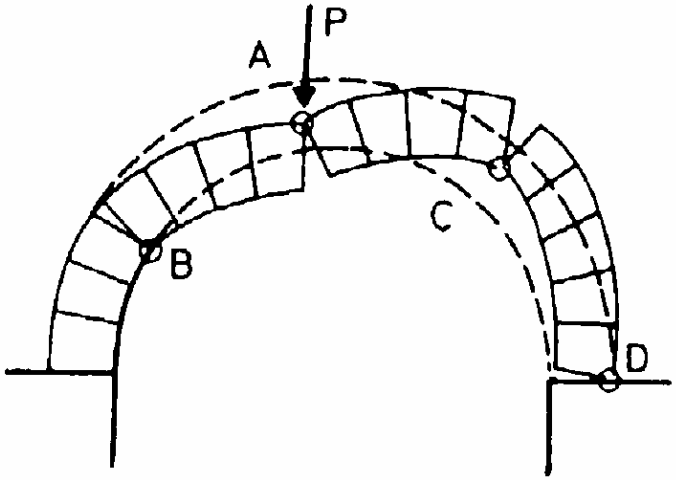
Készült az ERFP – DD2002 – HU – B – 01 szerzősésszámú projekt támogatásával

Chapter 8

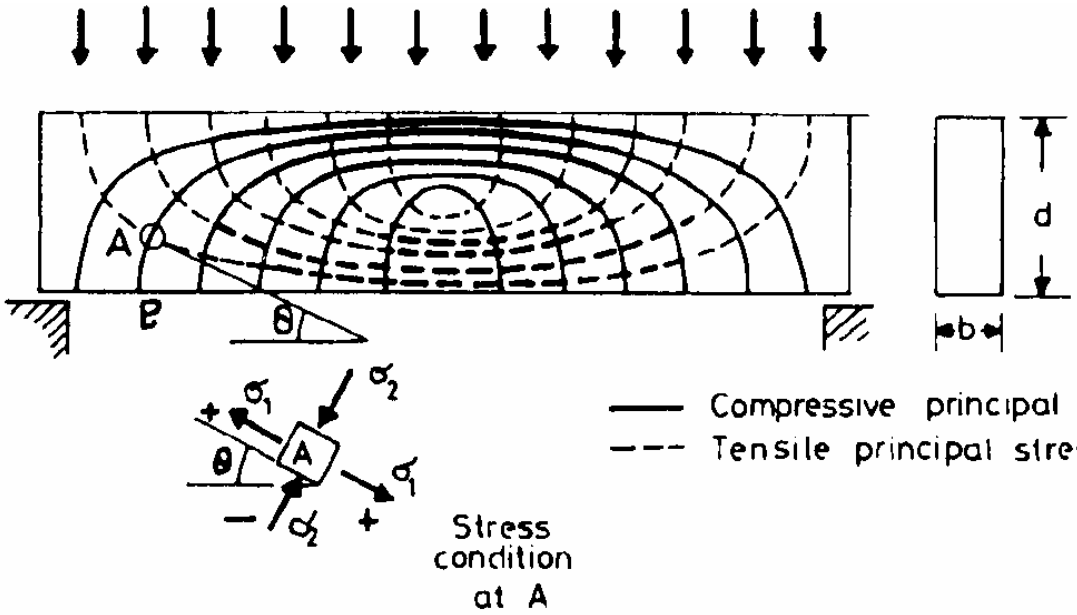
Stability and Ductility of Steel Frames

8.1. Ultimate Load Behaviour of Steel Framed Structures

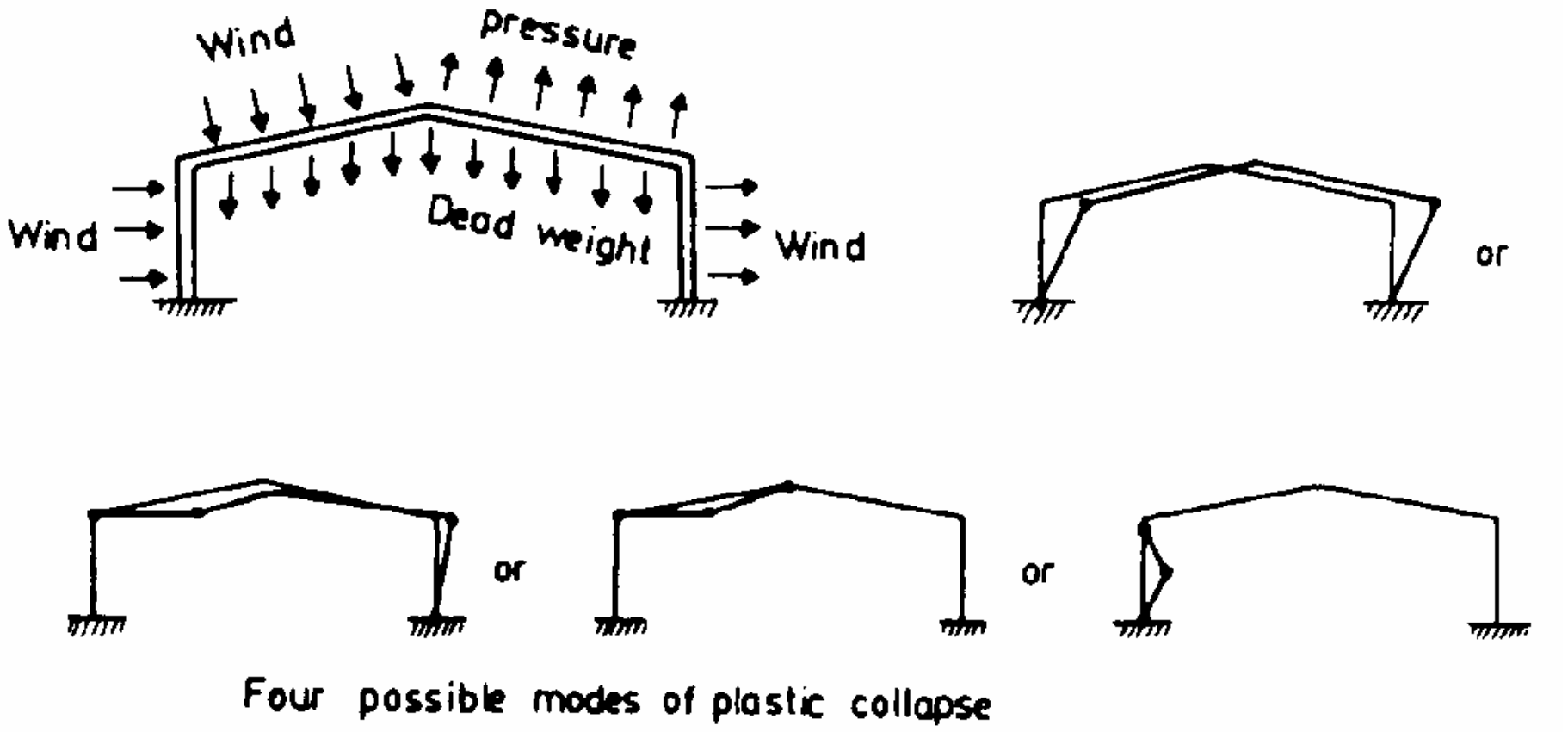
Possible mode of collapse of masonry arch



Arch collapses as a mechanism when hinges form at B, A, C and D



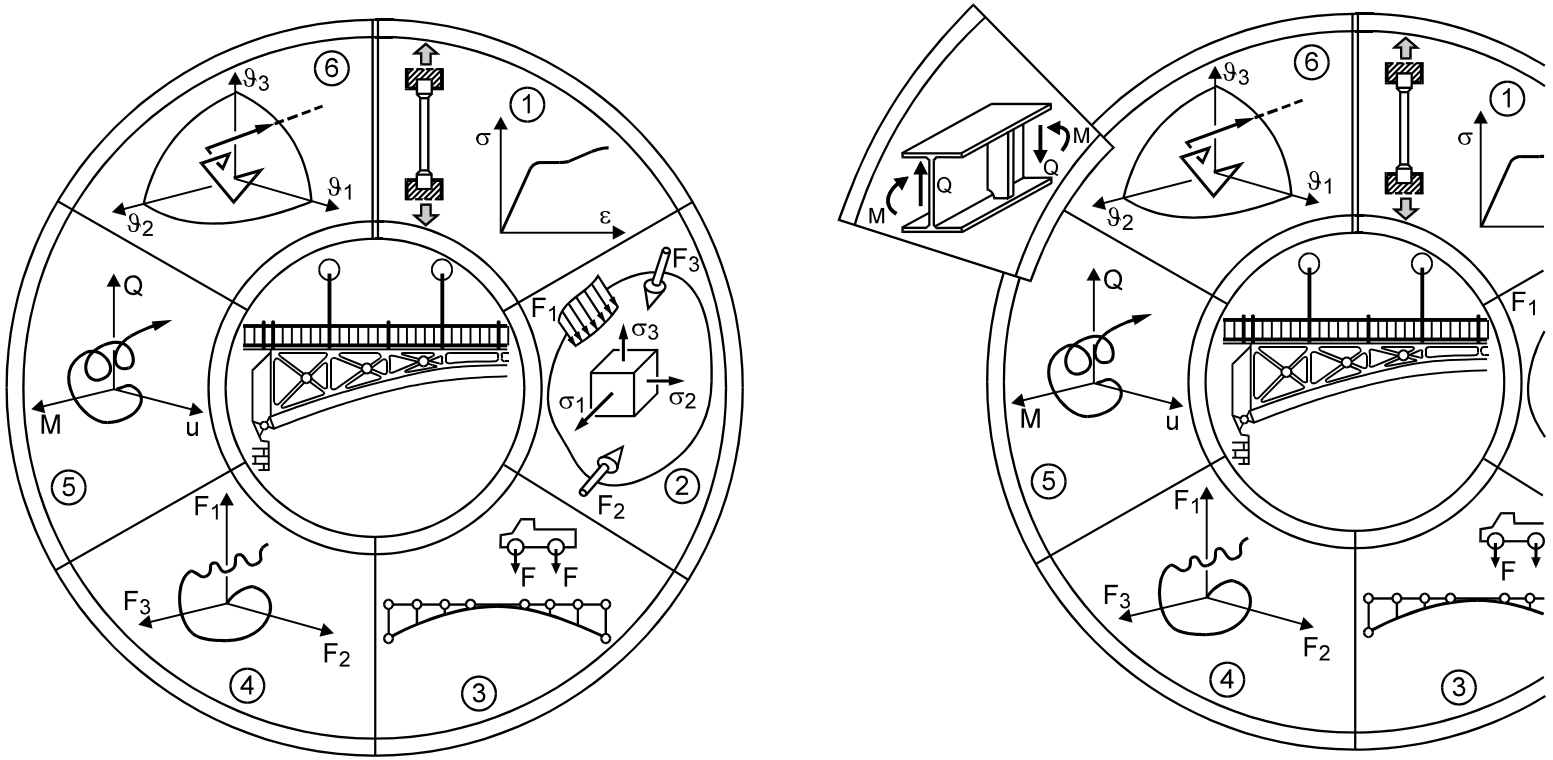
Principal stresses in a beam carrying a uniformly distributed load



Four possible modes of collapse of a single-storey frame

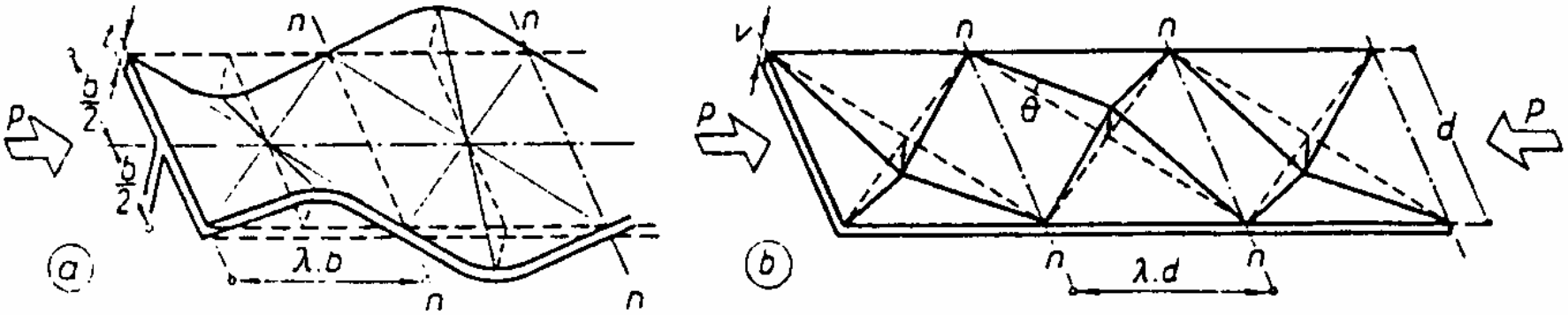
8.2. The Model of “Interactive Plastic Hinge”

8.2.1 Difficulties in Predicting Failure



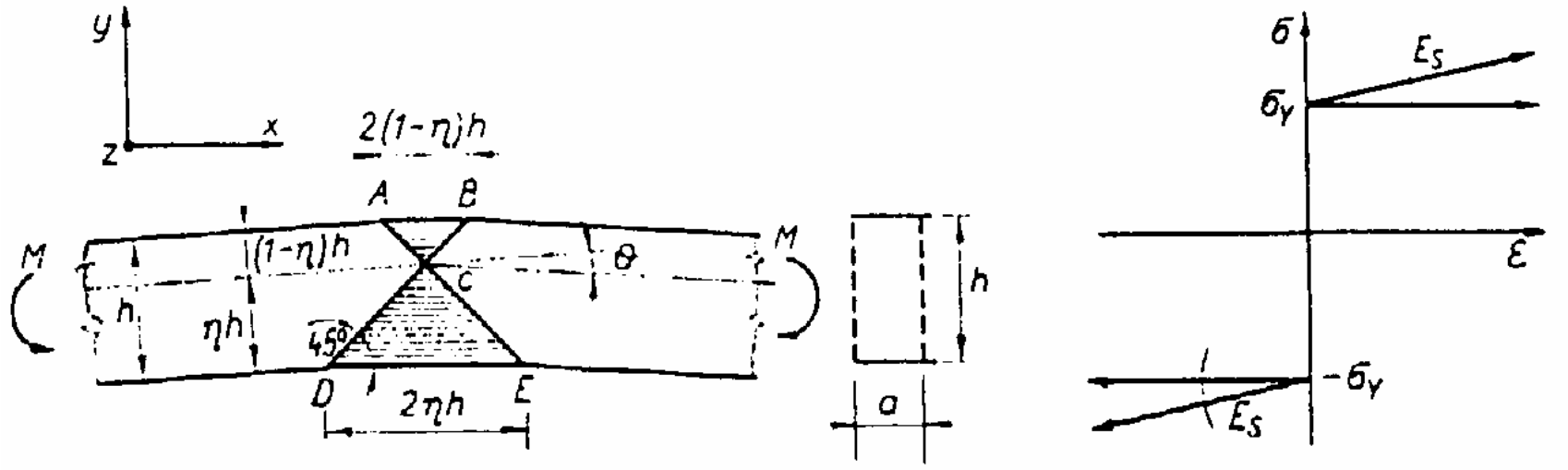
8.2.2 Preliminary Researches

[Haaijer, 1957] [Lay, 1965] [Kato, 1965]



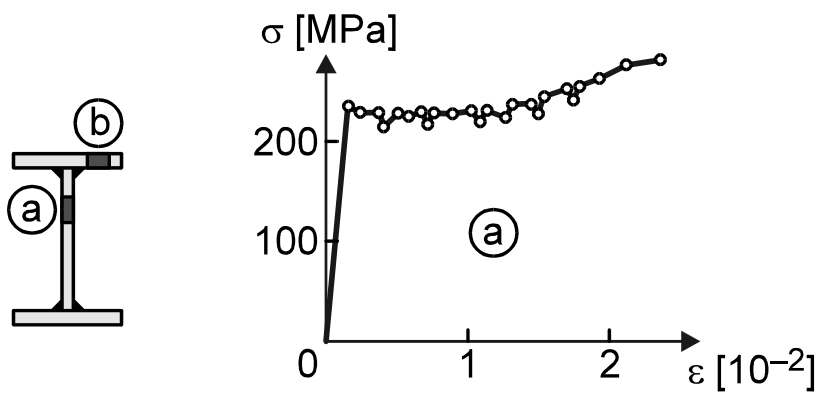
8.2.3 Basic Method and a Simple Example

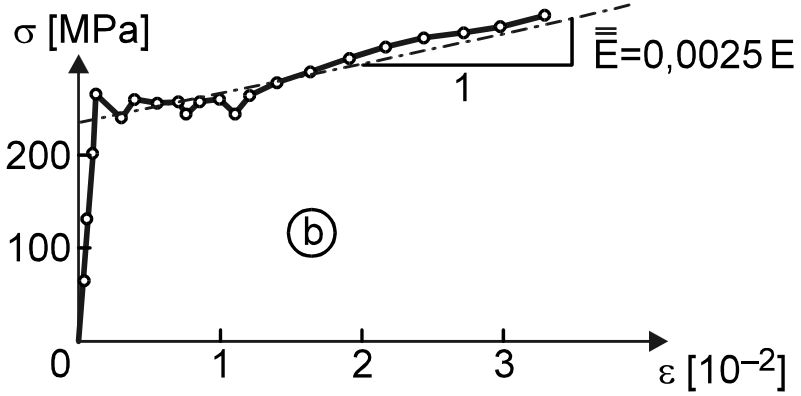
[Alexander, 1960] [Pugesley, Macaulay, 1960] [Climenhaga, Johnson, 1972]

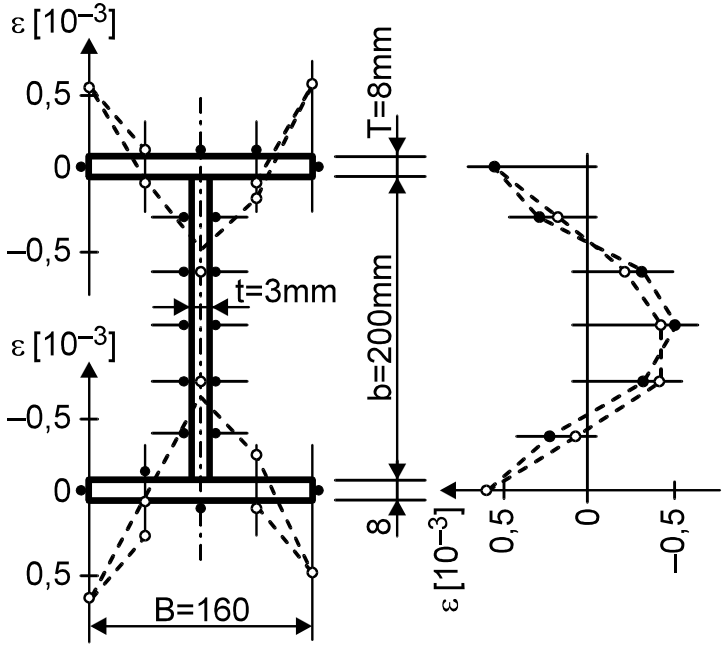


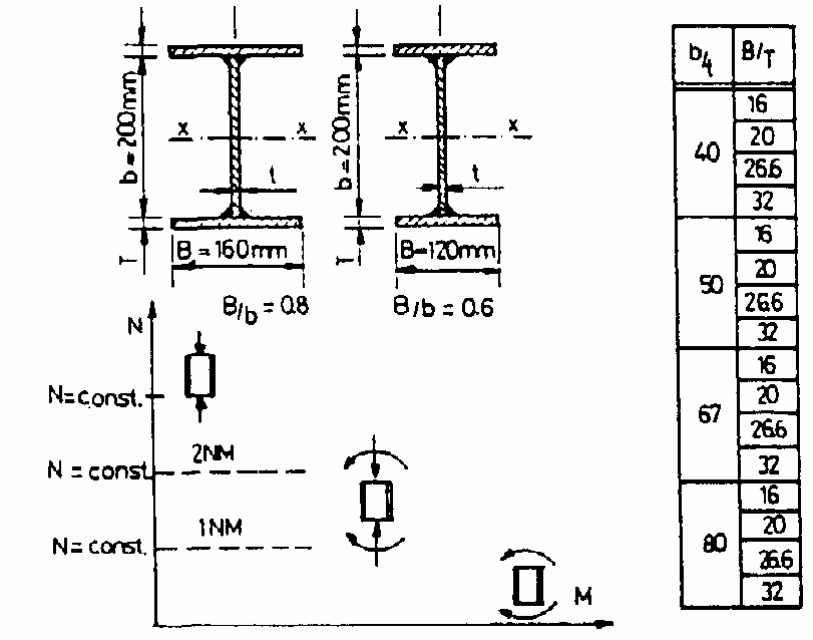
8.2.4 Yield Mechanism of Structural Members [Iványi, 1983]

8.2.4.1 Yield Mechanism Forms Based on Experimental Results



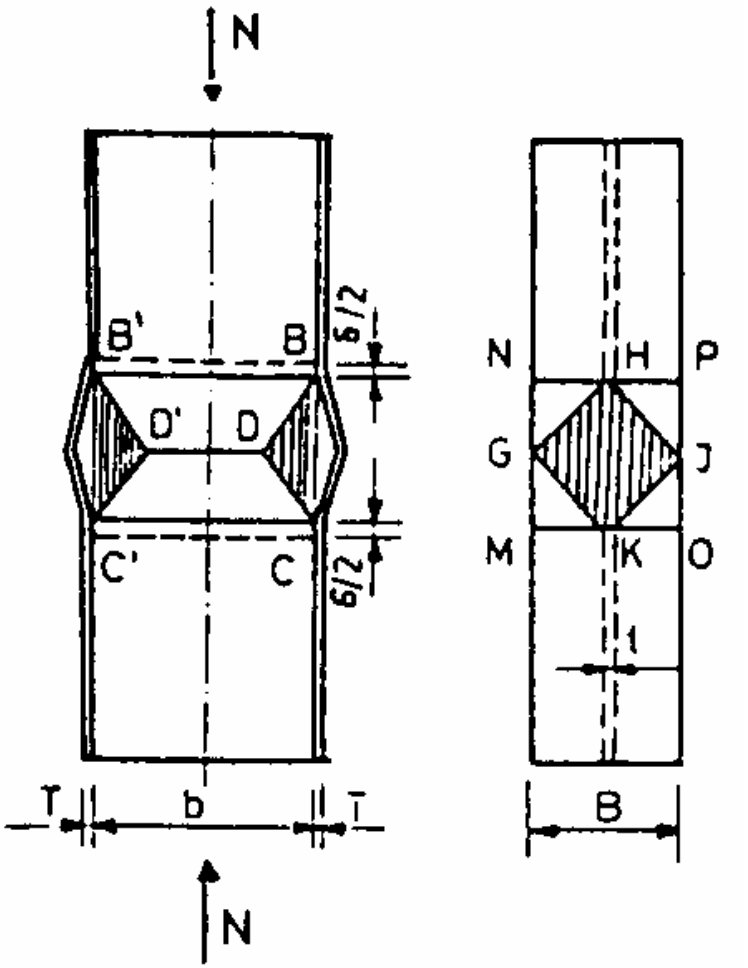




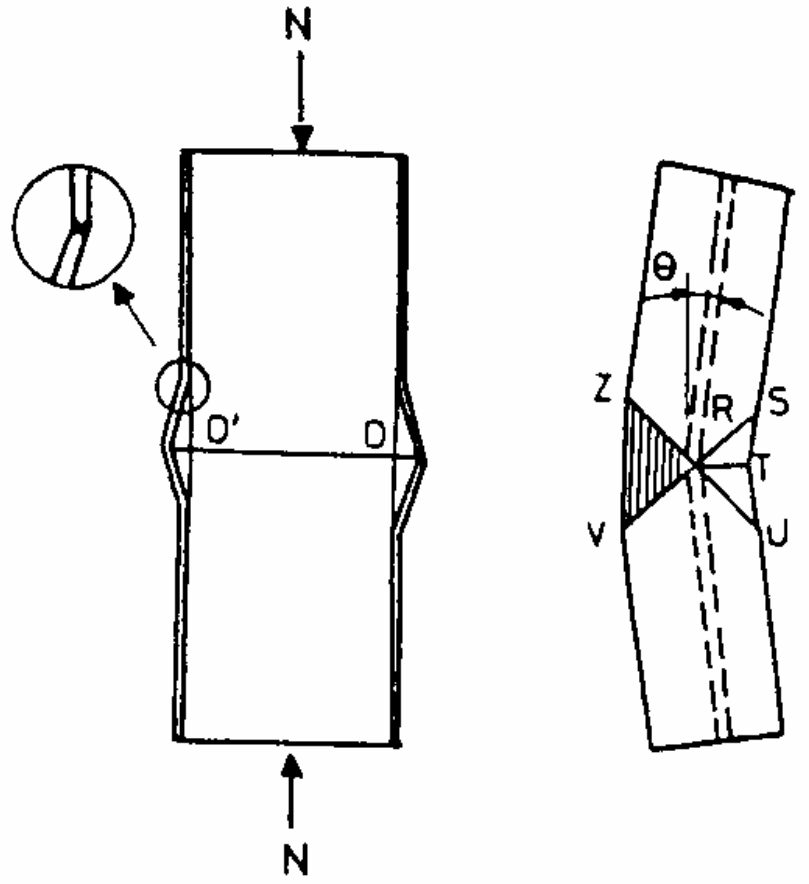


b_4	B/T
40	16
	20
	26.6
	32
50	16
	20
	26.6
	32
67	16
	20
	26.6
	32
80	16
	20
	26.6
	32

(a) Yield mechanism of compression members

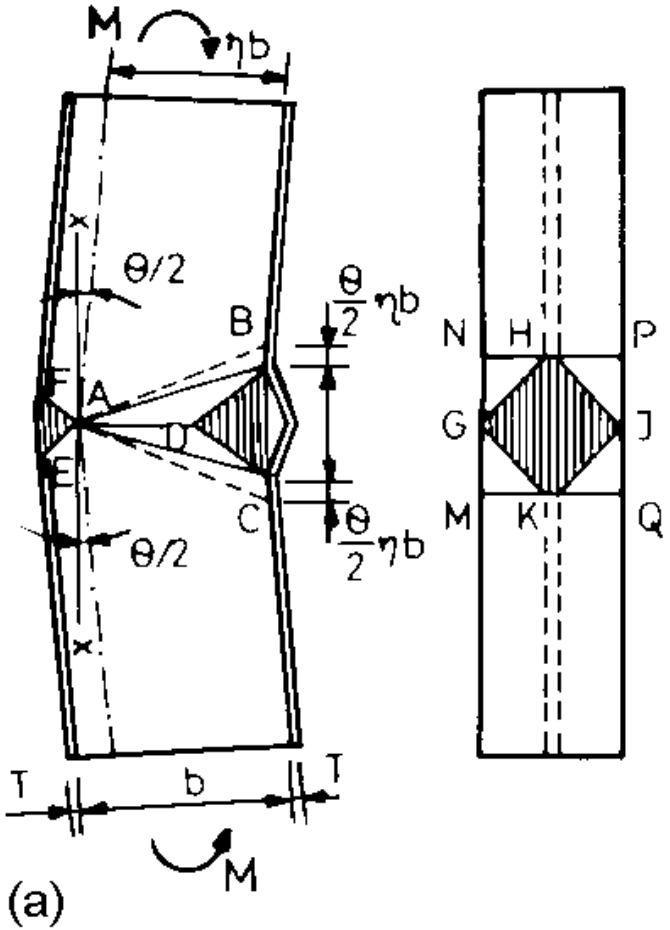


Planar yield mechanism

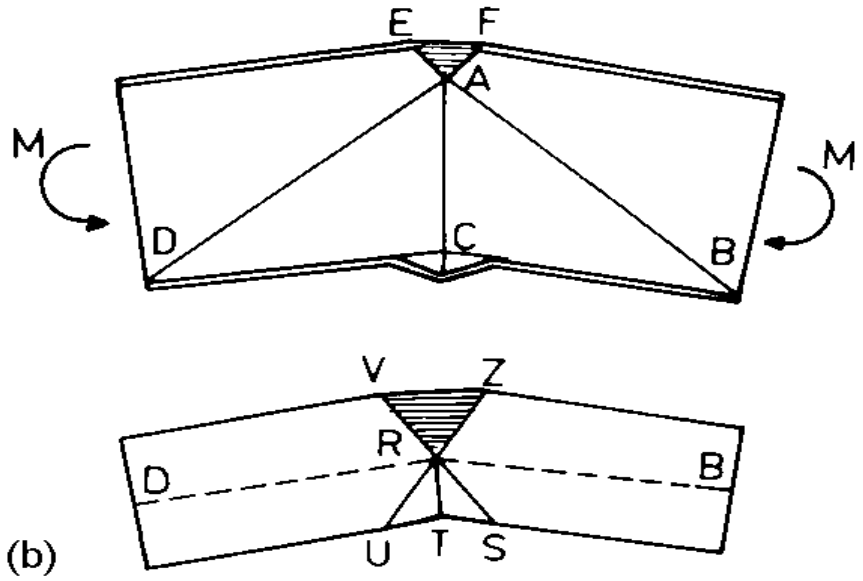


Spatial yield mechanis

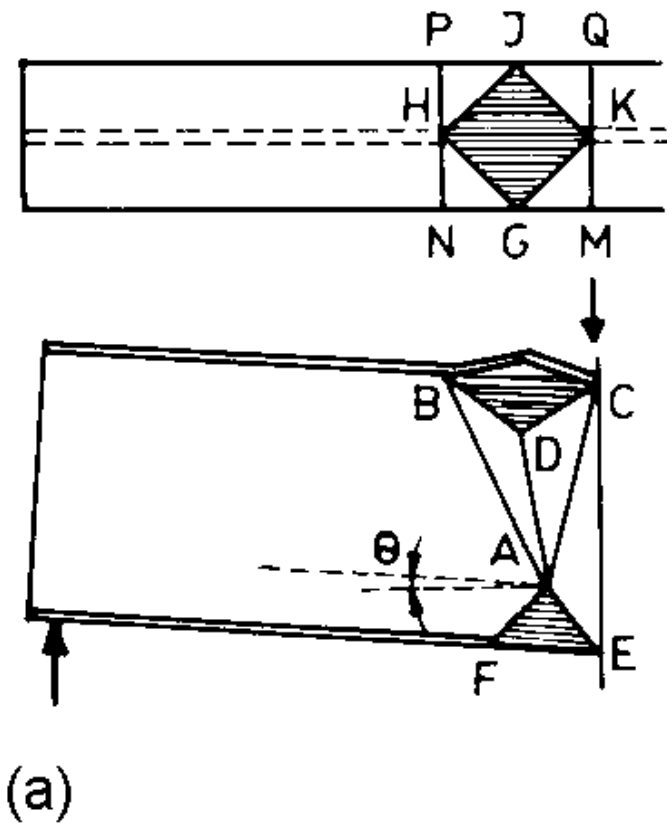
(b) Yield mechanism of bent members



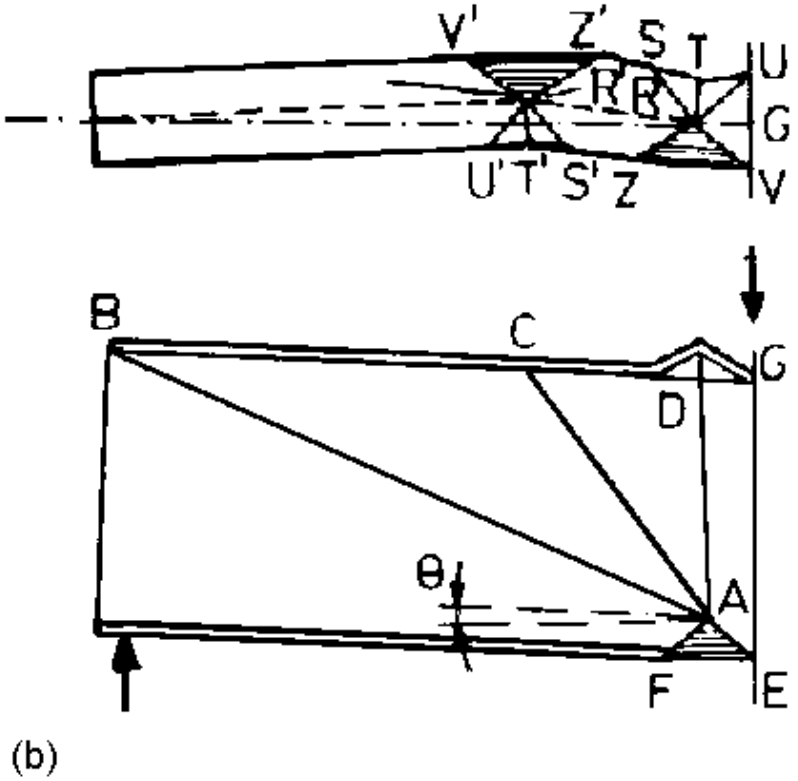
Constant bending moment –
Planar yield mechanism



Constant bending moment –
Spatial yield mechanism



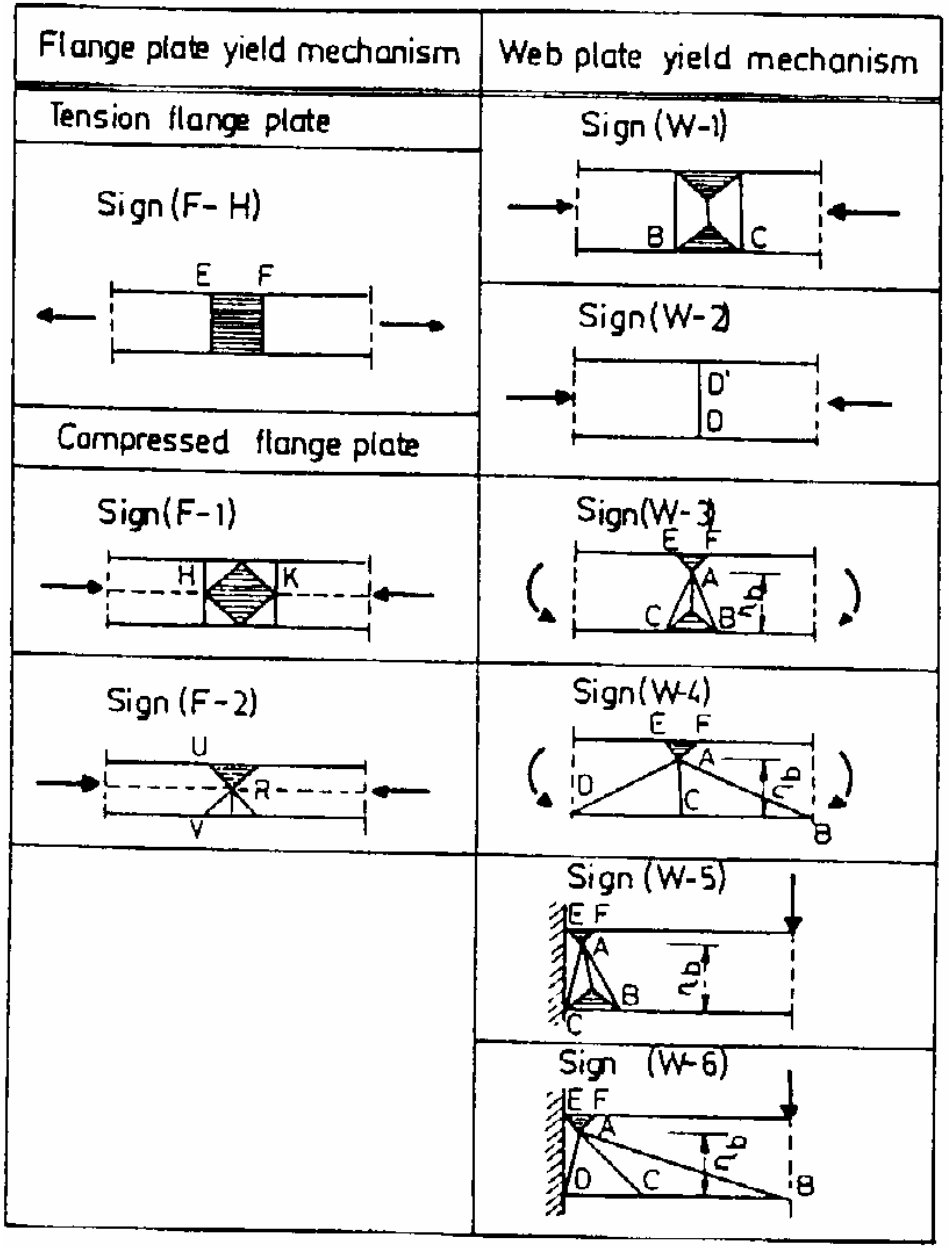
Varying bending moment –
Planar yield mechanism



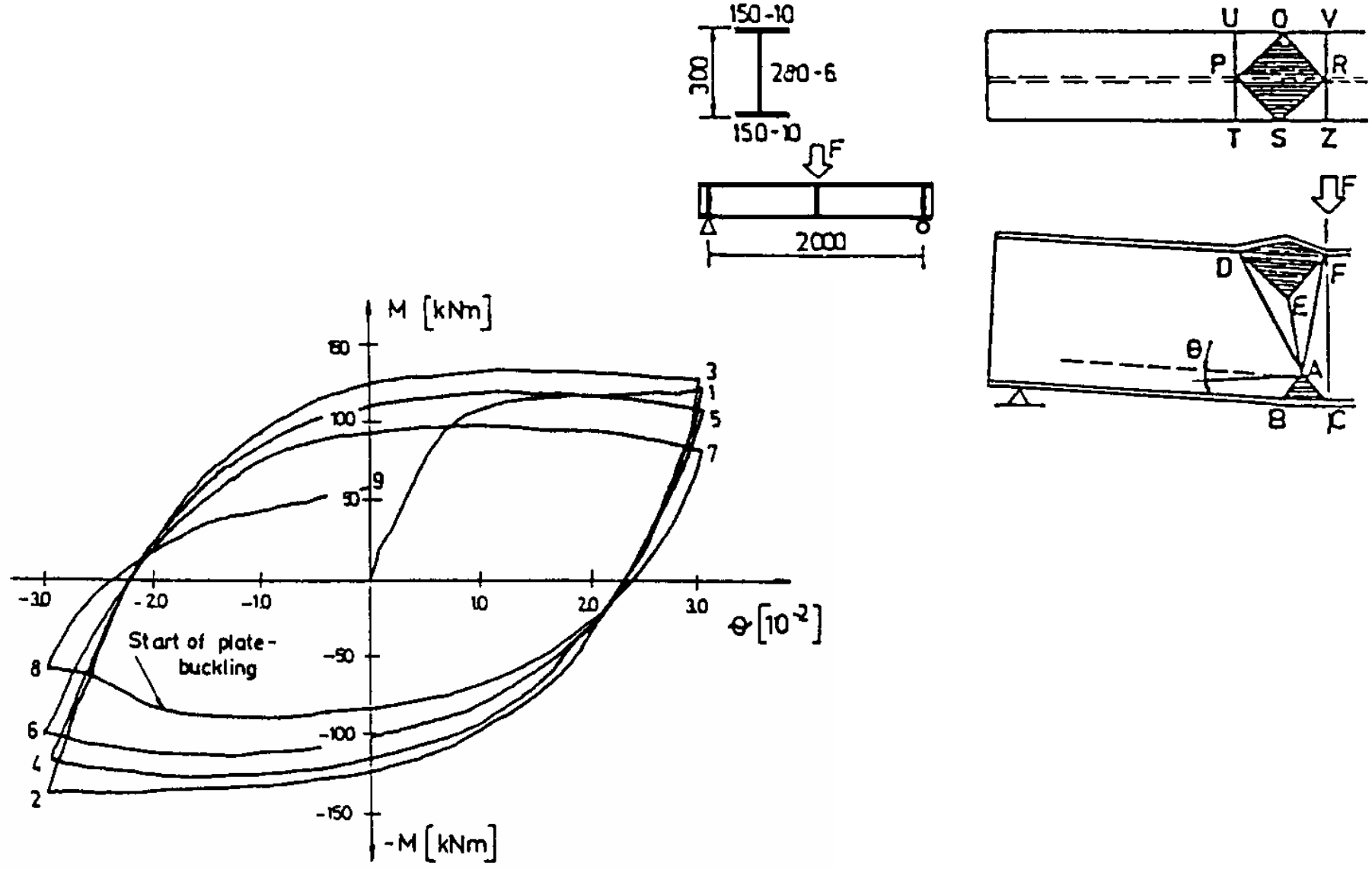
Varying bending moment –
Spatial yield mechanism

8.2.4.2 Yield Mechanism of the Component Plates of an I-section Member

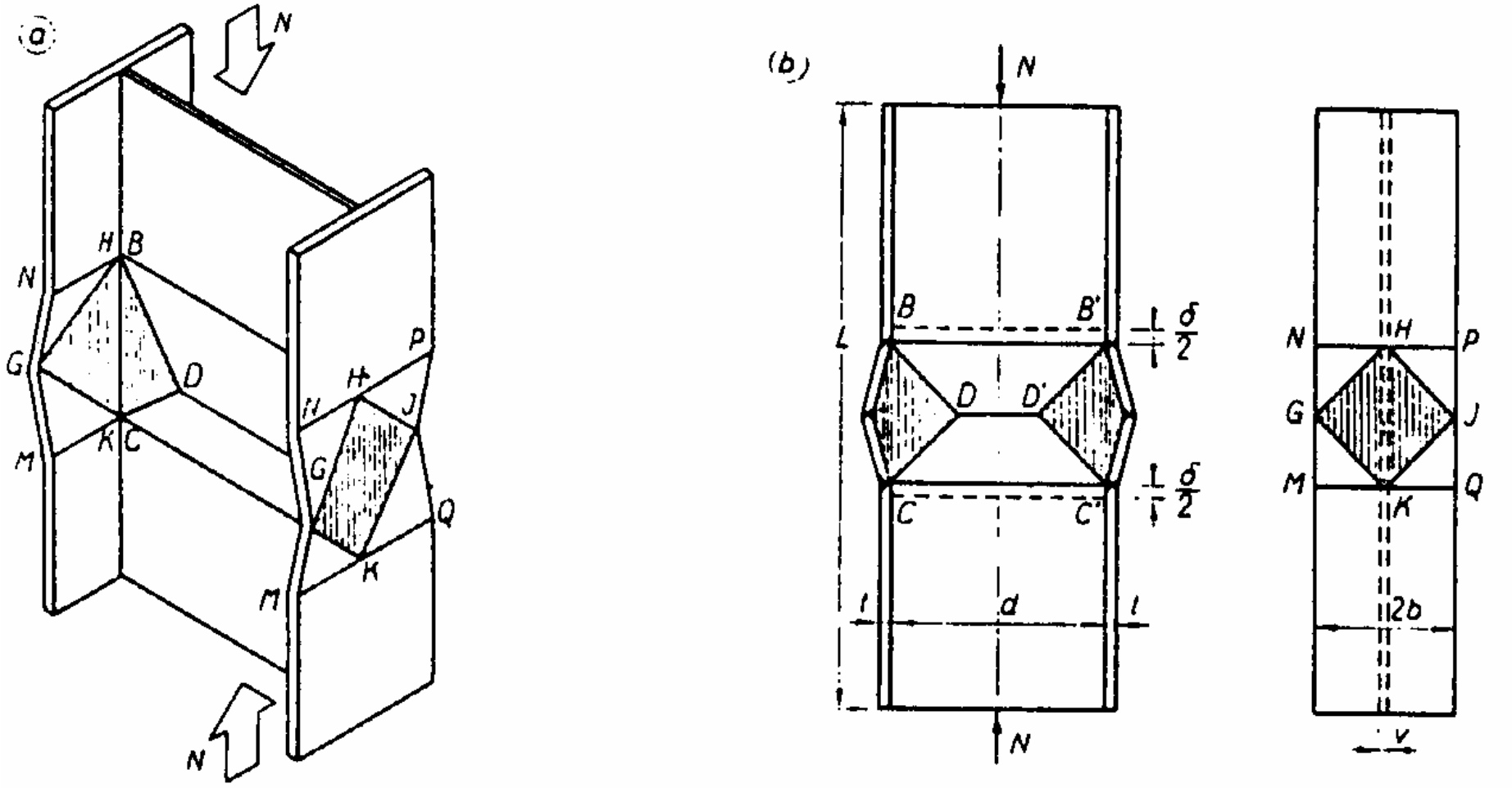
Flange plate yield mechanism	Web plate yield mechanism
Tension flange plate	Sign (W-1)
Sign (F- H)	Sign (W-2)
Compressed flange plate	Sign (W-3)
Sign (F-1)	Sign (W-4)
Sign (F-2)	Sign (W-5)
	Sign (W-6)



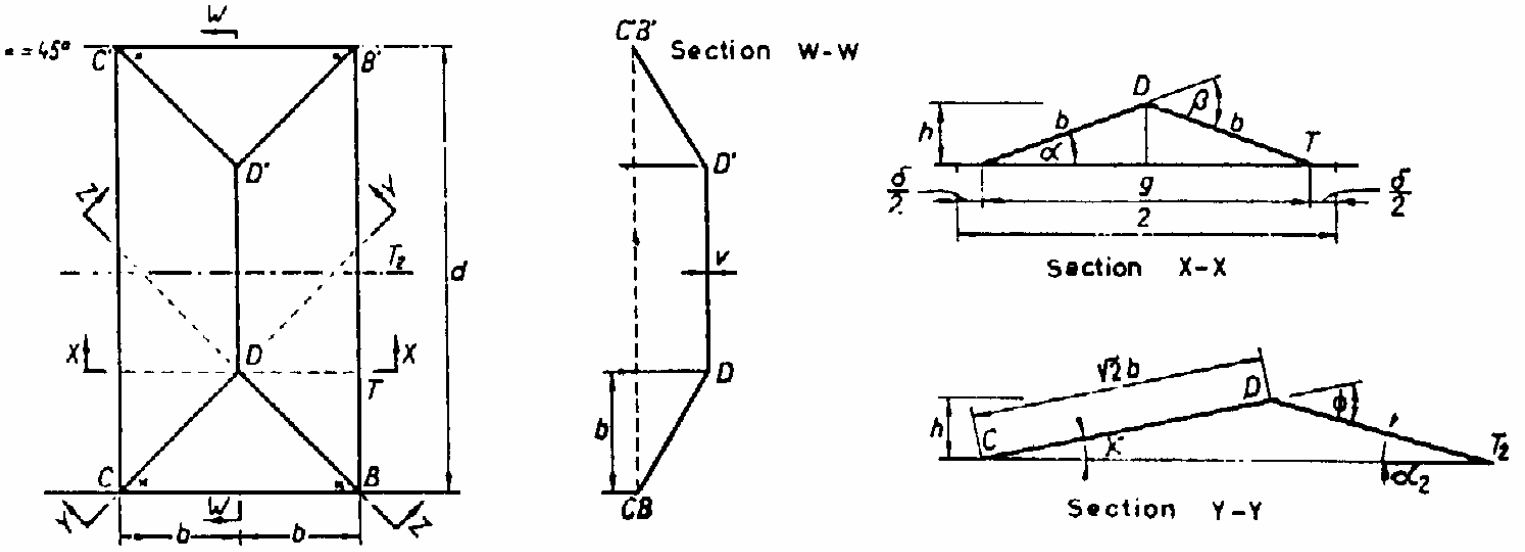
8.2.4.3 "Joining" the Yield Mechanisms of the Component Plates



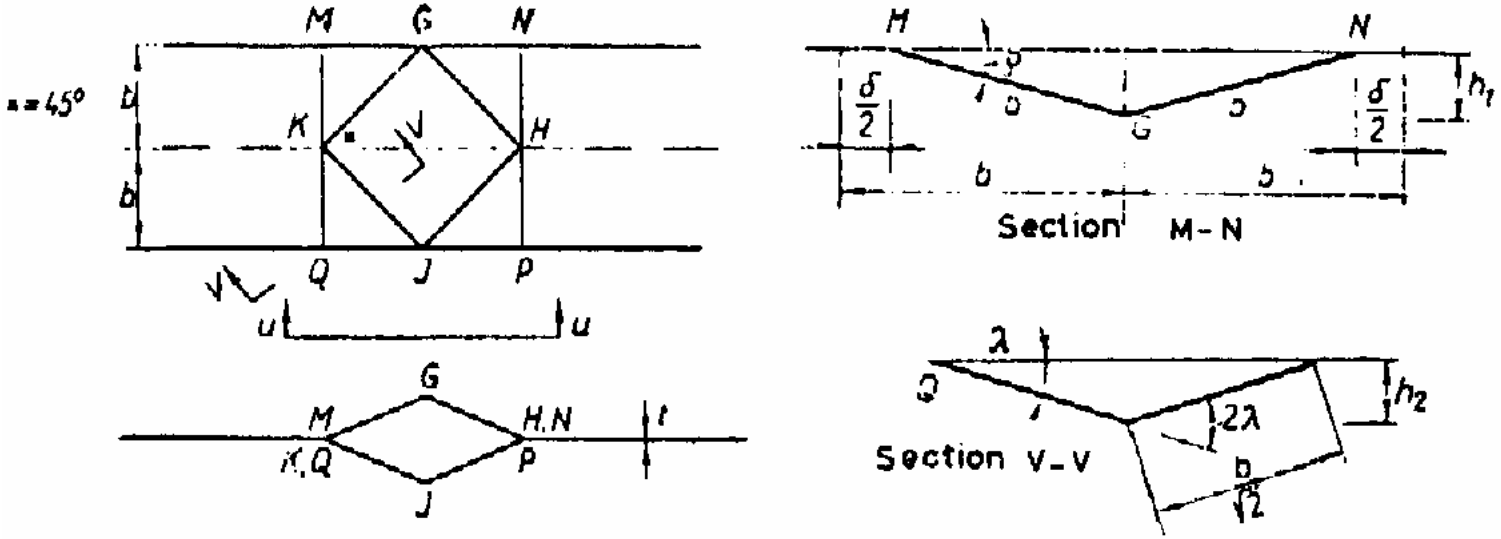
8.2.4.4 Yield Mechanism Curves of Compression Members



Web plate:

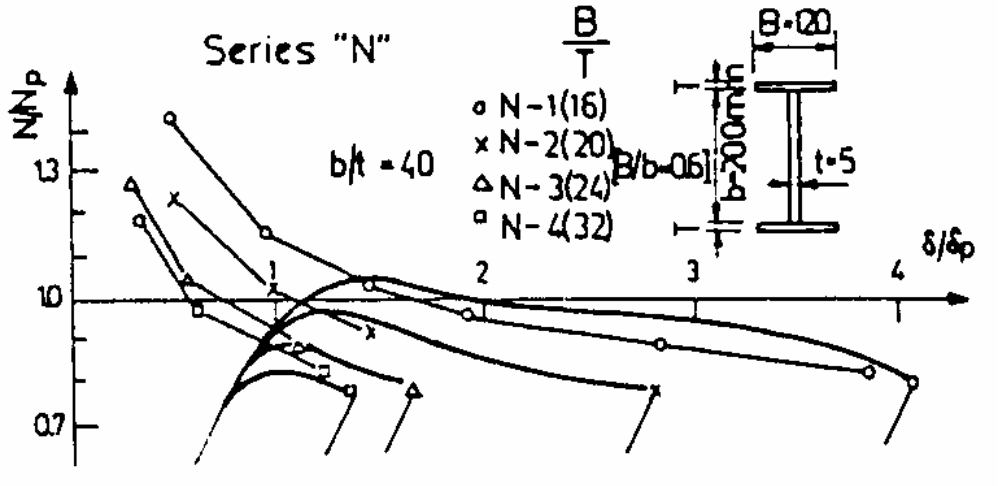


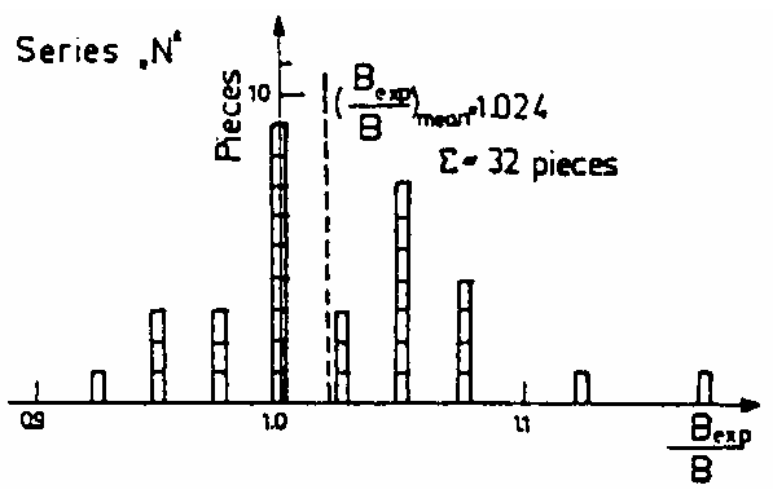
Flange plate:



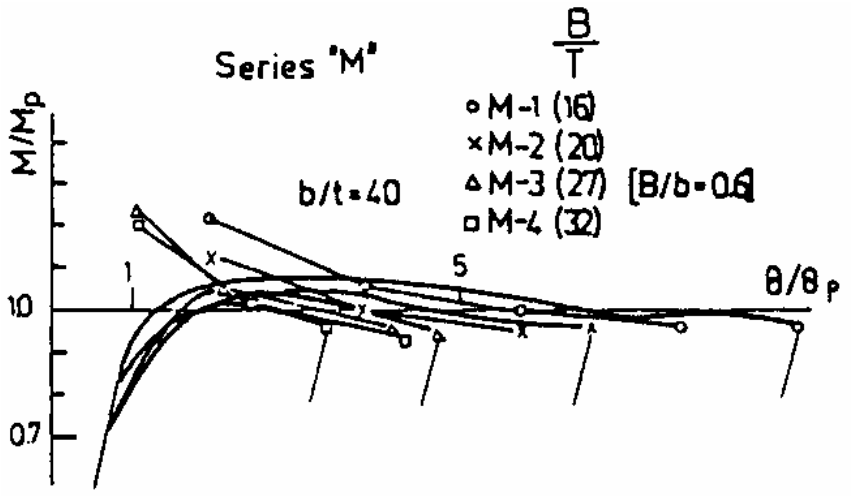
8.2.5 Comparison of Experimental and Theoretical Results [Iványi, 1983]

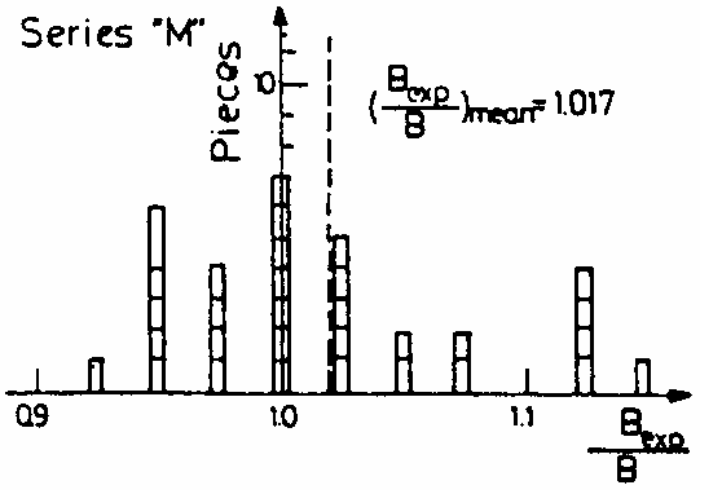
8.2.5.1 Investigation of the Results of Compression Members





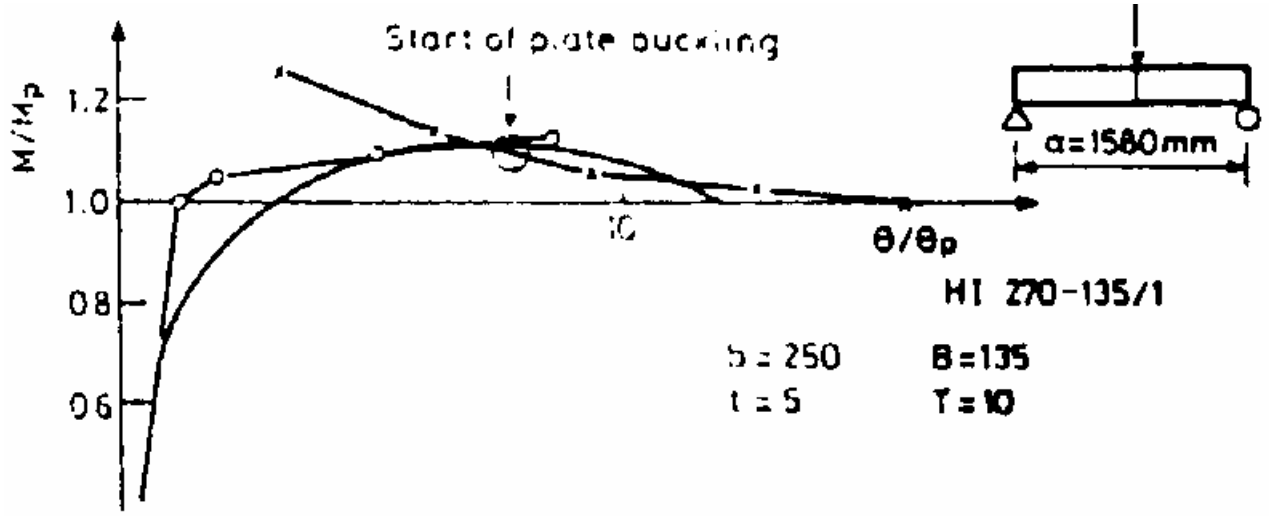
8.2.5.2 Investigation of the Results of Bent Members



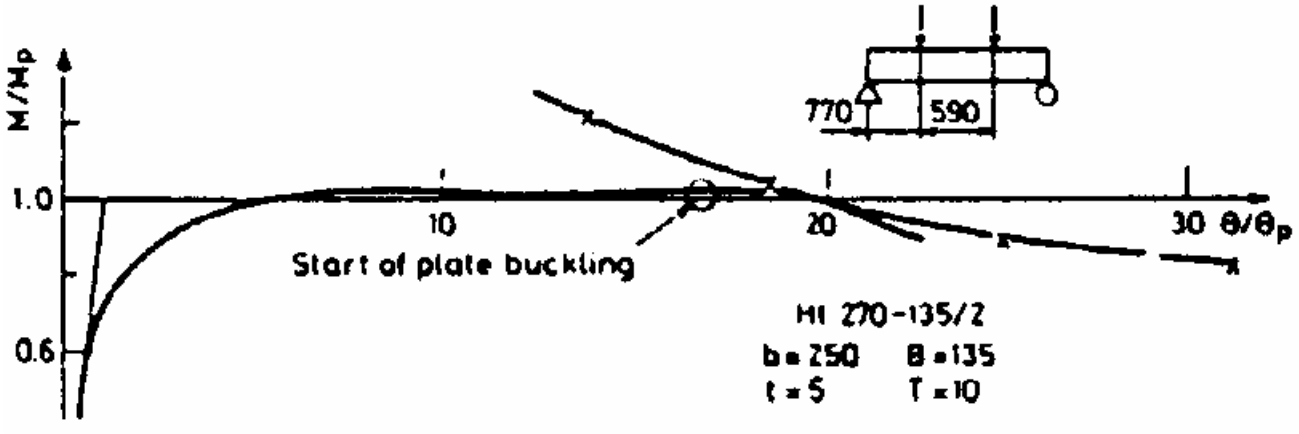


8.2.5.3 Investigation of the Results of Welded I-section Beams

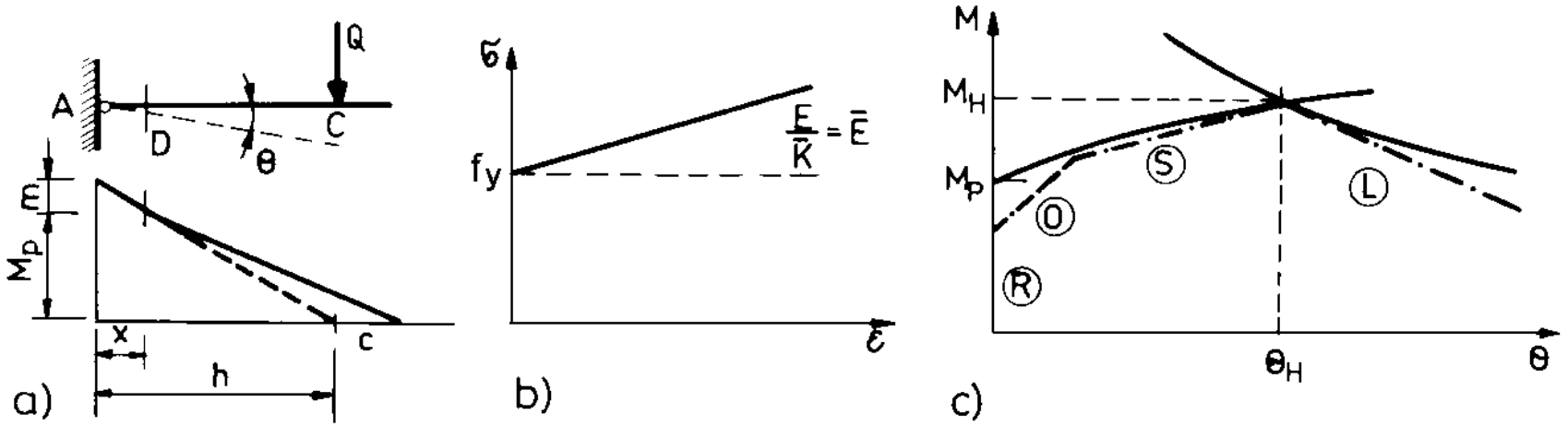
Varying bending moment



Constant bending moment



8.2.6 Model of the Interactive Hinge [Iványi, 1983]

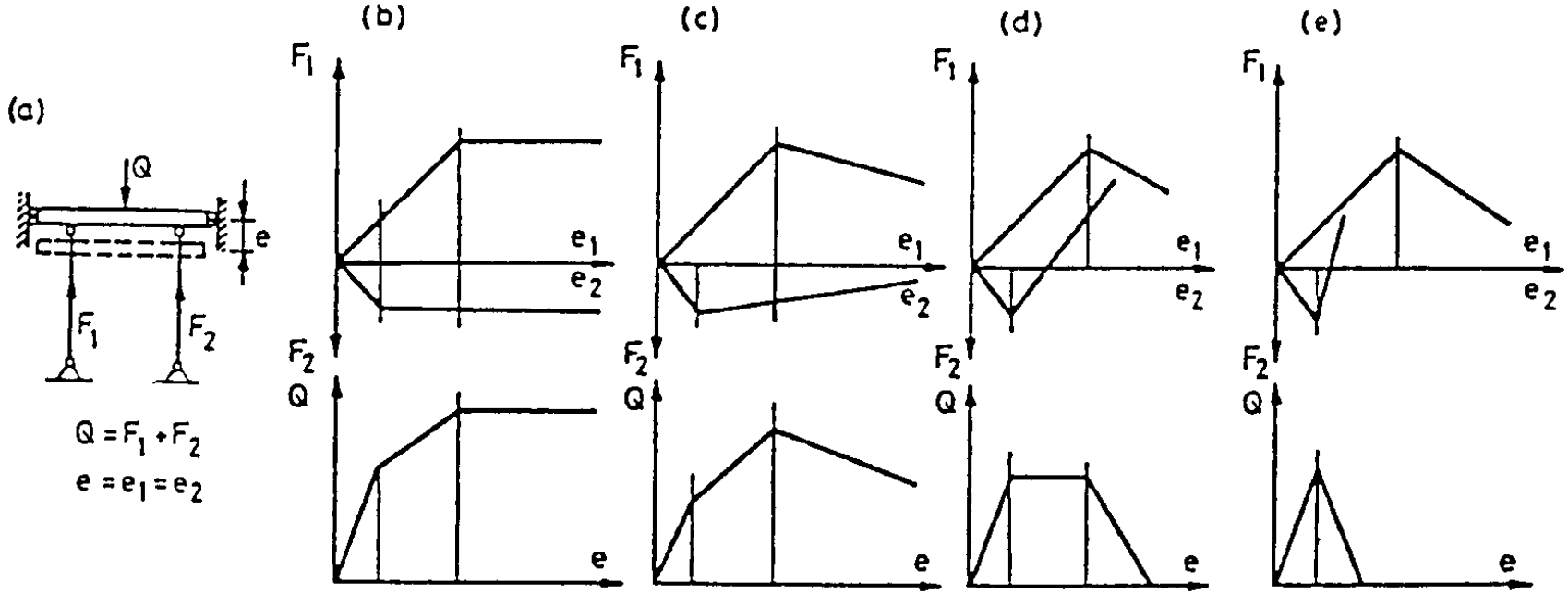


8.3. Prediction of Ultimate Load of Steel Frames

8.3.1 Introduction [Kazinczy, 1914]]

8.3.2 Effect of Local Instability

[Thürlimann, 1960] [Halász, 1976] [Drucker, 1951] [Maier, 1961] [Maier, Drucker, 1966]

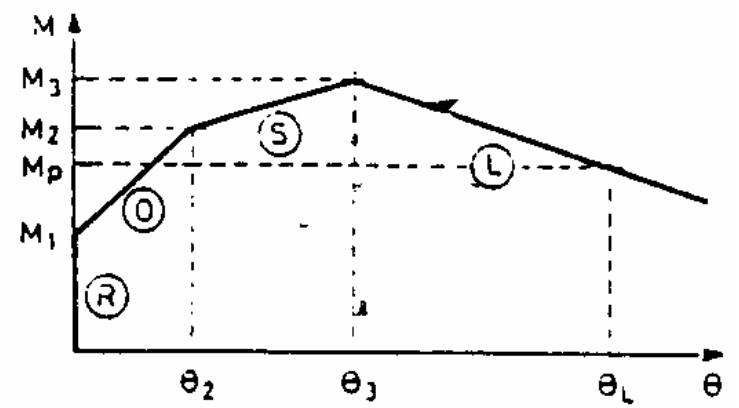


8.3.3 Computer Programs for Steel Frames

8.3.3.1 Analysis of Steel Frames with Conditional Joints

[Tassi, Rózsa. 1958] [Szabó, Roller, 1971] [Kaliszky, 1978] [Kurutz, 1975]

– Interactive hinge

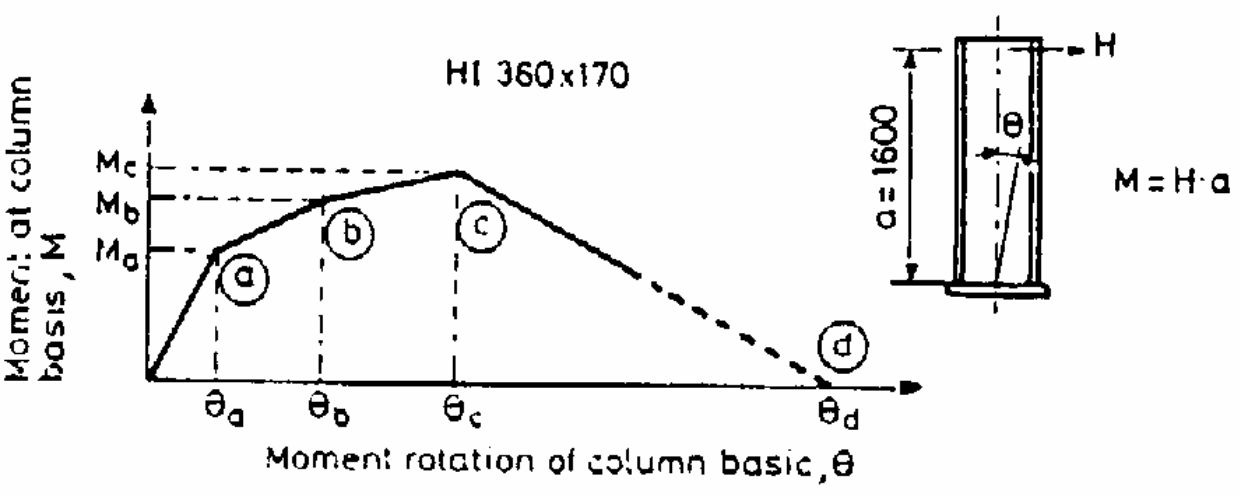


Rotation rigidity of the "interactive hinge"

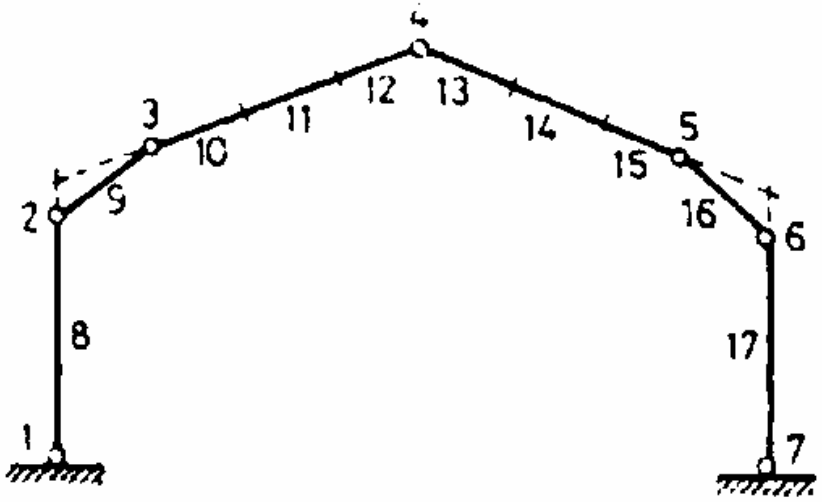
$$c = \frac{\Delta M}{\Delta \theta}$$

$$c_R = \infty \qquad c_S = \frac{M_3 - M_2}{\theta_3 - \theta_2}$$

$$c_O = \frac{M_2 - M_1}{\theta_2} \qquad c_L = -\frac{M_3 - M_p}{\theta_L - \theta_3}$$



– Model of planar frame structures



"Interactive hinge" : 1-7 (one degree of freedom)

"Elastic members" : 8-17 (three degrees of freedom)

Number of degrees of freedom : 37

$$\mathbf{G}^* \cdot \mathbf{s} + \mathbf{q} = 0$$

$$\mathbf{G} \cdot \mathbf{u} + \mathbf{F} \cdot \mathbf{s} + \mathbf{t} = 0$$

where:

- $\mathbf{G}$ — geometric matrix
- $\mathbf{s}$ — vector of load actions
- $\mathbf{q}$ — load vector
- $\mathbf{u}$ — displacement vector
- $\mathbf{t}$ — vector of "kinematic load"
- $\mathbf{F}$ — flexibility matrix

– Changes of state with a uni-parameter load system taken into account

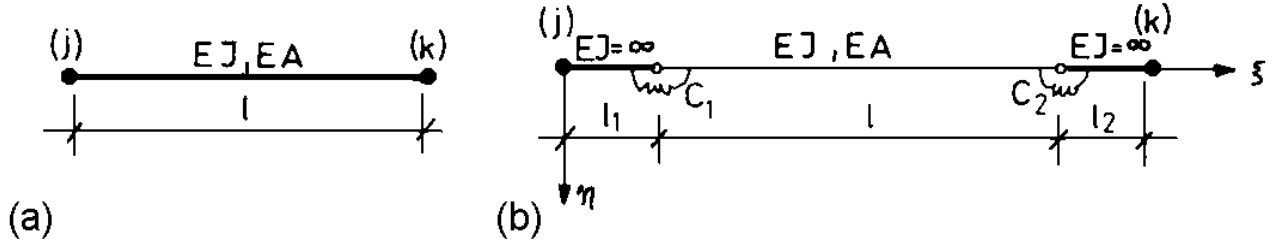
8.3.3.2 Analysis of Steel Frames with Global Bar Elements

[Iványi, 1983] [Baksay, Iványi, Papp, 1985]

– Fundamentals of bar system computation

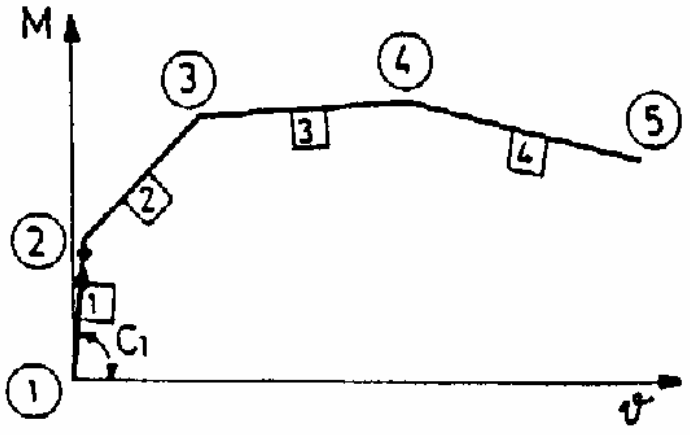
equilibrium equation system $\mathbf{K} \cdot \mathbf{u} = \mathbf{q} \longrightarrow \mathbf{u} = \mathbf{K}^{-1} \cdot \mathbf{q}$

– The applied bar element

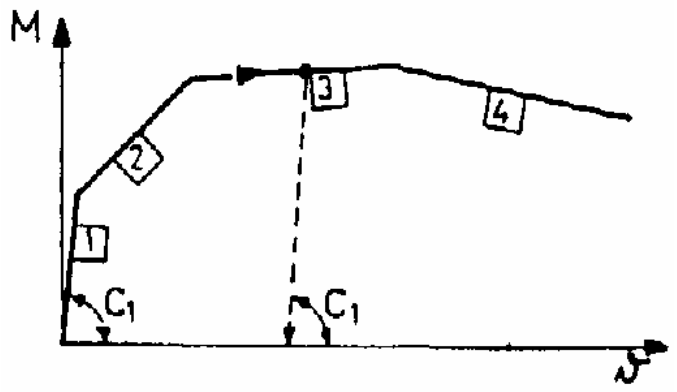


– Calculation of reaction forces of complex bars

– Spring characteristics

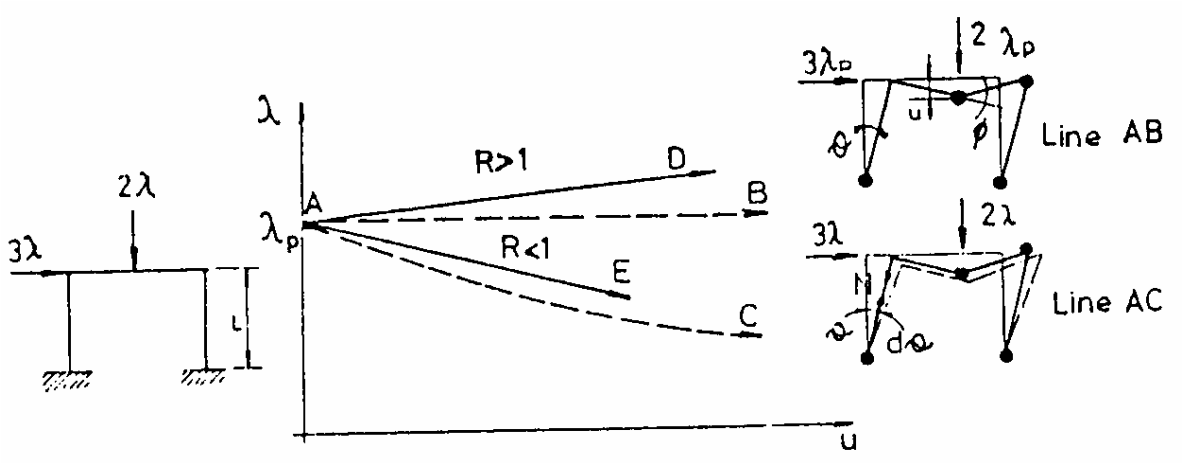


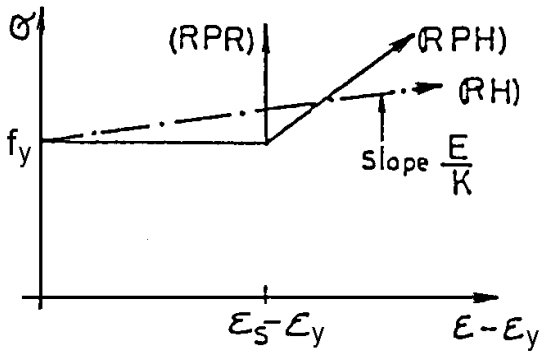
– Computation method



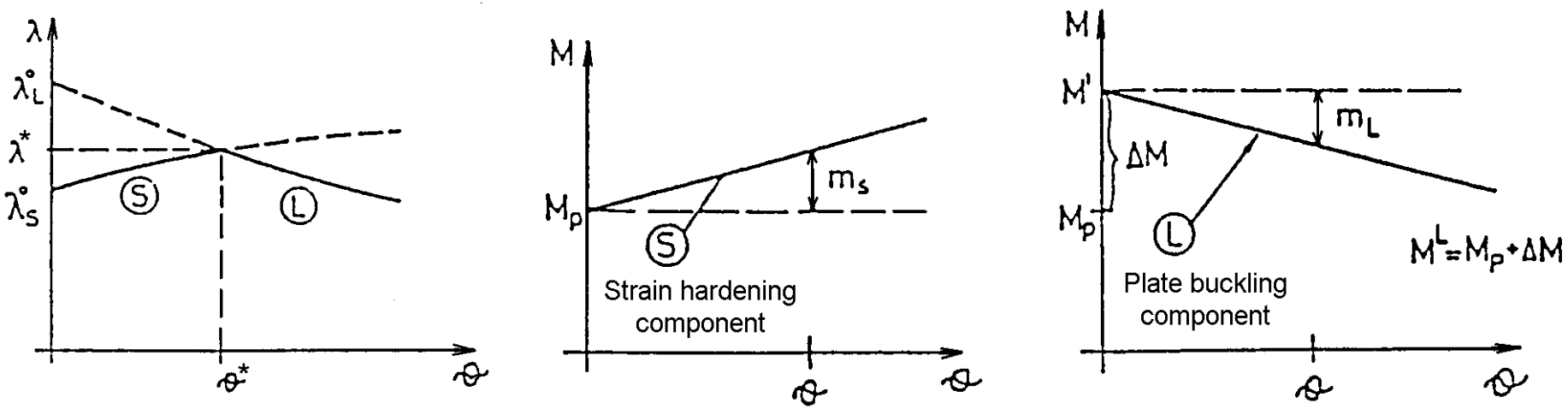
8.3.4 Simple Approximate Method

8.3.4.1 Mechanism Curve Method





8.3.4.2 Approximate Engineering Method to Take the Effect of Plate Buckling into Consideration

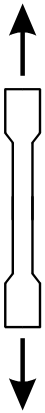


$$\lambda_{(S)}\left(\sum Qu + \sum NL\phi^2\right) = \sum M_p\theta + \sum m_S\theta \qquad \lambda_{(L)}\left(\sum Qu + \sum NL\phi^2\right) = \sum M'\theta - \sum m_L\theta$$

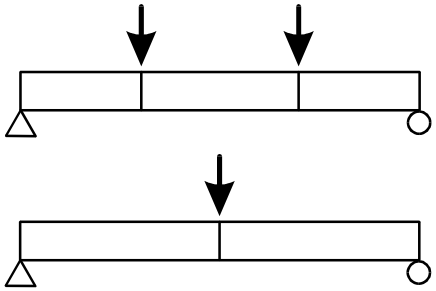
$$\lambda_{(S)} = \frac{\sum M_p\theta + \sum m_S\theta}{\left(\sum Qu + \sum NL\phi^2\right)} \qquad \lambda_{(L)} = \frac{\sum M'\theta - \sum m_L\theta}{\sum Qu + \sum NL\phi^2}$$

8.4. Evaluation of Load-Bearing Capacity of Steel Frames

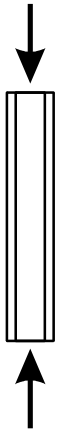
8.4.1 Test Program



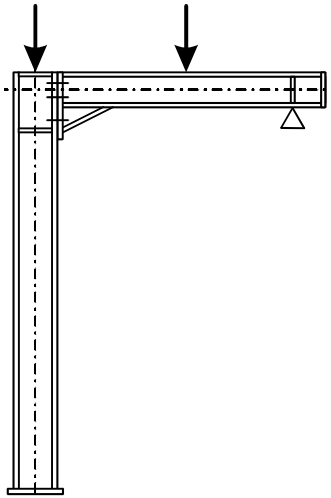
Tension specimens



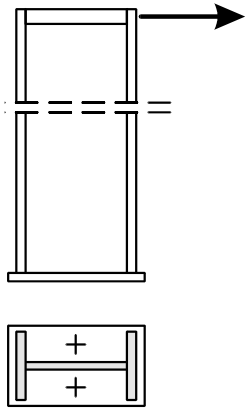
Beam specimens



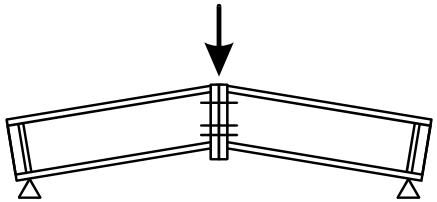
Axially compressed specimens

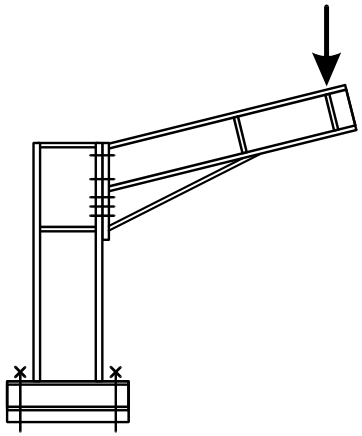


Sub-assemblies



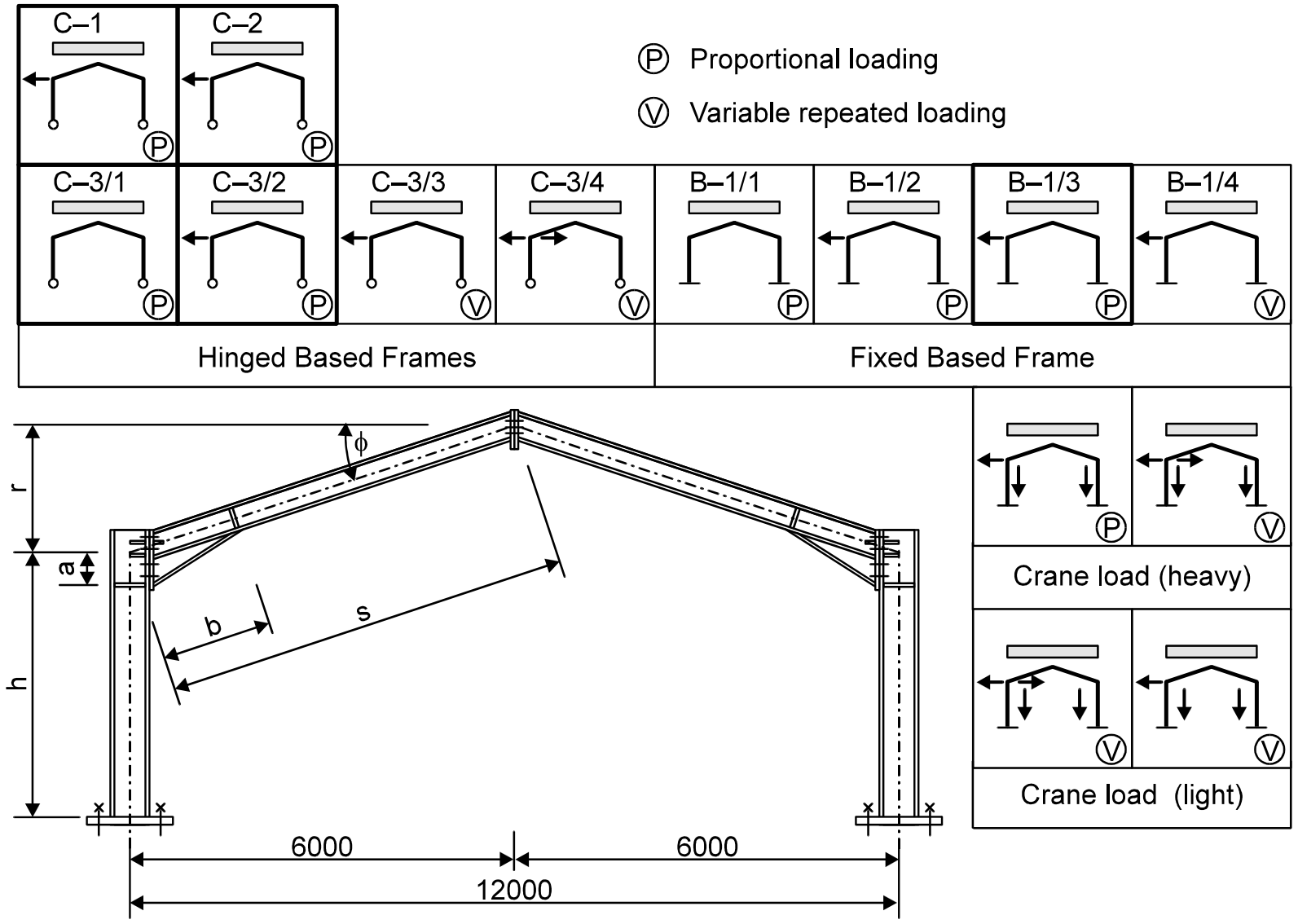
Column bases



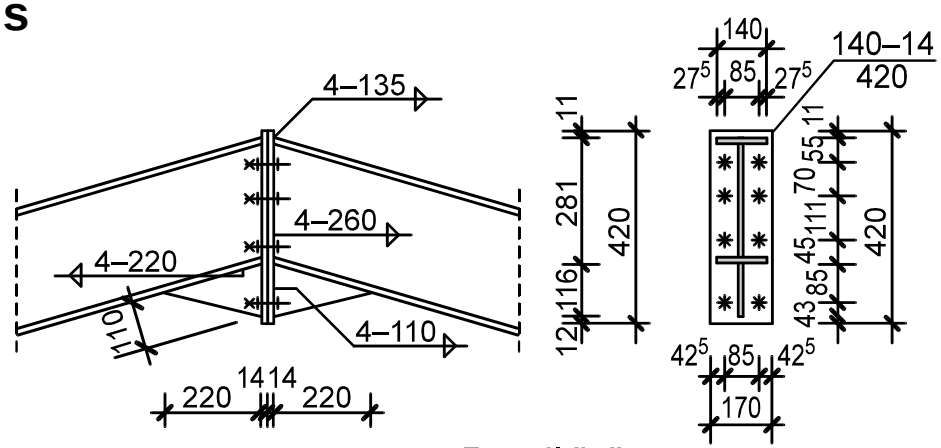


Frame connections with high-strength pre-stressed bolts

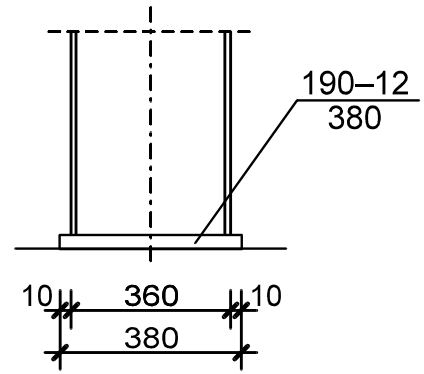
8.4.1.1 Full-Scale Tests of Frames [Iványi, 1983]



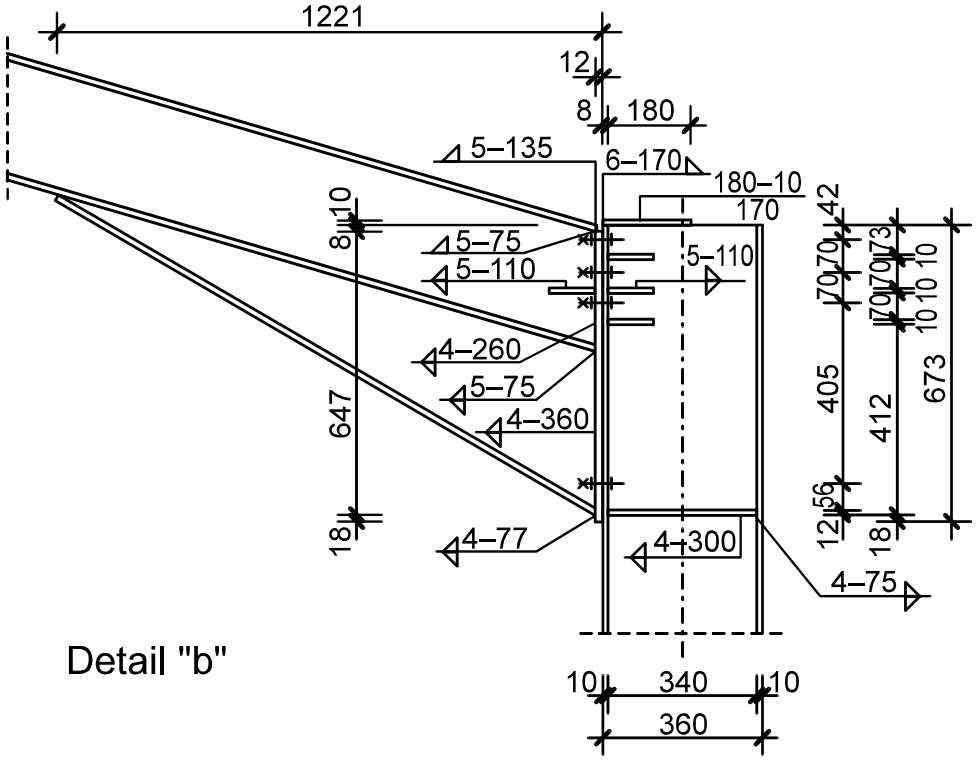
Details



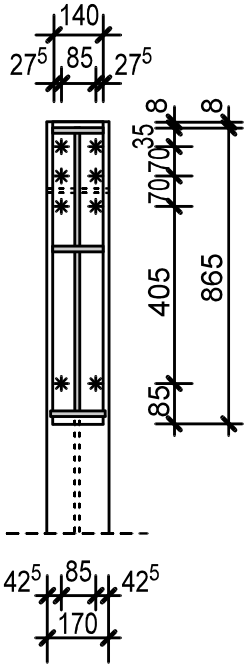
Detail "a"



Detail "c"

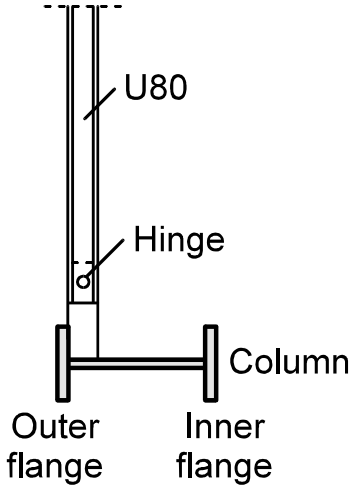


Detail "b"



Lateral supports

Type "a"



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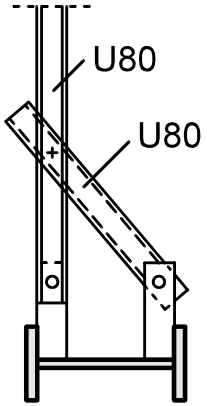
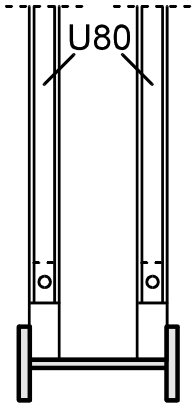
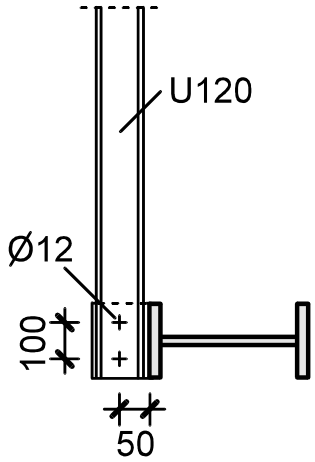


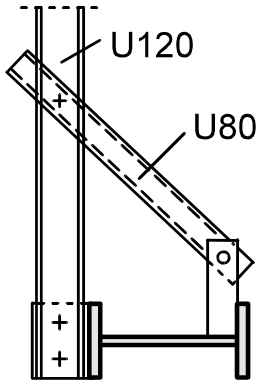
Type "c"



Type "d"



Type "e"



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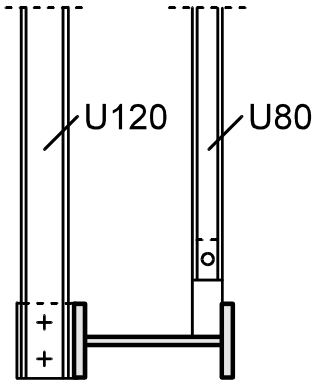
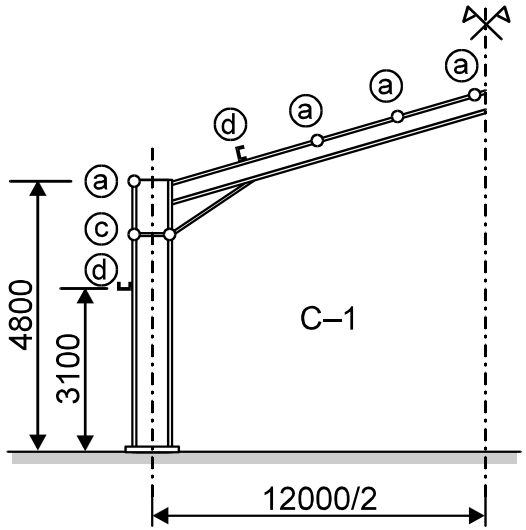
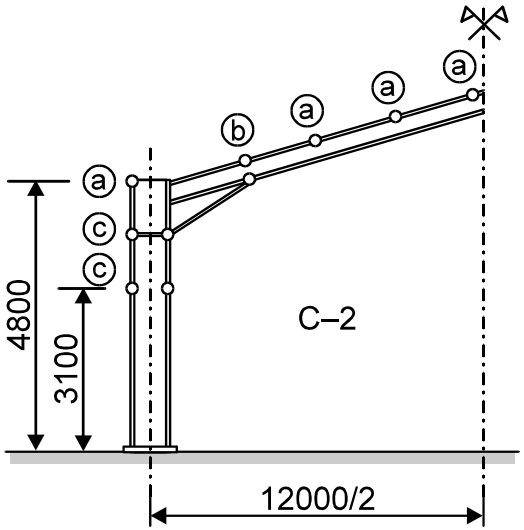
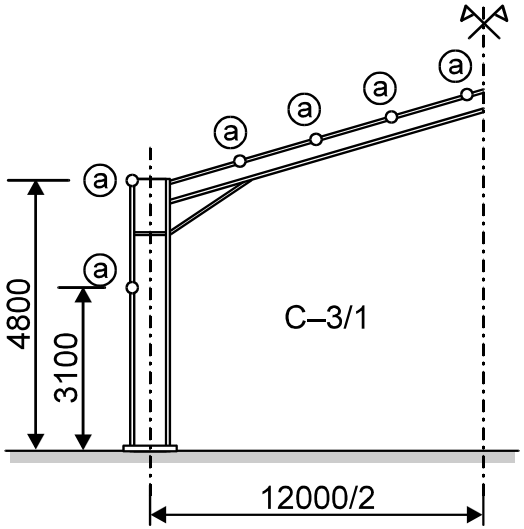
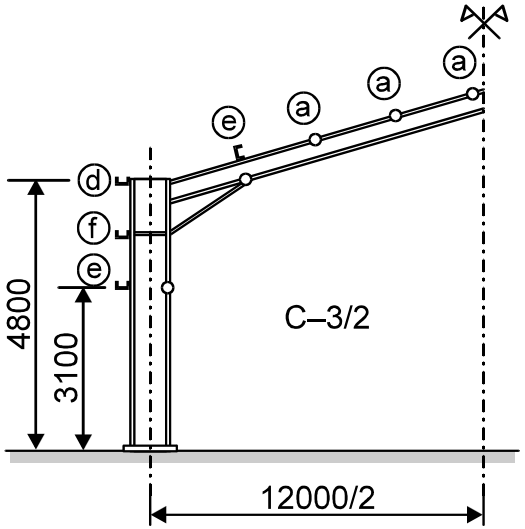


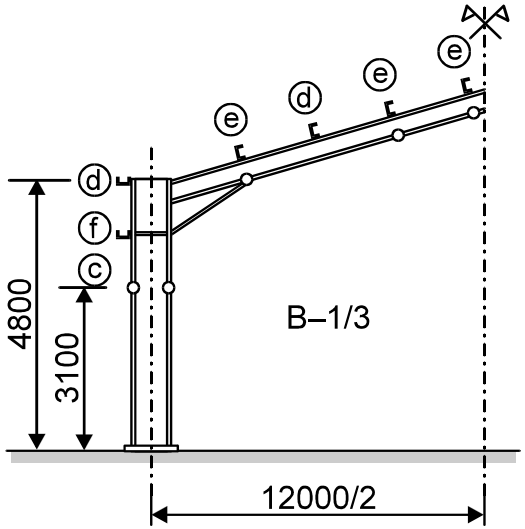
Positions of lateral supports



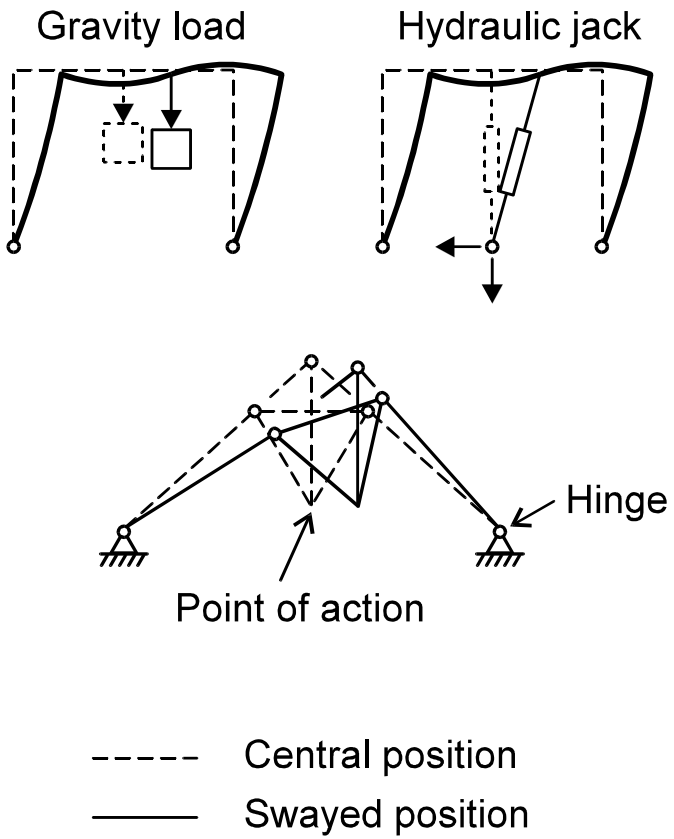


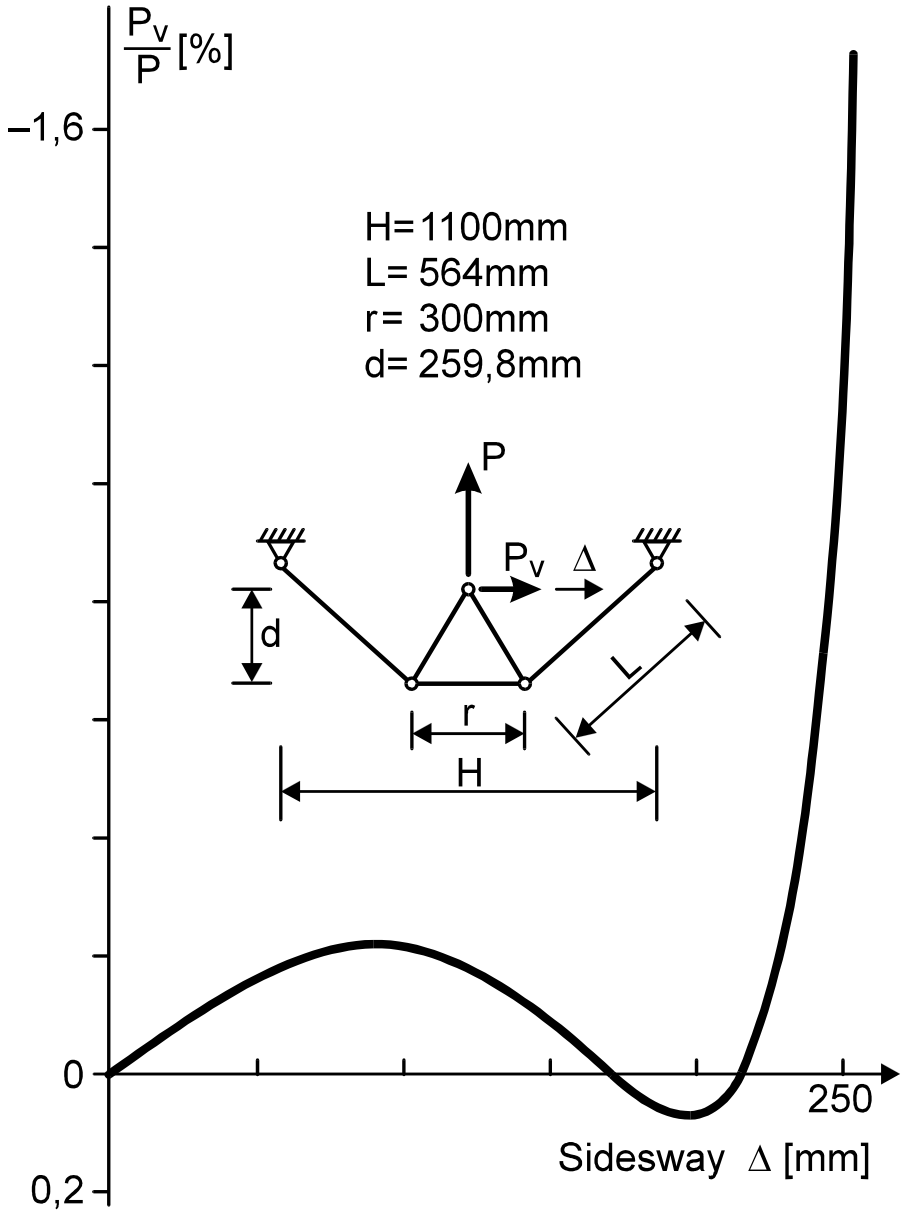


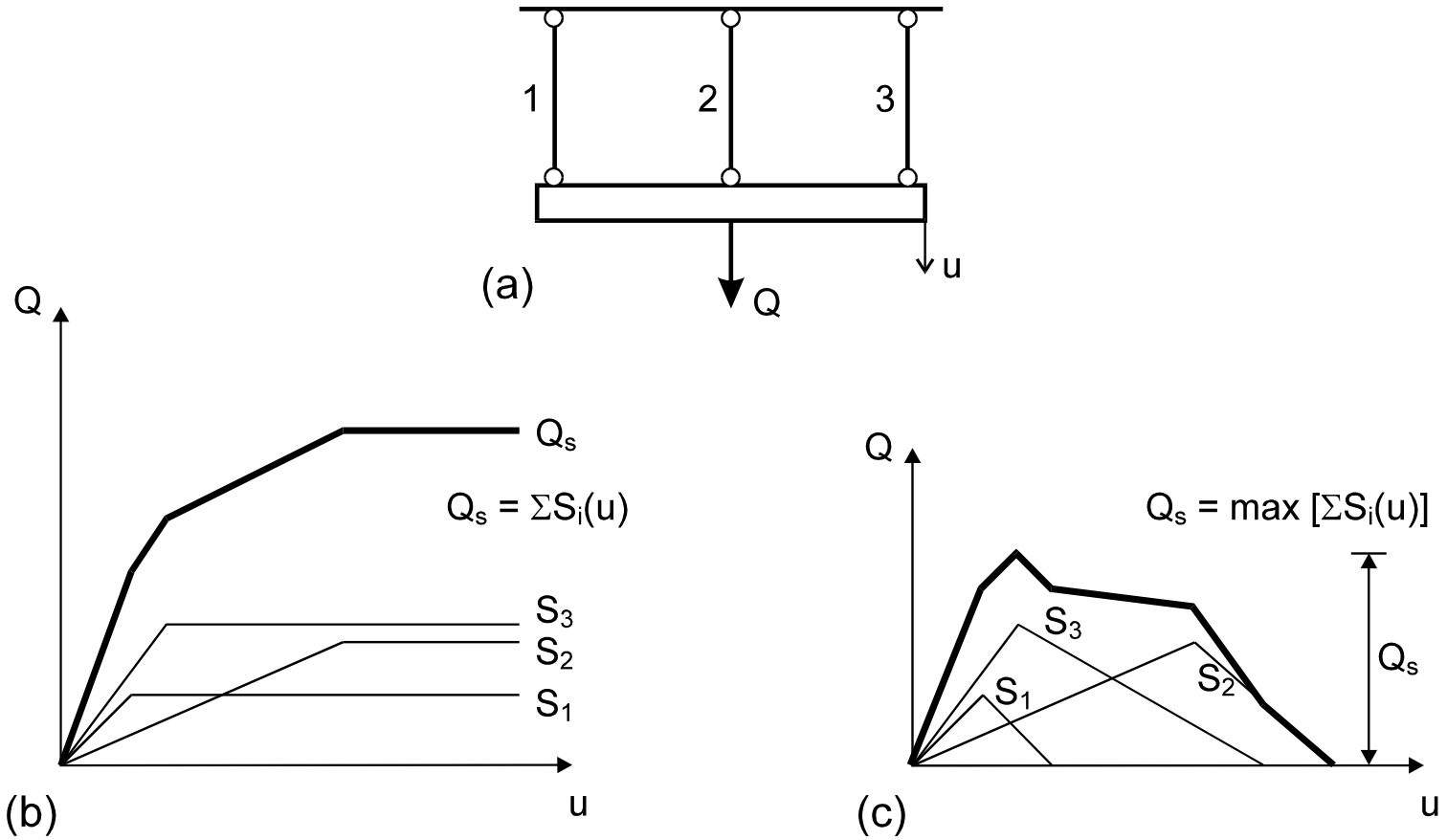




Gravity load simulator

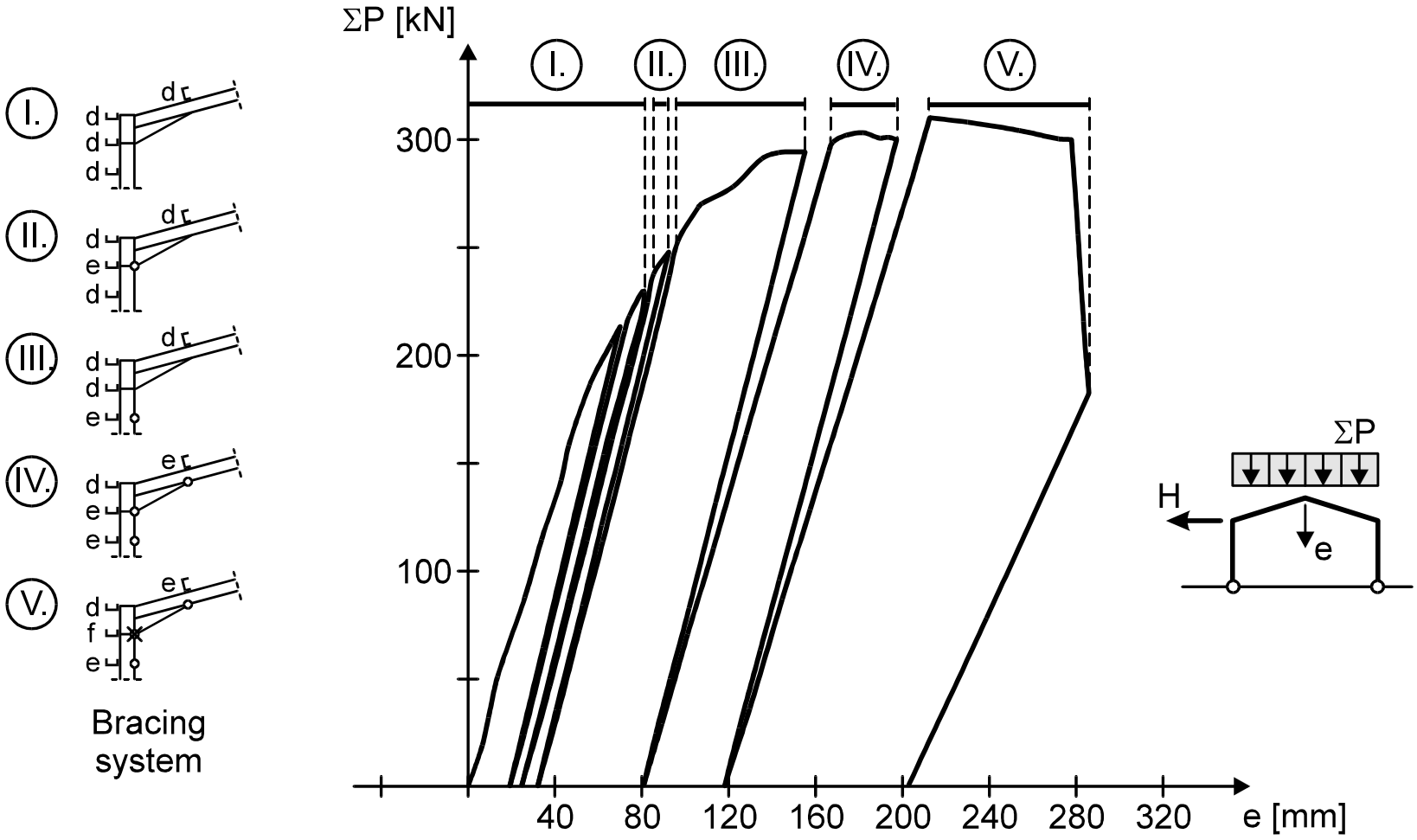




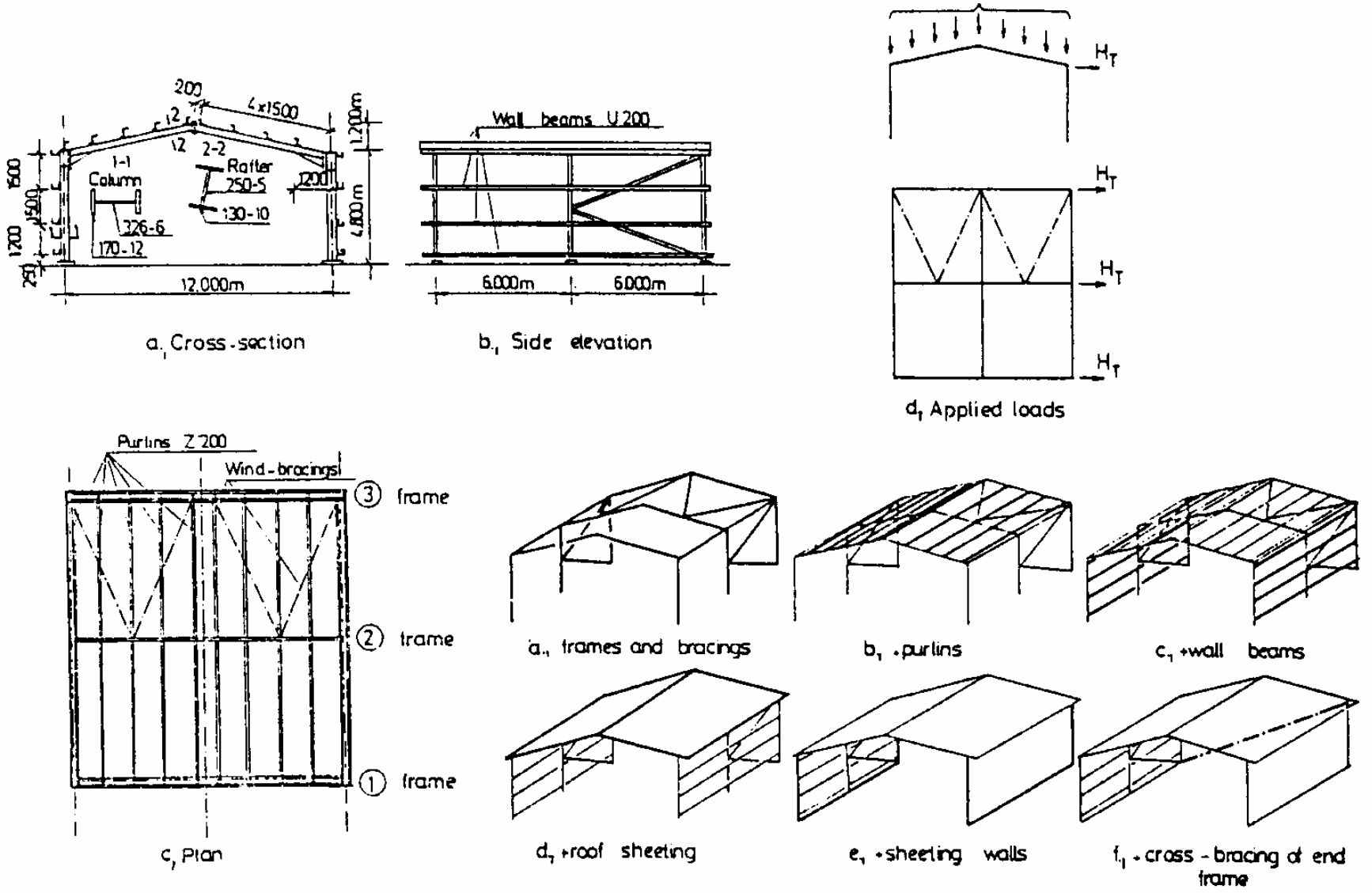


Effect of loading to structural behaviour and to experimental investigation

8.4.1.2 Test of Frame C-3/2

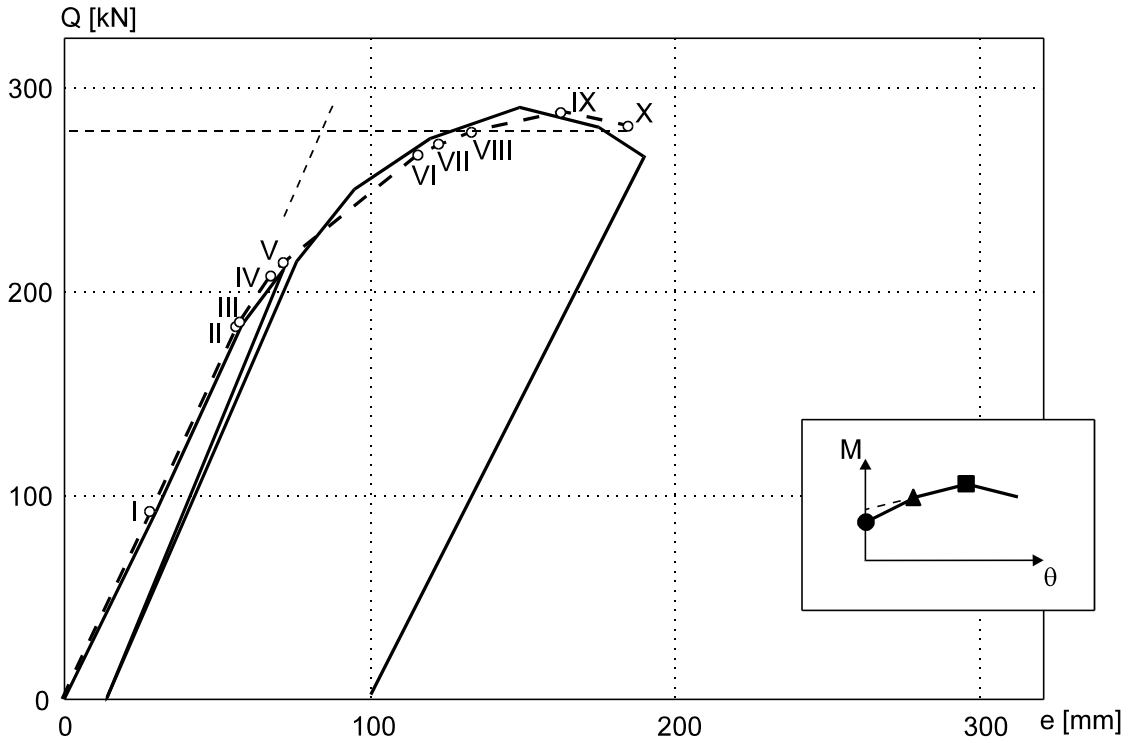


8.4.1.3 Building Section Test [Iványi, Kálló, Tomka, 1986]

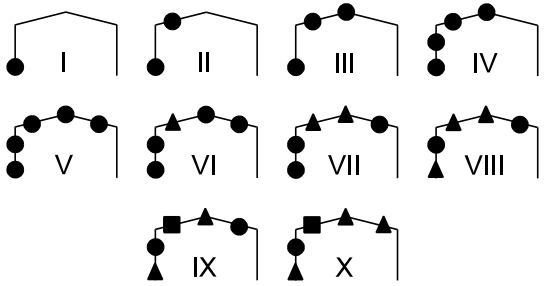


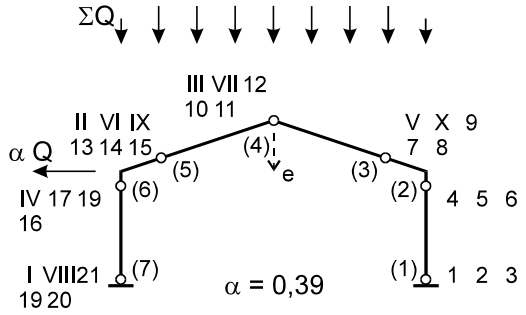
8.4.2 Results of Theoretical and Experimental Investigations [Iványi, 1983]

8.4.2.1 Application of Computer Programs

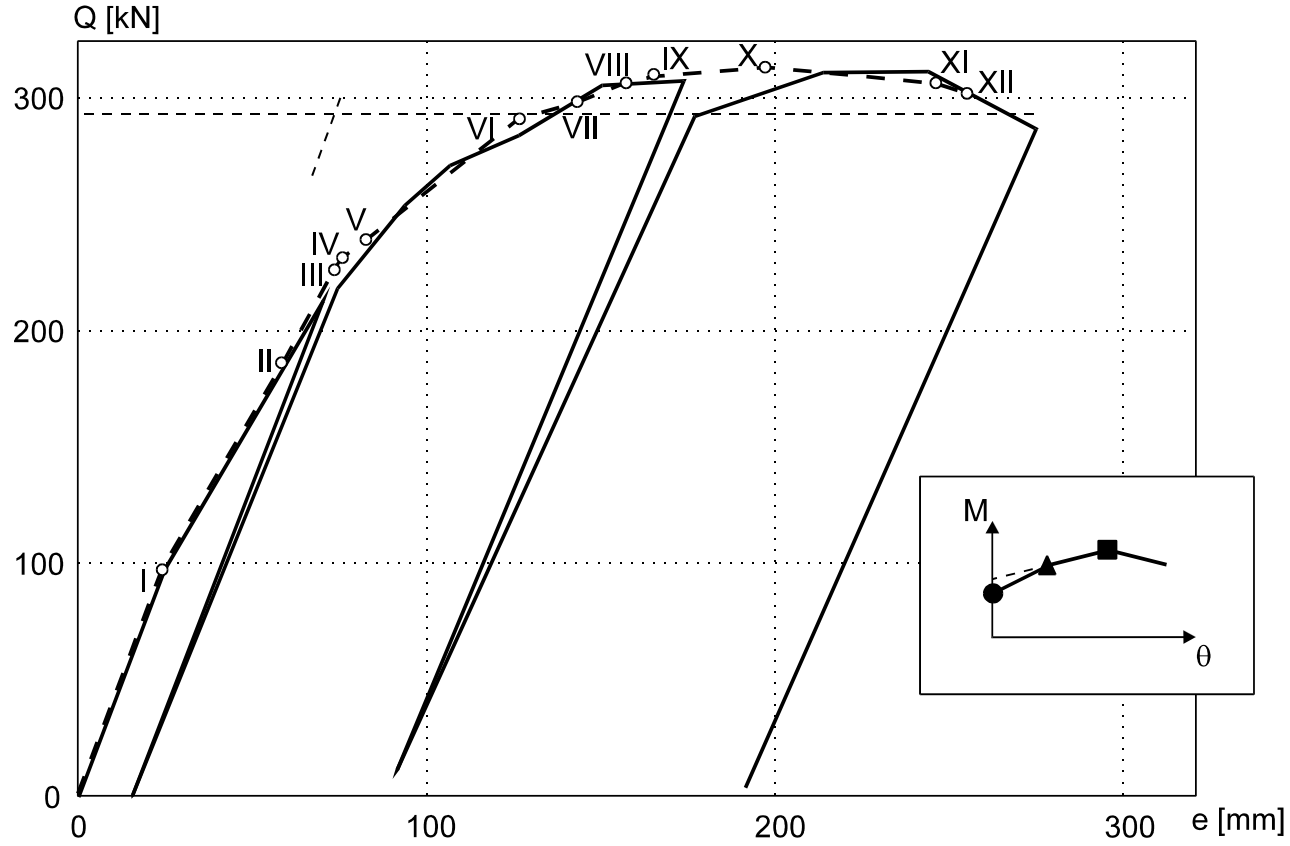


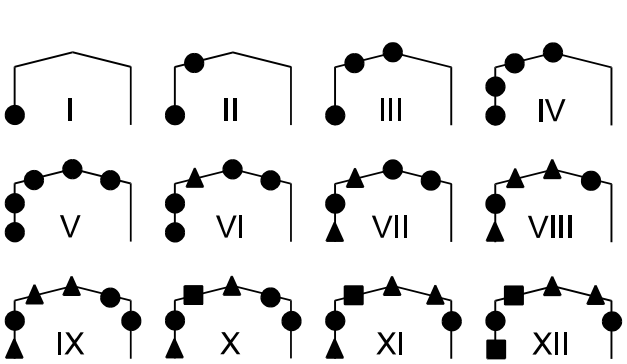
Experimental and calculated curves for frame C-1

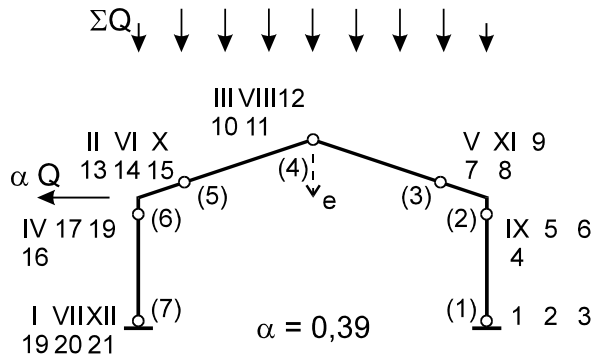




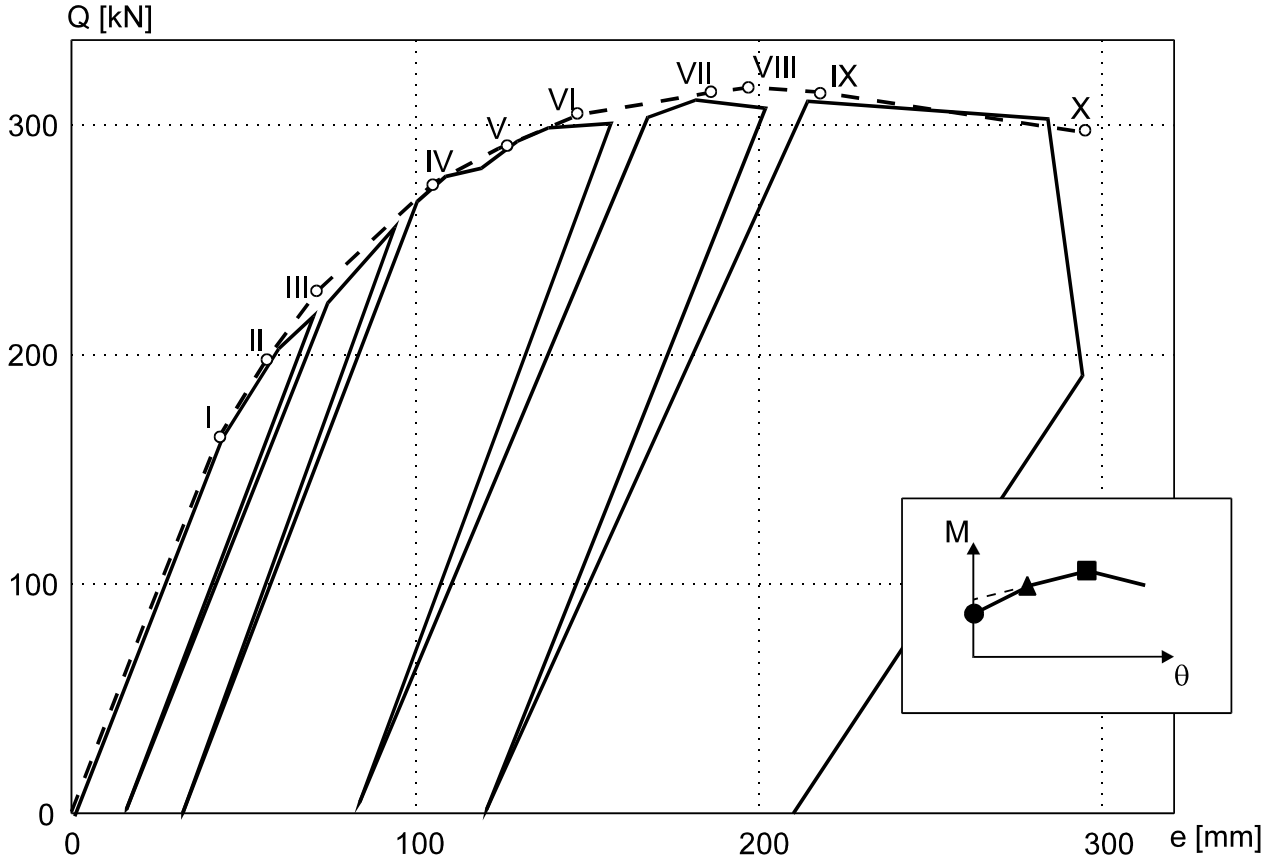
Készült az ERFP – DD2002 – HU – B – 01 szerzősésszámú projekt támogatásával

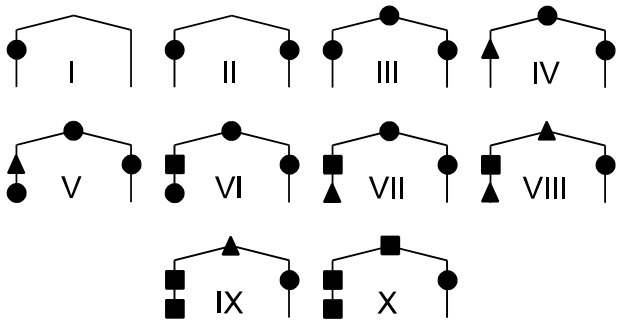


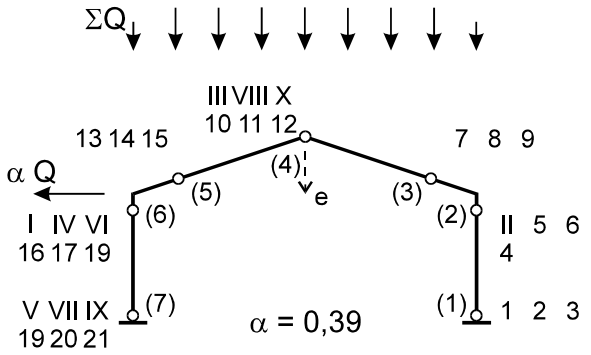




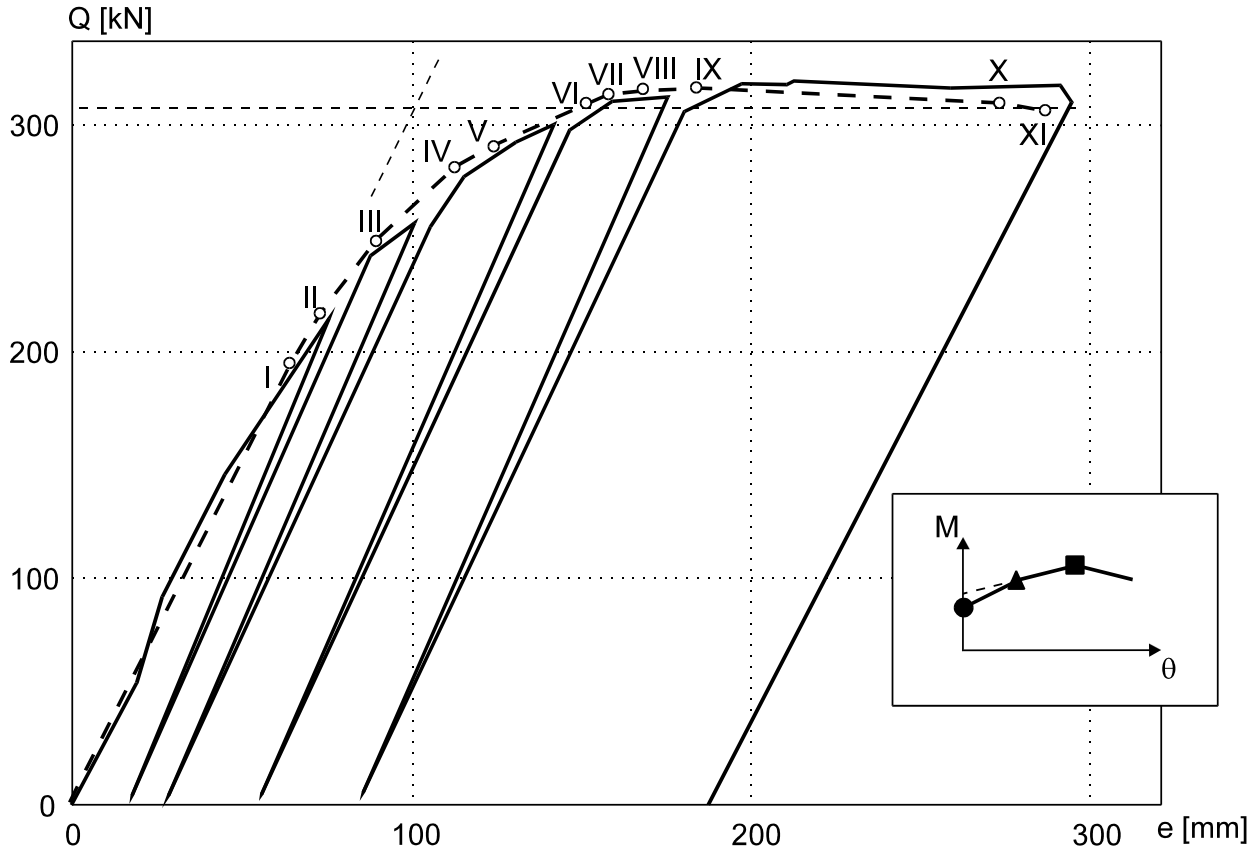
Experimental and calculated curves for frame C-2

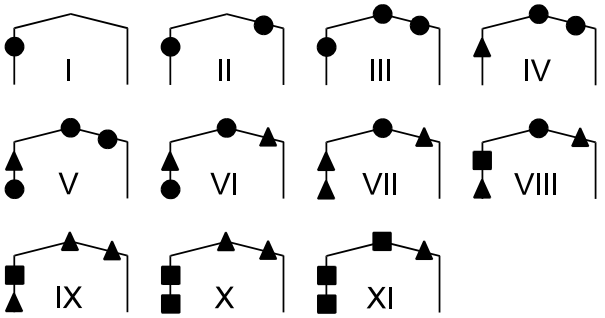


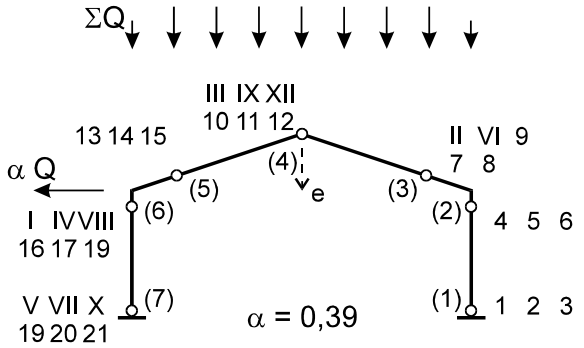




Experimental and calculated curves for frame C-3/2

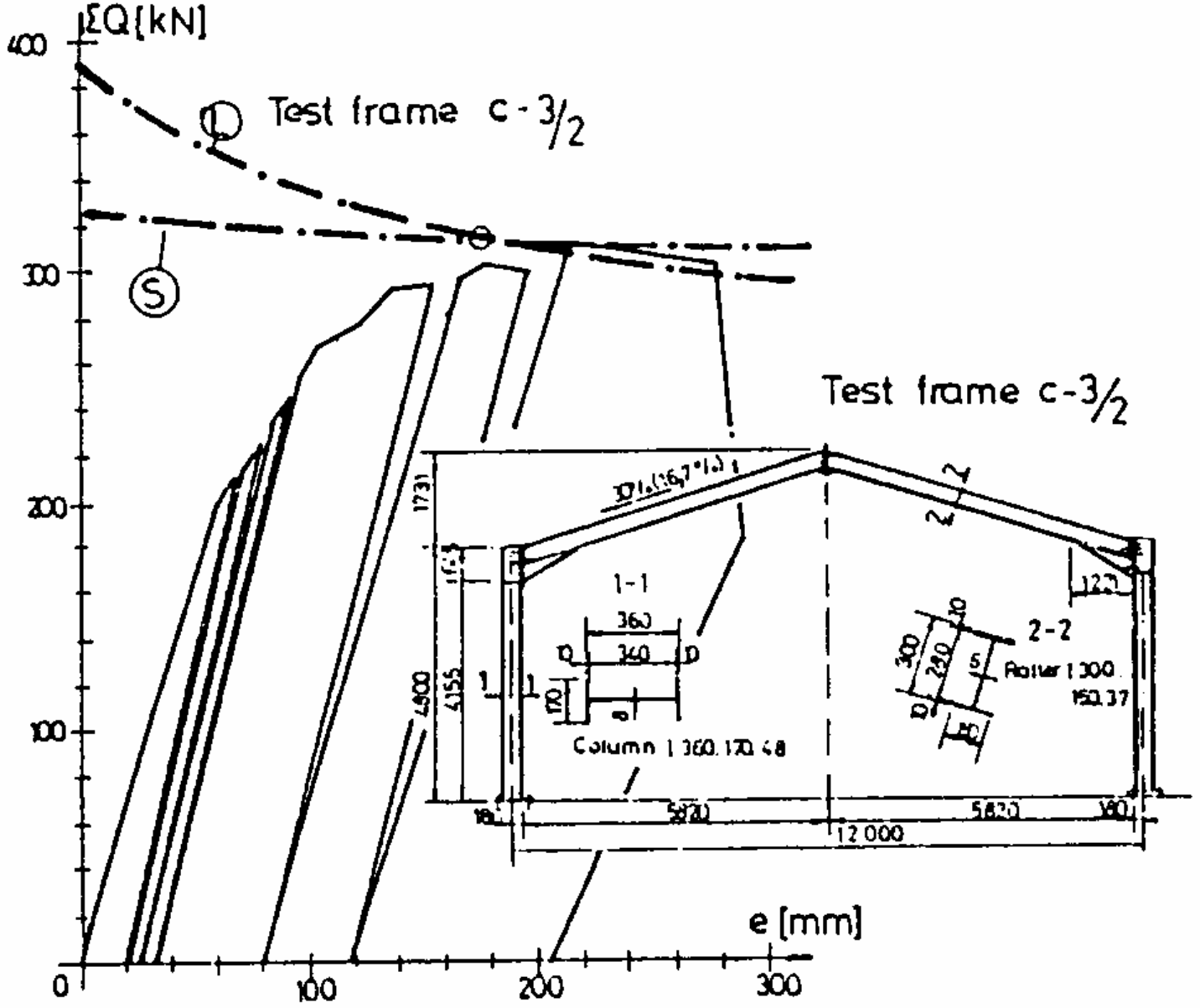






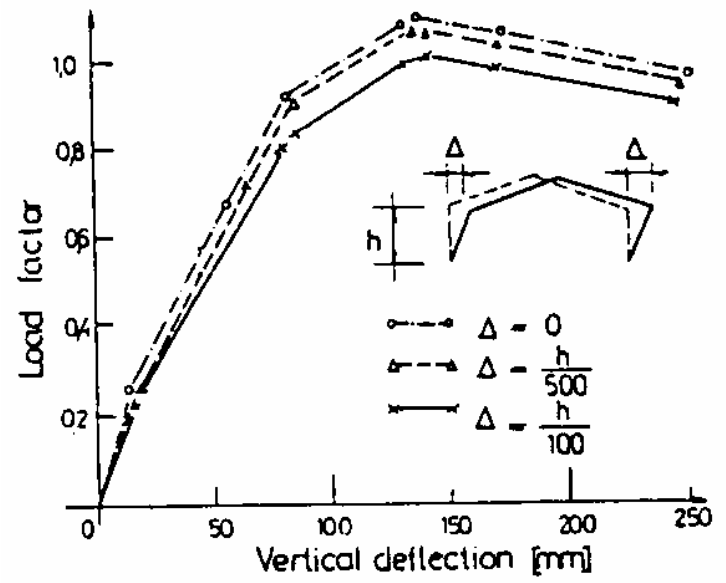
Experimental and calculated curves for frame B-1/3

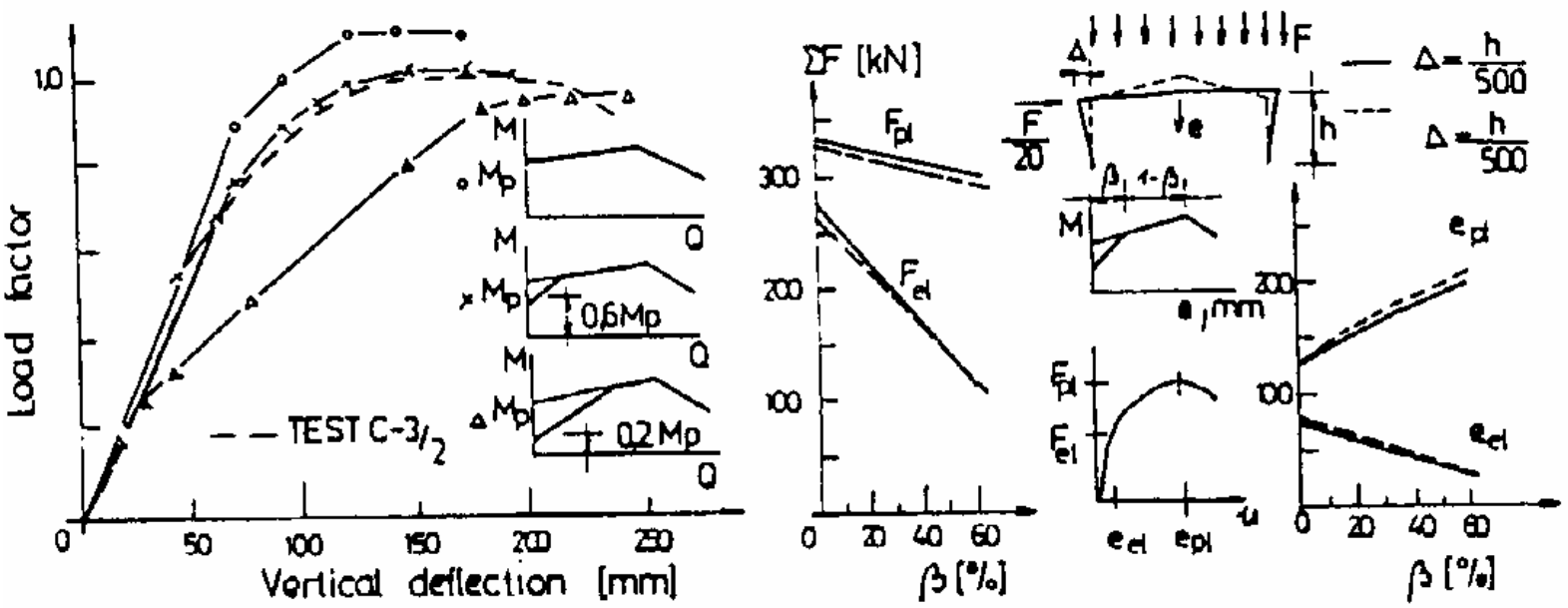
8.4.2.2 Application of Approximate Engineering Method [Iványi, 1983]



8.4.3 Analysis of the Influence Parameters [Iványi, 1993]

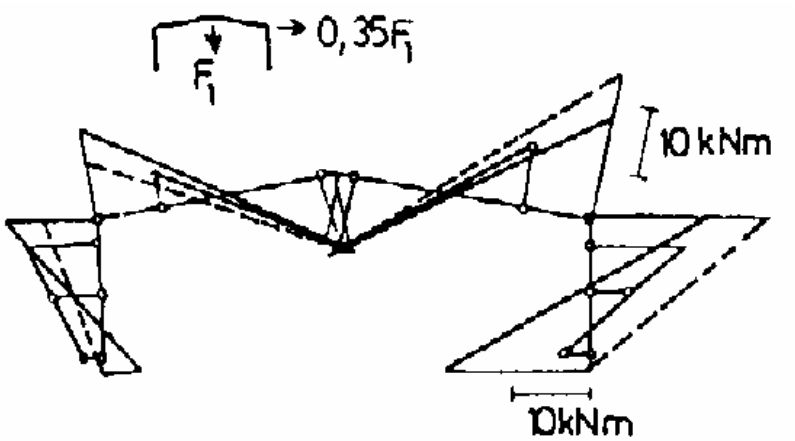
8.4.3.1 Effect of Fabrication and Erection



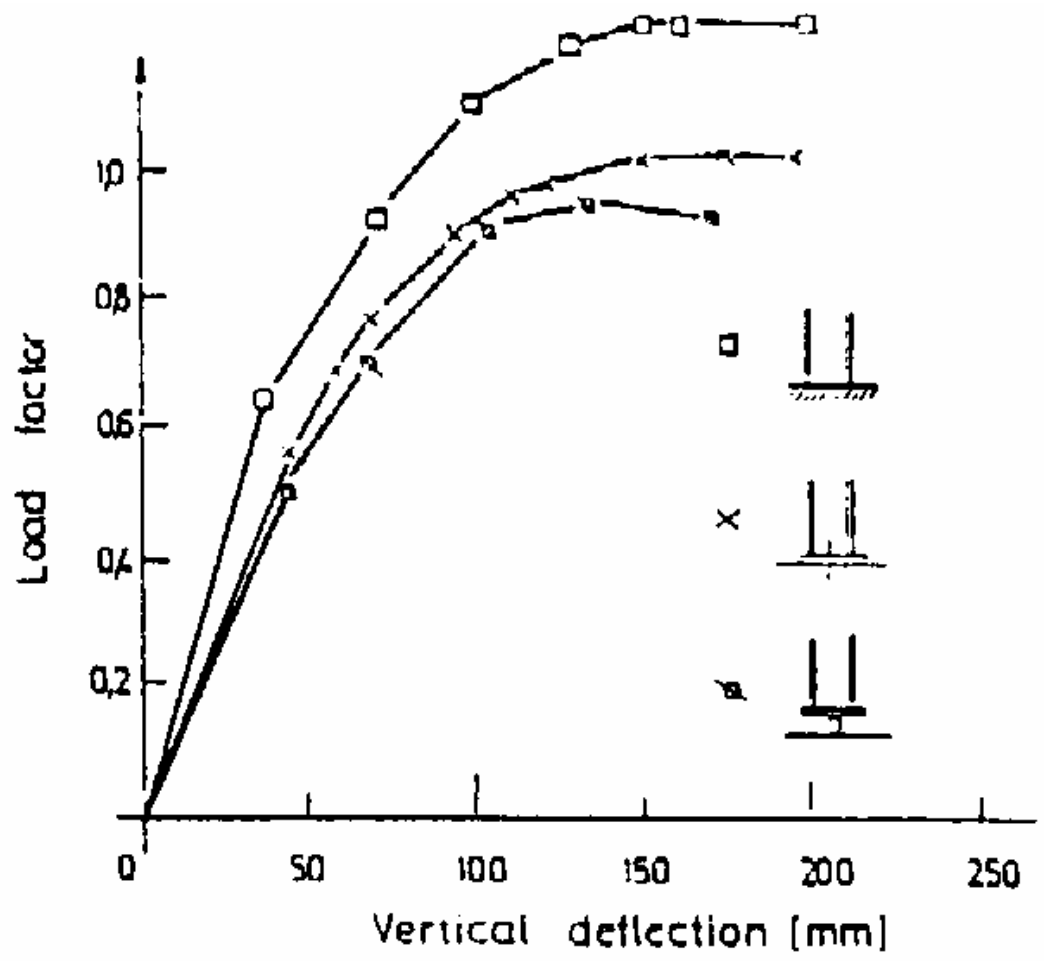


8.4.3.2 Effect of Structural Details

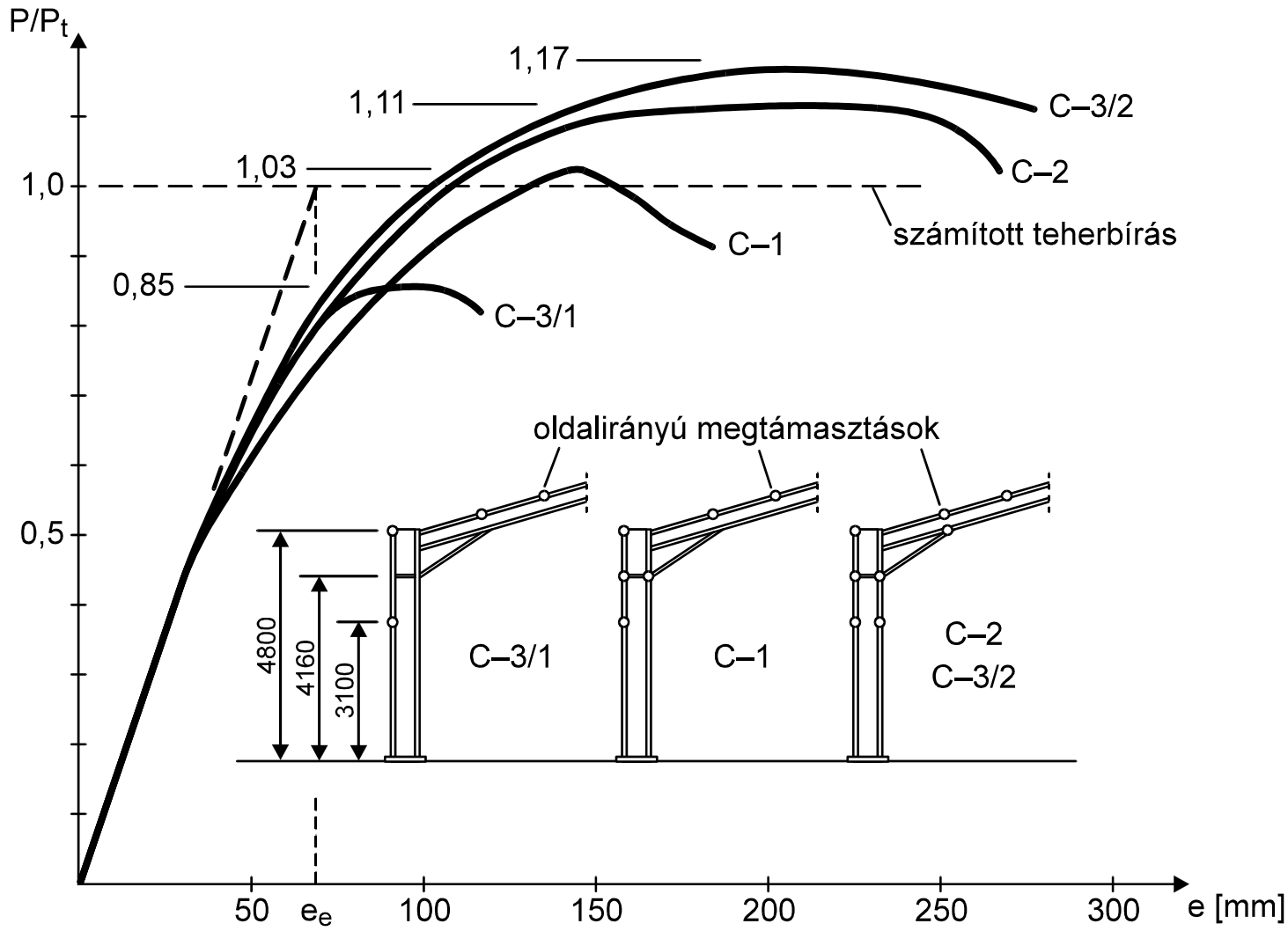
– Column bases

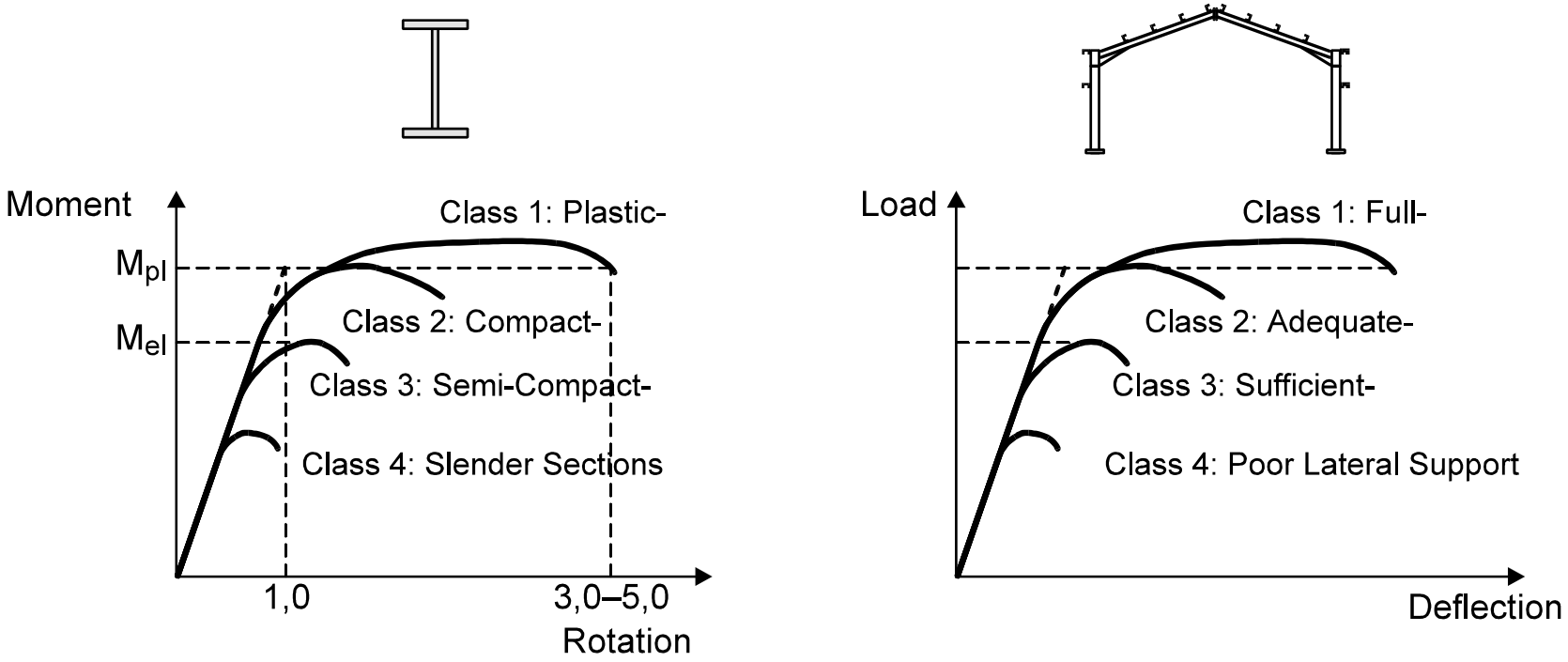


Measured and calculated bending moments



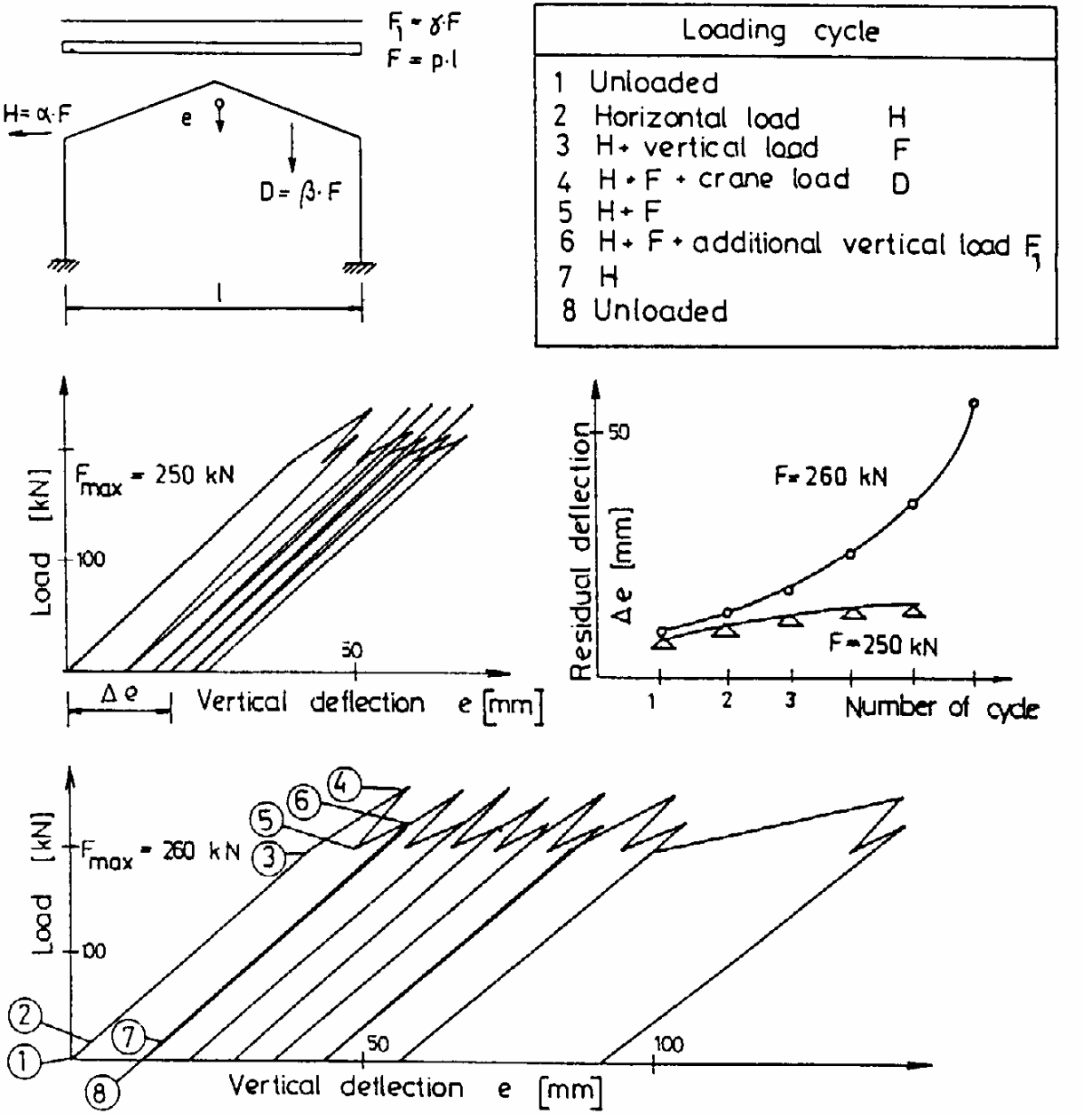
– Lateral supports





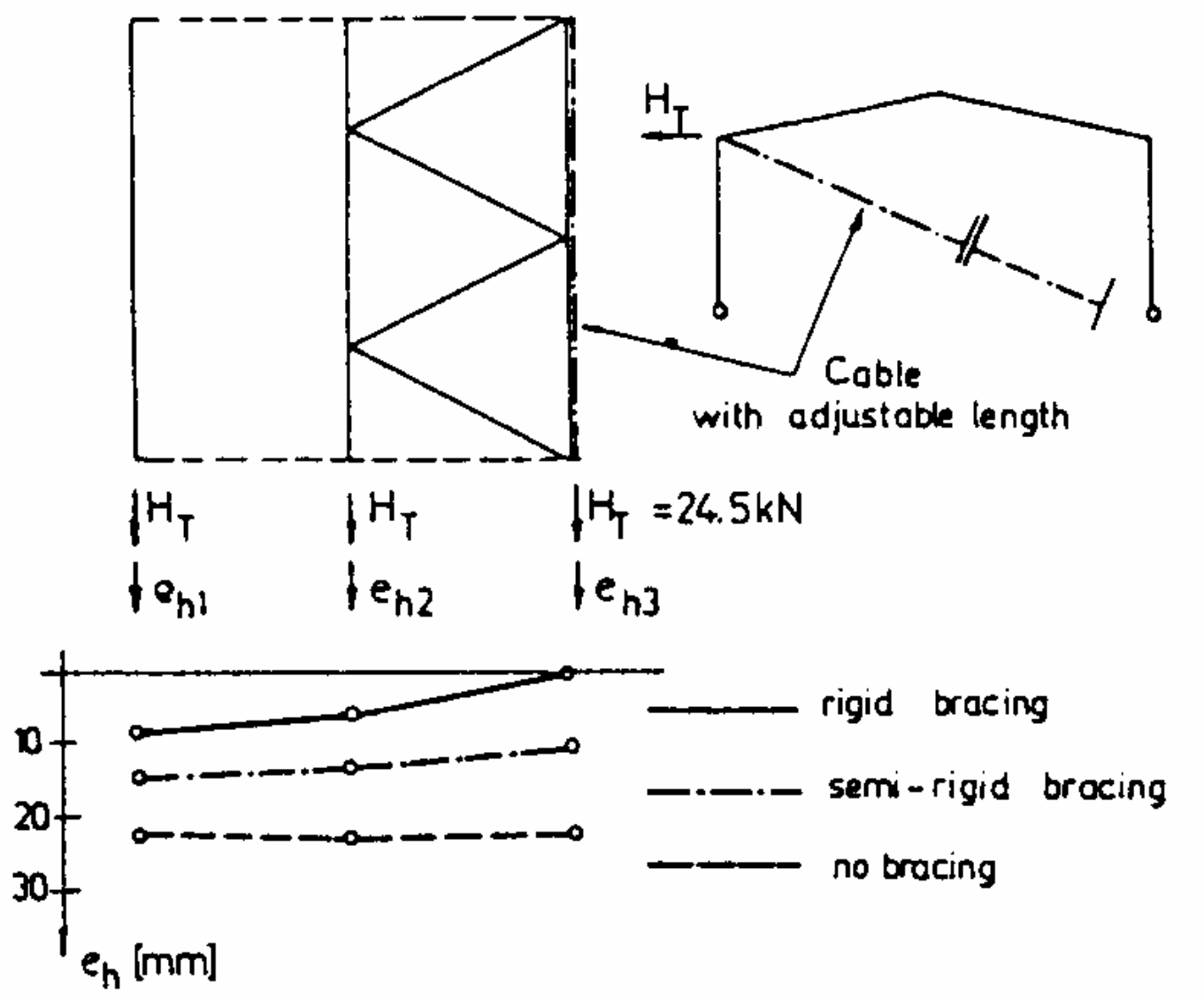
Two fundamental structural requirements of plastic design

8.4.3.3 Frame Structure Under Variable Repeated Load

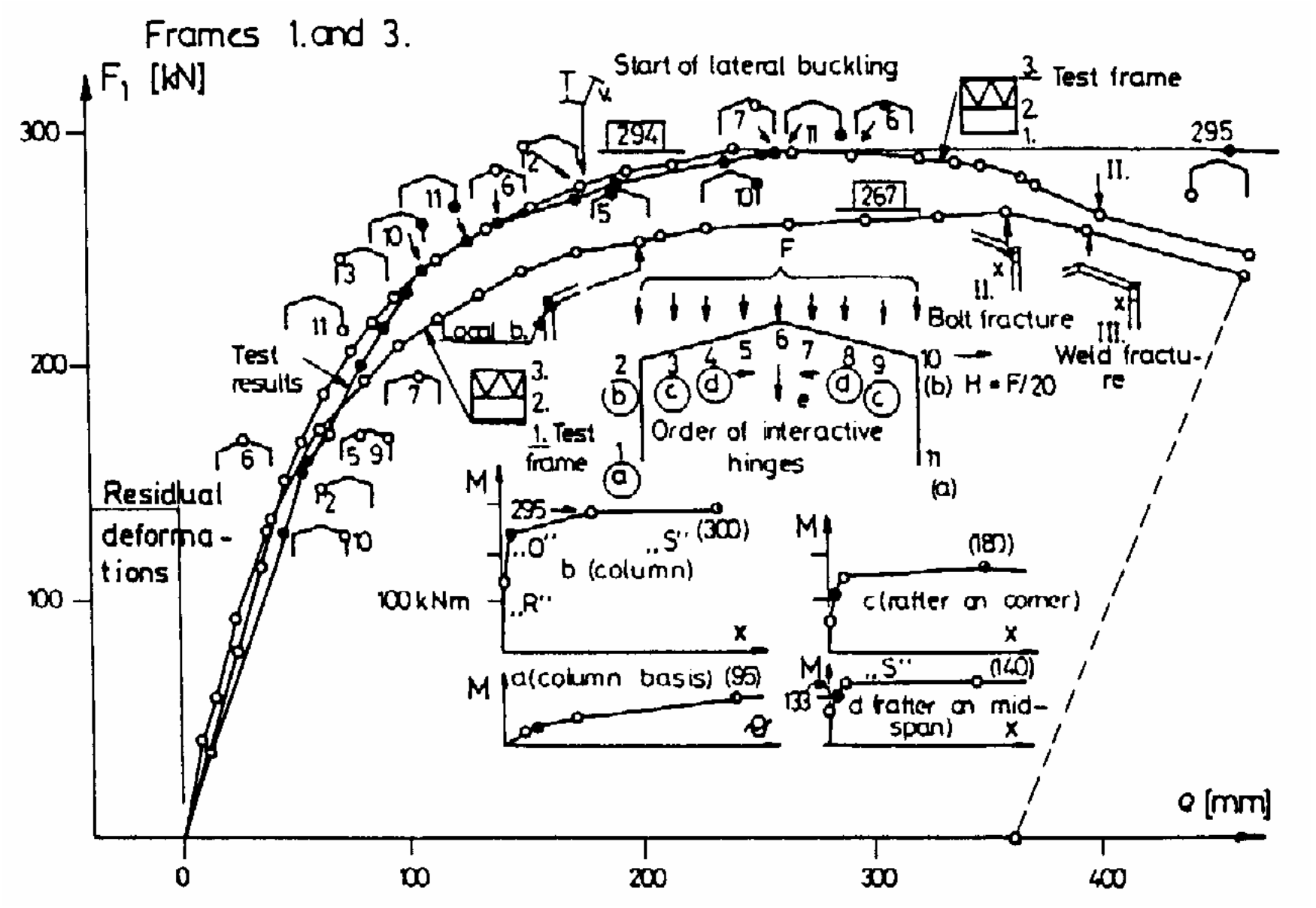


8.4.3.4 Building Under Proportional Loading

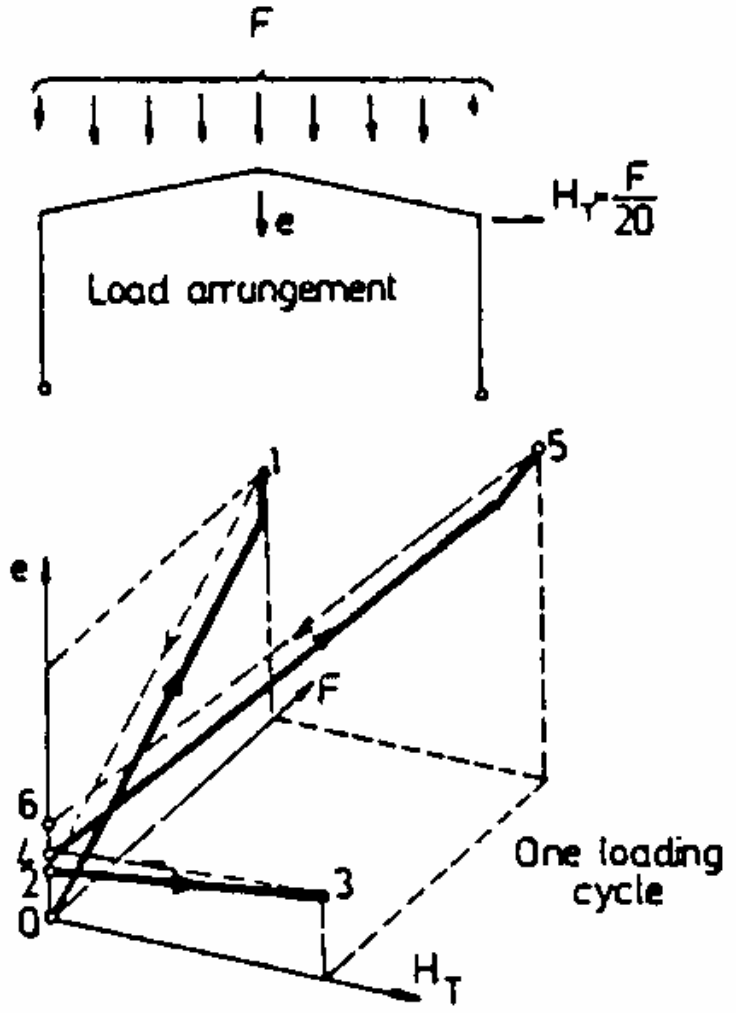
– Cross-bracing of the end-frame

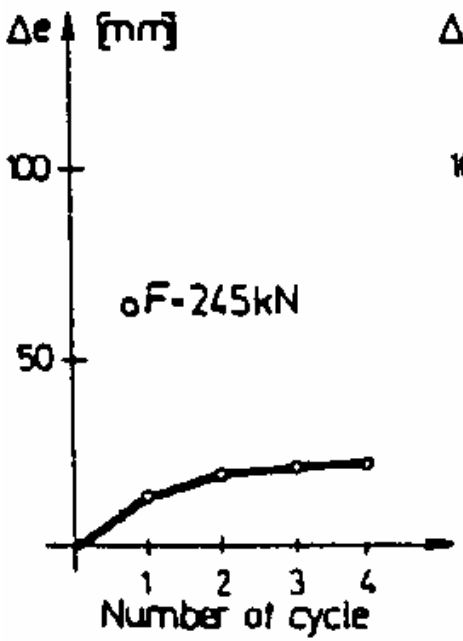


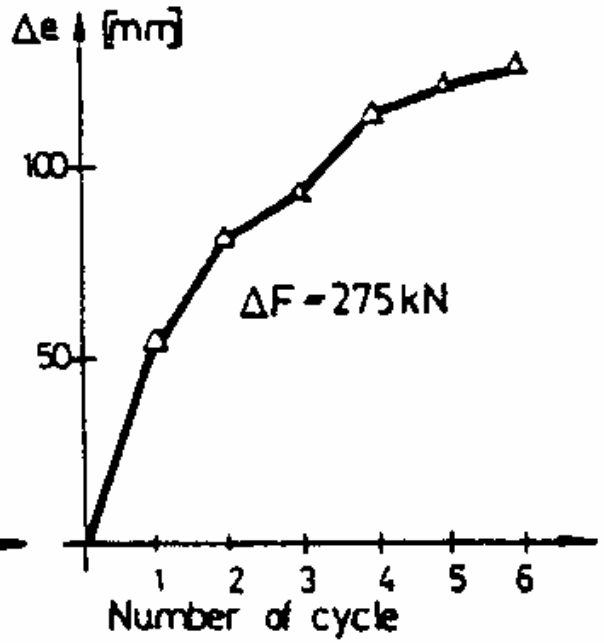
– Horizontal and vertical bracing system



8.4.3.5 Building Under Cyclically Repeated Meteorological Loads







8.4.4 Conclusion