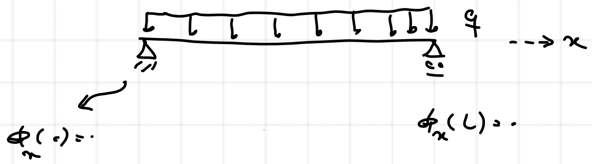
This series of videos teaches the calculation of buckling load for a simply supported beam under a distributed load. As you may have noticed, Eurocode does not provide an equation for critical bending moment in lateral torsional buckling calculation.

This video demonstrates how to calculate critical distributed load using a commonly used equation, interpret the results, and compare them with manual calculations and results from Ansys and RFEM.

Link for the source of equation can be found here.



2. Method for doubly symmetric sections

The method given hereafter only applies to uniform straight members for which the cross-section is symmetric about the bending plane.

The conditions of restraint at each end are at least :

- ❑ restrained against lateral movement
- ❑ restrained against rotation about the longitudinal axis

The elastic critical moment may be calculated from the following formula derived from the buckling theory :

$$M_{cr} = C_1 \frac{\pi^2 EI_z}{(kL)^2} \left\{ \sqrt{\left(\frac{k}{k_w}\right)^2 \frac{I_w}{I_z} + \frac{(kL)^2 GI_t}{\pi^2 EI_z} + (C_2 z_g)^2} - C_2 z_g \right\} \qquad \textbf{(1)}$$

where

E is the Young modulus ($E = 210000$ N/mm^2)

G is the shear modulus ($G = 80770$ N/mm^2)

I_z is the second moment of area about the weak axis

I_t is the torsion constant

I_w is the warping constant

L is the beam length between points which have lateral restraint

k and k_w are effective length factors

z_g is the distance between the point of load application and the shear centre.

Note : for doubly symmetric sections, the shear centre coincides with the centroid.

The factor k refers to end rotation on plan. It is analogous to the ratio of the buckling length to the system length for a compression member. k should be taken as not less than 1,0 unless less than 1,0 can be justified.

The factor k_w refers to end warping. Unless special provision for warping fixity is made, k_w should be taken as 1,0.

In the general case z_g is positive for loads acting towards the shear centre from their point of application (Figure 2.1).

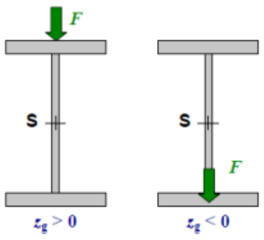
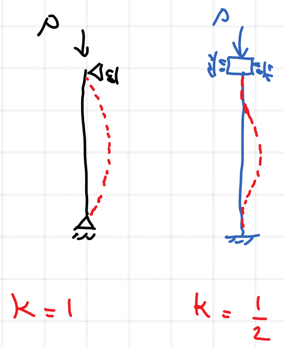


Figure 2.1 Point of application of the transverse load



$z_g := 95\ mm$

$$M_{cr} := C_1 \cdot \frac{\pi^2 \cdot E \cdot I_z}{(k \cdot l)^2} \cdot \left(\sqrt{\left(\frac{k}{k_w}\right)^2 \cdot \frac{I_w}{I_z} + \frac{(k \cdot l)^2 \cdot G \cdot I_t}{\pi^2 \cdot E \cdot I_z} + (C_2 \cdot z_g)^2} - C_2 \cdot z_g \right)$$

$M_{cr} = 320.354\ kN \cdot m$ $\qquad q_{cr} := \frac{8 \cdot M_{cr}}{l^2} = 160.177\ \frac{kN}{m}$

Des: H.C $\rightarrow$ $\begin{cases} q_{cr} = 188\ kN/m \\ M_{cr} = 376\ kN \cdot m \end{cases}$

Ansys: $\rightarrow$ $\begin{cases} q_{cr} = 171\ kN/m \\ M_{cr} = 342\ kN \cdot m \end{cases}$

RFEM: $\rightarrow$ $\begin{cases} q_{cr} = 170.5\ kN/m \\ M_{cr} = 341\ kN\ m \end{cases}$

EQ: $\rightarrow$ $\begin{cases} q_{cr} = 160.2\ kN/m \\ M_{cr} = 320\ kN\ m \end{cases}$

$z_g := 0\ mm$

$$M_{cr} := C_1 \cdot \frac{\pi^2 \cdot E \cdot I_z}{(k \cdot l)^2} \cdot \left(\sqrt{\left(\frac{k}{k_w}\right)^2 \cdot \frac{I_w}{I_z} + \frac{(k \cdot l)^2 \cdot G \cdot I_t}{\pi^2 \cdot E \cdot I_z} + (C_2 \cdot z_g)^2} - C_2 \cdot z_g \right)$$

$M_{cr} = 395.631\ kN \cdot m$ $\qquad q_{cr} := \frac{8 \cdot M_{cr}}{l^2} = 197.816\ \frac{kN}{m}$

Ne: H.C $\rightarrow$ $\begin{cases} q_{cr} = 230\ kN/m \\ M_{cr} = 460\ kN\ m \end{cases}$

Ansys: $\rightarrow$ $\begin{cases} q_{cr} = 206\ kN/m \\ M_{cr} = 412\ kN\ m \end{cases}$

RFEM: $\rightarrow$ $\begin{cases} q_{cr} = 206\ kN/m \\ M_{cr} = 412\ kN \cdot m \end{cases}$

EQ: $\rightarrow$ $\begin{cases} q_{cr} = 198\ kN/m \\ M_{cr} = 396\ kN\ m \end{cases}$

$z_g := -95\ mm$

$$M_{cr} := C_1 \cdot \frac{\pi^2 \cdot E \cdot I_z}{(k \cdot l)^2} \cdot \left(\sqrt{\left(\frac{k}{k_w}\right)^2 \cdot \frac{I_w}{I_z} + \frac{(k \cdot l)^2 \cdot G \cdot I_t}{\pi^2 \cdot E \cdot I_z} + (C_2 \cdot z_g)^2} - C_2 \cdot z_g \right)$$

$M_{cr} = 488.598\ kN \cdot m$

$q_{cr} := \frac{8 \cdot M_{cr}}{l^2} = 244.299\ \frac{kN}{m}$

St:

H.C $\rightarrow$ $\begin{cases} q_{cr} = 276\ kN/m \\ M_{cr} = 552\ kN\ m \end{cases}$

Ansys: $\rightarrow$ $\begin{cases} q_{cr} = 243\ kN/m \\ M_{cr} = 486\ kN\ m \end{cases}$

RFEM: $\rightarrow$ $\begin{cases} q_{cr} = 243\ kN/m \\ M_{cr} = 486\ kN \cdot m \end{cases}$

EQ: $\rightarrow$ $\begin{cases} q_{cr} = 244\ kN/m \\ M_{cr} = 489\ kN\ m \end{cases}$

Shah.fi