Package 'civilR'

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Author Alena Fournier-Carrie & Marc Fournier-Carrie

Maintainer Marc Fournier-Carrie <marc@shadowboxingskills.com>

Description Civil Engineering R package

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civilR

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R topics documented:

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`all_member_sizes` *Extract a vector of all member sizes*

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, AL = 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 $[N/mm^2]$, 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 $[GPa]$
AL	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 *Generate calculated NEd*

Description

Generate calculated N_{E_d}, $N_{E_{d_c}}$ $[kN]$.

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

$N_{E_{d_c}}$ Calculated N_{E_d} $[kN]$

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

Description

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

Usage

```
check_all_member_sizes(steel_grade, member_type, k, L, E, h0, Lch, Ad, n,
  isTopLevel, alpha_T, delta_T, k_T, Ned_no_TL, LL, AL, Lcry, Lcrz, ml,
  strut_name, base_file_name, export_xlsx)
```

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), $[cm^2]$

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 $[kN]$
LL	Live load / imposed load $[kN/m]$
AL	Accidental Impact Load $[kN/m]$
Lcry	critical length about major axis $[m]$
Lcrz	critical length minor axis $[m]$
ml	Lacing weight $[kN/m]$
strut_name	Strut name
export_xlsx	Boolean to export Excel spreadsheet or not [T/F]
file_name	Path and file name of the output table

Value

- *df* Dataframe containing relevant input and all computed data
- $optimal_member_size$ Optimal member size [height (mm) x width (mm) x mass (kg/m)]
- $optimal_TL$ Optimal Temperature Load $[kN]$
- $optimal_Ned$ Optimal @param Ned_no_TL Axial Compressional Force with Temperature Load $[kN]$

---

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 $[kN]$

$$N_{pl,R_d,ch} = 2(A\,fy)$$

2. The Euler buckling load $[kN]$

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

3. Relative slenderness [dimensionless]

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

4. Calculate Φ_{ch} parameter for slenderness reduction factor

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

5. Slenderness reduction factor [dimensionless]

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

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

$$N_{b,R_d,ch} = X_{ch}\, N_{pl,R_d,ch}$$

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

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,R_d}
- 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 $[kN]$

$$N_{pl,R_d} = 2(A\,fy)$$

2. The Euler buckling load $[kN]$

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

3. Relative slenderness [dimensionless]

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

4. Calculate Φ_X parameter for slenderness reduction factor

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

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 γ_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

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

$$N_{pl,R_d} = 2(A\,fy)$$

2. The Euler buckling load [kN]

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

3. Relative slenderness [dimensionless]

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

4. Calculate Φ_Y parameter for slenderness reduction factor

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

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, 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

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

`civilR` *Package civilR*

Description

Civil Engineering package.

`combined_vertical_load` *USL vs ALS verical load combinations*

Description

USL vs ALS verical load combinations

Usage

```
combined_vertical_load(DL, LL, AL)
```

Arguments

DL	Dead load / self-weight of member $[kN/m]$
LL	Live load / imposed load $[kN/m]$
AL	Accidental Impact Load $[kN/m]$

Details

Calculation steps are as follows:

1. $ULS : F = (1.35\, DL + 1.5\, LL + 1.5\, TL)$
2. $ALS : F = (1.0\, DL + 0.7\, LL + 1.0\, AL)$
3. $ALS : F = (1.0\, DL + 0.6\, LL + 1.0\, AL + 0.5\, TL)$

Value

combined_vertical_load $[kN/m]$

compute_output_table *Export output table to Excel file*

Description

Export output table to Excel file.

Usage

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

Arguments

file_name	Path and file name of the output table
export_xlsx	Boolean to export Excel spreadsheet or not [T/F]

Value

None

convert_member_dimensions_string_to_elements *Convert individual member dimensions to a string*

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 lengh 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 $[mm]$
- Iyy Second moment of area axis $y - y$ $[cm^4]$
- sh Depth of section $[mm]$
- sb Width of section $[mm]$
- Izz Second moment of area axis $z - z$ $[cm^4]$

`first_order_bending_moment` *Calculate first order bending moment about major axis $y - y$ $[kN.m]$*

Description

Calculate first order bending moment about major axis $y - y$ $[kN.m]$

Usage

```
first_order_bending_moment(combined_vertical_load, L)
```

Arguments

combined_vertical_load
: combined_vertical_load $[kN/m]$

L
: Length of strut between restraints $[m]$

Details

Calculated as

$$M_{Ed}^{I} = 0.08\,F\,L_{cr,y}^{2}$$

Value

M_{Ed}^{I} First order bending moment $[kN.m]$

`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]

`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_{E_d} $[kN]$ (for a laced strut subject to a compressive axial force only)

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

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_{E_d} 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,E_d} $[kN]$

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,
  isTopLevel, DL, LL, AL, TL, Lcry)
```

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 betwen 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
`isTopLevel`	Is member located at top level? [boolean]
`DL`	Dead load / self-weight of member $[kN/m]$
`LL`	Live load / imposed load $[kN/m]$
`AL`	Accidental Impact Load $[kN/m]$
`TL`	Temperature load $[kN/m]$
`Lcry`	critical length about major axis $[m]$

Value

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

`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,R_d} $[kN]$, about the axis, calculated as:

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

Usage

```
overall_buckling_resistance_about_axis(X, N_pl_Rd)
```

Arguments

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

Value

N_{b,R_d} 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` *Read input table from given Excel file*

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` *Calculate the relative slenderness*

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 [dimentionless]

`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, DL, LL, AL)
```

Arguments

`L`	Length of strut between restraints $[m]$
`Ned`	axial_compression_force $[kN]$
`Sv`	Shear stiffness for K-shape lacing $[kN]$
`Ncr`	Euler buckling load from check #2 global zz $[kN]$
`DL`	Dead load / self-weight of member $[kN/m]$
`LL`	Live load / imposed load $[kN/m]$
`AL`	Accidental Impact Load $[kN/m]$

Value

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

`shear_force_at_support` *Shear force at support calculation*

Description

Generate Shear force at support V_{Ed} $[kN]$.

Usage

```
shear_force_at_support(DL, LL, L, AL)
```

Arguments

`DL`	Dead load / self-weight of member $[kN/m]$
`LL`	Live load / imposed load $[kN/m]$
`L`	Length of strut between restraints $[m]$
`AL`	Accidental Impact Load $[kN/m]$

Value

V_{Ed} Shear force at support $[kN]$

`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 betwen 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 [dimentionless] for the general case.

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

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

Usage

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

Arguments

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

Value

X Slenderness reduction factor [dimentionless] `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` *Determine member size*

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)]

`yield_strength` *Calculate the yield strength*

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 $[N/mm^2]$

Examples

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

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