arguments

h0	Distance between centroids of chords [ $mm$ ]
A	Cross-section area of strut [ $cm^2$ ]

### Value

$I_{eff}$  Effective second moment of area [ $mm^4$ ]

---

Euler\_buckling\_load

*Calculate the Euler buckling load*

---

### Description

Calculate the Euler buckling load [ $kN$ ]

$$N_{cr,ch} = \frac{\pi^2 E I}{L_e^2}$$

### Usage

Euler\_buckling\_load(Le, E, I)

### Arguments

Le	Effective length of strut [ $mm$ ]
E	Young modulus [ $MPa$ or $MN/m^2$ ]
I	- check 1: $I_{yy}$ , second moment of area Axis $y - y$ [ $cm^4$ ]. Check 2: $I_{eff}$ , Effective second moment of area [ $mm^4$ ]. Check 3: $I_{eff}$ or $I_{zz}$ [ $mm^4$ ]

### Value

$N_{cr}$  Euler buckling load [ $kN$ ]

---

extract\_member\_dimensions

*Extract dimensions from reference table*


---

### Description

Function that looks into the Blue Book <https://www.steelforlifebluebook.co.uk/> for dimensions and properties.

### Usage

```
extract_member_dimensions(h, b, m, member_type, list_reference_tables)
```

### Arguments

h	Member height [mm]
b	Member width [mm]
m	Member mass [kg/m]
member_type	Member type, 'UB' or 'UC'
list_reference_tables	List of reference tables

### Value

- $A$  Area of section [ $cm^2$ ]
- $tw$  Thickness of web [mm]
- $tf$  Thickness of flange [mm]
- $I_{yy}$  Second moment of area axis  $y - y$  [ $cm^4$ ]
- $sh$  Depth of section [mm]
- $sb$  Width of section [mm]
- $I_{zz}$  Second moment of area axis  $z - z$  [ $cm^4$ ]

---

imperfection\_factor\_yy *Calculate the imperfection factor  $\alpha_{yy}$  for rolled section [dimensionless]*


---

### Description

Calculate the imperfection factor  $\alpha_{yy}$  for rolled section [dimensionless].

### Usage

```
imperfection_factor_yy(h, b, tf)
```

**Arguments**

<code>h</code>	Member height [ <i>mm</i> ]
<code>b</code>	Member width [ <i>mm</i> ]
<code>tf</code>	thickness of the flange [ <i>mm</i> ]

**Value**

$\alpha_{yy}$  Imperfection factor for  $y - y$  axis [dimensionless]

---

`imperfection_factor_zz` *Calculate the imperfection factor  $\alpha_{zz}$  for rolled section*

---

**Description**

Calculate the imperfection factor  $\alpha_{zz}$  for rolled section.

**Usage**

`imperfection_factor_zz(h, b, tf)`

**Arguments**

<code>h</code>	Member height [ <i>mm</i> ]
<code>b</code>	Member width [ <i>mm</i> ]
<code>tf</code>	thickness of the flange [ <i>mm</i> ]

**Value**

$\alpha_{zz}$  Imperfection factor for  $z - z$  axis [dimensionless]

---

`import_reference_BlueBook_tables`  
*Import Reference BlueBook Tables from Excel files*

---

**Description**

Import Reference BlueBook Tables from Excel files.

**Usage**

`import_reference_BlueBook_tables()`

**Arguments**

None

**Value**

List of 4 BlueBook reference tables

---

maximum\_shear\_force\_in\_the\_lacing

*Calculate the maximum shear force in the lacing*


---

### Description

Calculate the maximum shear force in the lacing,  $V_{Ed}$  [kN] (for a laced strut subject to a compressive axial force only)

$$V_{Ed} = \pi \frac{M_{Ed}}{L}$$

### Usage

```
maximum_shear_force_in_the_lacing(MEd, L)
```

### Arguments

MEd	Second order moment [kN.m]
L	Length of strut between restraints [m]

### Value

$V_{Ed}$  Maximum shear force in the lacing [kN] (for a laced strut subject to a compressive axial force only)

---

max\_compressive\_axial\_force\_in\_chords

*Maximum compressive axial force in the chords*


---

### Description

Determine maximum compressive axial force in the chords at mid-length of the strut,  $N_{ch,Ed}$  [kN]

### Usage

```
max_compressive_axial_force_in_chords(trial_member_size, member_type,
steel_grade, k, L, n, Ad, Lch, E, h0, Ned, list_reference_tables)
```

### Arguments

trial_member_size	Trial member size
member_type	member_type, categorical: 'UC' or 'UB'
steel_grade	steel_grade [N/mm <sup>2</sup> ], categorical: 'S355' or 'S275'
k	Coefficient of length as function of wall rigidity [dimensionless]
L	Length between two restraints [m]
n	Number of lacing planes, default [n = 2]

Ad	Section area of diagonal (lacing), [ $cm^2$ ]
Lch	Length of chord of between restrains (lace points) [ $m$ ]
E	Young modulus [ $GPa$ or $GN/m^2$ ]
h0	Distance between centroids of chords [ $m$ ]
Ned	Axial compression Force [ $kN$ ]
list_reference_tables	List of reference tables

**Value**

$N_{ch,Ed}$  Maximum compressive axial force in the chords [ $kN$ ],  $S_v$ ,  $N_{cr,ch}$ ,  $M_{Ed}$

---

overall\_buckling\_resistance\_about\_axis

*Calculate the overall buckling resistance of the member about the axis*

---

**Description**

General case to compute the overall buckling resistance of the member,  $N_{b,Rd}$  [ $kN$ ], about the axis, calculated as:

$$N_{b,Rd} = X N_{pl,Rd}$$

**Usage**

overall\_buckling\_resistance\_about\_axis(X, N\_pl\_Rd)

**Arguments**

X	Slenderness reduction factor [dimensionless]
N_pl_Rd	Plastic resistance of the cross-section to compression [ $kN$ ]

**Value**

$N_{b,Rd}$  Overall buckling resistance of the struts about the axis [ $kN$ ]

---

plastic\_resistance\_of\_cross\_section\_to\_compression

*Calculate the plastic resistance of the cross-section to compression*

---

**Description**

Calculate the plastic resistance of the cross-section to compression [ $N$ ], based on cross-section area  $A$  and yield strength  $f_y$ .

**Usage**

plastic\_resistance\_of\_cross\_section\_to\_compression(A, fy)



**Arguments**

A	Cross-section area of the strut [ $cm^2$ ]
fy	Yield strength [ $kN/mm^2$ ]

**Value**

$N_{pl,R_d}$  Plastic resistance of the cross-section to compression [ $N$ ]

---

read_input_table	<i>Read input table from given Excel file</i>
------------------	---

---

**Description**

Read input table from given Excel file.

**Usage**

```
read_input_table(file_name = "tables/input/trial1_kotik.xlsx")
```

**Arguments**

file_name	Path and file name of the input table
-----------	---------------------------------------

**Value**

Input table

---

relative_slenderness	<i>Calculate the relative slenderness</i>
----------------------	---

---

**Description**

Calculate the relative slenderness [dimensionless]

$$\bar{\lambda} = \sqrt{\frac{N_{pl,R_d}}{N_{cr}}}$$

**Usage**

```
relative_slenderness(N_pl_Rd, Ncr)
```

**Arguments**

N_pl_Rd	Plastic resistance of the cross-section to compression [ $kN$ ]
Ncr	Euler buckling load [ $kN$ ]

**Value**

$\bar{\lambda}$  Relative slenderness [dimensionless]

---

second\_order\_bending\_moment

*Calculate the second order bending moment*


---

### Description

Compute the second order bending moment,  $M_{E_d}$  [ $kN.m$ ]. The maximum bending moment, including the bow imperfection and the second order effects, calculated as:

$$M_{E_d} = \frac{N_{E_d} e_0 + M_{E_d}^I}{1 - \frac{N_{E_d}}{N_{cr,Y}} - \frac{N_{E_d}}{S_v}}$$

### Usage

```
second_order_bending_moment(L, Ned, Sv, Ncr)
```

### Arguments

L	Length of strut between restraints [ $mm$ ]
Ned	axial_compression_force [ $kN$ ]
Sv	Shear stiffness for K-shape lacing [ $kN$ ]
Ncr	Euler buckling load from check #2 global zz [ $kN$ ]

### Value

$M_{E_d}$  Second order moment [ $kN.m$ ]

---

shear\_stiffness

*Calculate the shear stiffness for K-shape lacing*


---

### Description

Calculate the shear stiffness for K-shape lacing [ $kN$ ]. The expression of shear stiffness is:

$$S_v = \frac{n E A_d L_{ch} h_0^2}{d^3}$$

### Usage

```
shear_stiffness(n = 2, Ad, Lch, E, h0)
```

### Arguments

n	Number of planes of lacing, default [ $n = 2$ ]
Ad	Section area of diagonal (lacing), [ $cm^2$ ]
Lch	Length of chord of between restrains (lace points) [ $m$ ]
E	Young modulus [ $GPa$ or $GN/m^2$ ]
h0	Distance between centroids of chords [ $m$ ]

### Value

$S_v$  Shear stiffness for K-shape lacing [ $kN$ ]

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slenderness\_reduction\_factor

*Calculate the slenderness reduction factor*


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**Description**

Calculate the slenderness reduction factor  $X$  [dimensionless] for the general case.

$$\Phi = 0.5 [1 + \alpha (\bar{\lambda} - 0.2) + \bar{\lambda}^2]$$

$$X = \frac{1}{\Phi + \sqrt{\Phi^2 - \bar{\lambda}^2}}$$

**Usage**

```
slenderness_reduction_factor(alpha, lambda_bar)
```

**Arguments**

alpha	Check #1: imperfection factor $\alpha_{yy}$ for rolled section [dimensionless]. Check 2 & 3: imperfection factor $\alpha_{zz}$ for rolled section [dimensionless]
lambda_bar,	Relative slenderness $\bar{\lambda}$ [dimensionless]

**Value**

$X$  Slenderness reduction factor [dimensionless]

---

temperature\_load

*Calculate the temperature load*


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**Description**

Calculate Temperature Load as a function of a surface changes of temperature, TL [kN].  
Usually used for calculation of Axial Compression Force for the top level member.

$$TL = \alpha_T \delta_T k_T E A$$

**Usage**

```
temperature_load(alpha_T = 1.2e-05, delta_T = 10, k_T = 0.8,  
E = 210, A = 94.4)
```

**Arguments**

alpha_T	Thermal coefficient of expansion [degC]
delta_T	Change in temperature from the Installation temperature [degC]
k_T	Coefficient Of temperature effect [dimensionless]
E	Young's Modulus of Elasticity [GPa or GN/m2]
A	Sectional area from table for given member size [cm <sup>2</sup> ]

**Value**

TL Temperature load [kN]

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trial_member_size	<i>Determine member size</i>
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### Description

Find optimized designation [ height (mm) x width (mm) x mass (kg/m) ] (also called member size) for given Axial Compression Force and critical length for major and minor axis. Searching into the tables based on the 'Compression' tables of the Blue Book <https://www.steelforlifebluebook.co.uk/>

### Usage

```
trial_member_size(Lcry, Lcrz, Ned, steel_grade, member_type,
list_reference_tables)
```

### Arguments

Lcry	critical length major axis [ $m$ ]
Lcrz	critical length minor axis [ $m$ ]
Ned	Axial compression force [ $kN$ ]
steel_grade	steel_grade [ $N/mm^2$ ], categorical: 'S355' or 'S275'
member_type	member_type, categorical: 'UC' or 'UB'
list_reference_tables	List of reference tables

### Value

Member size [ height (mm) x width (mm) x mass (kg/m) ]

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yield_strength	<i>Calculate the yield strength</i>
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### Description

Calculate the yield strength,  $f_y$  [ $N/mm^2$ ]

### Usage

```
yield_strength(tw, tf, steel_grade)
```

### Arguments

tw	Thickness of the web [ $mm$ ]
tf	Thickness of the flange [ $mm$ ]
steel_grade	steel_grade [ $N/mm^2$ ], categorical: 'S355' or 'S275'

### Value

$f_y$  Yield strength [ $N/mm^2$ ]

*yield\_strength*

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### **Examples**

```
yield_strength(tw=47.6, tf=77, steel_grade="S355")
```

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