

Package ‘civilR’

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Description Civil Engineering R package

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R topics documented:

axial_compression_force	2
calculated_NEd	3
check_local_buckling_resistance_about_zz_axis	4
check_overall_buckling_resistance_about_yy_axis	5
check_overall_buckling_resistance_about_zz_axis	6
civilR	7
compute_output_table	8
convert_member_dimensions_string_to_elements	8
convert_member_dimensions_to_string	9
effective_length_of_member	9
effective_second_moment_of_area	10
Euler_buckling_load	10
extract_member_dimensions	11
imperfection_factor_yy	11
imperfection_factor_zz	12

maximum_shear_force_in_the_lacing	12
max_compressive_axial_force_in_chords	13
overall_buckling_resistance_about_axis	13
plastic_resistance_of_cross_section_to_compression	14
process_input_table	14
read_input_table	15
relative_slenderness	15
second_order_bending_moment	16
shear_stiffness	16
slenderness_reduction_factor	17
temperature_load	17
trial_member_size	18
yield_strength	18

Index	19
--------------	-----------

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)
```

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 ²], 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

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>
----------------	--------------------------------

Description

Generate calculated N_{Ed} , N_{Ed_c} [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_{Ed_c} Calculated N_{Ed} [kN]

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 Φ_{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 γ_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)

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]

Value

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

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

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

Usage

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

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]

Value

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

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

The partial factors γ_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)
```

Arguments

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

Value

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

civilR

Package civilR

Description

Civil Engineering package.

compute_output_table	<i>Export output table to Excel file</i>
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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)
```

Arguments

h	Member height [mm]
b	Member width [mm]
m	Member mass [kg/m]
member_type	Member type, 'UB' or 'UC'

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 α_{yy} for rolled section [dimensionless]*

Description

Calculate the imperfection factor α_{yy} for rolled section [dimensionless].

Usage

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

Arguments

h	Member height [mm]
b	Member width [mm]
tf	thickness of the flange [mm]

Value

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

imperfection_factor_zz *Calculate the imperfection factor α_{zz} for rolled section*

Description

Calculate the imperfection factor α_{zz} for rolled section.

Usage

imperfection_factor_zz(h, b, tf)

Arguments

h	Member height [mm]
b	Member width [mm]
tf	thickness of the flange [mm]

Value

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

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)
```

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 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]

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 memeber 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

χ	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	<i>Calculate the plastic resistance of the cross-section to compression</i>
--	---

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]
f_y	Yield strength [kN/mm^2]

Value

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

process_input_table	<i>Process input table</i>
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Description

Process input table.

Usage

process_input_table()

Value

Processed table, adding computed outputs:

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]

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

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_{Ed} [kN.m]. The maximum bending moment, including the bow imperfection and the second order effects, calculated as:

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

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_{Ed} 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]

slenderness_reduction_factor

Calculate the slenderness reduction factor

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

Value

X Slenderness reduction factor [dimensionless]

temperature_load

Calculate the temperature load

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 ²]

Value

TL Temperature load [kN]

trial_member_size	<i>Determine member size</i>
-------------------	------------------------------

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)
```

Arguments

Lcry	critical length major axis [<i>m</i>]
Lcrz	critical length minor axis [<i>m</i>]
Ned	Axial compression force [<i>kN</i>]
steel_grade	steel_grade [<i>N/mm²</i>], categorical: 'S355' or 'S275'
member_type	member_type, categorical: 'UC' or 'UB'

Value

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

yield_strength	<i>Calculate the yield strength</i>
----------------	-------------------------------------

Description

Calculate the yield strength, f_y [*N/mm²*]

Usage

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

Arguments

tw	Thickness of the web [<i>mm</i>]
tf	Thickness of the flange [<i>mm</i>]
steel_grade	steel_grade [<i>N/mm²</i>], categorical: 'S355' or 'S275'

Value

f_y Yield strength [*N/mm²*]

Examples

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

Index

axial_compression_force, [2](#)

calculated_NEd, [3](#)

check_local_buckling_resistance_about_zz_axis,
[4](#)

check_overall_buckling_resistance_about_yy_axis,
[5](#)

check_overall_buckling_resistance_about_zz_axis,
[6](#)

civilR, [7](#)

civilR-package (civilR), [7](#)

compute_output_table, [8](#)

convert_member_dimensions_string_to_elements,
[8](#)

convert_member_dimensions_to_string, [9](#)

effective_length_of_member, [9](#)

effective_second_moment_of_area, [10](#)

Euler_buckling_load, [10](#)

extract_member_dimensions, [11](#)

imperfection_factor_yy, [11](#)

imperfection_factor_zz, [12](#)

max_compressive_axial_force_in_chords,
[13](#)

maximum_shear_force_in_the_lacing, [12](#)

overall_buckling_resistance_about_axis,
[13](#)

plastic_resistance_of_cross_section_to_compression,
[14](#)

process_input_table, [14](#)

read_input_table, [15](#)

relative_slenderness, [15](#)

second_order_bending_moment, [16](#)

shear_stiffness, [16](#)

slenderness_reduction_factor, [17](#)

temperature_load, [17](#)

trial_member_size, [18](#)

yield_strength, [18](#)