Compressed elements of constant cross section. Compressed transition elements of constant cross section

Pillars are one of the oldest building structures. More than 3,000 years ago, the Egyptians carved stone pillars for tombstones. In the fifth century, pillars were often used in public buildings by the ancient Persians, Greeks, and Romans.

At that time, the pillars were built only according to empirical rules, looking at the surrounding buildings.

Parthenon Temple

By order of Pericles, B.C. 447 and BC Graduated in 432.
There are 8 columns on the contact facades of the rectangular building, and 17 along the length.

Persepolis is an ancient Iranian complex
BC 518 Xerxes I graduated from Darius
Corridor of a hundred pillars

- The scientific study of the problems of the work of compressible elements began in the XVIII century when Peter Van-Musschenbrook developed a test tool for compression and Leonard Euler developed his famous formula.

Columns are vertical elements that receive loads from superstructures and deliver them to the foundation or to structures below it.

The pillars consist of three parts (Fig. 12.1):

- supporting structures - the main part (4);
- the main part that receives the compressive forces - the rod (3)
- the part that transmits the compressive forces from the column to the foundation or to the lower structure - the base (2).

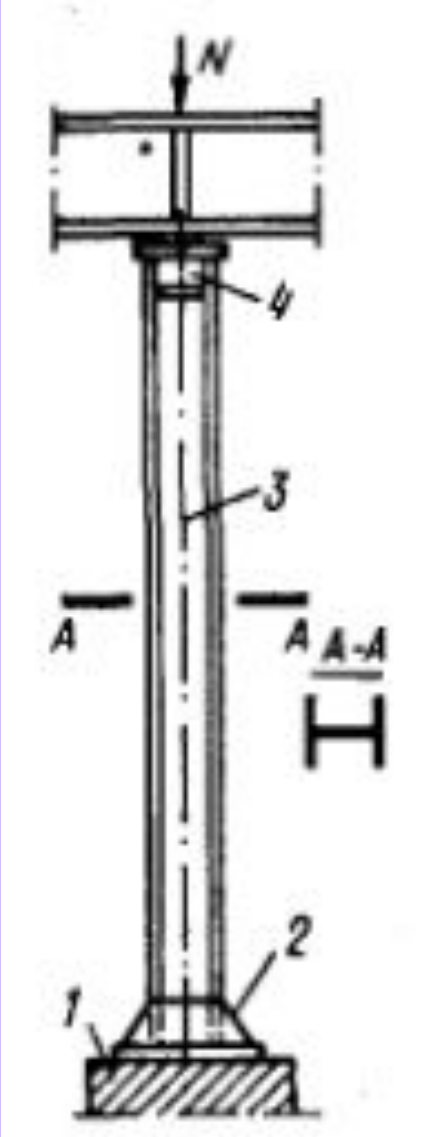


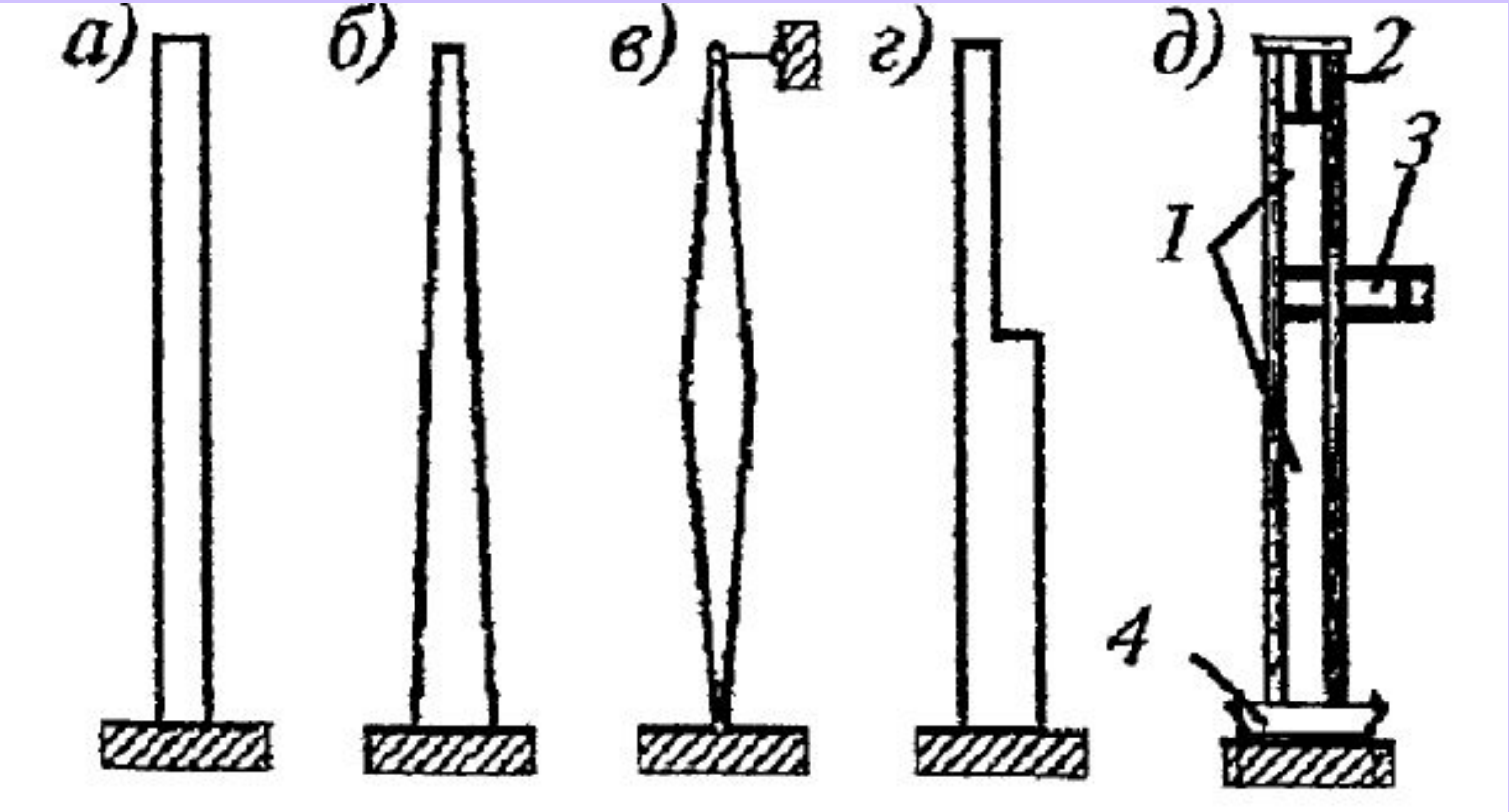
Figure 12.1. Medium compressible column.

Foundation 1; Base 2;

Rod 3; Section 4

Types of columns

- constant cross section (a);
- variable cross section (b, c);
- stepped (d)
- fixed cross section with console



1 - rod;

2 - the main part;

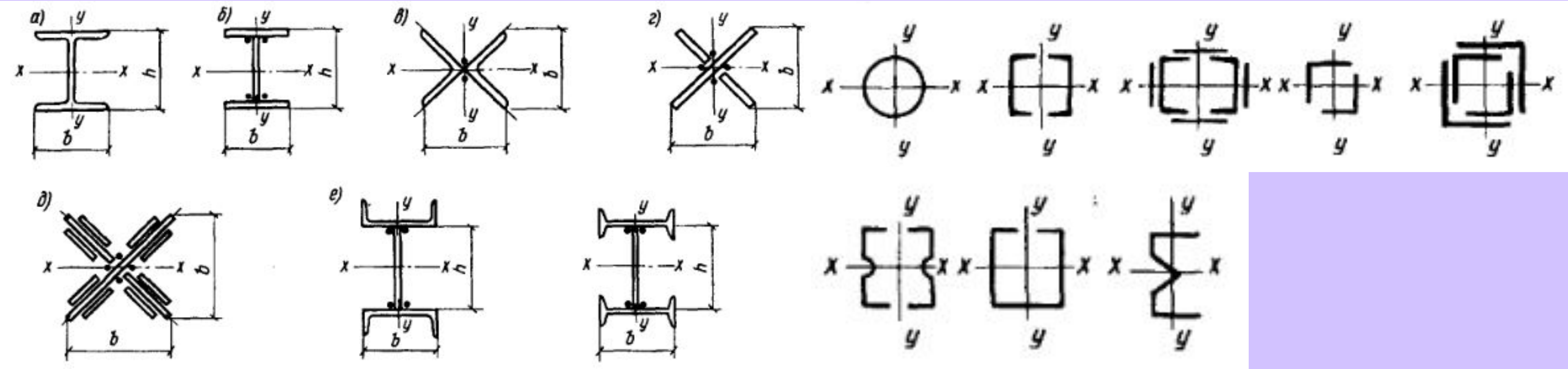
3 - console;

4 - base

Types of columns:

by design of rod sections:

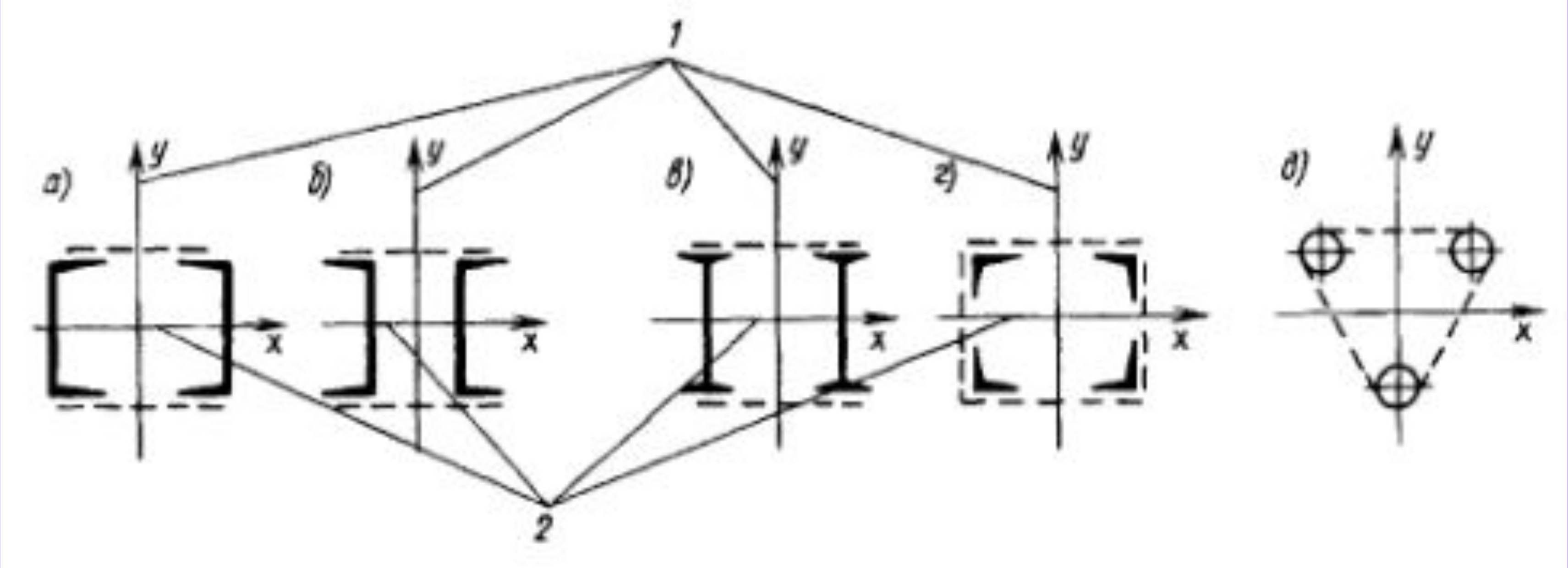
- solid (solid-walled)



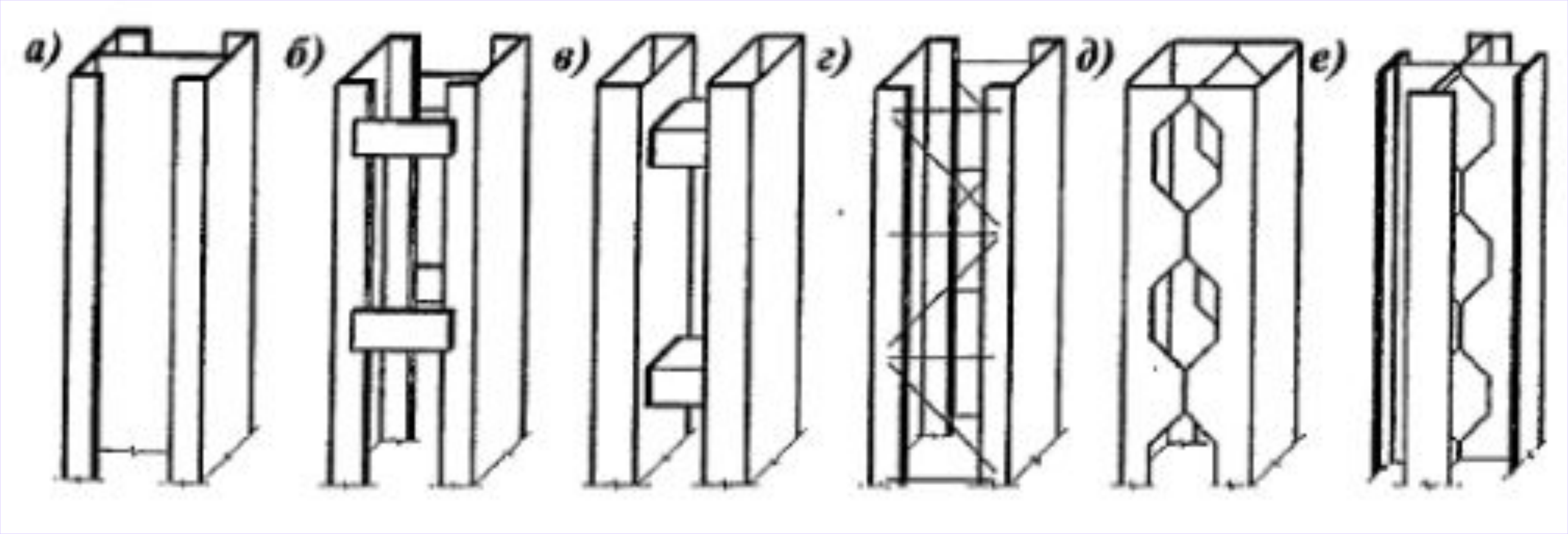
The main cross section of the compressible elements is the welded joint. Automatic welding is one of the cheapest industrial methods of making such columns.

Types of columns:

by design of rod sections:
- transitional (lattice)



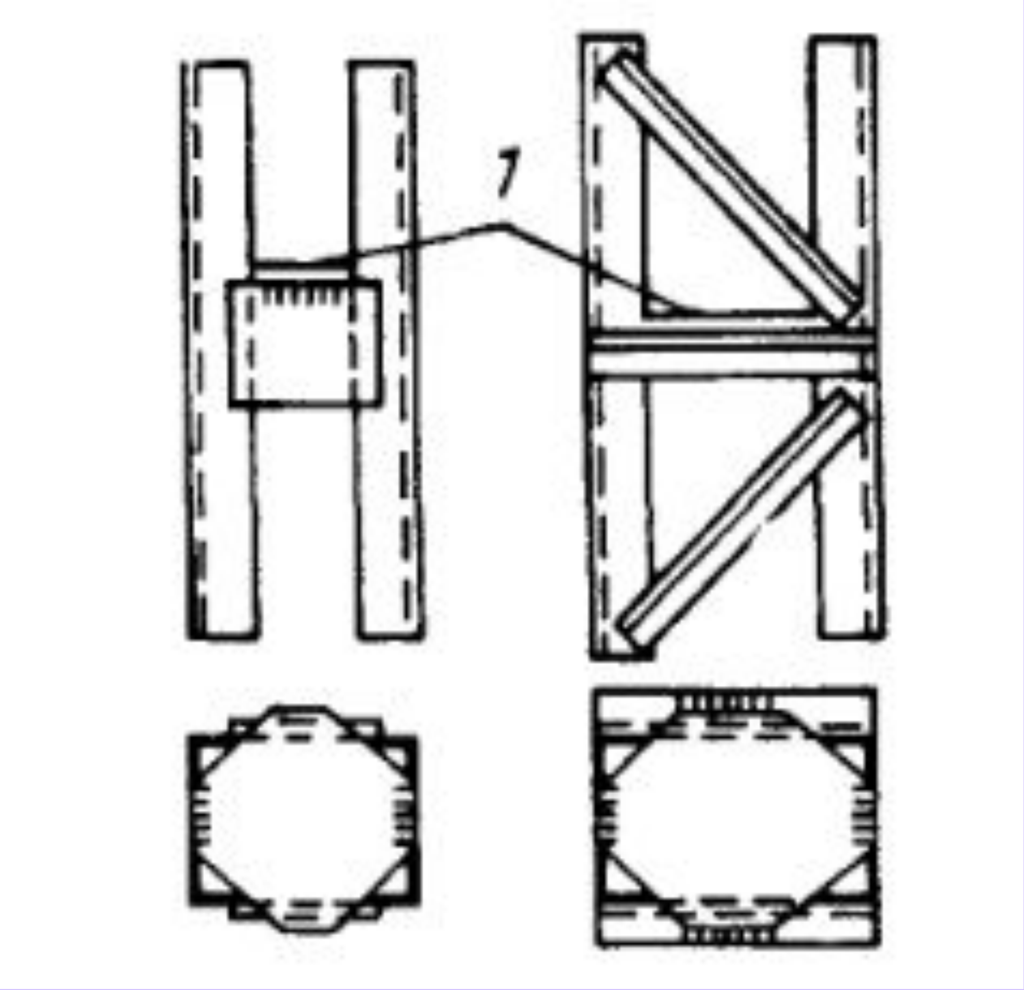
The cross-sectional columns are lattice rods (b, c), lattice (d) and perforated (d, e) without independent slopes.



The maximum design load of a transition beam with a cross section of two channels is 2700 ÷ 3500 kN, from two girders - 5500 ÷ 5600 kN.

As the load increases, it becomes more difficult to prepare the cross-section of the transition beams, so they should be made as a whole.

Grids without slopes have a beautiful appearance and are the simplest, so they are often used when the rated load is 2000 ÷ 2500 kN and the distance between the branches does not exceed 0.8 ÷ 1 m



1- Place horizontal diaphragms every 3 ÷ 4 m.

Figure.12.3. Horizontal diaphragms

The design scheme of the compressive columns depends on its fastening to the foundation and connection with beams (Figure 12.4).
Fixing of beams to the foundation can be hinged or rigid. The latter requires a very strong foundation, and it is necessary to rigidly fasten the column with anchor bolts.

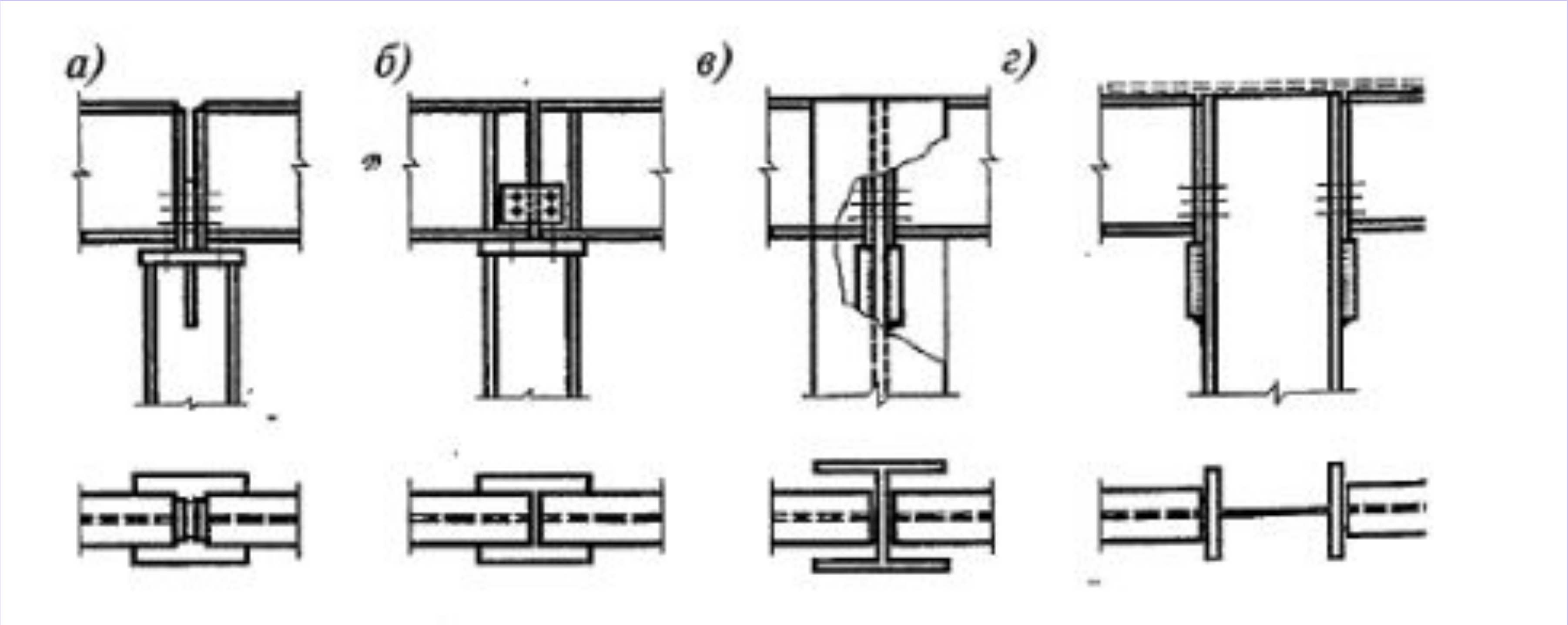


Figure 12.4. Schemes of connection of beams with beams.
a, b, c - group combination; d - a strict combination

Lifting capacity in terms of longitudinal bending.

The stability of the compressed element should be checked as follows:

$$\frac{N_{Ed}}{N_{b,Rd}} \leq 1{,}0;$$

NEd - calculated value of compressive strength;

Nb, Rd is the calculated value of bearing capacity for the stability of the compressed element.

For elements of Class 4 asymmetric sections, the additional moment ΔMEd caused by the eccentricity of the central axis of the effective calculation must be taken into account, and see paragraph 6.3.2.5 (d) of this instrument, and the perception of the combined effect of axial force and moment in paragraphs 7.3 or 7.4 of this instrument. The design value of the bearing capacity of the compressed element in terms of stability:

$$N_{b,Rd} = \frac{\chi A f_y}{\gamma_{M1}}$$

- For class 1, 2 and 3 cross sections

$$N_{b,Rd} = \frac{\chi A_{eff} f_y}{\gamma_{M1}}$$ - Class 4 for cross sections

where: χ is the reduction factor for the corresponding stability loss curve.

Stability loss curves

When the elements are compressed from the medium, the value of λ - depending on the conditional elasticity should be determined by the following formula in accordance with the corresponding curve of loss of stability: $\chi = \frac{1}{\Phi + \sqrt{\Phi^2 - \bar{\lambda}^2}}$ - но $\chi \leq 1{,}0$;

where: $\Phi = 0{,}5 \cdot \left[1 + \alpha \cdot \left(\bar{\lambda} - 0{,}2\right) + \bar{\lambda}^2\right]$;

$$\bar{\lambda} = \sqrt{\frac{A f_y}{N_{cr}}}$$ - For class 1, 2 and 3 cross sections

$$\bar{\lambda} = \sqrt{\frac{A_{eff} f_y}{N_{cr}}}$$ - Class 4 for cross sections

α - coefficient taking into account the initial defect;
Ncr is the critical force for the corresponding form of loss of stability in the elastic period, depending on the characteristics of the gross cross section.

The coefficient α corresponding to a certain corresponding loss curve is taken from Tables 12.1 and 12.2.

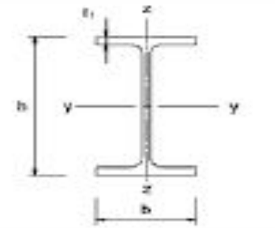
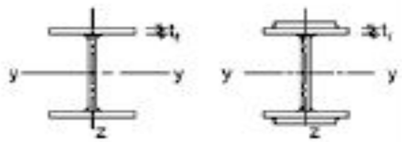
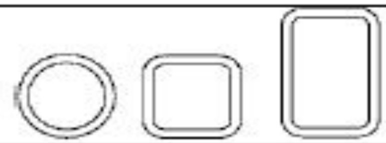
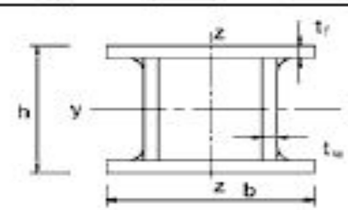
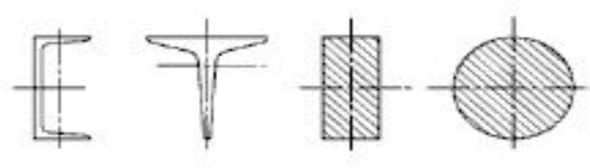
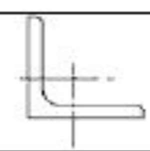
Numerical values of the reduction factor χ for the corresponding conditional flexibility can be determined from the graph in Figure 12.5.

Flexibility $\bar{\lambda} \le 0,2$ or $\frac{N_{Ed}}{N_{cr}} \le 0,04$ loss of stability is not taken into account and the cross section can only be checked for strength.

Table 12.1 - Coefficient taking into account the initial disadvantage for the curves of loss of stability in compression

Stability loss curve	a_0	a	b	c	d
α - coefficient	0,13	0,21	0,34	0,49	0,76

Table 12.2 - Selection of loss stability curves

Поперечные сечения		Пределы		Потеря устойчивости относительно оси	Кривая потери устойчивости: S 235, S 275, S 355, S 420	Кривая потери устойчивости: S 460
Прокатные сечения		$h/b > 1,2$	$t_f \le 40$ мм	$y-y$ $z-z$	a b	a_0 a_0
			40 мм $< t_f \le 100$ мм	$y-y$ $z-z$	b c	a a
		$h/b \le 1,2$	$t_f \le 100$ мм	$y-y$ $z-z$	b c	a a
			$t_f > 100$ мм	$y-y$ $z-z$	d d	c c
Сварные двутавровые сечения		$t_f \le 40$ мм		$y-y$ $z-z$	b c	b c
		$t_f > 40$ мм		$y-y$ $z-z$	c d	c d
Замкнутые сечения		Горячедеформированные		Все	a	a_0
		Холоднодеформированные		Все	c	c
Сварные коробчатые сечения		В целом (в общем случае) (кроме перечисленных ниже)		Все	b	b
		С толщиной сварных швов: $a > 0,5t_f$; $b/t_f < 30$; $h/t_w < 30$		Все	c	c
Швеллеры, тавры и сплошные сечения				Все	c	c
Уголки				Все	b	b

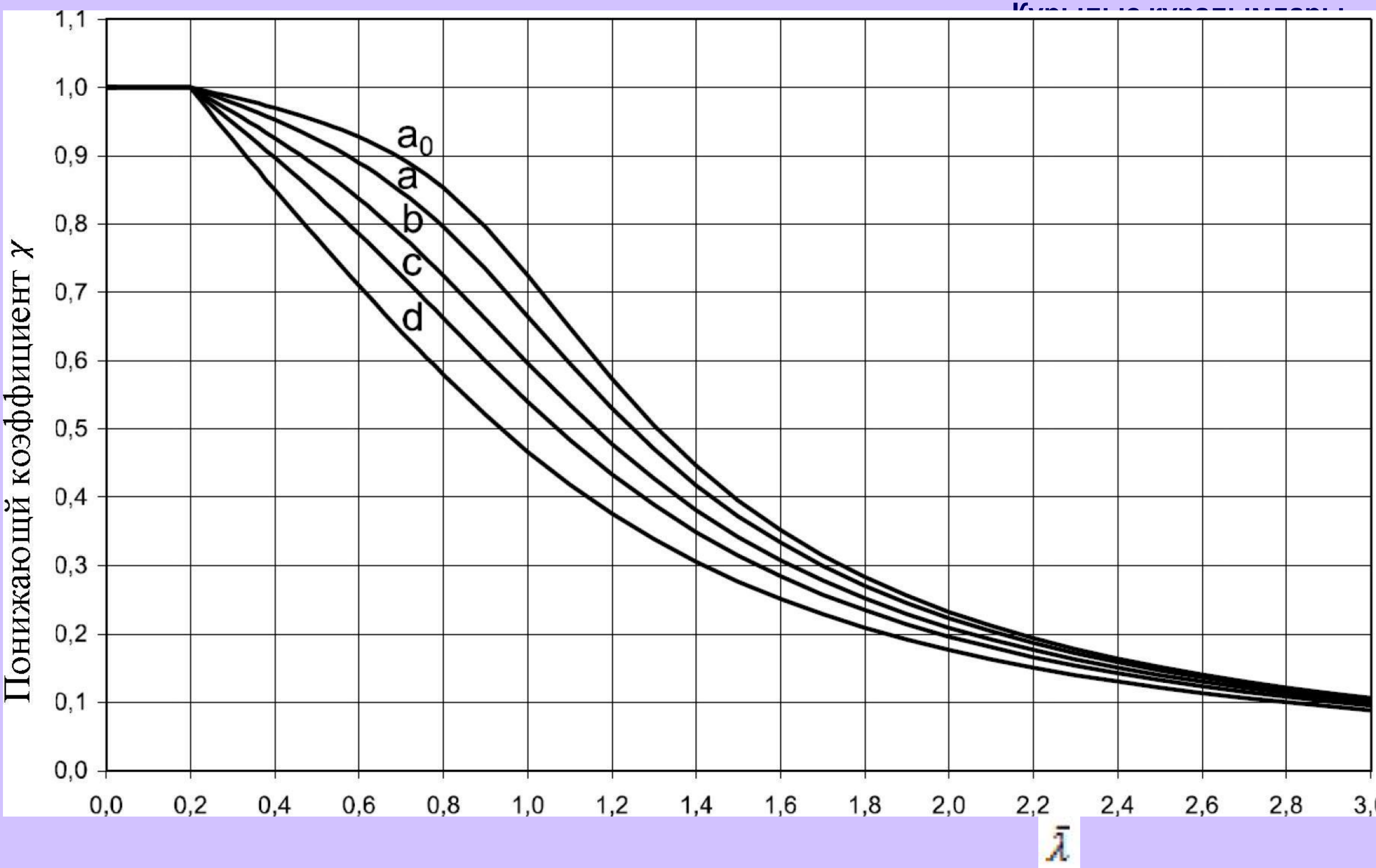


Figure 12.5 - Loss of stability curves

Flexibility in longitudinal bending

$\bar{\lambda}$ conditional flexibility:

$$\bar{\lambda} = \sqrt{\frac{Af_y}{N_{cr}}} = \frac{L_{cr}}{i} \cdot \frac{1}{\lambda_1}$$

- For class 1, 2 and 3 cross sections

$$\bar{\lambda} = \sqrt{\frac{A_{eff} f_y}{N_{cr}}} = \frac{L_{cr}}{i} \cdot \frac{\sqrt{\frac{A_{eff}}{A}}}{\lambda_1}$$

- Class 4 for cross sections

where: Lcr - design length;

i is the radius of inertia of the gross cross section relative to the corresponding axis

$$\lambda_1 = \pi \sqrt{\frac{E}{f_y}} = 93{,}9\varepsilon;$$

$$\varepsilon = \sqrt{\frac{235}{f_y\ [\text{Н/мм}^2]}};$$

The corresponding curve of loss of stability during longitudinal bending is determined in Table 12.2.

Compressed transition elements of constant cross section

Fixed cross-section compressed transition elements with hinged fixed supports should be designed according to the following model, Figure 12.6:

1) - an element with an initial curvature can be considered as a column;

2) the effect of the elongation of the slope or lattice lattice on the reduction of the stiffness of the transition element is taken into account in the calculations by introducing a constant shear stiffness Sv, see Figure 12.6

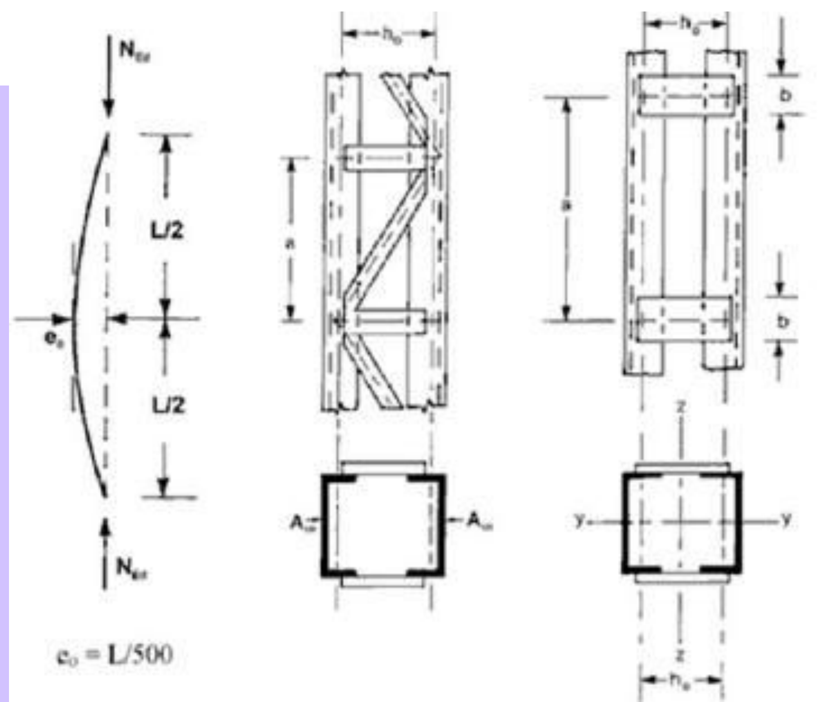


Figure 12.6 - Pillars with a fixed cross-section with a sloping and lattice grid

b) The model of a compressive transition element with a constant cross section is used in the following cases:
1) the distance between the nodes of the sloping or lattice grids is constant along the length of the element with branches;
2) the minimum number of panels in an element is three.
NOTE: This assumption allows you to consider a discrete structure as a whole.
c) this calculation method is used for transition elements with a sloping grid in two planes, Figure 12.7.

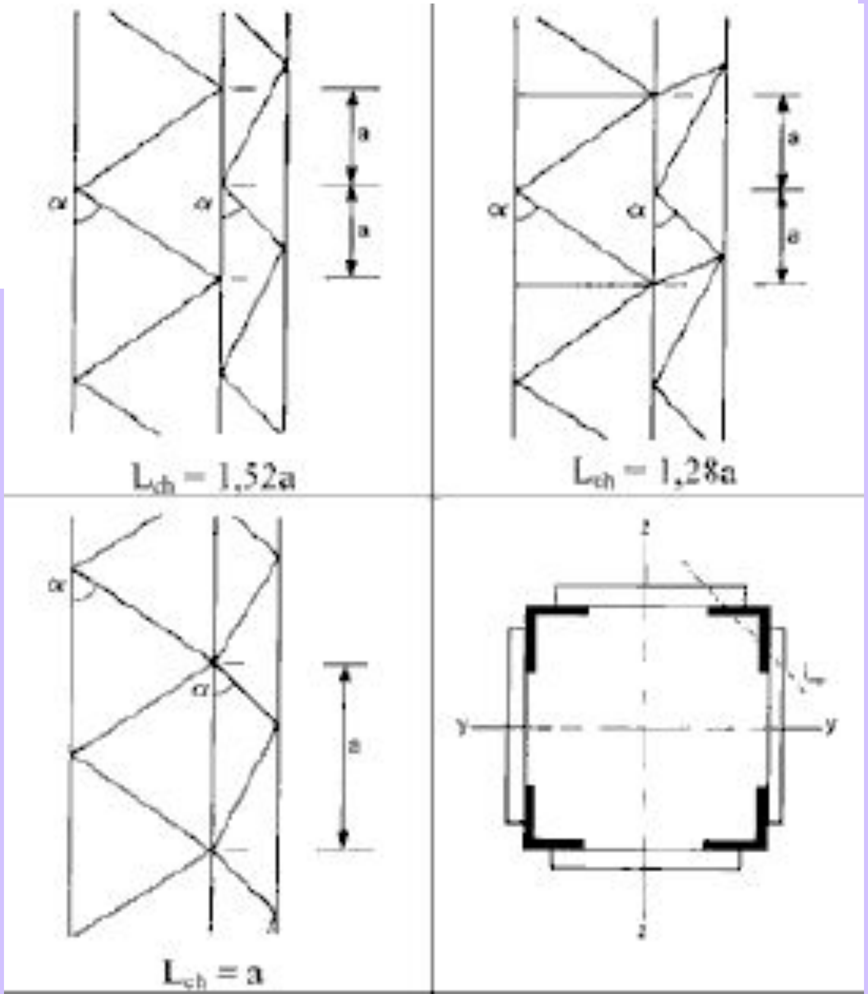


Figure 12.7 - Lch calculated length of the lattice and branches on the four sides of the element

d) The branches may have a single cross-section or a transition with sloping or lattice grids relative to the y-y axis.

e) When checking the branches, use the compressive forces in the branches Nch, Ed, resulting from the compression forces NEd and the moments MEd in the middle of the transition element interval.

e) For an element with two identical shelves, the calculation force Nch, Ed should be determined by the following formula:

$$N_{ch,Ed} = 0,5N_{Ed} + \frac{M_{Ed} h_0 A_{ch}}{2I_{eff}},$$

where

NEd - the calculated value of the compressive force acting on the transition element;

H0 the distance between the centers of gravity of points;

Ach-cross section of one branch;

Ieff is the moment of inertia of the effective section passing through the element, see paragraphs 8.2 and 8.3 of this tool;

MEd- the maximum design moment in the middle of the length of the transition element from the effects of the second type:

$$M_{Ed} = \frac{N_{Ed} e_0 + M'_{Ed}}{1 - \frac{N_{Ed}}{N_{cr}} - \frac{N_{Ed}}{S_v}}$$

where

M`Ed - the calculated value of the maximum moment that occurs in the middle of the length of the transition element, excluding the effects of the second type;

Sv - shear stiffness of a column with sloping or lattice grids, paragraphs 8.2 and 8.3 of this tool; -

Ncr is the critical force in the transition element

$$N_{cr} = \frac{\pi^2 EI_{eff}}{L^2}$$

g) the slopes or bars of the transition elements shall be checked for the transverse force determined by the following formula for the edge panel:

$$V_{Ed} = \pi \cdot \frac{M_{Ed}}{L}.$$

Compression points and slopes must be designed for stability.

NOTE: Moments of the second type of effect can be ignored.

Checking the stability of the shelves should be performed according to the following formula:

$$\frac{N_{ch,Ed}}{N_{b,Rd}} \leq 1,0;$$

Nch, Ed - calculated internal compressive force at the branch of the transition element (12.6); -

Nb, Rd - Lch according to Figure 12.7 - the calculated value of the load-bearing capacity of the branch in terms of longitudinal bending of the branch with the calculated length.