Eurocode 3 :
Design of Steel Structures

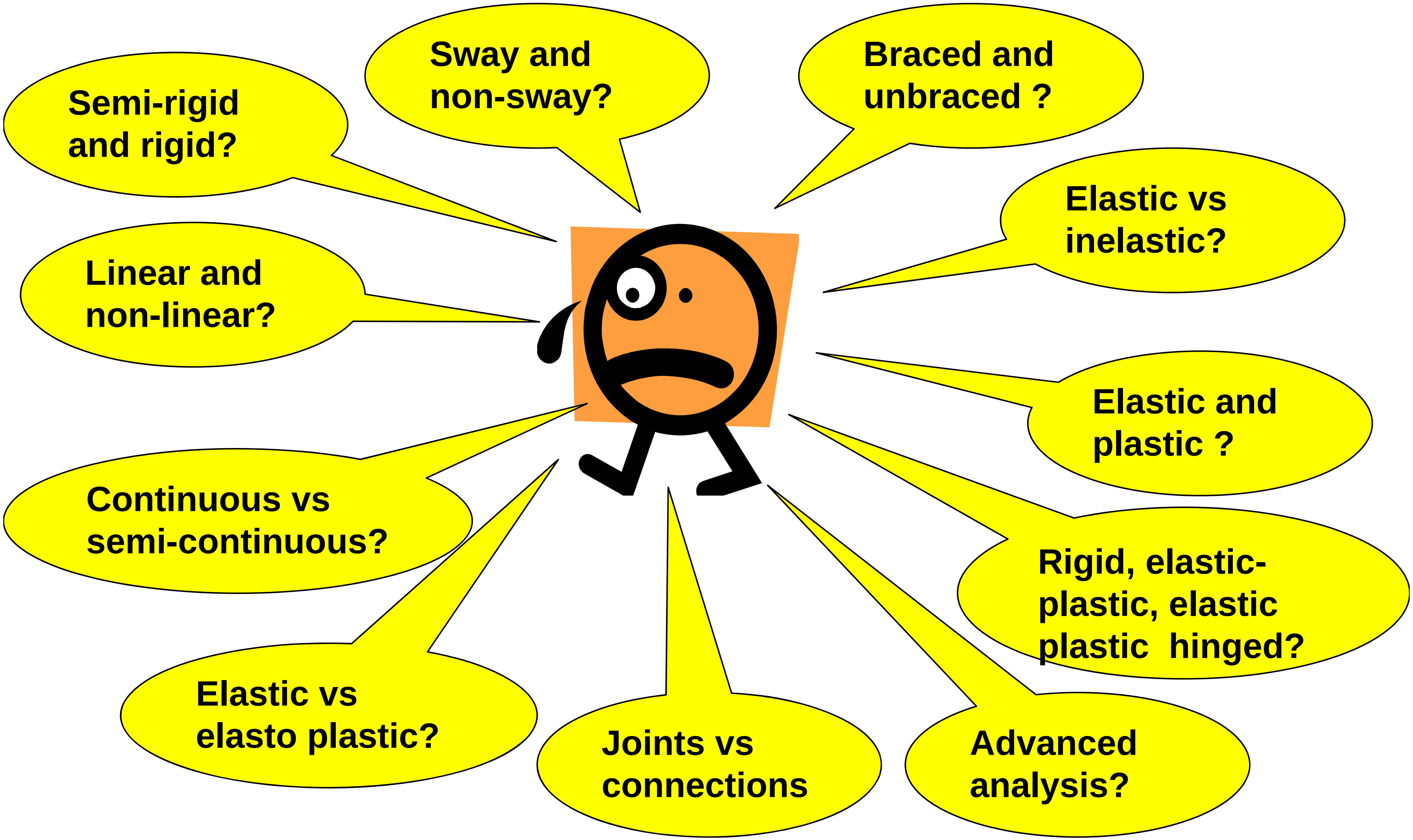
Frame Idealisation, Classification and Analysis

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?



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 PΔ 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

Sway Stability

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Multistorey Steel Frame

Definiton	Non-sway	Sway
	Depends on frame geometry and load cases under consideration	
	Determined by influenced of PΔ effect	
	Horizontal loads are carried by the bracing or by horizontal support	Horizontal loads are carried by the frame
	Change of geometry (2nd-order effect) is negligible	Change of geometry (2nd-order effect) significant

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

α_{cr} is the factor by which the design loading would have to be increased to cause elastic instability in a global mode

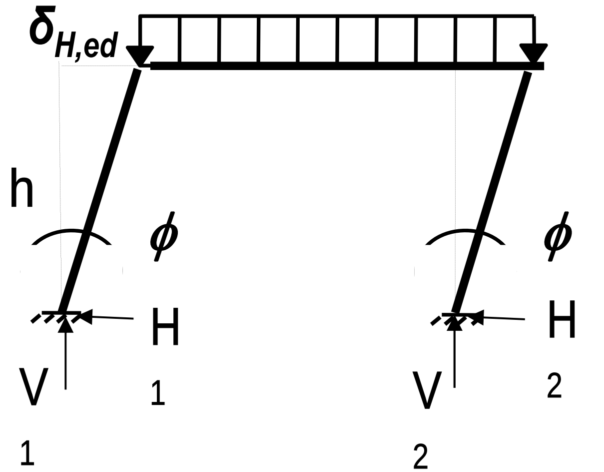
F_{Ed} is the design loading on the structure

F_{cr} is the elastic critical buckling load for global instability mode based on initial elastic stiffnesses

Sway Stability

α_{cr} may be calculated using the following approximate formula,

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



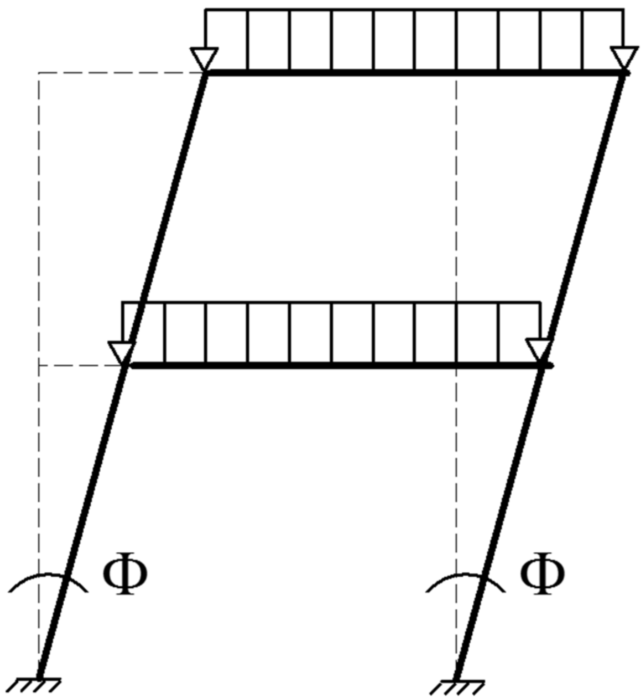
$H_{Ed} = H_1 + H_2$

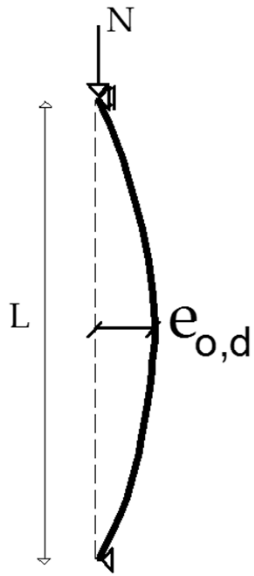
$V_{Ed} = V_1 + V_2$

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***

Allowing Imperfections





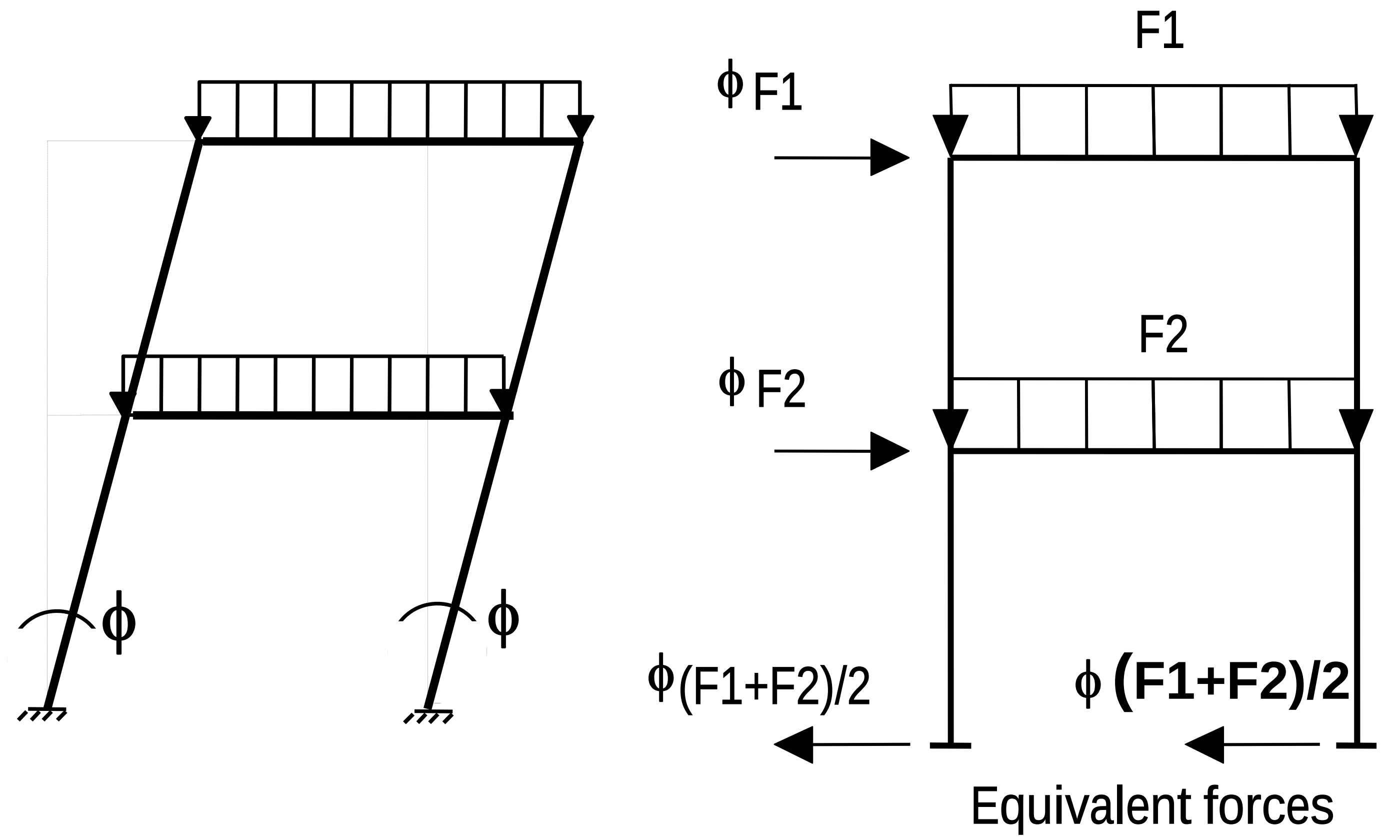
Frame imperfection

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:

$$\phi = \phi_o \alpha_h \alpha_m$$

$$where \quad \phi_0 = 1/200$$

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

$$\alpha_m = \sqrt{0{,}5\left(1 + \frac{1}{m}\right)}$$

h is the height of the structure in meters

m is is the number of columns in a row including only those columns which carry a vertical load

	Number of columns (m)					
Height of the structure (h)	**1**	**2**	**3**	**4**	**5**	**6**
1	0.00500	0.00433	0.00408	0.00395	0.00387	0.00382
2	0.00500	0.00433	0.00408	0.00395	0.00387	0.00382
3	0.00500	0.00433	0.00408	0.00395	0.00387	0.00382
4	0.00500	0.00433	0.00408	0.00395	0.00387	0.00382
5	0.00447	0.00387	0.00365	0.00353	0.00346	0.00341
6	0.00408	0.00354	0.00333	0.00323	0.00316	0.00312
7	0.00378	0.00327	0.00309	0.00299	0.00293	0.00289
8	0.00354	0.00306	0.00289	0.00280	0.00274	0.00270
9	0.00333	0.00289	0.00272	0.00264	0.00258	0.00255
10	0.00333	0.00289	0.00272	0.00264	0.00258	0.00255
12	0.00333	0.00289	0.00272	0.00264	0.00258	0.00255
13	0.00333	0.00289	0.00272	0.00264	0.00258	0.00255
14	0.00333	0.00289	0.00272	0.00264	0.00258	0.00255
15	0.00333	0.00289	0.00272	0.00264	0.00258	0.00255
16	0.00333	0.00289	0.00272	0.00264	0.00258	0.00255
17	0.00333	0.00289	0.00272	0.00264	0.00258	0.00255
18	0.00333	0.00289	0.00272	0.00264	0.00258	0.00255
19	0.00333	0.00289	0.00272	0.00264	0.00258	0.00255
20	0.00333	0.00289	0.00272	0.00264	0.00258	0.00255
22	0.00333	0.00289	0.00272	0.00264	0.00258	0.00255
24	0.00333	0.00289	0.00272	0.00264	0.00258	0.00255
25	0.00333	0.00289	0.00272	0.00264	0.00258	0.00255

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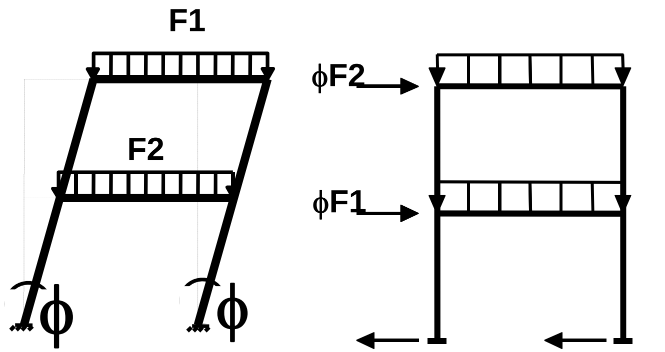
Global initial sway imperfections ϕ,

$$\phi = \phi_o \alpha_h \alpha_m$$

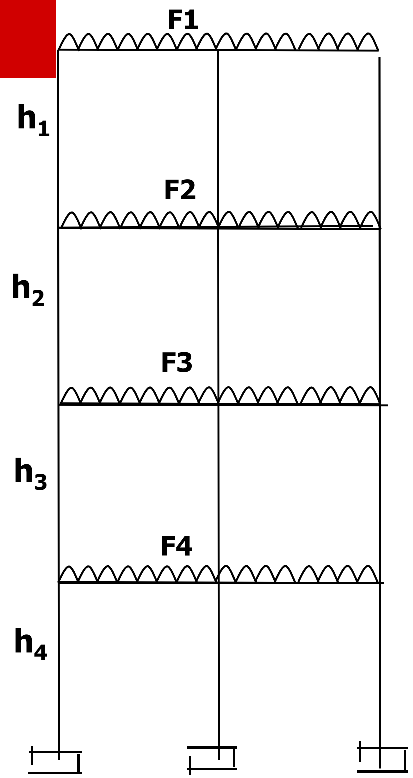
$$where \quad \phi_0 = 1/200$$

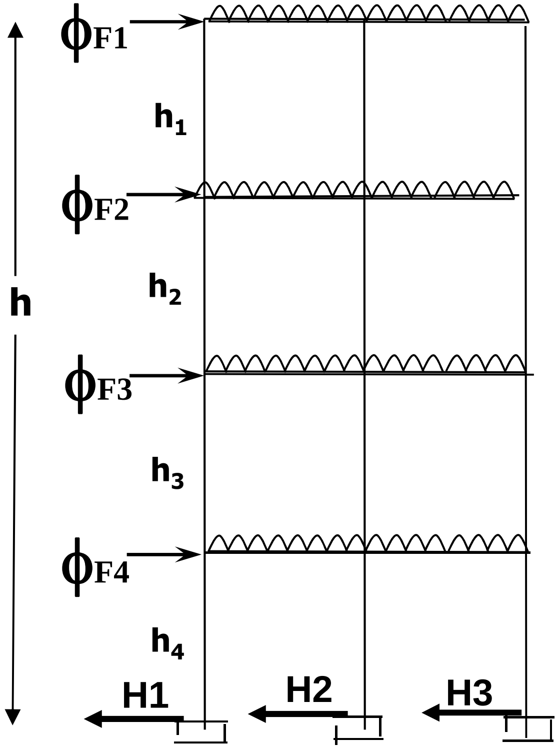
$$\alpha_h = \left(\frac{2}{\sqrt{h}}\right) \text{but } \frac{2}{3} \leq \alpha_h \leq 1$$

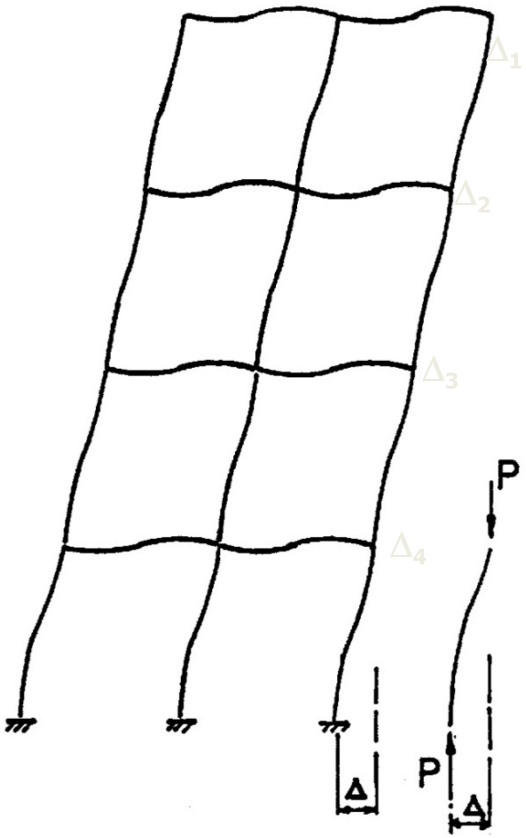
$$\alpha_m = \sqrt{0{,}5\left(1 + \frac{1}{m}\right)}$$



Equivalent forces







$$\delta_{1Hed} = \frac{h_1}{\Delta_1 - \Delta_2}$$

$$\delta_{2Hed} = \frac{h_2}{\Delta_2 - \Delta_3}$$

$$\delta_{3Hed} = \frac{h_3}{\Delta_3 - \Delta_4}$$

$$\delta_{4Hed} = \frac{h_4}{\Delta_4}$$

$$\downarrow$$

$$\max\left(\frac{h}{\delta_{H,Ed}}\right)$$

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

Elastic Analysis	$\alpha_{cr} < 10$	Sway Frame
	$\alpha_{cr} \geq 10$	Non-Sway Frame
Plastic Analysis	$\alpha_{cr} < 15$	Sway Frame
	$\alpha_{cr} \geq 15$	Non-Sway Frame