Eurocode 3:
Design of Steel Structures
Frame Idealisation, Classification and Analysis
14 Dec 2011
General approach in analysing and designing steel frames

- Classification of the frames
- Assessment of imperfections
- Choice of the method of analysis
- Computation of internal member and moments
- Ultimate limit states check
  - resistance of cross-sections
  - Buckling resistance of members
- Serviceability limit states check
  - Deflections
  - Dynamic effects
drown with terminologies?

- Semi-rigid and rigid?
- Sway and non-sway?
- Braced and unbraced?
- Elastic vs inelastic?
- Elastic and plastic?
- Continuous vs semi-continuous?
- Rigid, elastic-plastic, elastic plastic hinged?
- Elastic vs elasto plastic?
- Joints vs connections
- Advanced analysis?
Frame Idealisation and Classification

sway resistance
connections
methods of analysis
Frame Idealisation

sway resistance
Sway Stability

Consideration whether a frame is sway or non-sway case:

- Depends on frame geometry and load cases under consideration
- Determined by influenced of $P\Delta$ effect

Non-sway frame

- Horizontal loads are carried by the bracing or by horizontal support
- Change of geometry (2nd-order effect) is negligible

Sway frame

- Horizontal loads are carried by the frame
- Change of geometry (2nd-order effect) is significant
Multistorey Steel Frame

- **Non-sway**
  - Depends on frame geometry and load cases under consideration
  - Determined by influenced of $P_\Delta$ effect
  - Horizontal loads are carried by the bracing or by horizontal support
  - Change of geometry (2nd-order effect) is negligible

- **Sway**
  - Horizontal loads are carried by the frame
  - Change of geometry (2nd-order effect) significant

**Definition**

**Sway Stability**
Sway Stability

A frame is considered to be sway case if:

\[ \alpha_{cr} = \frac{F_{cr}}{F_{Ed}} \leq 10 \text{ for elastic analysis} \]
\[ \alpha_{cr} = \frac{F_{cr}}{F_{Ed}} \leq 15 \text{ for plastic analysis} \]

where

- \( \alpha_{cr} \) is the factor by which the design loading would have to be increased to cause elastic instability in a global mode
- \( F_{Ed} \) is the design loading on the structure
- \( F_{cr} \) is the elastic critical buckling load for global instability mode based on initial elastic stiffnesses
Sway Stability

\( \alpha_{cr} \) may be calculated using the following approximate formula,

\[
\alpha_{cr} = \frac{F_{cr}}{F_{Ed}} = \left( \frac{h}{\delta_{H,Ed}} \right) \left( \frac{H_{Ed}}{V_{Ed}} \right)
\]

where:

- \( \delta_{H,ed} \) is the sway at the top of storey \( i \)
- \( h \) is the height of storey \( i \)
- \( H_{Ed} \) the total horizontal reactions respectively at the bottom of storey \( i \)
- \( V_{Ed} \) the total vertical reactions respectively at the bottom of storey \( i \)

\[
H_{Ed} = H_1 + H_2 \\
V_{Ed} = V_1 + V_2
\]
Allowing Imperfections

Frame imperfection
always to be allowed for

Member Imperfection
only for slender members in sway frames,
otherwise it is covered in the relevant buckling
curve
Allowing frame imperfection

Frame imperfection can be replaced by an equivalent closed system of horizontal forces applied at the floor levels (including the foundation level).
Frame imperfection

- The frame imperfection is as follows:

\[ \phi = \phi_o \alpha_h \alpha_m \]

where \( \phi_0 = 1/200 \)

\[ \alpha_h = \left( \frac{2}{\sqrt{h}} \right) \text{ but } \frac{2}{3} \leq \alpha_h \leq 1 \]

\[ \alpha_m = \sqrt{0.5 \left( 1 + \frac{1}{m} \right)} \]

- \( h \) is the height of the structure in meters
- \( m \) is the number of columns in a row including only those columns which carry a vertical load
Global initial sway imperfections $\phi_i$

$$\phi = \phi_0 \alpha_h \alpha_m$$

where $\phi_0 = 1/200$

$$\alpha_h = \left(\frac{2}{\sqrt{h}}\right) \text{ but } \frac{2}{3} \leq \alpha_h \leq 1$$

$$\alpha_m = \sqrt{0.5 \left(1 + \frac{1}{m}\right)}$$

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<th>Number of columns (m)</th>
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Equivalent forces
\[ \alpha_{cr} = \frac{F_{cr}}{F_{Ed}} = \max \left( \frac{h}{\delta_{H,Ed}} \left( \frac{H_{Ed}}{V_{Ed}} \right) \right) \]

<table>
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<th>( \alpha_{cr} &lt; 10 )</th>
<th>( \alpha_{cr} \geq 10 )</th>
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<td><strong>Elastic Analysis</strong></td>
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