



**56567—
2015
(15512:2009)**

-

**(E N 15512, Steel static storage systems —
Adjustable pallet racking systems —
Principles for structural design, MOD)**



1 « » («8 ») -
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2 253 « » -
3 14 2015 . 1339- -
4 15512:2009 -
« » (EN 15512:2009 «Steel static storage systems—Adjustable pallet racking systems — Principles for structural design». MOD) -

1.5—2012 (3.5). -

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(www.gost.ru) -

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Adjustable pallet racking systems.		
Design code		
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5	4
5.1	4
5.2	8
5.3	9
5.4	14
6	14
6.1	14
6.2	14
6.3	14
6.4	(.....).....	18
6.5	20
6.6	20
6.7	20
7	20
7.1	20
7.2	20
7.3	20
7.4	.....	21
7.5	.....	21
7.6	.....	22
7.7	.....	22
8	.....	22
8.1	.....	22
8.2	.....	23
8.3	.....	23
8.4	.....	24
8.5	.....	24
8.6	.....	24
9	.....	24
9.1	.....	24
9.2	.....	24
9.3	.....	27

9.4	.....	28
9.5	.....	32
9.6	.....	33
9.7	.....	34
9.8	.....	44
9.9	.....	45
9.10	.....	46
9.11	.....	48
10	.....	48
10.1	.....	48
10.2	.....	49
10.3	..... ^ .....	53
10.4	.....	54
10.5	..... - .....	55
10.6	.....	55
11	.....	56
11.1	.....	56
11.2	.....	56
12	.....	56
12.1	.....	56
13	.....	57
13.1	.....	57
13.2	.....	57
13.3	.....	58
	()	61
	()	80
	()	82
	D ()	85
	iji ()	86
	F ()	87
	G ()	89
	()	92
	()	92
	15512:2009	93
	95

Adjustable pallet racking systems. Design code

— 2016—07—01

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2

28766—90
55525—2013

.16.13330.2011
.20.13330.2011

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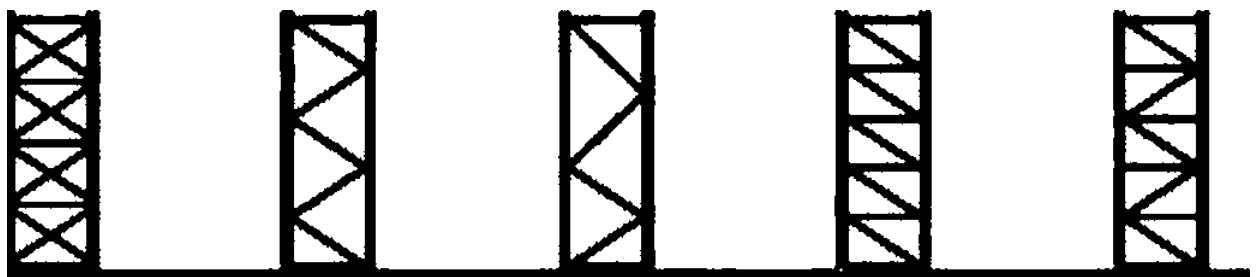
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5.1

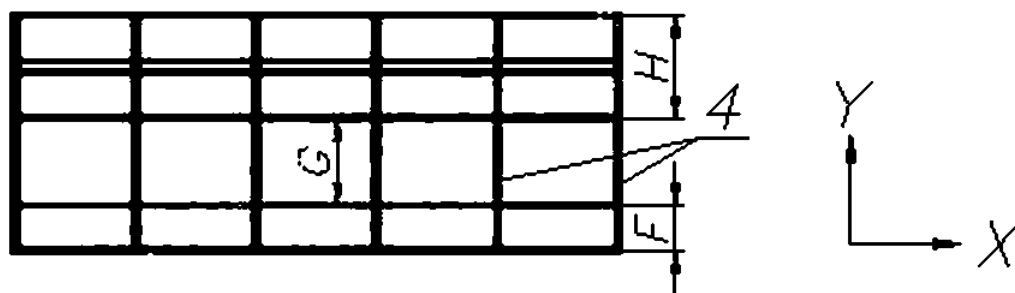
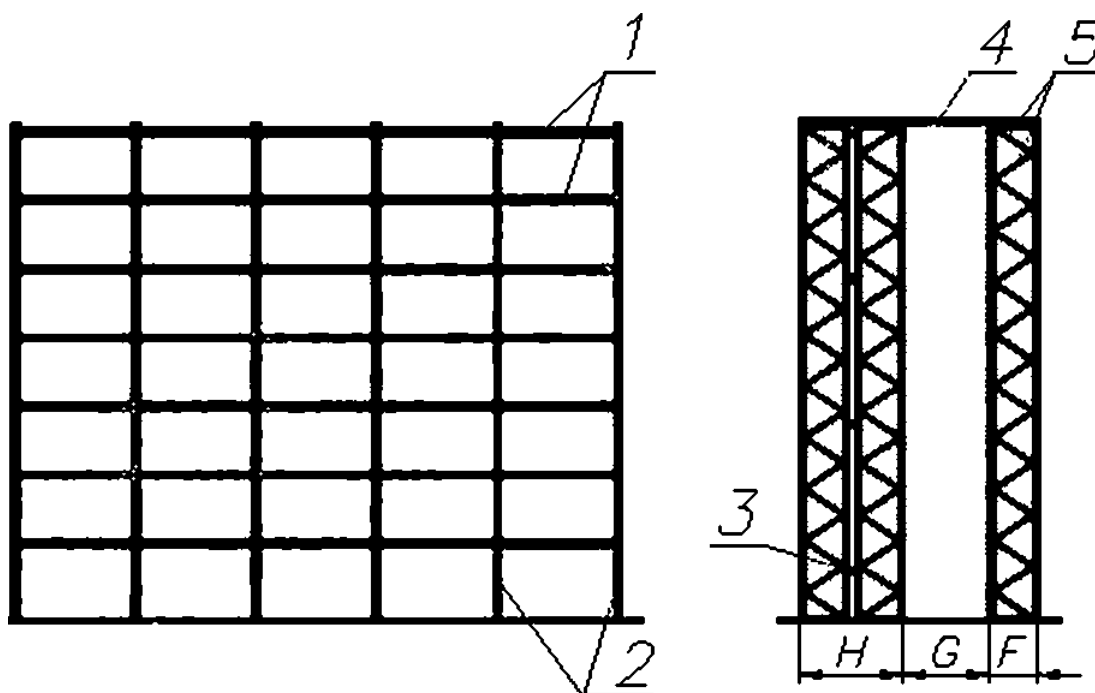
5.1.1

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[1]. [2] [3].

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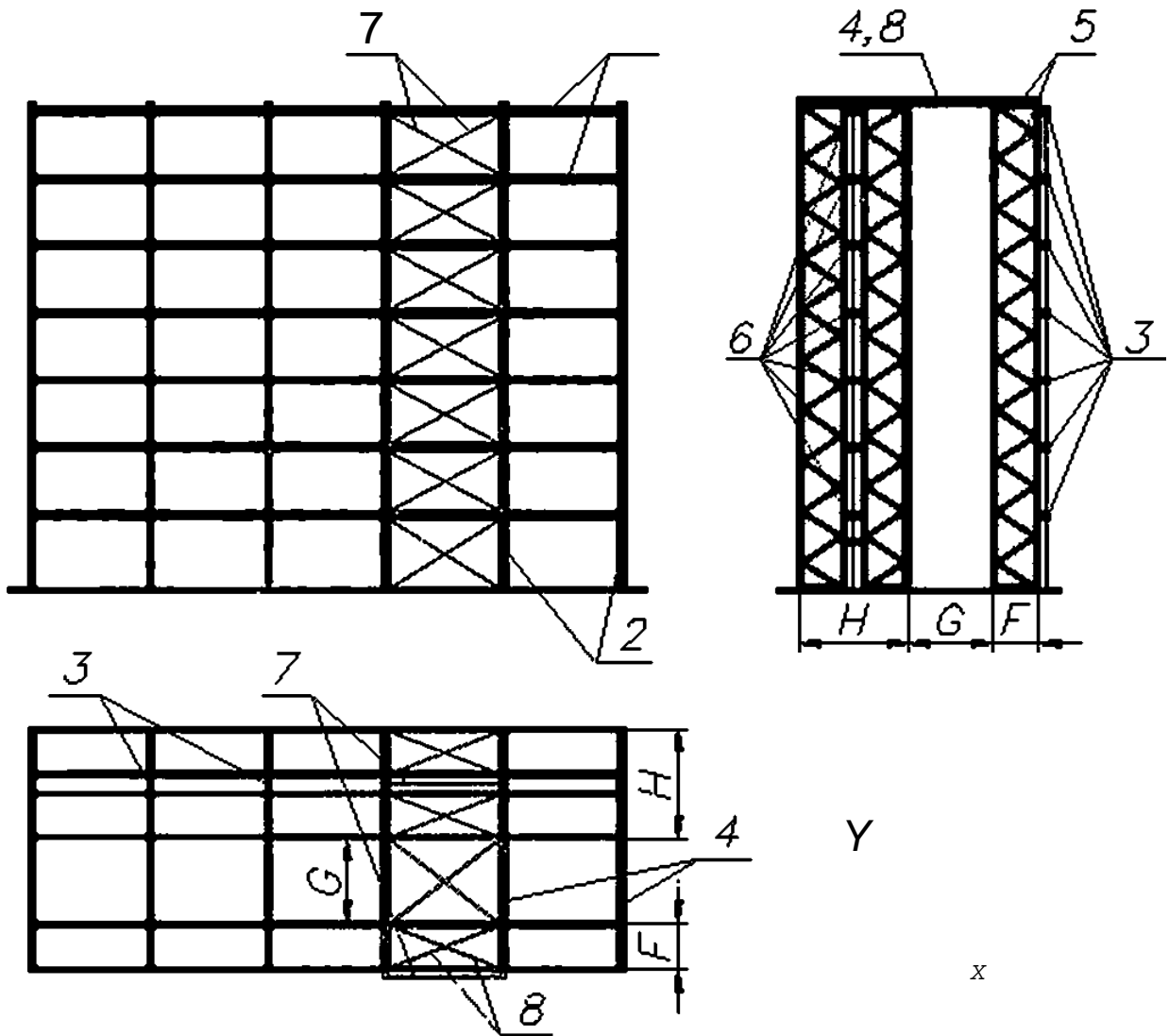


1— : 2— : 3— ()
 , F— : ←
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5.1.3

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1— ; 2— ; 3— ; 4— () ;
 5— ; 6— ; 7— ; 8— ;
 F— ; G—

3—

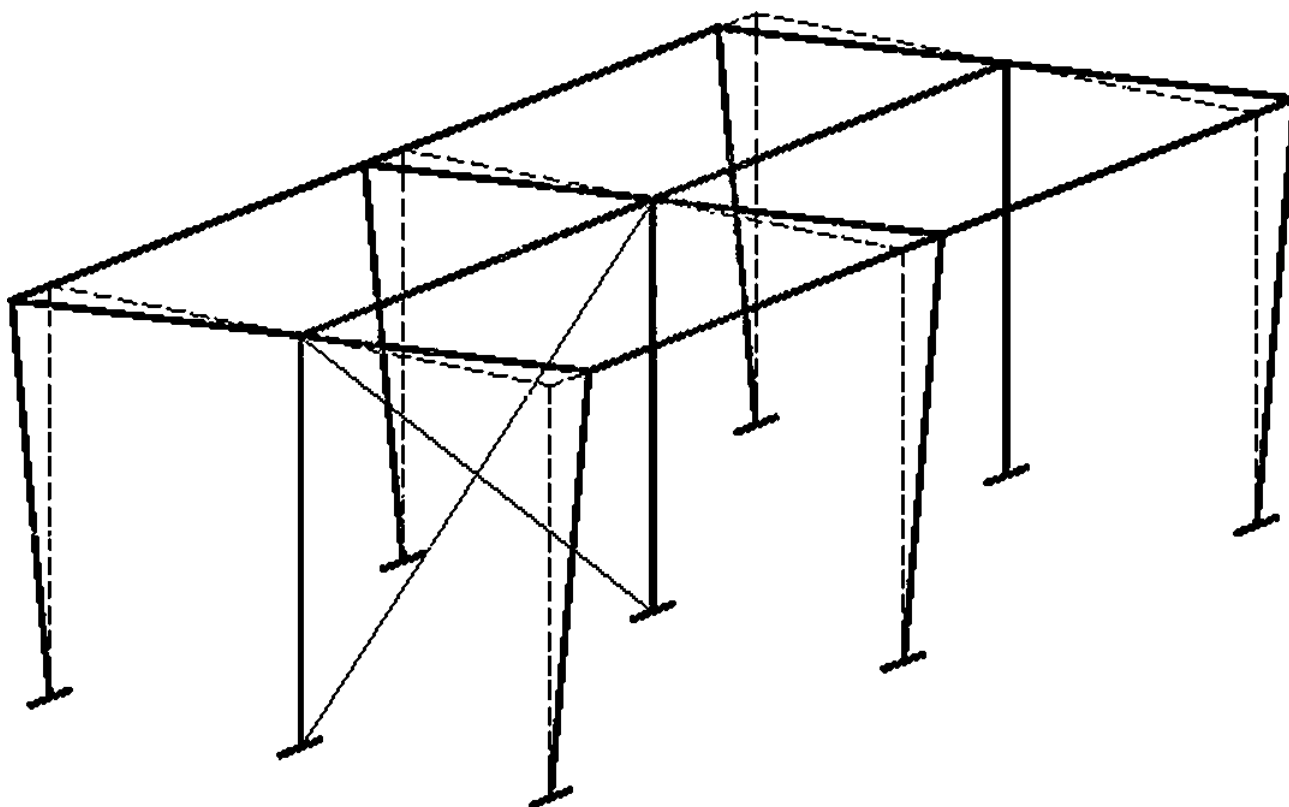
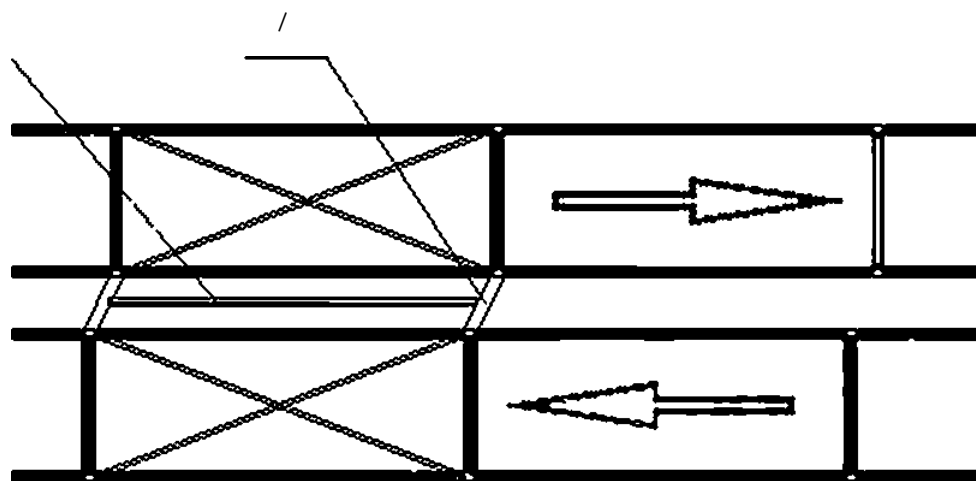


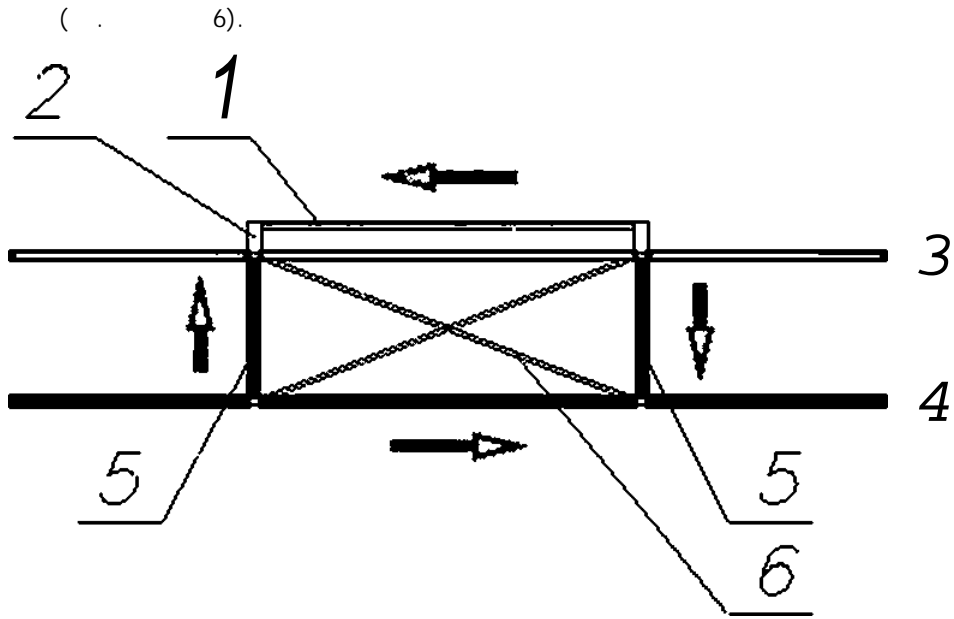
Рисунок 4 — Схема несимметричного отклонения от вертикальной плоскости двойного ряда стеллажей



— & ; 2—

5—

()



1—
2—
3—
4—
5—
6—

6—

5.1.4

10

(55625).

5.1.5

55625.

5.2

5.2.1

5.2.2

) ()
() ,
() .

- b)
- c)
- d)
-)

10000

5.2.3

5.3

5.3.1

- a)
- b)
- c)

5.3.2;

5.3.3;

5.3.5.

5.3.2

$$\phi = \sqrt{\frac{1}{2} + \frac{1}{n_c}} \sqrt{\frac{1}{5} + \frac{1}{n_s}} (2\phi_s + \phi).$$

(2+ |)

2(< +0,5)

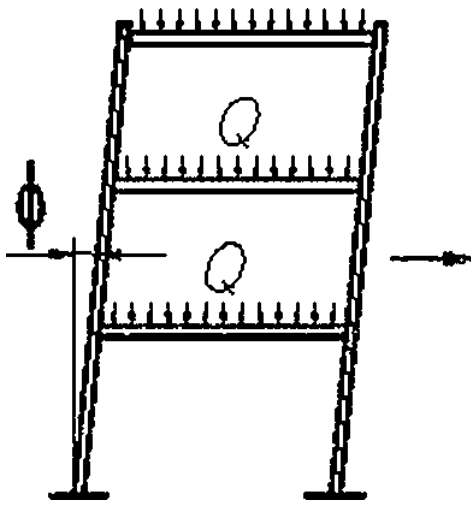
& 1/500

:

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(. 55525);

.2.5.



	nnUULUHn
3	
3	0
	° \

7—

5.3.3
5.3.3.1

(8).

5.3.3.2.

5.3.3.3.

5.3.3.2

* *Iff!* 2*

2.

0 5 2 8 , £ 1/ 500.
(2)

/-
(5.3.3.3

).

(9),

0 - 1/400
0 - 1/200

$$\sqrt{0.5 \cdot \left(1 + \frac{1}{n_s}\right)}$$

(3)

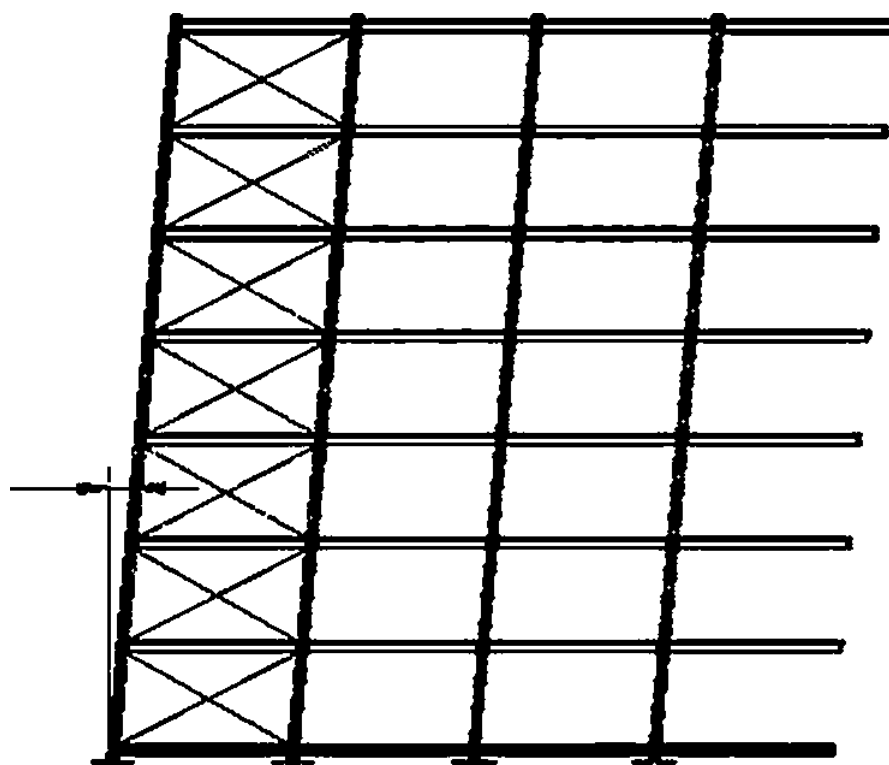
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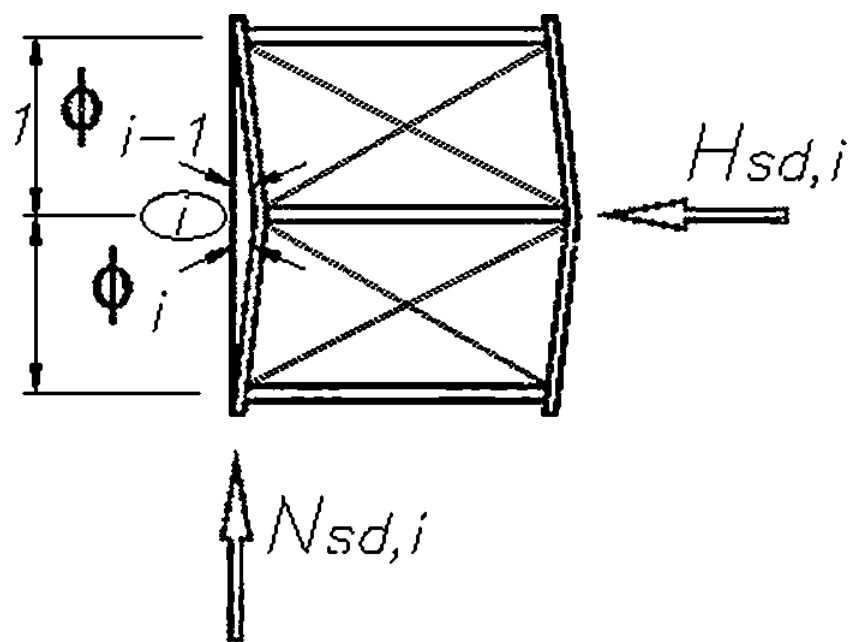
4|..-* - /

\ V



8—

$$\sqrt{j}N_{sd, i-1}$$



9—

H_{sd}

$$F_{i,j} = W_{w,i} \cdot \dots + W_{s,i} \cdot \dots$$

$H_{s<v>}$ —

N_{sd} —

$$5.3.4 \quad \dots \sim \dots \sim \dots \sim \dots$$

5.3.2. () 5.3.3, (-)

5.3.5

9.7 4.2.

5.3.6

10.1.3.

a)

«0» (.

10).

b)

«G₂»*

1.5

«G, γ »

2.0

(. 10). 8

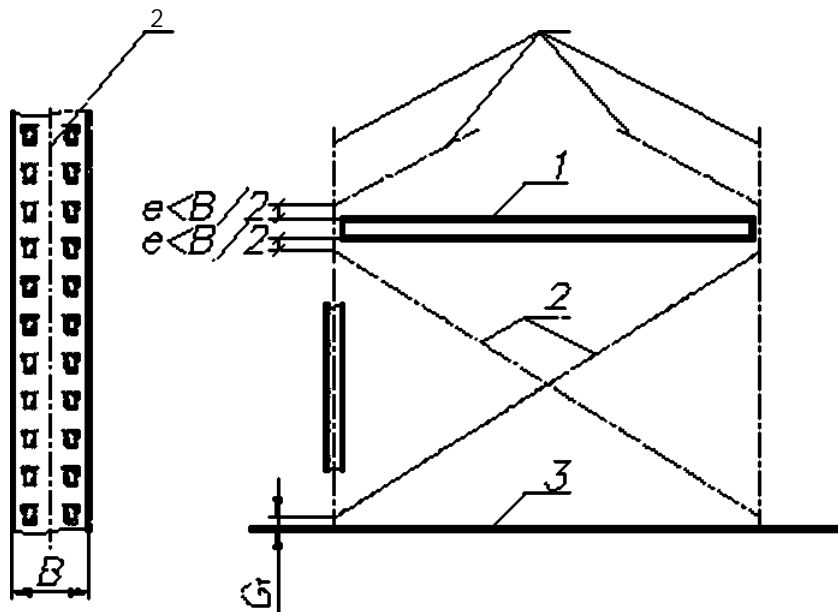
(.

10)

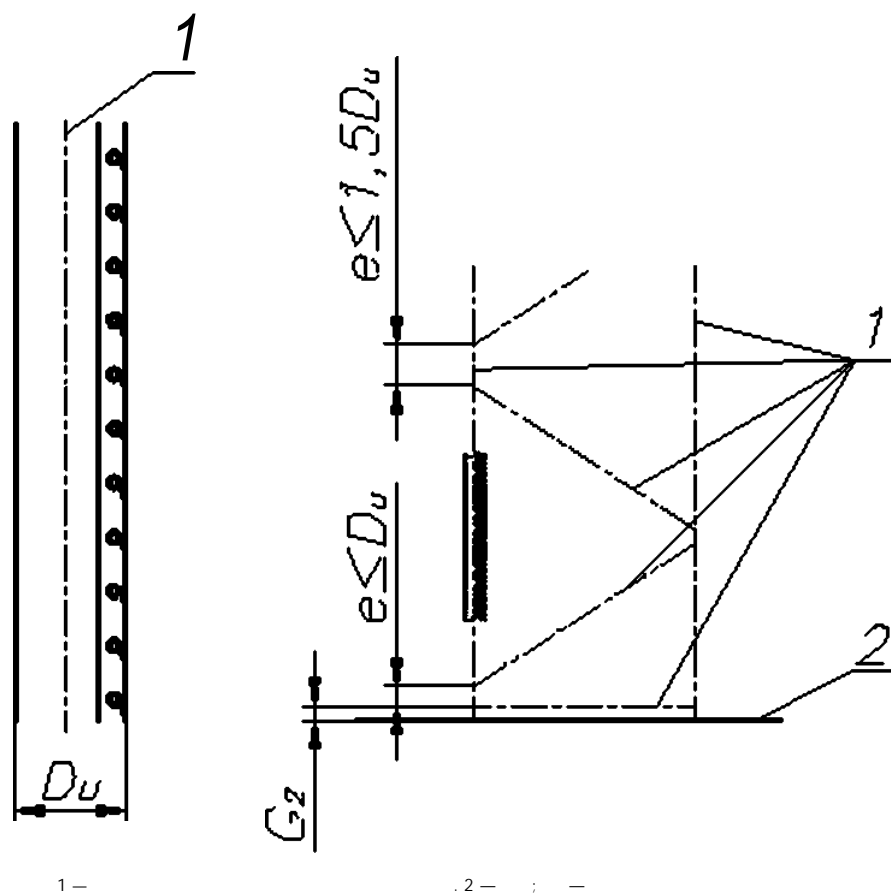
1 — 20° 70°.

2 — 5.3.6

2.7.



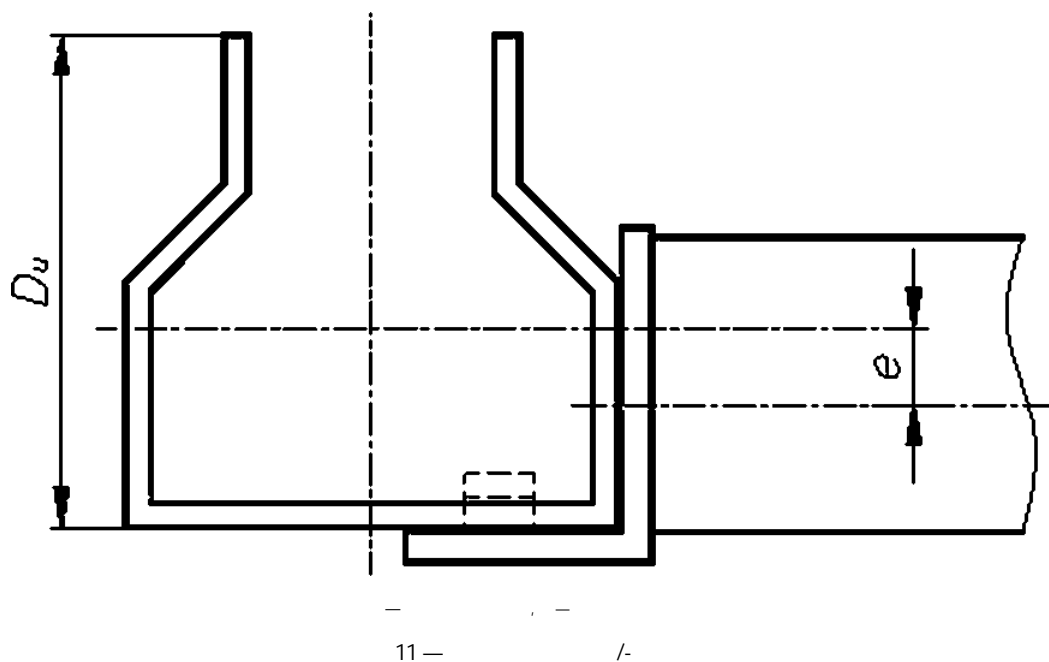
) — . 2 — : 3 — : — : — () : , —



5.3.7

« »

11.



< 0,25 D_u.

11

5.4

(. . .)

6.4.2.

6

6.1

6.

6.2

6.2.1

(. . .)

6.2.2

6.3

6.3.1

1)

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6.3.2

55525.

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80 %

- 4) (-)
 5) (-)
 12 %
 12 %
 = (5)

£1,12. s 1.
 U2fipfi1.24.TO = 2 -1.24 .
 1.24, = .

Q₀—

6.3.3

- a) (. .)
 ()
 25 %
 ()
 b) ()
 (Q_{pv}*), 100 %
 ()

6.3.4

6.3.4.1

X- ^-

6.3.4.2

6.4.

- 1) 3 O_{ph} = 0.5 ()
 2) 0,25 . 0.5
 3) 3 6 O_{ph} 3
 1) 2); 0.5 . 3 .

b)

0.25

c)

0.25

Q^{\wedge}

$Q_u -$

1 —

2 —

d) Q_{ph}

1)

2)

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3)

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= *1

= 0.1

e)

$Q_{ph} - 0.25$

6.3.4.3

X-

Q^{\wedge}

2

6.3.4.4

/-

/-

a)

).

(

/-

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(

$Q_{ph} t/6$;

b)

Z

0.50^{\wedge} .

)

0^{\wedge} .

6.3.5

0.7

1.

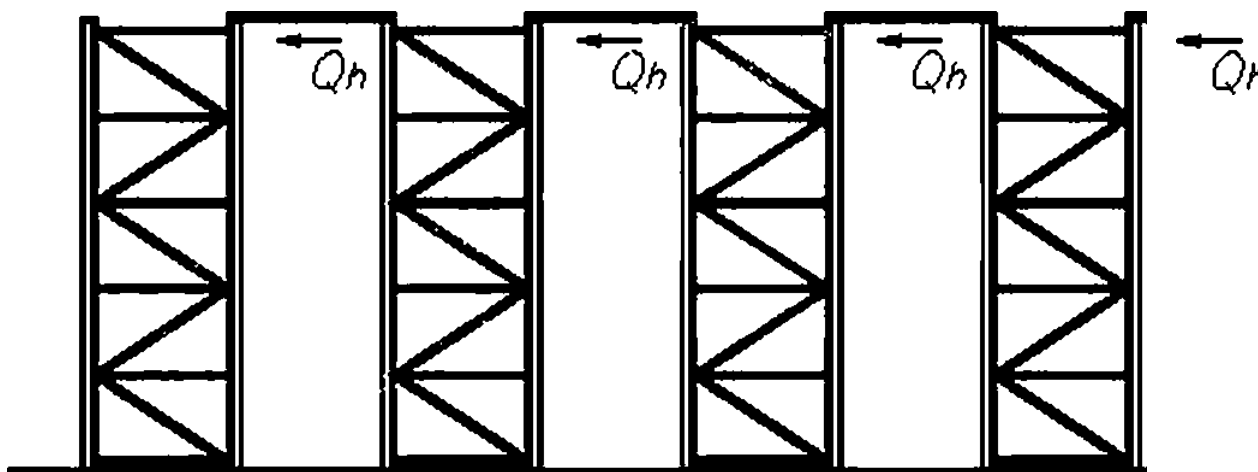
1 —

1	2	*
3		$0.85 \times Q_h$
4		$0.70 \times Q_h$
25		Q_h

28766. $Q_{h'}$ —

12).

Q_b, t



12 —

1.

$Q_{h'}$

6.3.6

()

a)

()

()

1.2 :
 $<7 = 2,5 / ^2 ($
 $, - 2.0 ($

);

50 * 50).

()

1,2 .

q- 1.0 / ^2

b)

()

1,2

c)

1,2 :

q- 3,0 / ^2 (

).

, - 3,0 (

100 * 100).

1,2 :

q- 3,5 / ^2 (

).

, - 3,0 (

100 * 100).

d)

([4]. . 6.3).

1)

5 / - 1.2;

2)

7.5 / - 1.4;

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10 / - 2.0.

6.3.6 — 6.3.6

(),

20.13330.

1 —

2—

6.3.6,

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6.3.7

6.4

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6.4.1

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400
400

- a)
- b)
- c)
- d)
- e)

()- 400
100 400
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1 — ()
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3 —
4 —

[5].

55525.

6.4.2

A_{pv} Z.

7.4:

)
= 5.0
 $p_v = 0.5 Q_u$
 $A_{pv} = 0.25$
 $A_{pV} = 5.0$

.2.6.

6.4.3

- a)

400
 $A_{ph} = 2.5$
 $A_{oh} = 1.25$

[5]
(55525).

- b)

$A_{ph} = 0.5$ X- /- ()

6.5

6.6

6.7

7

7.1

7.2

-

:

$$1\gamma cG_t + 0.9E_{\gamma_0} Q_{tj} \quad (6)$$

$$Z + Z_7 \cdot \frac{Y^*}{1.1} \quad (7)$$

G_k—

);

, —

Q_k(—

y_G —

0 —

7.3

0

[1].

(6), (7) (8).

•

$$2 > * | , \quad (9)$$

$$0.9 \frac{E}{M} \quad (10)$$

1 — (, ,), (. 55525).
0.0.

2 —

7.4

2.

2—

• : •	1.3 1.0	1.0 1.0
• ; y_0 • • - ; • : •	1.4 1.4 1.3 (. 1) 1.4 1.5	1.0 1.0 1.0 1.0
GA	1.0 1.0 1.0	— —

1 —

1.4 1.3.

2 —

).

(. 6.3).

7.5

3.

3—

	1.05	1.05

	1.25	1.0
)	1.1	1.0

7.6

O_{pj}

7.7

8

8.1

8.1.1

(2) (3.1) (3) (3.1 . 3.1),

196

- a) (3.1) [3] (3.1);
- b)

[2]

.1.2

$f_{ji} * 1.05.$

/ . f_u —

[2].

1 —

8.1.1,

2 —
(f_u

D

8.1.2

: f_y /
 a) $f_y - (v - R_m)$

b) 8.1.5:

c) 8.1.4.

8.1.3

a) $- 210\,000 / ^2;$
 b) $G = \text{£}/[2\{1+ \}], / ^2;$
 c) $(\quad) = 0.3:$
 (3) $= 12 \cdot 10^0 ;$
) $= 7850 / ^3.$

8.1.4

8.1.4.1

8.1.4.2

.1.1.
 (. 13.3.3).

a)

b)

c)

13.3.3.

100
 12
).

8.1.5.

8.1.5

• $- 200 / ^2; i_y$
 • $- 140 / ^2.$

8.2

[3]. f_{ya}

8.3

90 %

8.4

6

6 2 (35 * 8.1.5) [6].

8.5

55525. [7]. [8]. (9).

: 0.5 8.0

8.6

- a)
- b)
- c)
- d)

10-

9

9.1

9.2

9.2.1

9.2.3.

9.2.2

- a) 1 —
- b) /_n —
- c) 0 —
- d) /_i —

Y

[3] (. 5.1).

9.2.3

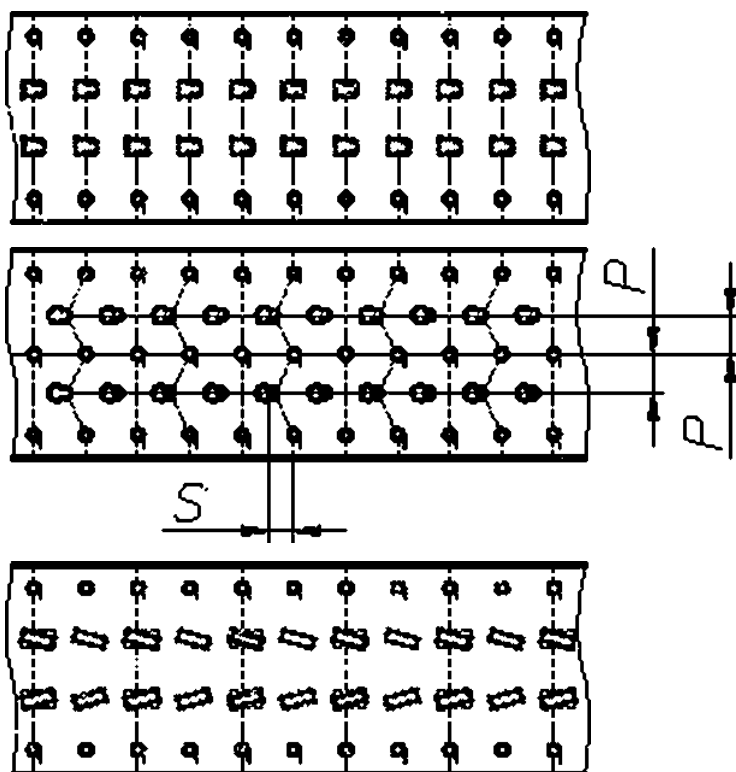
(. 13).

&)

(. 13).

- a) S —
- b) —

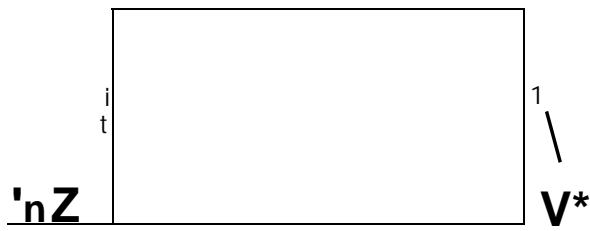
(. 13).



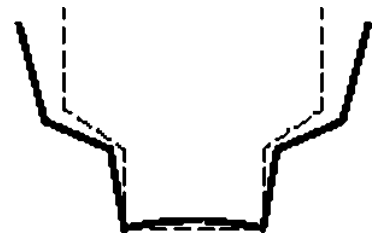
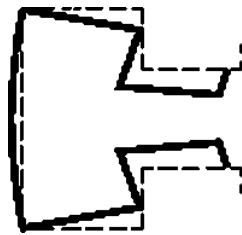
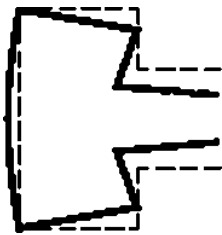
9.2.4

- a) ; (. [3]);
 b) (,
 c)); (-).

1: 14 ([3].
 2: 15 (),
 .2.2.



14—



15—

- a) ;
 b) ;
 c) 1 — (),
 2 —

(. .2.2).

9.2.5

[3]

.2.1.

(.2.1. .2.2. .2.3).

)
():

$$\frac{b_p}{t} \leq 1,28 \sqrt{\frac{E}{f_y}} \quad (11)$$

)
():

(12)

w

Eyf.

4.

4—

11

f_y

t /	b/t	
220	39.5	13
235	38	12.5
250	36.5	12
275	35	11.5
280	35	11
320	32	10.5
350	31	10
355	31	10
360	30	10
400	29	9
420	28	9
460	27	9
500	26	8

9.3

9.3.1

- a)
- b)
- c)
- d)
- e)
- 0

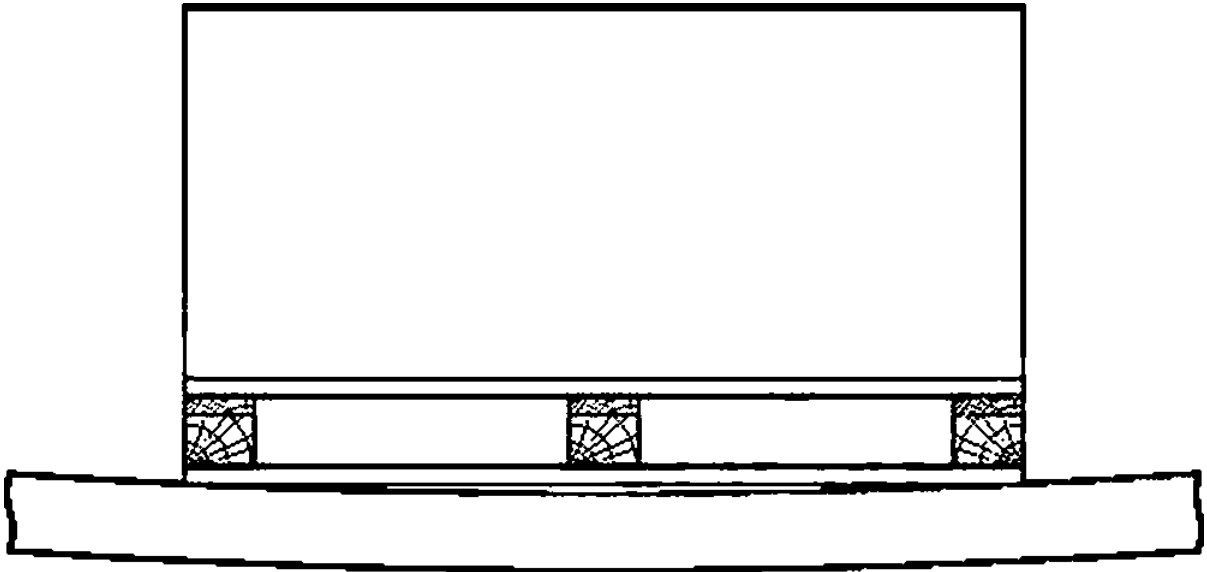
1 —

(. 2.10).

2 —

3 —

16.



16 —

()

4 —

9.3.2

> >

(3) (. 6.1.4).

9.4

9.4.1

—

9.4.1

a)

9.5 9.6

10.2.

b)

11.2.

—

.2.5.

9.4.2

F.

1 —
2 —

9.4.6.

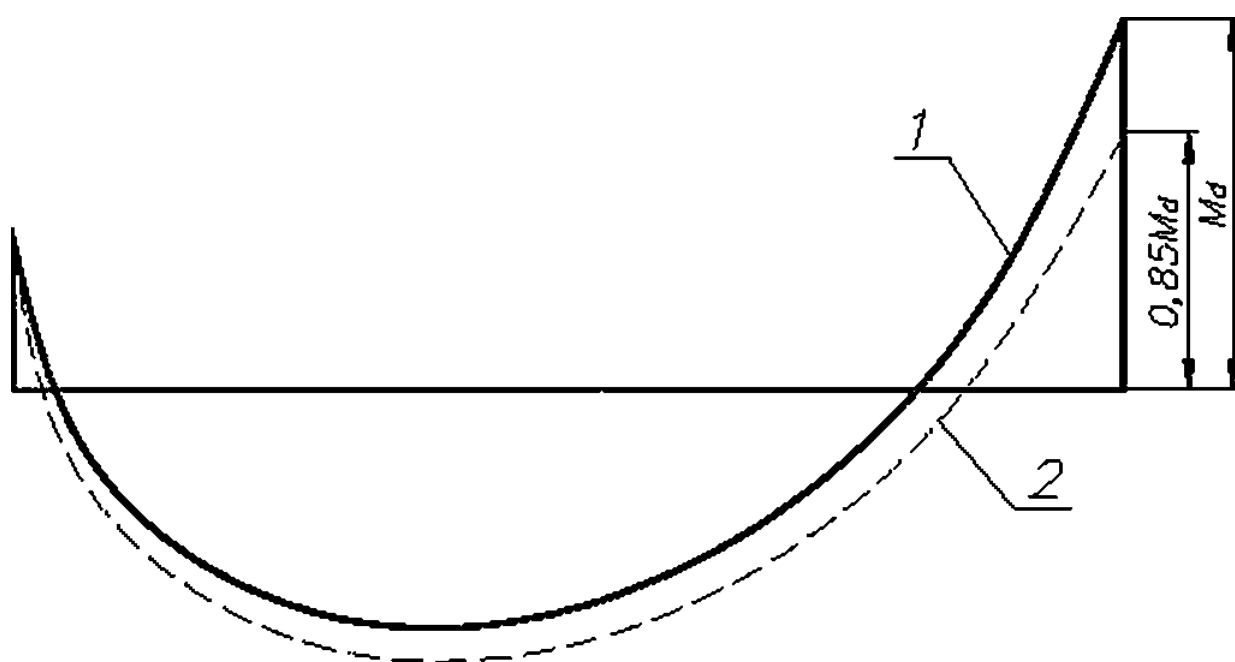
9.4.3

9.4.3.1

9.4.3.2

15 %

(17)



1 — момент по результатам линейного анализа, 2 — момент после перераспределения, M_d — расчетный момент

Рисунок 17 — Перераспределение моментов балок

b)

(9.5 9.6).

1 —
15 %

2 —

(6.3.4.2).

9.4.3.3

$$\sigma = \frac{5}{1} \frac{2}{kL} \quad (13)$$

$$kL \quad (14)$$

$$1 + \frac{k \cdot h}{3 EI}$$

W_d —

L —

h —

1 —

$/$ —

p_w

F .

9.4.4

$$-V_{Sa}$$

(15)

V_{Sa} —

V_{ef} —

(6.3).

Z

$$\frac{2^2 (\dots -1)_0}{4L^2} \quad (16)$$

$$\frac{W \cdot 2 \cdot 2^2 \cdot (-1)}{41} \quad (17)$$

9.4.5

$$\frac{5 W_s L^3}{384 E I} \beta_s \left(1 - \frac{0,8 \beta_s}{\beta_s \left[1 + \frac{2 E I_b}{k_s L} \right]} \right) \quad (18)$$

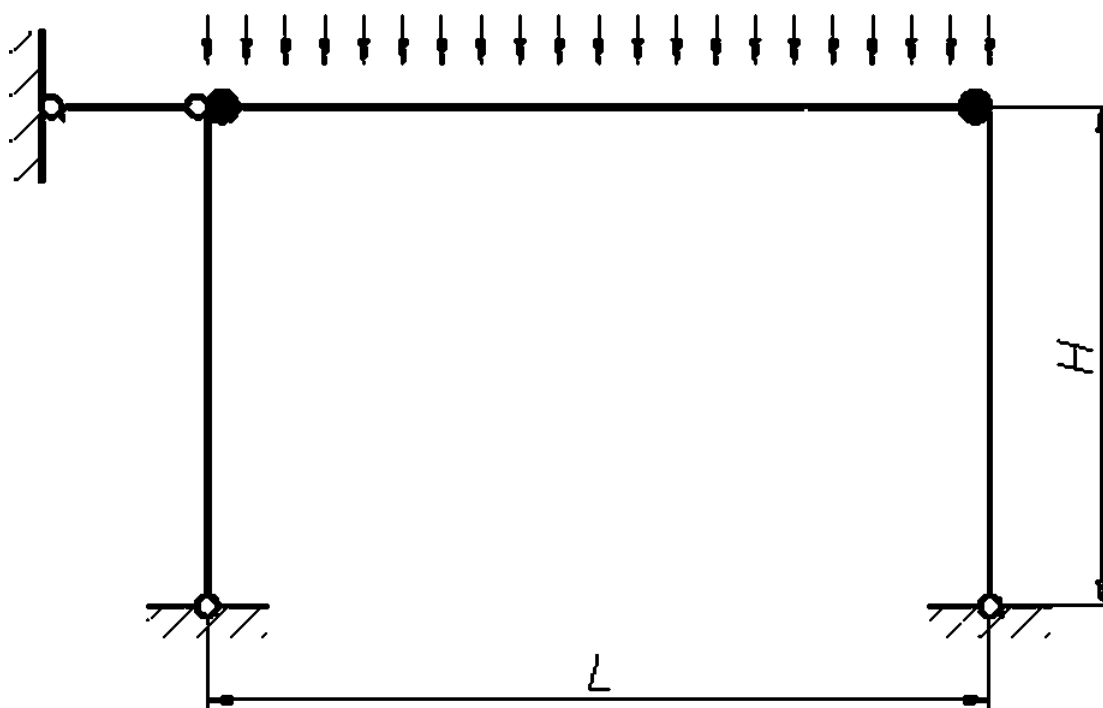
W_{scf} —
0

F.

(1).

16.

W_{ser}



• — упругая связь; H — высота уровня; L — пролет.

18—

9.4.6

1—

2—

- a)
- b)
- c)

L_b-L.

5.

5— { = -)

1 2	0.6	0.5
1 3 {)	1.0	0.9
2 3 {)	0.6	0.5
2 4	0.7	0.6
3 4	0.5	0.45

9.4.7

{3}.

9.4.8

[3].

9.4.9

(3).

9.5

9.5.1

:

- (. 9.4.3.2);
-

9.5.2

().

)

(19)

- " -)

$$12 u^2 J L \overset{\wedge}{\underset{-1}{>}} \quad (20)$$

$$\frac{W_a L}{12} \left(1 + \frac{2}{x_*} \right) F. \quad (21)$$

9.5.2

9.4.4.

9.5.4

.2.4),

9.6

9.6.1

[3].

9.6.2

M_{bRd}

.2.10.

$$\ll " * / W \quad (22)$$

$$\ll \dots \dots \dots 1 \dots \dots \dots x i f s l. \quad (23)$$

$$= 0,5 [\ll_1 (\dots -0,2) + X^*_{ir}], \quad (24)$$

*
W.

8.1:

Y (.

19.20);

$$a_{tr} = 0.34 ($$

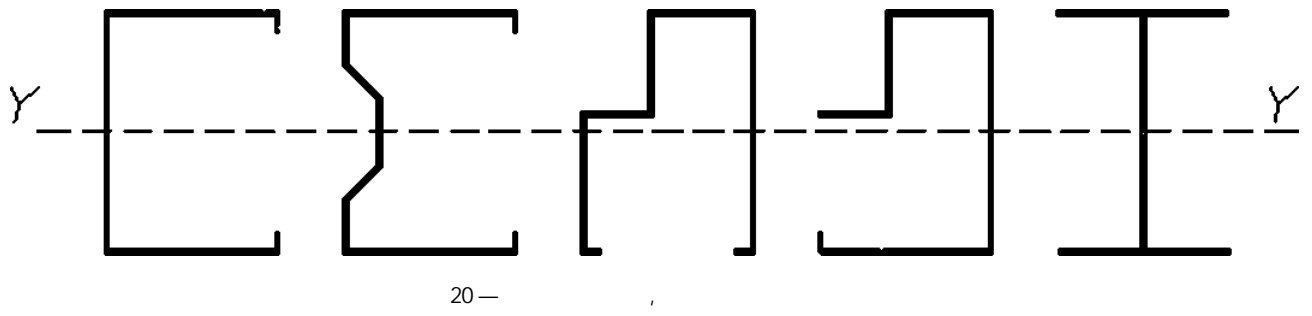
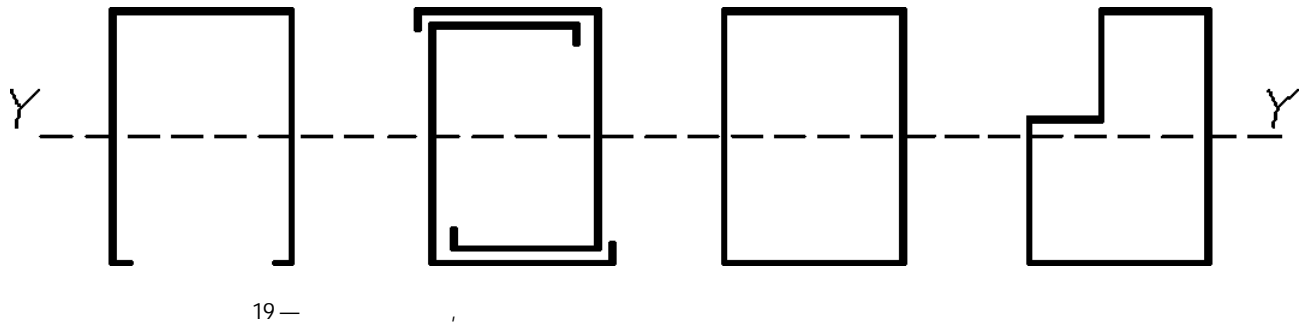
{3]);

M_{ct} —

« »

[3].

(2)
— 19 20



9.7

9.7.1

9.7.2

a)

b)

.2.1 .2.3.

(

c)

(.2.1),

1)

1).

N_{db}

.2.2

(

2) $N_{bR<J}$

9.7.4 9.7.5.

3) $= N_{abRb} / N_{bRa} = 1,0$

4) $t < 1,0;$ $N_{bR<J} / Ra = 1.$

9.7.3 "

$N_{sa} \wedge N_{eAe}$ (25)

Ngj —

N

11 — 7.5.

9.7.4
9.7.4.1

$N_b \wedge$ (26)

$\frac{v \wedge v < 1}{+ * ** *}$ (27)

$\cdot 0.s[l + (-0,2) + ^{21}$ (28)

1 — 8.1; = /,).

$\bar{\lambda} = \sqrt{\frac{A_{cr} f_y}{N_{cr}}} = \frac{\lambda}{\lambda_c} \sqrt{\beta_{cr}}$ (29)

N_{cr} —

==

$-tA_d$ ($= (y/i_{gy} * 1 / > q_2).$

$$\lambda_1 = \pi \sqrt{\frac{E}{f_1}}$$

t—

9.7.4.3;

—

:

9.7.4.2

9.7.4.2.

)

(. .

6.

6—

	®0			
	0,13	0,21	0,34	0,49

7.

7—

			2-2
		<1*0,34	= 0,34
		= 0,49	= 0,49
tfc i lz		= 0,21	= 0,34
' >		= 0,34	*0,34
2 * t		= 0,34	= 0,34
iu* y*VI 4-4*«		= 0,49	= 0,49

a)

b)

8.2

f_{ya}

E

.2.3.

9.7.4.3

{

1 —

2 —

7

3 —

X- /-

/-

10.1.3

),

(

(-KL.

L—

(. .):

a)

: -1.

b)

/-

1)

2)

5.3.6 5.3.7:

3)

4)

-0.9

3) 4):

-1.0.

L—

[21 .).

(. 5.3.6).

c)

$\gamma = 1.0$.

L—

{ 21 .).

[21 ,
21].

d)

20

-0.9

-1.0.

5.3.6),

(. . .

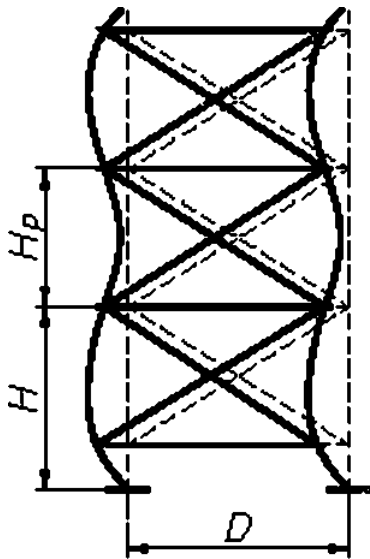


Рисунок 21а

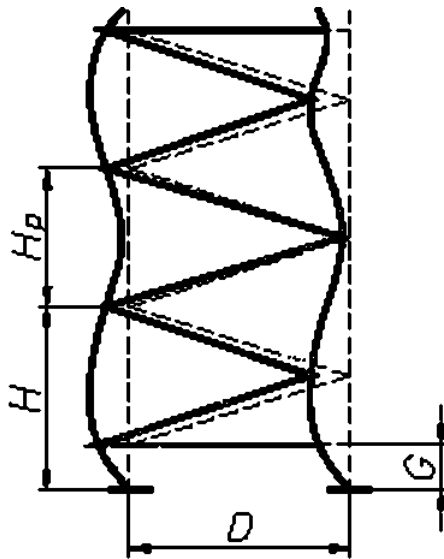


Рисунок 21б

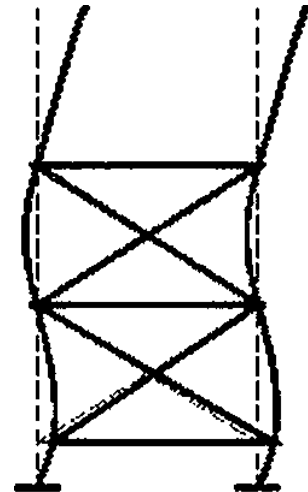


Рисунок 21с

21—

)

).

)) /-

(. . . 22).

1:

L—

(22).

2:

L—

(22).

3:

L—

{ 22).

L—

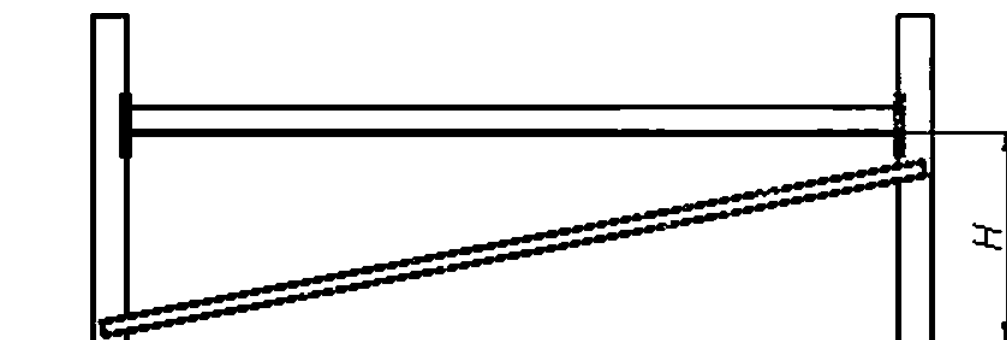


Рисунок 22а, вариант 1: Узлы крепления раскоса не совпадают с узлами крепления балки

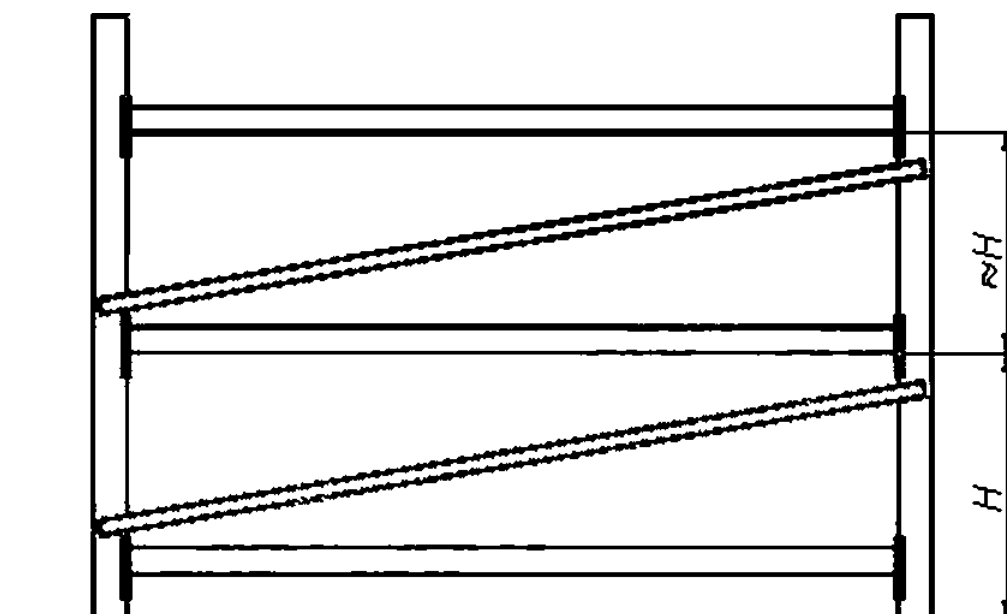
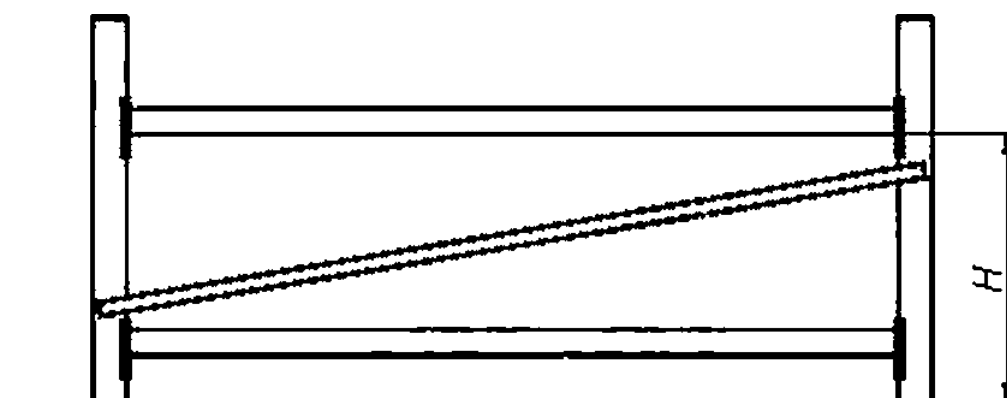


Рисунок 22б, вариант 2: Высота нижней балки над полом аналогична высоте между соседними балками



22 . 3:

22 —

5.3.6.

0

-1

L

9.7.4.3

9.7.5

9.7.5.1

9.7.5.2

$N_{bR<L}$

9.7.4.

$N_{\alpha T}$ $N_{df,T}$ N_{ct} :

$$N_{\alpha T} = \frac{1}{i_0^2} \left(G I_T + \frac{\pi^2 E I_w}{L_{\alpha T}^2} \right) \quad (30)$$

()

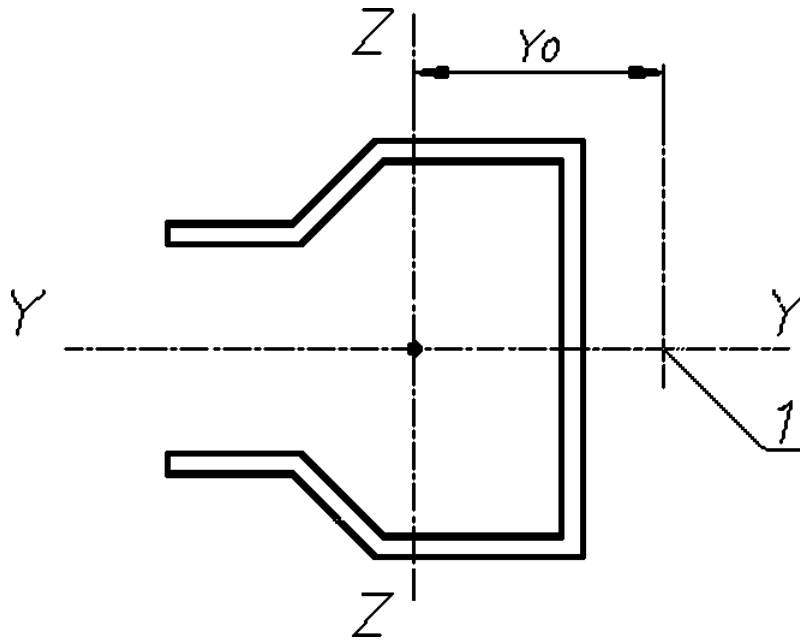
$$N_{aFT} = \frac{N_{\alpha T}}{2\beta} \left[1 + \frac{N_{\alpha T}}{N_{\alpha Y}} - \sqrt{\left(1 - \frac{N_{\alpha T}}{N_{\alpha Y}} \right)^2 + 4 \left(\frac{y_0}{i_0} \right)^2 \frac{N_{\alpha T}}{N_{\alpha Y}}} \right] \quad (31)$$

(31)
- { . ^ = 0.

$$\beta = 1 - \left(\frac{y_0}{i_0} \right)^2, \quad (32)$$

N. —
N. —

9.7.4.3.



— ;

E —*

G — ;

$$\beta = 1 - \left(\frac{y_0}{i_0} \right)^2;$$

— (. 23);

i_1, i_2 — z ; ;

1 — ; ;

— ;

L_{CT} —

$L_{eT} = 1,0$ ()

$L_{eT} = 0,5$ ()

24 , . 1 = 0,7 (

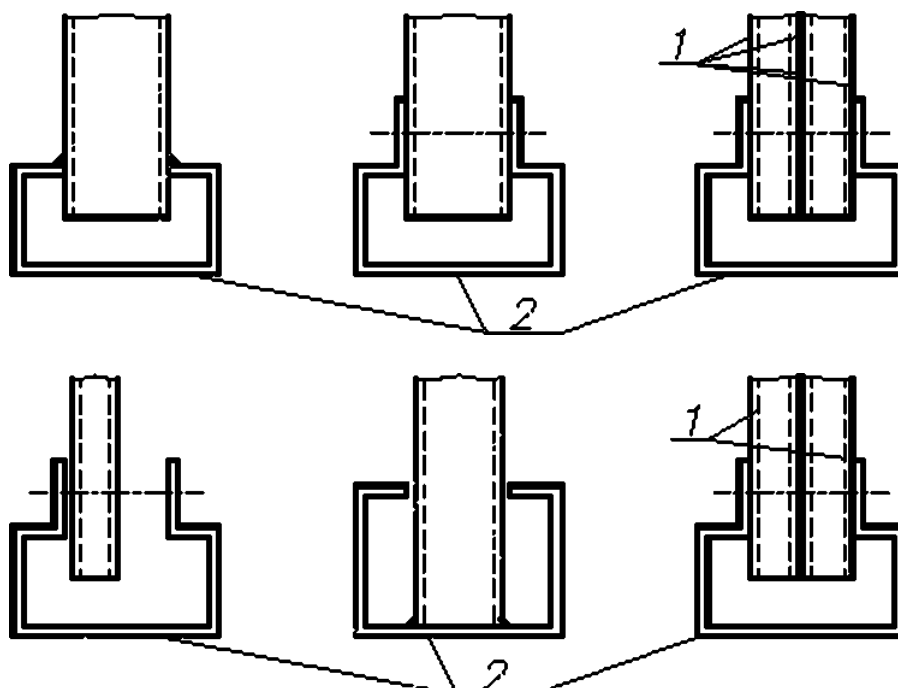
).

24 , . $L_{eT} = 1,0$ (

).

), — L_{eT} , L_{eT} 0,5 {

.2.3.



1 — стенки; 2 — рассматриваемые стойки

24 — (— —

: b — — —)

9.7.6
9.7.6.1

[2] [3].

9.7.6.2

$$+ \text{---} + \quad \text{£1,} \quad (33)$$

Mgj —
— 9.7.3.

* » // ..

9.7.6.3

97.6.2.

$$\text{»} \text{-----} \text{*, *}, \quad (34)$$

N

$$* \text{ }_{-1-77} > 0 \wedge 1 * 5$$

$$-4). \quad , *0.90$$

$$. 1 - \pm \text{£} \wedge 1 \text{---}, \quad S1.5$$

$$, = , (2 \wedge -4). \quad , *0.90$$

$$X_{min} \text{---} \quad 9.7.2b \quad X/ \quad \wedge ,$$

$$9.7.4 \quad - \quad z-z$$

$$- N_{Cnt} - () ' (\lll' ($$

.2.3

9.7.2.

$$\wedge \quad (. 97.6.4).$$

$$). \quad s 1 / \quad \wedge s 1.$$

$$). \quad - / \quad \sim$$

$W_{e(r)}$ —
 $W_{e(i_z)}$ —
97.6.4

z-z.

97.5.

$$\frac{l^{st}}{k_{tr} M_{yst}} \wedge \quad \text{---} \text{£4} \quad \wedge \quad (35)$$

$$* \text{ }_{-1-7TT} \text{---} \text{H0*} \text{---} s1 \quad (36)$$

$$\wedge , = 0.15 X 4 \wedge , -0.15. \quad p_{tr} S0.9. \quad (37)$$

ir

$A_{eff} \cdot W_{chly} \cdot W'_{yz}$ 9.7.6.3.

() (9.7.2), % (° 9.7.4)

X_{LT}

(. 13)).

25

8.

8—

$I_{m, y}$	-	-
	Z-Z	Z-Z
	-	Z-Z

f_y

2.1.

$W_{eff} \cdot X_{LT} \cdot W_{chly} \cdot W'_{yz}$ //

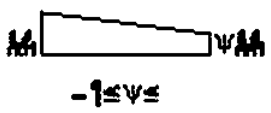
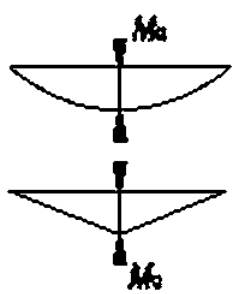
2.9

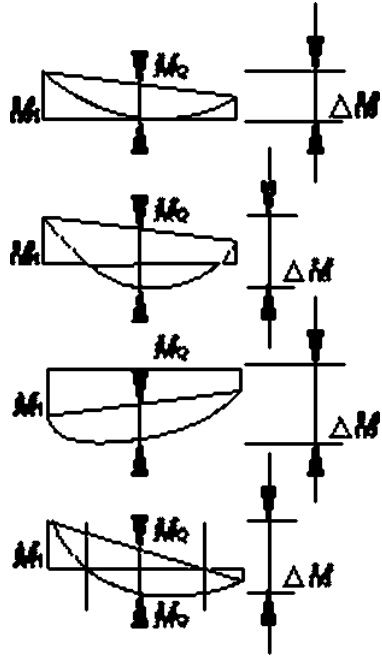
X_{min}

2.3

(. 2.1)

(. 9.7.2).

Эпюра изгибающих моментов	Эквивалентный коэффициент равномерных моментных напряжений β_M
<p>Моменты на концах балки</p>  <p>$-1 \leq \psi \leq 1$</p>	<p>$\beta_{M,\psi} = 1.8 - 0.7\psi$</p>
<p>Моменты вследствие поперечных нагрузок в одной плоскости</p> 	<p>$\beta_{M,0} = 1.3$</p> <p>$\beta_{M,0} = 1.4$</p>



$$v = \frac{1}{E} \int \frac{M}{I} dx$$

25. 2

97.6.5
97.6.5.1

[2] (. 6.2.3).

(3) (. 6.1.2).
97.6.5.2

$$M_{Sij} = N_{Sij} - \frac{N_{1A} \cdot y_{1A}}{i_{Se}} \quad (38)$$

9.3.2. 97.6.5.1.

[2].

9.8

.2.11.

a)

b)

$N_{S<}$

c) (. . . 2.11)

d)

e)

$$\frac{N_{sd}}{A_{sp} f_y / \gamma_M} + \frac{M_{acc} + M_{1, sd}}{M_{ed} / \gamma_M} \leq 1, \tag{39}$$

$$M_{1, sd} = M_{1, ed} + N_{sd} \left(\frac{1}{\lambda} - 1 \right) \frac{W_{sp}}{A_{sp}} \sin \frac{\pi x}{l} \tag{40}$$

X
 \ "
 W_{ed}
 —
 7—
 —
 —
 —

9.7.4;

1.5 %

10%

9.9

9.9.1

△

2.7.

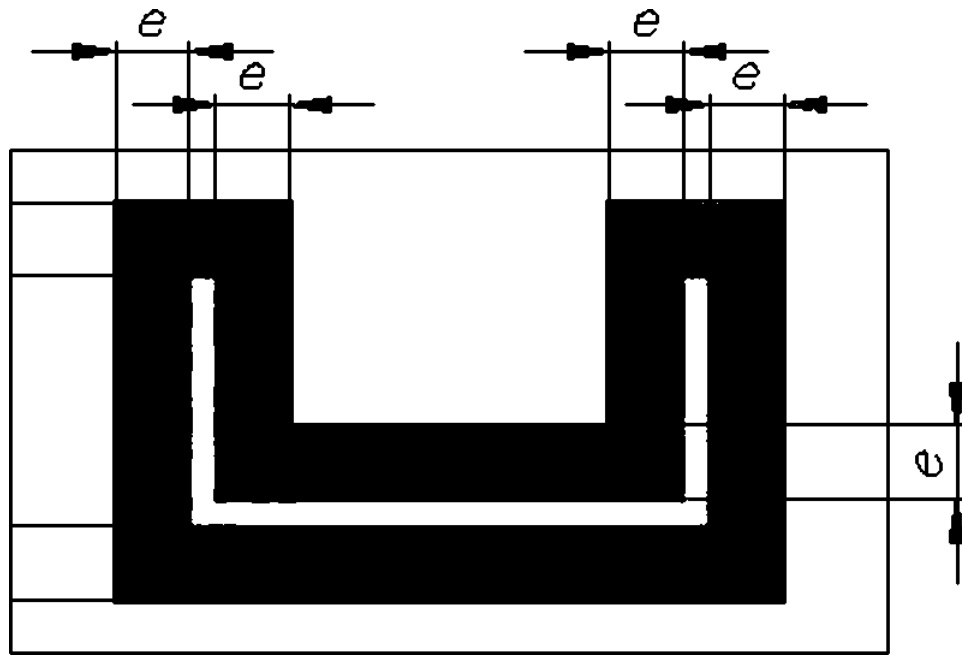
9.9.2

A_{bgs}

26

$$e = f_c \sqrt{\frac{f_c}{3f_y}} \tag{41}$$

(. . 9.10).



26—

l_{str}

(«)

26:

(—

9.10.1.

9.10

9.10.1

/'

(. $2.5^{-\wedge}_*$

(43)

$f_{ch} = 1.5 ($

).

20/25

[10].

$l = 20 l^2$.

9.10.2

f_e

9.

. 3

t_j

f_c

:

(44)

9.

9—

		$t_c / ^\circ$	
		0.3	0.8
		0.3	0.8
	/	0.3	0.8
	-	0.3	0.8
	+ +	0.3	4.0
	,	0.3	—
		0.3	—

1 —
25°

9.

2 —

/

(

9.10.3

9.10.4

{11}.

3

() 5 ().

a)

);

b)

c)

d)

)

f)

)

() -

9.11

(. 2).

10

10.1

10.1.1

()

(2) [3]

10.1.2

10.1.3.

10.1.3

5.1.2 5.1.3.

(2) [. 5.3.2 (11)].

a)

b)

[2] [. 5.3.2 (11)].
.2.3),

a_{LT}

()

(-

c) ().
d) .
e) .
0 -

s 1 ().

10.2

10.2.1

10.2.1.1

6.

10.2.1.2

7.4,

7.2 7.3.

10.2.2

10.2.2.1

/-

9.7.

()

5.3.2

10.2.2.2

a)

b)

c)

d)

e)

•

•

-

•

5.3.

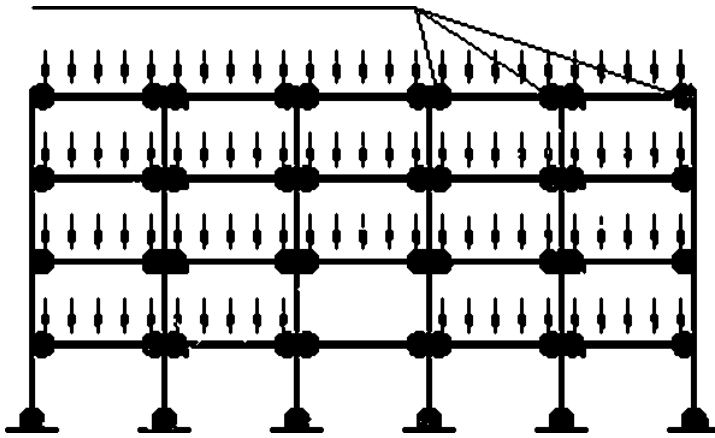
(. 27).

27 .

1 —

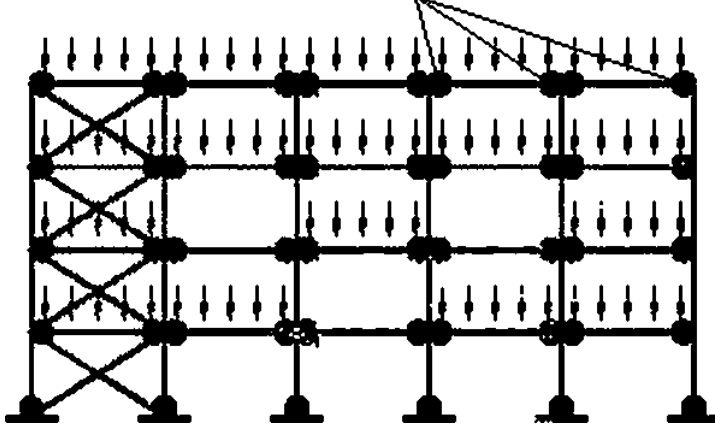
27 .

2 —

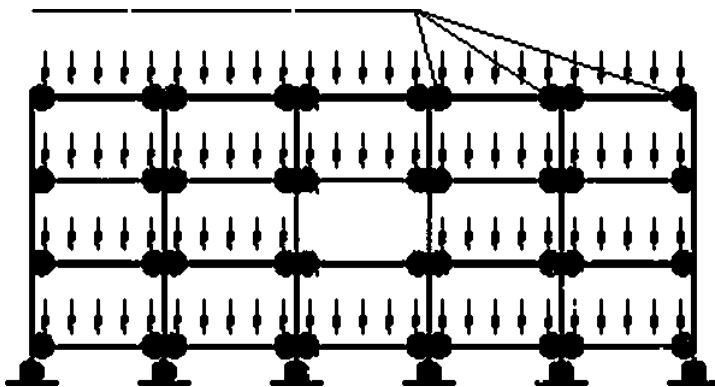


27 —

Упругая связь



27 —



27 —

27 —

10.2.2.3

- a)
- b)
- c)
- d)

6.3.3 6.3.4);

e)

- 1—
- 2—
- 3—

™ 8/

10.2.2.4

6.3.4.3),

5.3 (

11.2.

10.3.3

10.2.3

a)

);

- b)
- c)
- d)
- e)

0

5.3.

.2.8.

1 —

2 —

3 —

1 2

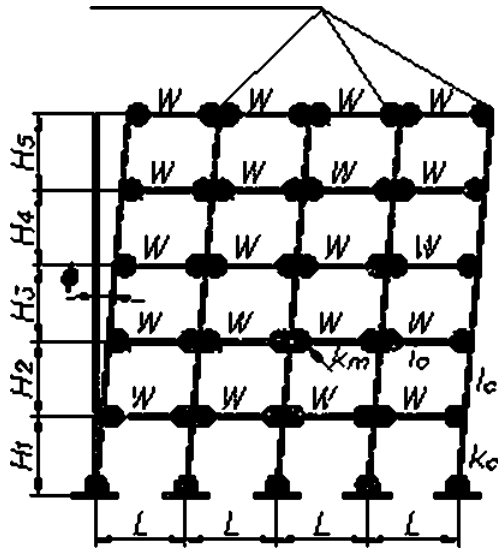
4 —

(. 7.7).

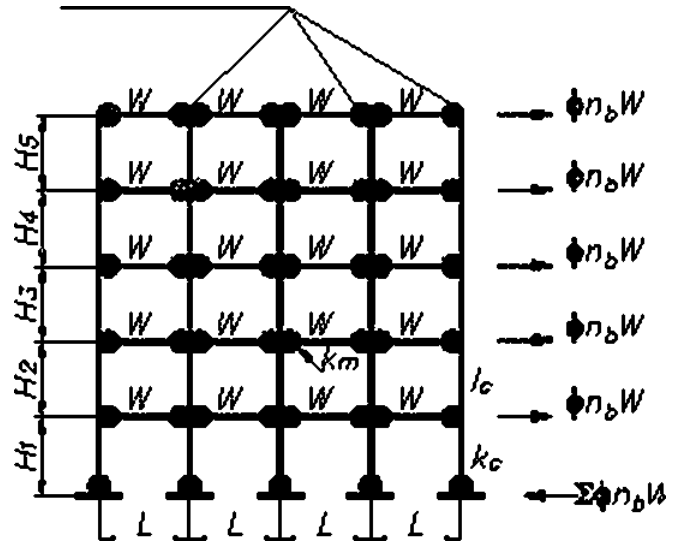
5 —

28. 29.

28 29.

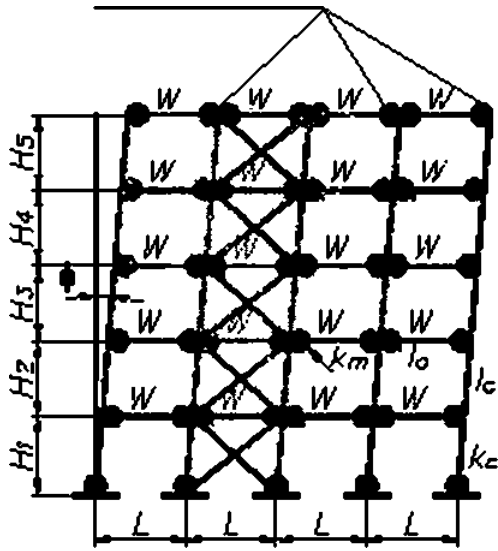


26 —

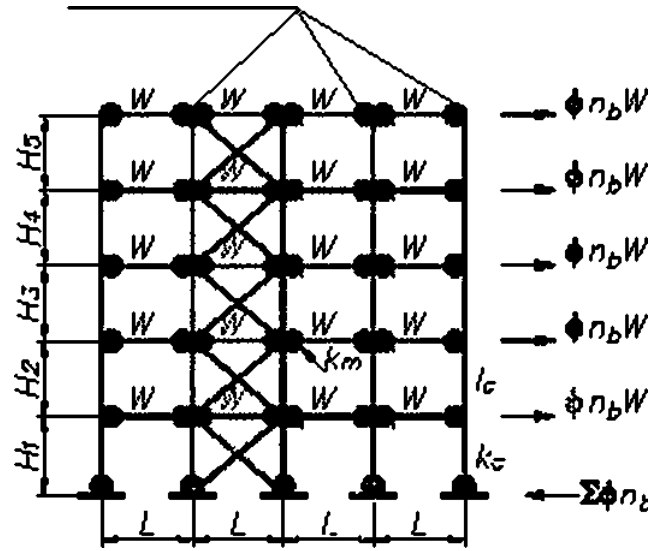


28 —

28—



29 —



29 —

29—

10.2.4 *

.?.4.

10.2.5

$1 -$
 $h -$

$E_y/h,$

$(\quad Y);$

(.2.7)

16.3

10.3.1

a)

.2.8):

b)

c)

d)

)

0

5.3.3.

30.

10.3.2

a)

b)

c)

(-)

10.3.3

$V_s J_{V_a} S_{0.1}$

. . G.

10.4.

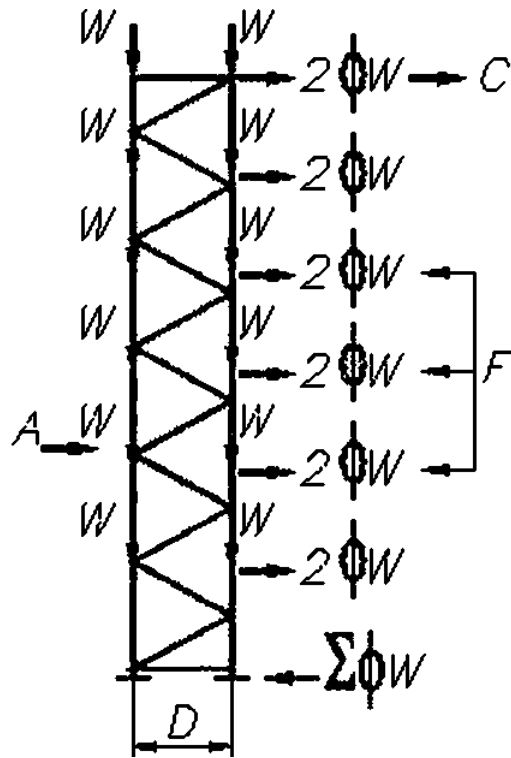
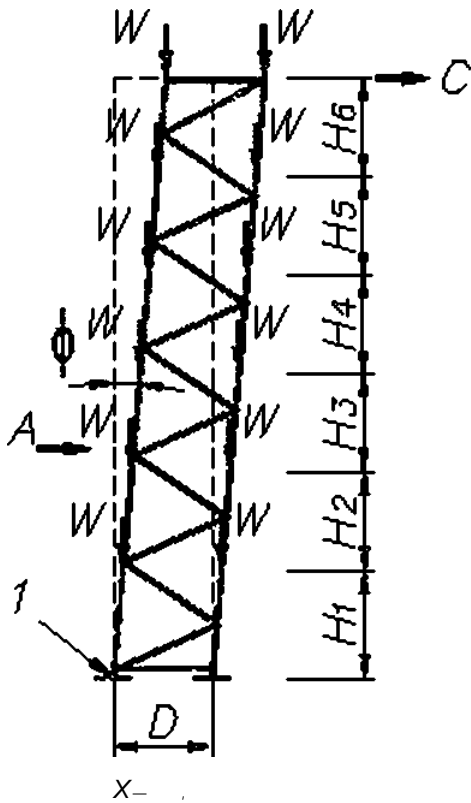
$0.1 < V_s V_{\sigma} \leq 0.3$

2-

$V_s V_{\sigma} > 0.3$

1-

[2].



F-

D-

30-

1-

() G

2-

30.

5.3.6.

10.4

X• /-
1:

1)

8

5.3.2.

2)

5.3.2.

2:

)

(

),

V.-4

(45)

b)

c)

1 —

Z

+

2 —

3 —

a)

b)

c)

d)

)

f)

4 —

10.5

2-

G

10.6

10.6.1

9.7

6.

10.6.2

9.7.6.

1 —

(. 7.1).

8 2 —

3 —

4 —

8

11

11.1

11.2

6.

5.2.3. 7.3 7.4.

1/200.

55525.

a)

(. 8.5.6): 6°;

b)

: /250.

/250

2.5 / ² (. 6.3.6).

/200.

12

12.1

13

13.1

10

10—

8.1.4		.1
8.1.4.2		
8.1.16)		.2
		.2
9.7.2		.2.1
9.7.2		A.2.2W2.3
10.2.4		.2.4
5.3.2		.2.5
6.4.2		.2.6
9.9		.2.7
10.3.1		.2.8
9.7.6		.2.9
9.4.3		.2.10
9.8		.2.11

13.2

13.2.1

(.).

±2 %

13.2.2

13.2.3

13.2.4

5 %

13.2.5

13.2.6

a)

b)

c)

d)

e)

0

)

h)

i)

j)

k)

l)

13.3

13.3.1

)

)
13.3.2

13.3.3 ()

R_k :

$$R_{f,m} R_{m-k}, S. \tag{46}$$

R_m —

$$s = \sqrt{\frac{1}{n-1} \sum_{i=1}^n (R_m - R_{m-k})^2}$$

(3);

$$s = \sqrt{\frac{1}{(n-1)} \sum_{i=1}^n (R_m - R_{m-k})^2}$$

11.

11 —

k_s

95 %

75 %.

3	3.37
4	2.63
5	2.33
6	2.18
7	2.08
8	2.00
9	1.95
10	1.92
15	1.82
20	1.76
30	1.73
40	1.71
50	1.69
100	1.68
	1.64

13.3.4

$$\begin{aligned}
 & \left(\dots \right) \\
 & \dots \\
 & S_n \\
 & \dots \\
 & \dots
 \end{aligned}
 \tag{47}$$

R_m —
—
S_n —

11. —

13.3.5

$$\begin{aligned}
 & \dots \\
 & \dots * \left(\dots \right) \dots \tag{48} \\
 & \dots \\
 & R_n \dots \\
 & \dots \\
 & \dots \wedge \dots \\
 & \dots = f_y a f_{\zeta} = 1,0 \quad (< \dots \\
 & \dots \\
 & t < \dots \quad 1. \quad 1 S \quad S 2 \tag{49}
 \end{aligned}$$

a t_ζ 0,

- 0,64 —
- 0,21 —
—

()

.1
.1.1

[12].

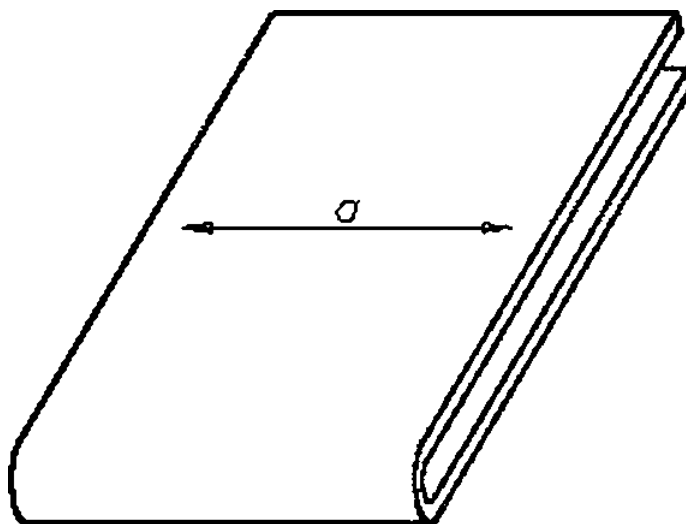
- a)
- b)
- c)

.1.2

[13].

8.1.1

()
180° .1.



a — направление проката

Рисунок А.1 — Испытания на изгиб

.2
.2.1
.2.1.1

180°

*!

()

2.1.2

— 1

2:

a)

).

b)

(

);

c)

—

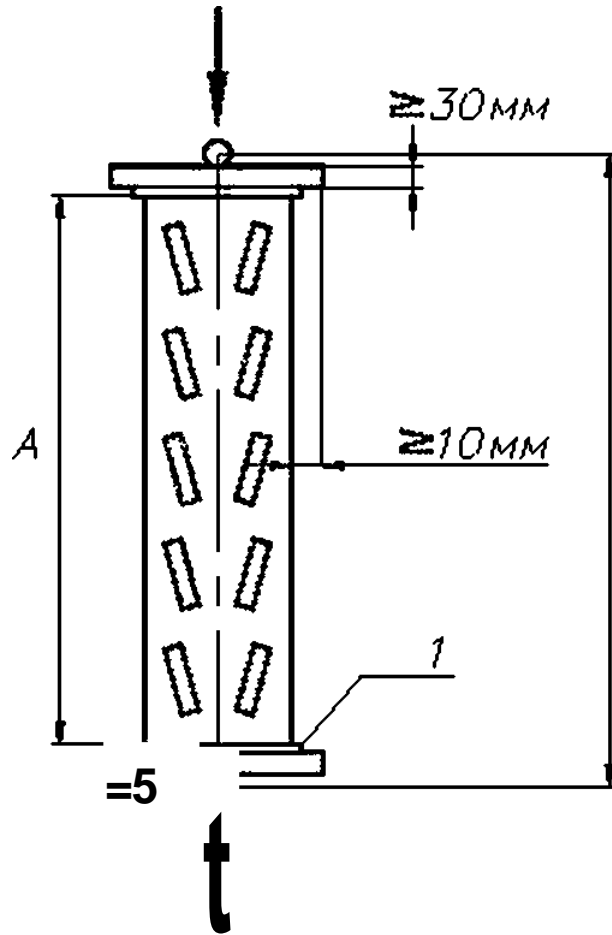
(

)

10

2).
(

2).



1—

2—

2.1.3 — 2

(0,5 %

()

)

.2.1.2.

2.1.4

2.1.5 (13.3.5.)

13.3.3,

$$A_{eff} = \frac{R}{l}$$

(.1)

>. = 0,2.

9.7.4 9.7.5

$N_b \wedge \wedge$

A_{eff}

1 .2.1.2.

().

2 .2.1.3 (. 2).

.2.2
.2.2.1

9.7.2

.2.2.2

.2.1.2.

9.7.2 .

2.3.

2.2. ()

2.3.4.

R_k

13.3.3.

9.7.2

!

2.3

2.3.1

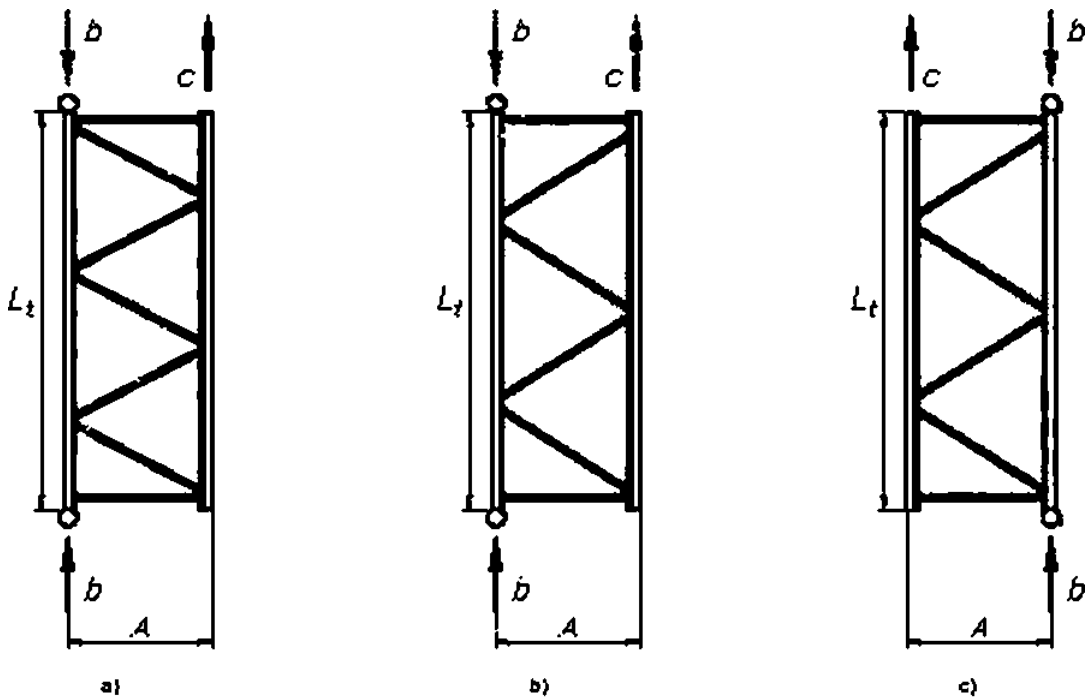
(L4)

7.

7

2.3.2

2.1.2.

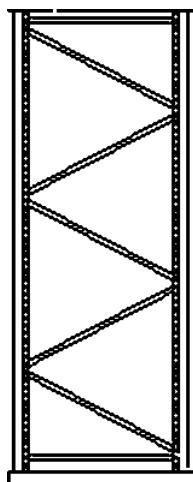


A — ширина рамы; L_t — расчетная длина при продольном изгибе;
 b — направление нагрузки; c — сила, компенсирующая вес рамы

3

).

(.4).



.4—

.23.

>. = 1.5

— 5.

.23.4

13.35

(.2)

OSXS0.2; $C = (\frac{f}{\dots})$

osxsi.5: = $(\frac{-0.2 + \dots - (1.5 - \dots)}{\dots})$

15*/ = 10



< .)

X—

13.3.5.

2.3.5

)

?nf

!

(.4)

(.5)

i-

t

$$\beta_1 = \frac{A_{11}}{A}$$

b)
c)

(?,*))

d)

e)

(s)

-).

(.6)

k_s

11

9.7.4

9.7.5.

2.2

.24
.24.1

a)
b)
c)
d)
)
0
)

13.3.3.

13.3.4.

10

2.4.2

a)

$$= (\quad) + 2($$

(\quad)

.5.

b)

c)

750

400

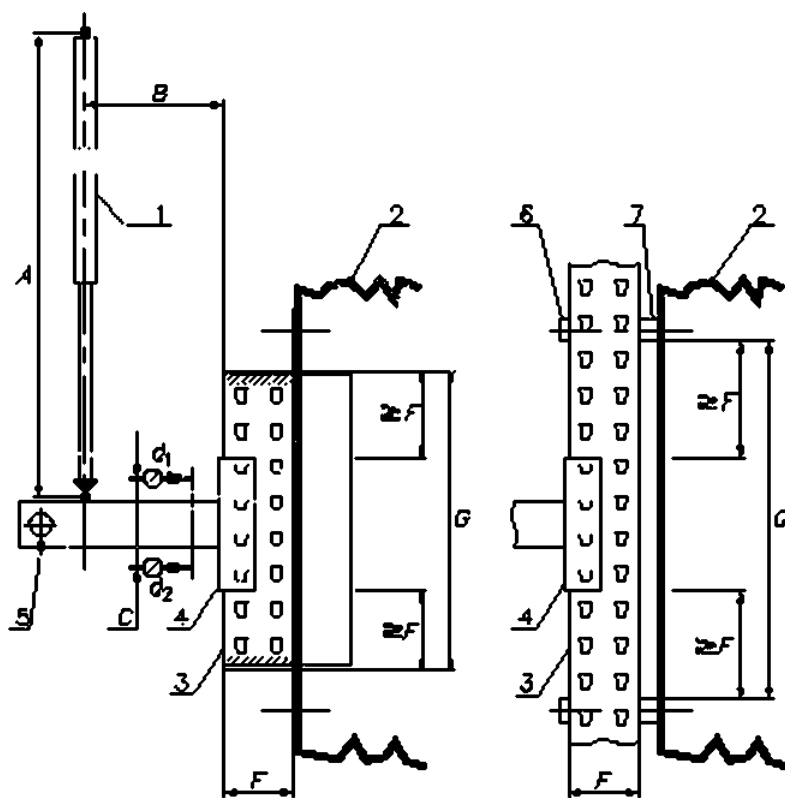
.5.

d)

1)

{ d, dj .5);

2)



4 — : S — : 2 —
 7 — . A i 750 * 400 —
 <3 — : F — : G —

.5 —
 ()

2.4.3

.5.

F, 10 %

F

$$M = FB \tag{.7}$$

$$\theta = \frac{\delta_2 - \delta_1}{d}$$

—
—
1—
—
2.4.4

F:
d,
d;
d;
d%.

C_yf

$$n = \{ \dots \} \tag{.9}$$

^ — ()
fy—
^ — ()
l—
= 0. f_y i lf
= 1. ly < tf.

1.25

15%

(, — 0)

- a)
- b) (Kq)
- c) ,/
- d) M_nsM_t = 0.15 + S 1.0
- e) () M/kQ.
- f) 0_n = 0 + AV*b- (— 0).

1 —

2 —

2.4.5
2.4.5.1

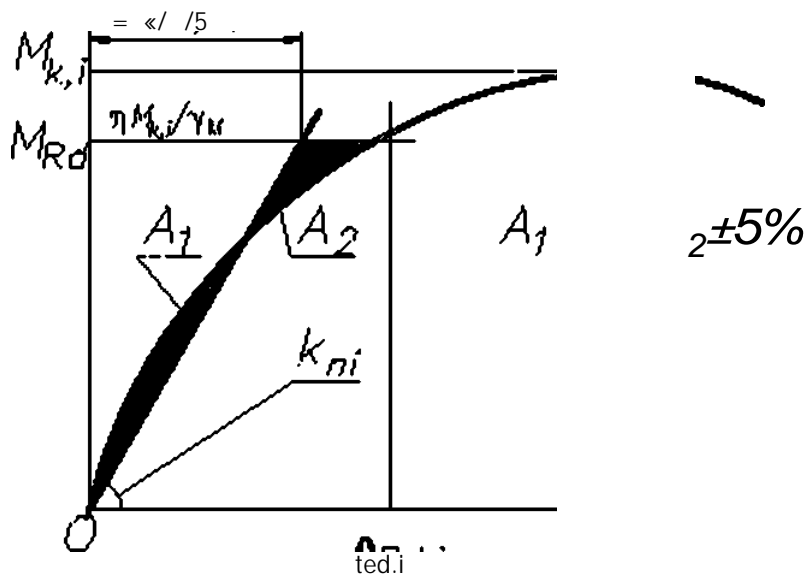
.6.

13.3.3.

Mf^

$$\dots \tag{.10}$$

7.5.
s 1.



.6—

24.5.2

.10.

(

),

.6.

.. *1,15^.

(.11)

15%.

A_d

$$k_n \leq \frac{1}{n} \sum_{i=1}^n k_{ni} \quad (.12)$$

24.5.3

2.4.3

()

2.4.4.

M_{Rd}C

.7.

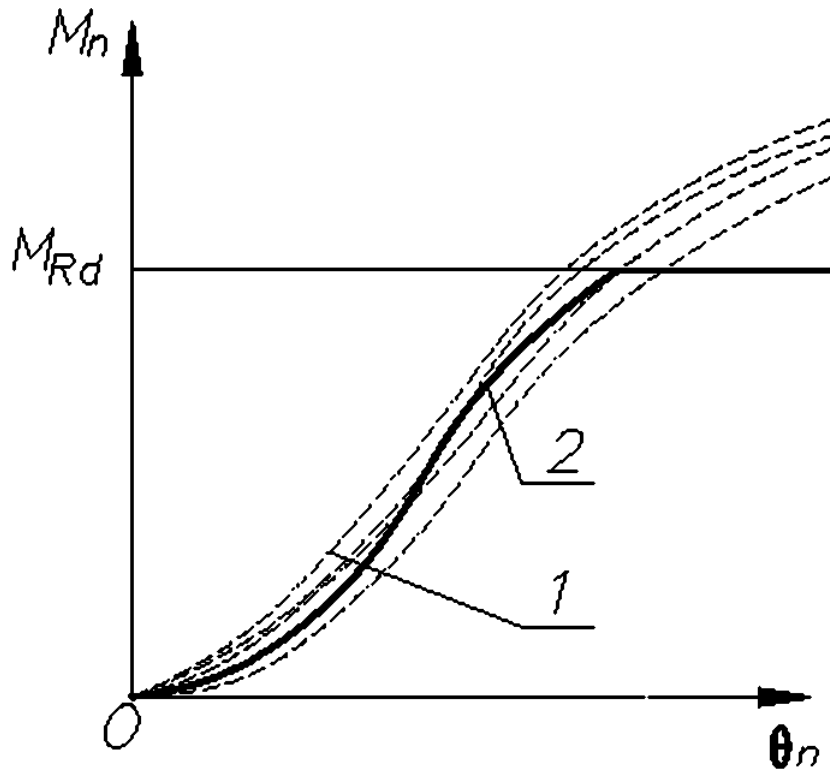
2.5,

5.3.2,

.8

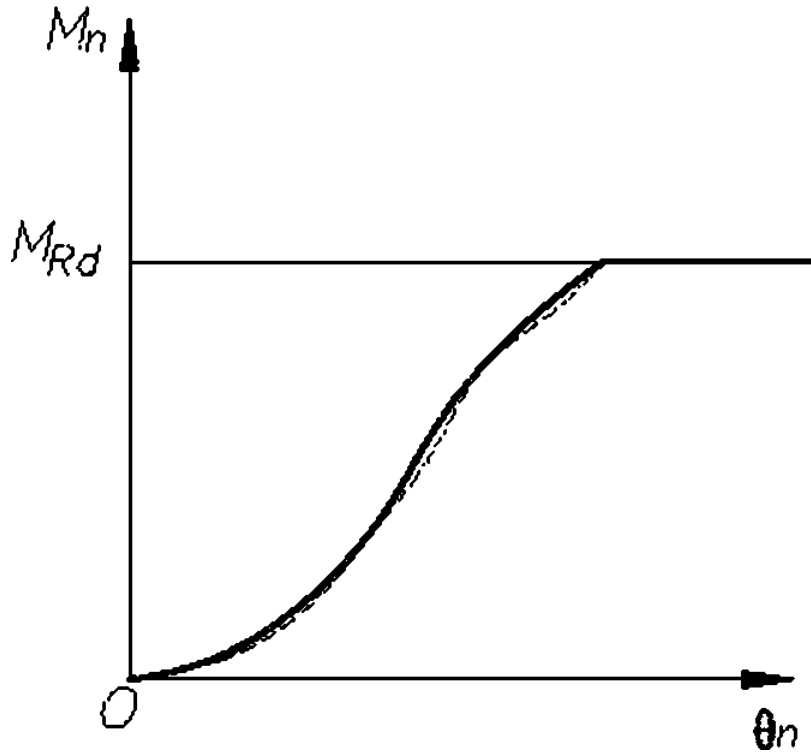
(02. .9).

8.



— ряд скорректированных экспериментальных кривых; 2 — полученная средняя кривая

.7— « »



.0—

.25
.25.1
5.3.2.
.25.2

.24.

{ ()

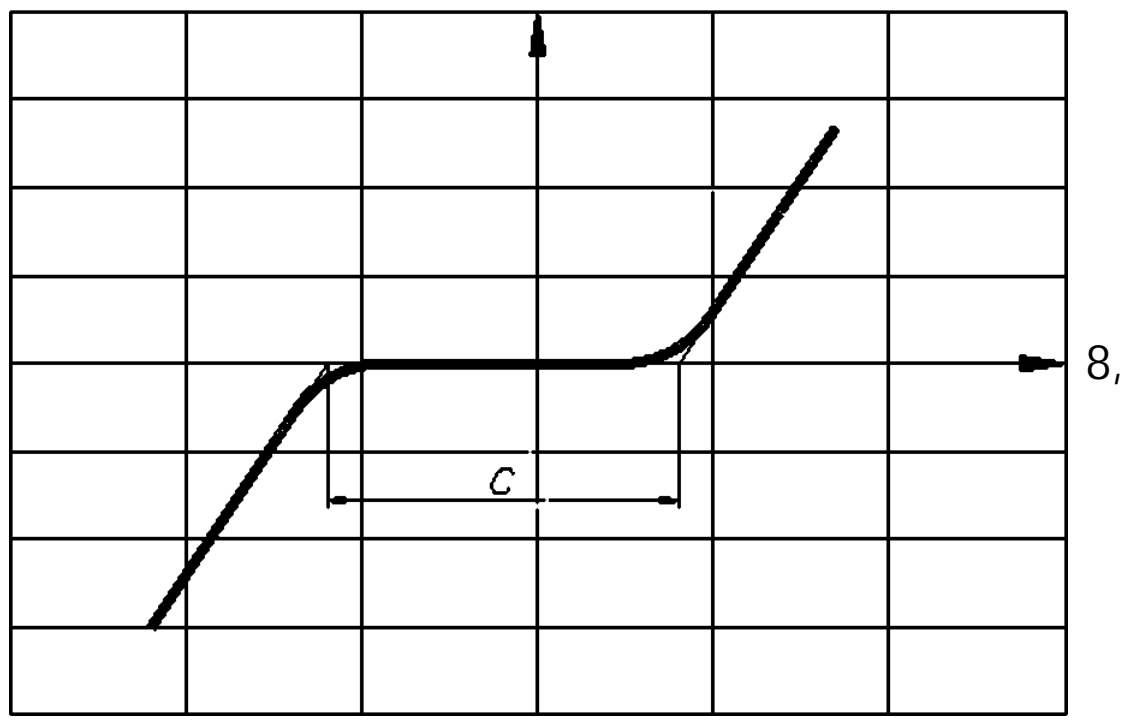
.25.
10 % F

.24.

10 %

.9

$M, \text{кНм}$



.9—

.25.4

.25.5 ()

.26 ()
.26.1

.26.2

10.

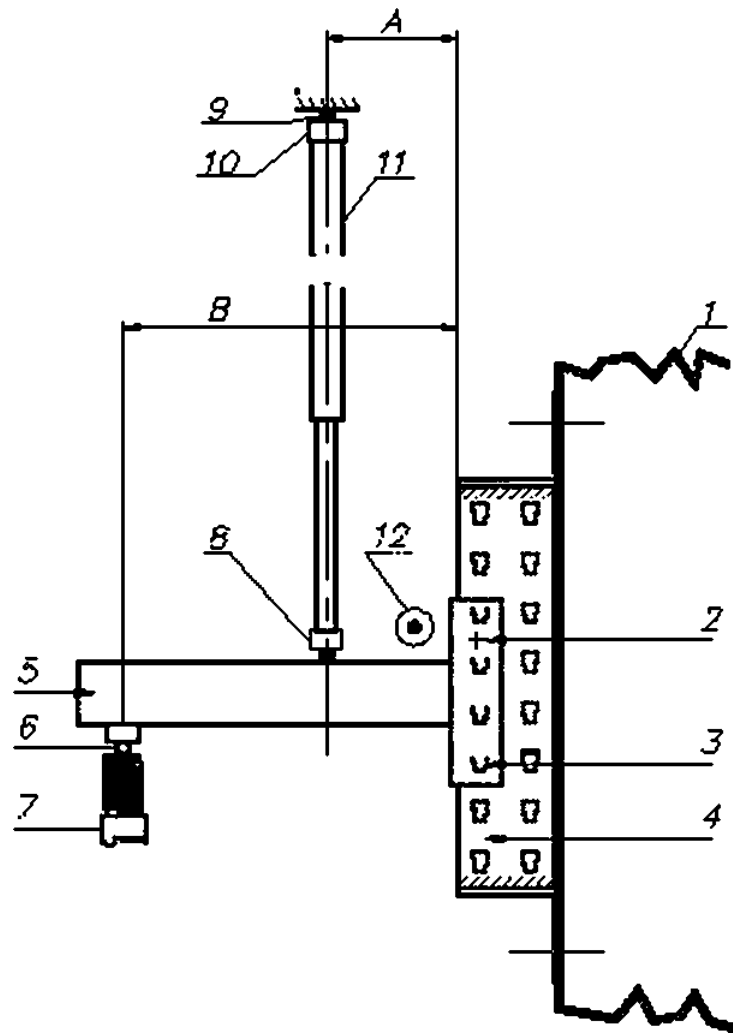
400

10.

180°
10.

500
12

10).



1 — : 2 — : 3 — : 4 — : 5 — :
6 — »* : 7 — : 8 — : 8 — : — :
11 — : 12 — : — : — :
— : Z 400

10—

1 —

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[12].

2.6.

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2.6.4

.2.4.4.

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13.3.3

-2.7

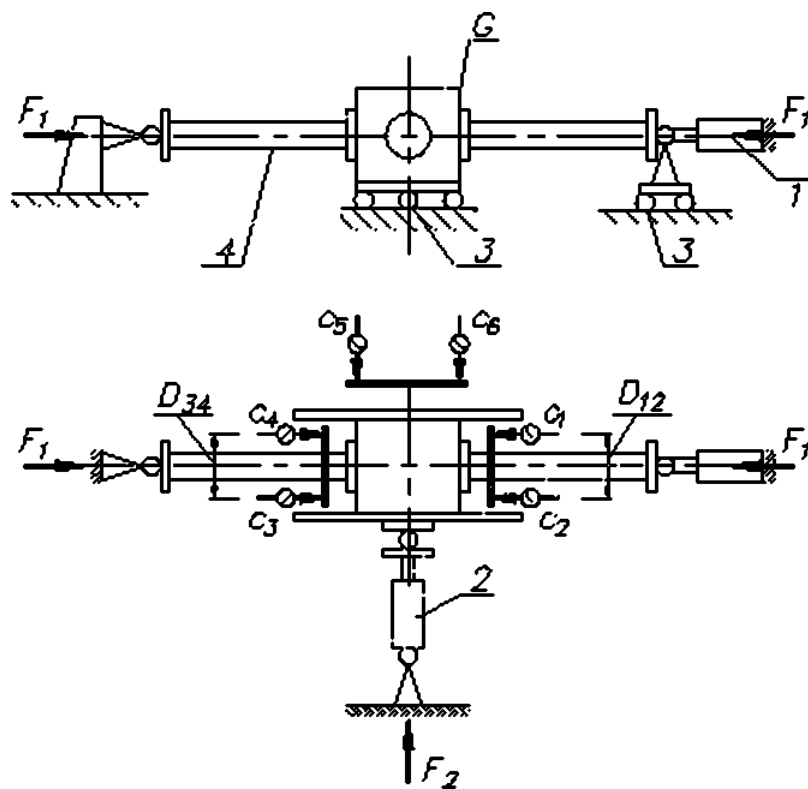
2.7.1

2.7.2

.11;

.11.

20/25



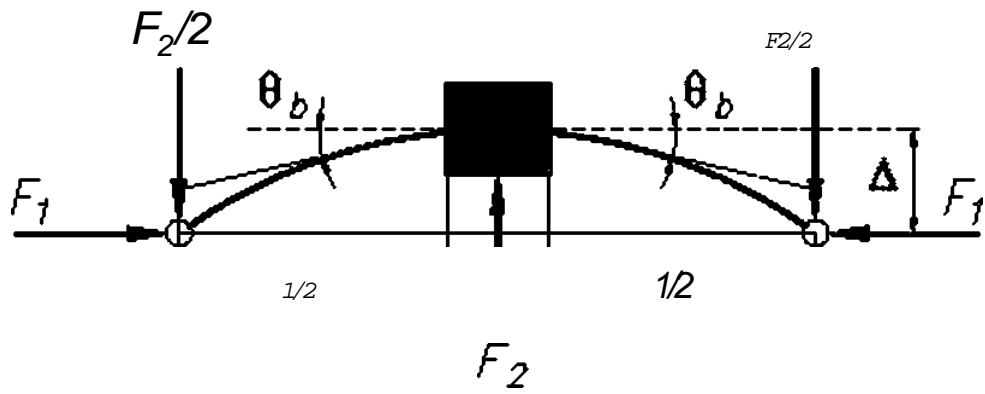
0.2 Ojj -

2 -

3 -

4 -

G -



.12—

$$M_2 = \frac{F_1 l}{2} + F_2 \Delta \quad (.14)$$

$$\theta_2 = \frac{1}{2} \left[\frac{\delta_1 - \delta_2}{D_{1,2}} + \frac{\delta_2 - \delta_1}{D_{2,1}} \right] \quad (.15)$$

F_1 2 —
5, -6 — 1-6 ;

1 2 ;

$$\Delta = \frac{\delta_1 + \delta_2}{2} \quad (.16)$$

.27.

.27.4 ()

.24.5

()

()

.24.5.

.28
2.8.1

2.6.2

.13.

.13.

(2 (1 .13).

13).

()

3.

.13.

6

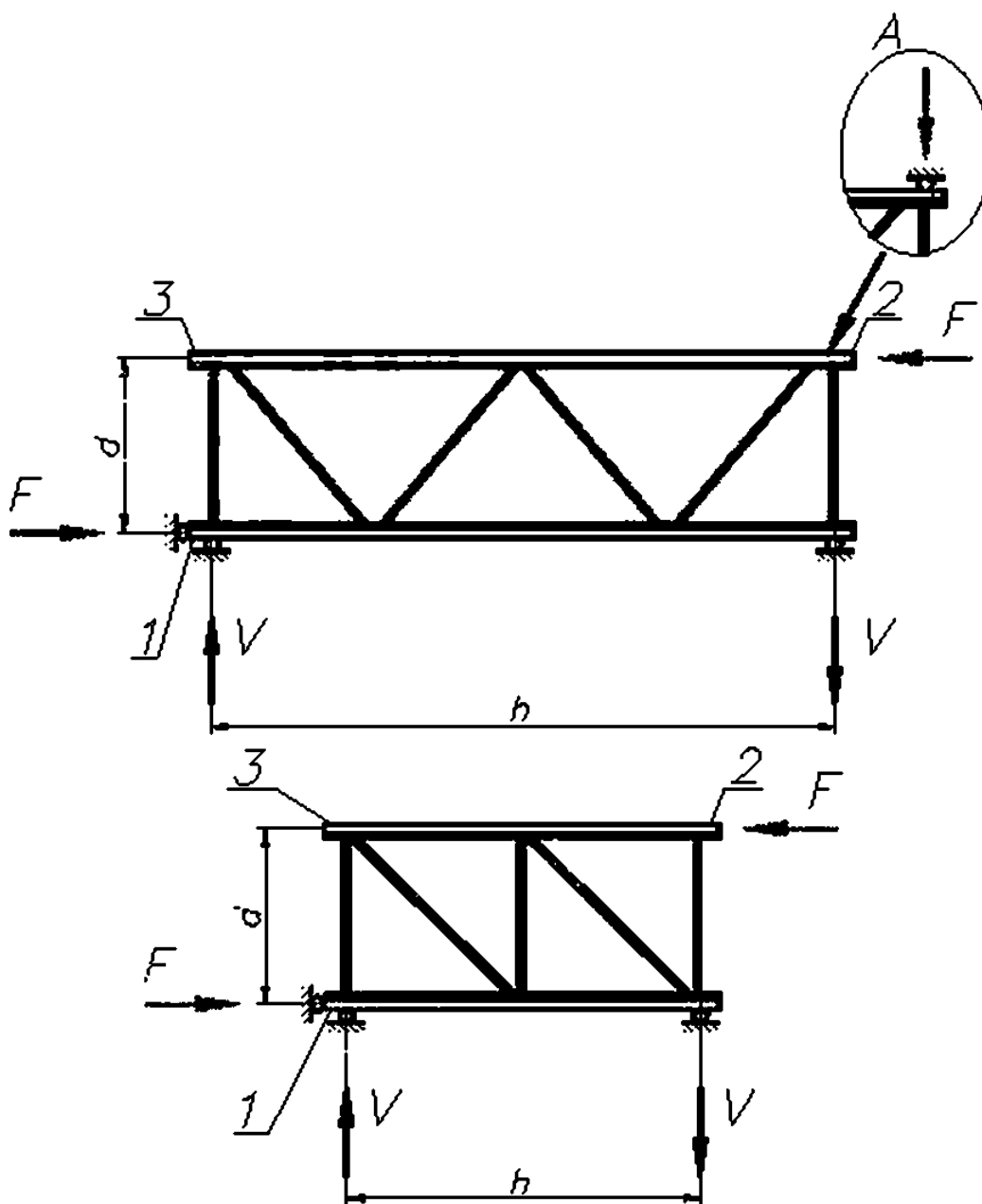
.28.3

F

6.

5

2



A — альтернативное место закрепления; d — размер между центрами масс сечений стоек; h —

.13—

.28.4

.28.5 { }

6

.14.

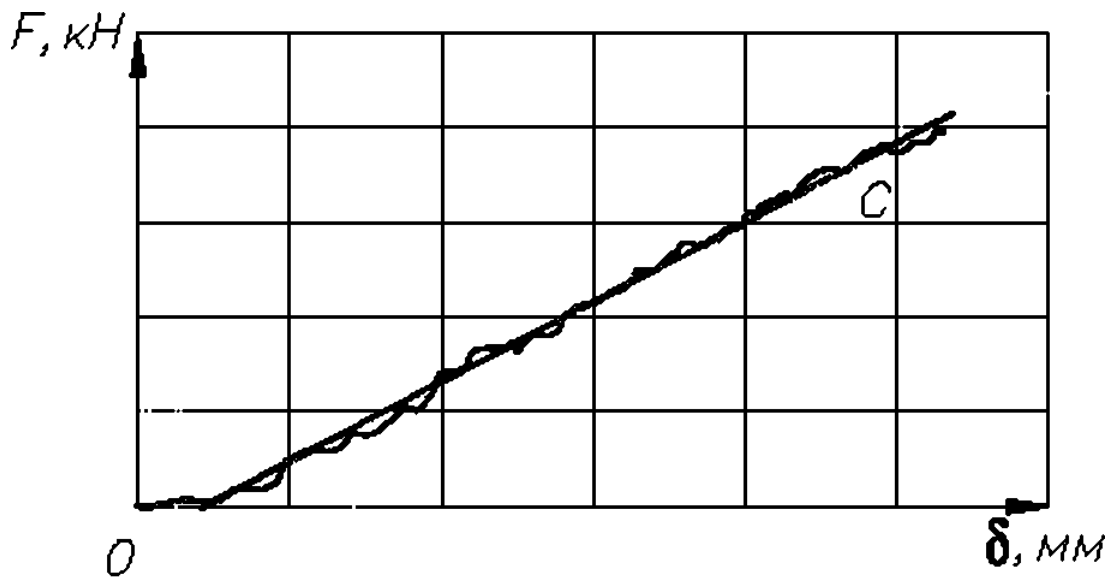
S_b

$$S. = \frac{*}{h}$$

(.17)

h— , d—

.13.



C — кривая с наклоном k_{δ}

.14 —

.2.
.2.9.1

.2.9.2

L

L t 300.

15.

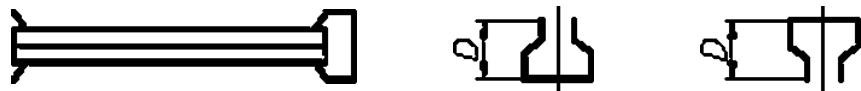
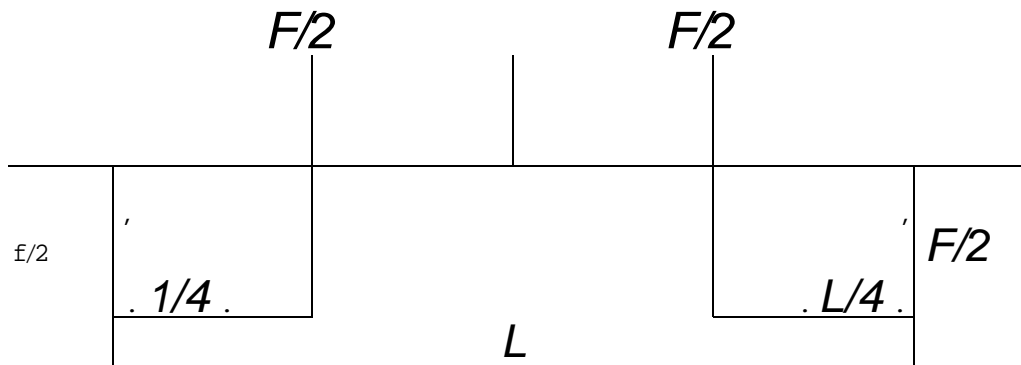
D—

(. . . .15).

(. . 18)

15.

(. . . .)



.15 —

2.9.3 *F*

2.9.4

2.9.5 () 13.3.5.

13.3.3

2.10
2.10.1

2.10.2

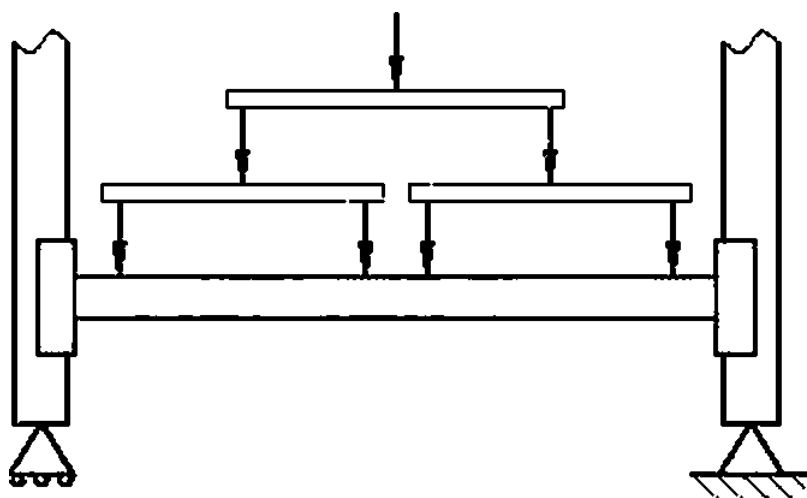
50 .16.

1/4

100 .15.

1 — ()

2—



.16—

2.10.3

F

G_h

-

.2.9.2.

.16,

2.10.4

O_{ft}

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(.19)

2.10.5

()

13.3.3.

2.11

2.11.1

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2.11.2

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+

.17.

2.11.

$0.25 \wedge, 0.5 \wedge 0.75 \wedge 1.0 F_{stf} \quad F \wedge -$

F_v

2

2

0,-0\$.

(.20)

(.21)

2.11.4

-

(

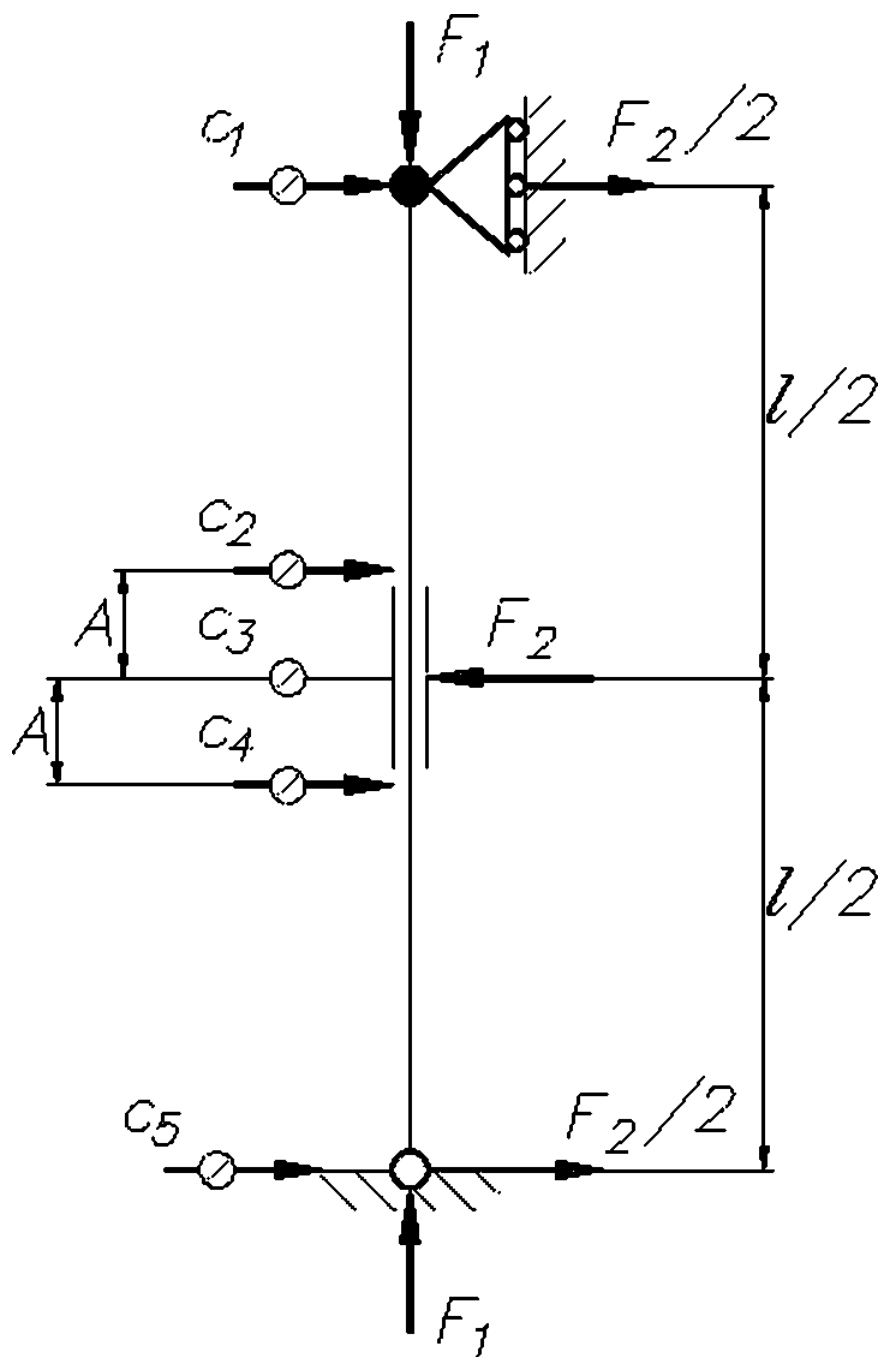
).

2.11.5

()

.2.7.5.

() F_1 $\pm 10\%$



— F_2 — F_1 —

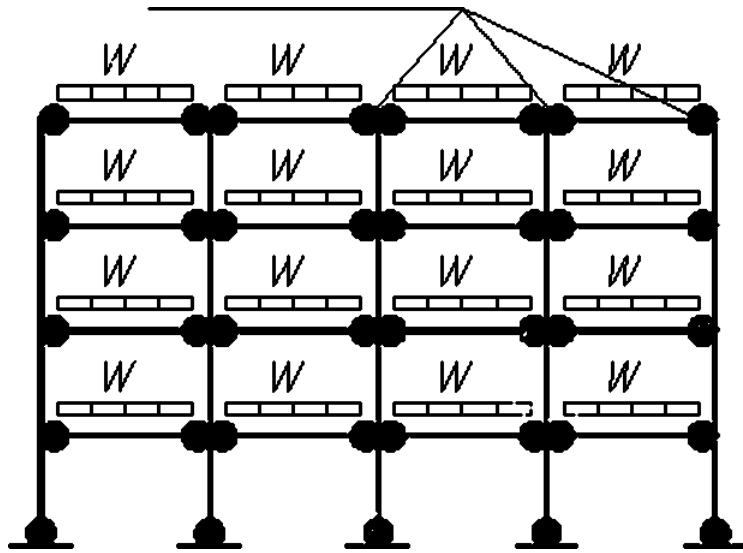
()

^^

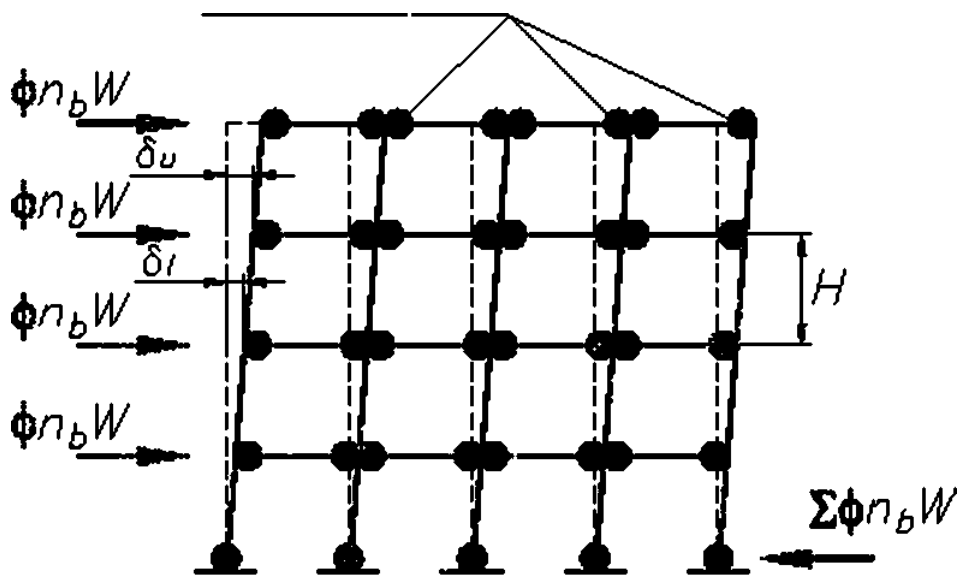
.1

V_a

.1.



6.1 —



6.1b

Рисунок В.1 — Схема метода увеличенных моментов

.2

8

5.3.2

7.

.1.

(. . 2.7).

V_{er}

Z

$\text{E}\ll$

(B.1J)

S_i

5_t

.4

V'
 $\Psi - V_t$

(. 2)

()

/-

.1

- $N_s = 5$ —
- $N_b = 5$ —
- $l = 700000$ —
- $= 90000$ — / —
- $W_c = 0$ —
- $l = 550000$ —
- $= 70000$ — / —
- $W_b * 6$ —
- $l_s = 1500$ —
- $h = 1500$ —
- $L = 2700$ —
- $= 0.01$ —
- $= 1.0$ —
- $= 210$ / 2 —

$$S_e W = 1_0 (N_t + tV_e) \text{ — (.1)}$$

$$S_i = S_e W - N_t W'' \text{ — (.2)}$$

$$S_e W_t = \frac{N_s (N_s - 1)}{2} N_s W_s h + N_s N_b W_b h + (N_s h + h - h) N_b W_s \text{ (.)}$$

$$l_s S (W_t + 1) \text{ — (.4)}$$

$$= (1 + 1) \text{ — (.5)}$$

$$\frac{12}{6 EIMKL} \text{ (.)}$$

$$C = F + \frac{EI_{cc} K_{cc}}{e/rt} + \frac{EI_{cc}}{e/rt} \text{ (.7)}$$

$$\frac{S_e MK_A + 2EI_{cc} S_e b}{2 \text{ " } + 1 \text{ " } 2} \text{ (.8)}$$

$$B = \frac{EI_{cc}}{hC} \text{ (.9)}$$

$$\ll (AIL-1 + g)F + \text{ " " } \text{ (.)}$$

$$G = \frac{S_e Wh}{2} \left[\frac{K_{cc} h}{K_{cc} h + EI_{cc}} \right] + \frac{EI_{cc} K_{cc} A}{K_{cc} h + EI_{cc}} - S_e Wh + FA \text{ (.11)}$$

$$\theta_s = A - \frac{BG}{D} \text{ (.12)}$$

V_c

$$V_{uo} = \left[\frac{K_{cc} h}{2} + EI_{cc} \right] \theta_s + \frac{S_e Wh^2}{12EI_{cc}} (K_{cc} h + 4EI_{cc}) \text{ (.13)}$$

$$G \quad \circ = \gg \quad + \quad \dots \quad (.14)$$

$$0, \quad . = \dots) \quad (.15)$$

$$) = 3.576 \quad 0.8 + 0.24 \quad (.16)$$

$$V_t = s \text{ ft}^{\wedge} 0.e + 0.2 \text{ - } \wedge \text{ - } j \wedge . y_e j \quad v_e t \ 3.576 \quad (C.17)$$

$$3.333) .. \quad \text{---} \text{f-} \quad (.18)$$

« S 0.02

$$, = 0.0039 \quad (.19)$$

$$\ll 2 = 0.0034 \quad *' = \text{f} \bullet \quad (.20)$$

$$= 0.0026 \quad ' t \quad (-21)$$

$$20 \% \quad \dots \quad 0.6 + 0.2 / \dots$$

$$.2 \quad \dots \quad > . W_t L \quad (.22)$$

$$\frac{4 / \dots (* + 3E}{(K_p L + 2E f_t) i (K_p L + 6E I.)} \quad (.23)$$

$$\frac{* , \text{ ?CJ it}}{- \sqrt{K_t L^2 2E I_e}} \quad (.24)$$

$$* , = \frac{4E I \ K A * 3E t}{* h , * 4 / ,} i \text{---} \quad (.25)$$

$$\langle \rangle = \frac{A P I}{\text{---}} \quad (.26)$$

$$\$ = + + + \text{---} \quad (.27)$$

$$\frac{6 | W_{+M}}{6} \quad \left[\begin{matrix} K_s \\ S_x \end{matrix} \right] \quad (.28)$$

$$\dots = \frac{SW}{4} \tag{.29}$$

$$\frac{-(S.WH) \cdot 4ft + 2E/J}{2(4) LM_{+}EI, J} \quad \frac{EI'KJM, W.+1}{4ft + , W,} \tag{.}$$

$$4 \tag{.31}$$

$$\wedge = -512.118.$$

$$\frac{-(ps_0wi) \cdot 4ft}{2(4+i) K-ft + E'.J \cdot 4ft+}, \tag{.32}$$

$$= 2\left(\frac{4ft}{+ /<}; \tag{.}$$

$$) = -322.228.$$

$$_2 = () .$$

$$\frac{-(PS_{\gg}ft) \cdot [\&]}{* \cdot 2(4) L \quad \frac{4+1}{ft J 4}} \tag{.34}$$

$$\tag{.35}$$

$$= -427,114$$

$$\wedge 2(4 \gg L ft ft J \tag{.36}$$

$$\cdot 0.5 .$$

$$\sim -525.076.$$

.4

()^D

f_{fy} ()

() ! 1
)

3.1.1. (3). 40 f_{fy}
1.10. 1,20). ([3] (3.1).
(1,09). 1.08 [14]

$i_{fy} < 1.10$.

- a) 1,108
- b)

c)

$t > 3$

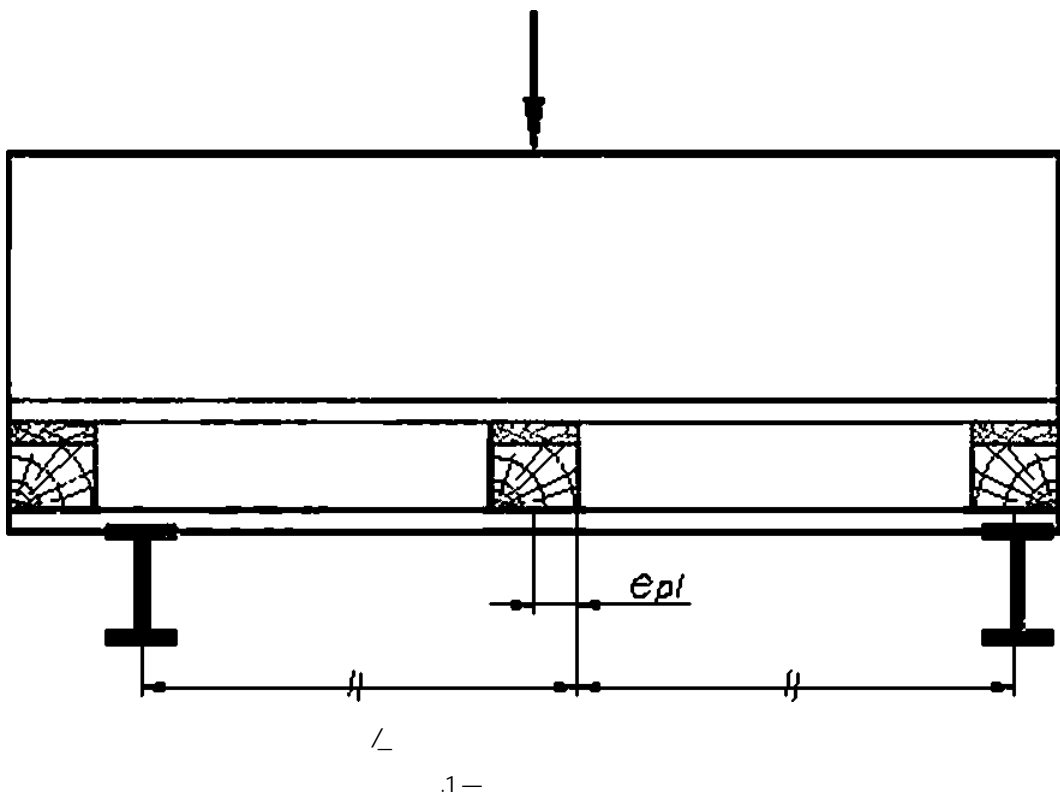
.12.

()

12%

()

(.1).



(F)

F.1.

F.1—

		◀●	
rrnurfrriMii II 1 .	1.0	1.0	1.0
	2.0	1.5	1.6
I U41 U2 ¥ t	1.0	1.12	1.1
I WW2 IW/2 f)	1.33	1.33	1.36
I w/3 1 1 3? L/3 1U8	1.311	1.06	1.05

F.1

	1*		
<p>| IW/3|</p> <p>U41 U4 L/4 LM</p> <p>r^A</p>	1.33	1.25	1.27
<p>a W4tW?4MW4tW/4</p> <p>W1U4V1 L/41UB</p> <p>tt</p>	1.0	1.03	1.02
<p>| IW4</p> <p>178¥ L/61LZS US1L/B</p> <p>||</p>	1.2	1.2	1.21
<p>—W— ;L— (</p> <p>);</p>			

()^G

/«

G.1

G.2

$$v_{cr} = \frac{1}{\frac{1}{V_{cr}} + \frac{1}{S_c}} \quad (G.1)$$

$$\frac{v_{cr}}{2} > \text{®} \quad (G-2)$$

V'cr

$$-2 \cdot 1 \frac{1+2,8W}{3,18}$$

G1a. (G.3)

$$-J \frac{1}{15,42}^*$$

G1b. (G.4)

Wq —

IV, —

S_D —

(. G.1c):

(. G.1c):

n_s =

G.3

I V , =

).

Sq

$$\frac{-1}{\ll} \frac{1}{S_{\pi}} + \frac{1}{S_{\alpha}} + \frac{1}{S_{\beta}} \quad (G.5)$$

G.2

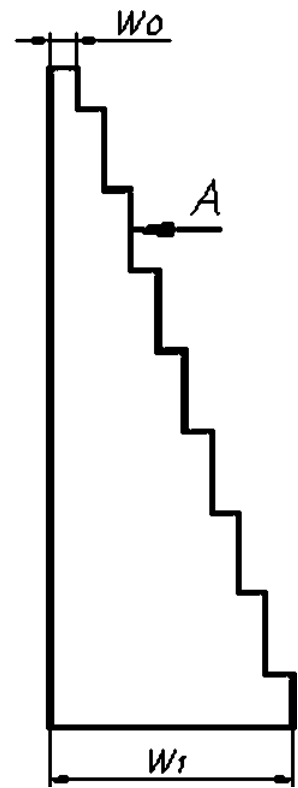
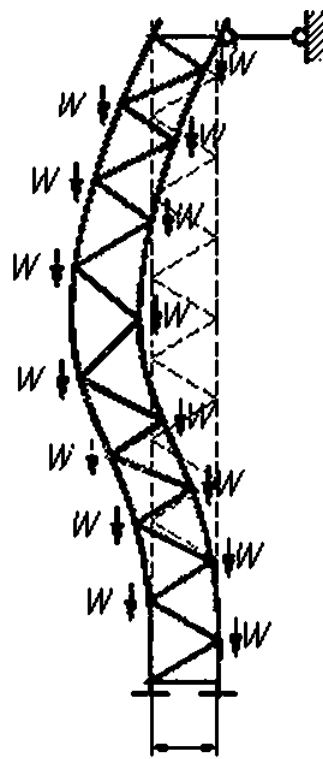
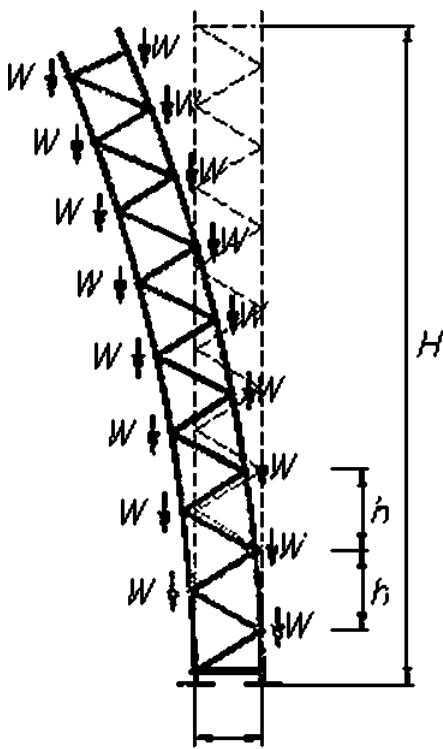
G.4

< 0.1.

«3.6)

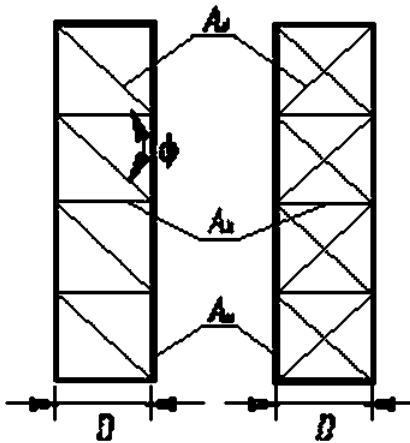
V_{gff} —

G.16.



G.1—

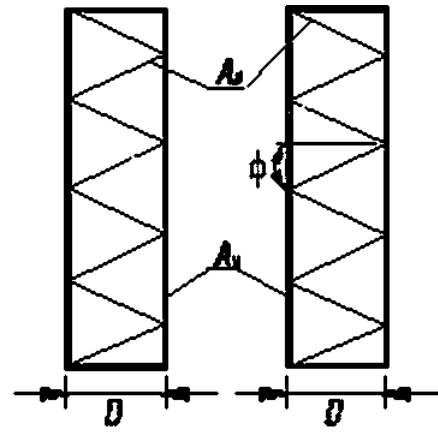
/-



$$\frac{1}{S_{xx}} = \frac{1}{A_1 E \sin \phi \cos^2 \phi}$$

$$\frac{1}{S_{yy}} = \frac{1}{A_1 E \tan \phi}$$

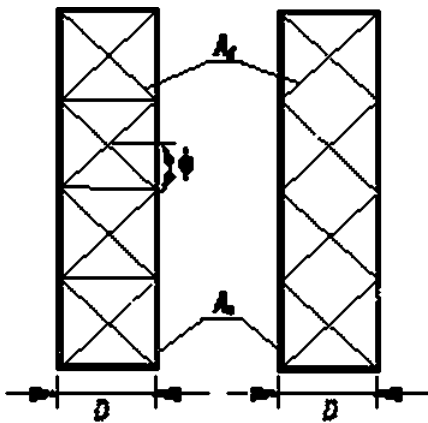
$$\frac{1}{S_{zz}} = 0$$



$$\frac{1}{S_{xx}} = \frac{1}{A_1 E \sin \phi \cos^2 \phi}$$

$$\frac{1}{S_{yy}} = 0$$

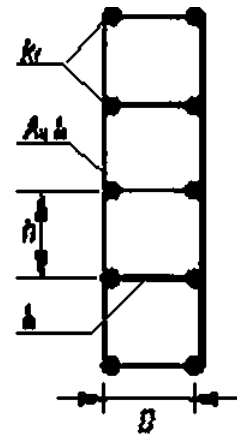
$$\frac{1}{S_{zz}} = 0$$



$$\frac{1}{S_{xx}} = \frac{1}{2A_1 E \sin \phi \cos^2 \phi}$$

$$\frac{1}{S_{yy}} = 0$$

$$\frac{1}{S_{zz}} = 0$$



$$\frac{1}{S_{xx}} = 0$$

$$\frac{1}{S_{yy}} = 0$$

$$\frac{1}{S_{zz}} = \left[\frac{hD}{12EI_c} \left(1 + \frac{6EI_c}{Dk_1} \right) + \frac{h^3}{24EI_c} \right]$$

G.2—

()

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.2

12

20

$$k, +2sik -2s.$$

(.1)

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k_d-
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6.1,

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5.3	5.3
5.3.6	-
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5.4	-
6	6
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8	8
8.5	8.5
—	8.5.1
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—	8.5.3
—	8.5.4
—	8.5.5
—	8.5.6
—	8.5.7
—	8.6
—	8.7
—	8.8
8.6	8.9
9	9

.1

	15512:2009
10	10
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()	()
()	()
()	()
D()	0()
()	()
F()	F()
G()	G()
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- (1) EN 1990 Eurocode — Basis of structural design (no) -
- [2] EN 1993-1-1:2005 Eurocode 3: Design of steel structures — Part 1-1: General rules and rules for buildings { 3: 1-1. -
- [3] EN 1993-1-3:2006 Eurocode 3 — Design of steel structures — Part 1-3: General rules — Supplementary rules for cold-formed members and sheeting (3 1-3. -
- ! EN 1991-1-1:2002 Eurocode 1: Actions on structures — Part 1-1: General actions — Densities, self-weight, imposed loads for buildings (1. 1-1. -
- [5] EN 1991-1-7:2010 Eurocode 1: Actions on structures — Part 1-7: General actions — Accidental actions (1. 1-7. -
- EN 1993-1-10:2010 Eurocode 3: Design of steel structures — Part 1-10: Material toughness and through-thickness properties { 3. 1-10. -
- (71) EN 10162:2003-12 Cold rolled steel sections — Technical delivery conditions — Dimensional and cross-sectional tolerances () -
- [8] EN 10346:2009 Continuously hot-dip coated steel flat products. Technical delivery conditions () -
- [9] EN 10143:2006 Continuously hot-dipped coated steel sheet and strip — Tolerances on dimensions and shape () -
- [10] EN 1992-1-1:2004 Eurocode 2. Design of concrete structures. General rules and rules for buildings (2. 1. -
- (111) ETAG No 001 Guideline for European Technical Approval of Metal Anchors for Use in Concrete (no) -
- [12] EN ISO 6892-1:2009 Metallic materials — Tensile testing — Part 1: Method of test at room temperature (1. -
- [13] EN ISO 7438 Metallic materials — Bend test (ISO 7438:2005) () -
- [14] AISI S200-series AISI-S200 Cold-formed steel framing (AISI. S200) —

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