

«

»

(

5, 6, 7, 8)



5.1.

( 5.1, ),

$$\tau = \frac{M_K}{J_P} \cdot \rho \quad (5.1)$$

$$J_P = \frac{\pi \cdot d^4}{32}$$

;  $d$  -

. 5.1, .

$$\rho = \rho_{\max} = \frac{d}{2} :$$

$$\tau_{\max} = \frac{M_K}{W_P} \quad (5.2)$$

$$W_P = \frac{J_P}{\rho_{\max}} = \frac{\pi \cdot d^3}{16} \quad (5.3)$$

 $45^\circ$ 

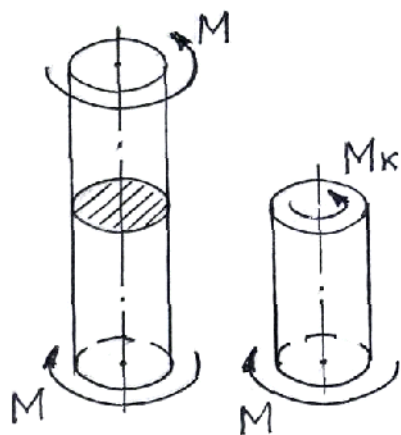
( 5.2):

$$\sigma_1 = \sigma_{\max} = \tau, \quad \sigma_3 = \sigma_{\min} = -\tau, \quad \sigma_2 = 0$$

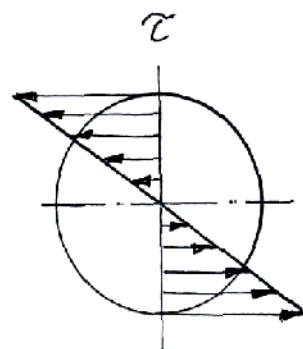
45°

1.

)



)



.5.1



.5.2

$$\tau = \frac{\max}{W_P} \quad (5.4)$$

$M_{\max}$  -

$$\tau_T = \overline{W_P} \quad (5.5)$$

$M_T$  -

$$\theta_B = \frac{\varphi_B}{l}, \quad (5.6)$$

$\varphi_B$

5.2.

3565-71

-50

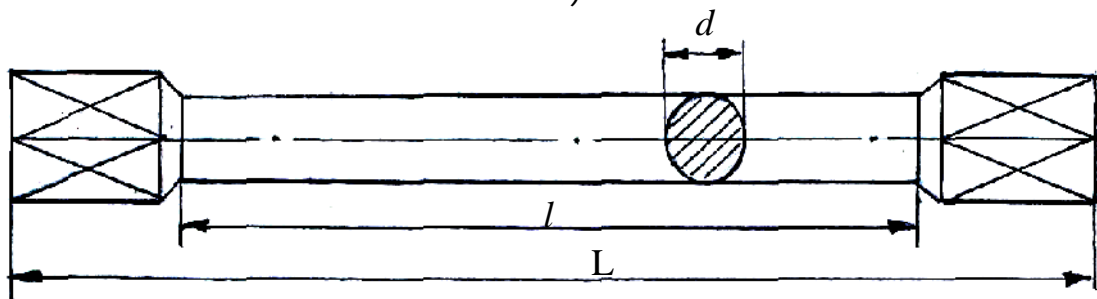
50 (500 ).

$d=10$

$l=100$

.5.3 (

).



.5.3

$M_k$

$\varphi$

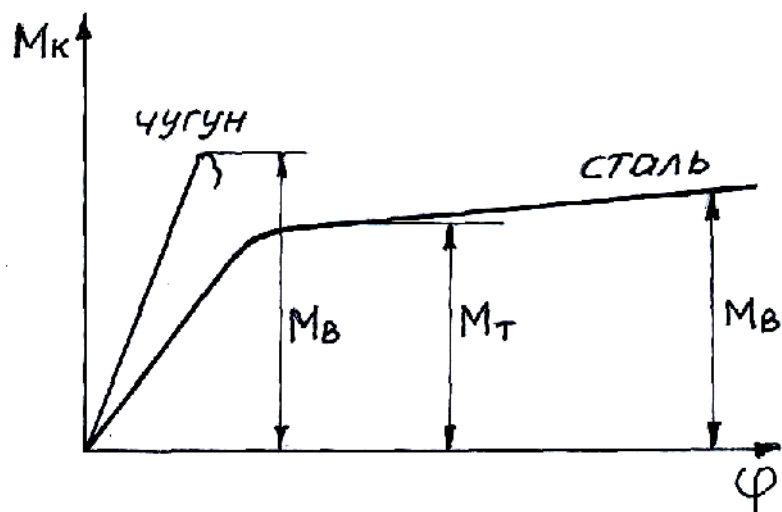
$\mu = 0,333$  /  $= 3,33$

$\mu = 0,4$  /

.5.4.

$\varphi$

(5.4) (5.5).



5.4

5.3.

5.3.1.

$l$ ,

$d$ ,

-

$W_P$ .

-

5.1

( . . 5.4).

5.3.2.

-

(

-

),

$\varphi$ ,

-

5.2.

5.3.3.

5.3.4.

(5.4), (5.5), (5.6)

(

),

-

5.3.

5.3.5.

5.3.6.

5.4.

5.4.1.

:

5.4.2.

:

-50.

5.4.3.

-

( .5.3).

5.1

-	$d$ ( )	$l$ ( )	- - $W_P$ ( <sup>3</sup> )

5.4.4.

5.2

	( )	( )	$\varphi$ ( )	-

5.4.5.

:

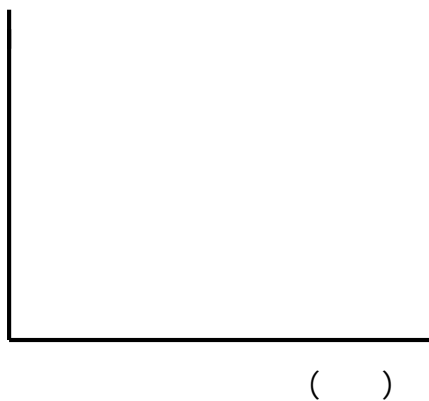
$$W_P = \frac{\pi \cdot d^3}{16} = \quad \tau_T = \frac{M_T}{W_P} = \quad \tau_B = \frac{M_B}{W_P} \quad \theta_B = \frac{\varphi_B}{l}$$

5.4.6.

5.3

	- $\tau$ ( )	- $\tau$ ( )	- $\theta_B$ ( / )

$M_K$   
( )



5.4.7.

" " 20 .

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$$\vdots$$

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5.5.

1.

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2.

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3.

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4.

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6

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$$\vdots$$

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6.1.

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1

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•

1

***I***

***I***

.

 $D_i$ 
$$n$$

—

 $S_i$ 

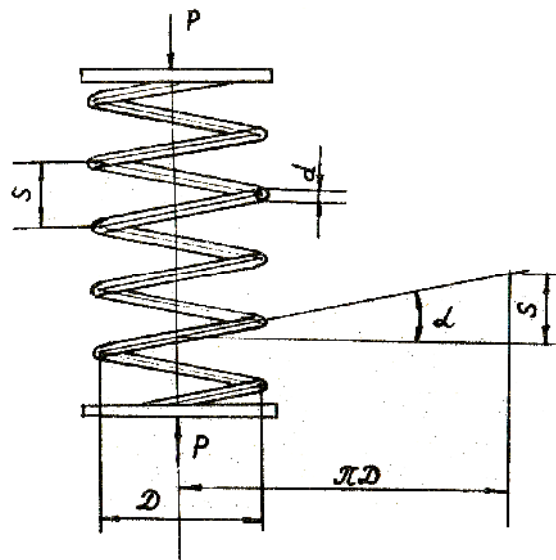
(. 6.1).

 $D, n,$ 

—



(  
 $d$ .



.6.1

:

$$\lambda = \frac{8PD^3n}{Gd^4}, \quad (6.1)$$

— ;  $n$  — ;  $D$  — ;  $G$  — ;  $d$  —

$$( \quad , 1 \quad ). \quad (6.1)$$

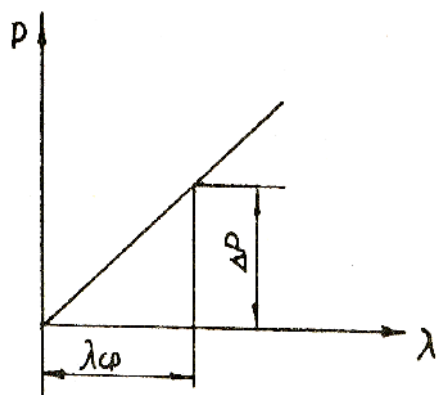
:

$$C = \frac{P}{\lambda} = \frac{Gd^4}{8D^3n}. \quad (6.2)$$

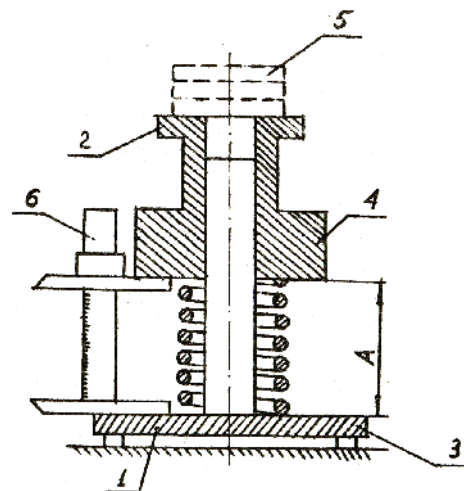
:

$$C = \frac{\Delta P}{\lambda} \quad (6.3)$$

$\Delta P$  — ;  $\lambda_{cp}$  —



.6.2



.6.3

6.2.

.6.3.

1, 2, 3

4.

$$G = 8 \cdot 10^5 / 4^2 = 8 \cdot 10^4$$

5.  
6.

0,1

6.3.

6.3.1.

$$D ;$$

$$:D=1/2 \cdot (D + D ) ;$$

$D ;$

$d ;$

$n.$

6.1.

6.3.2.

( . 6.3.).

6.3.3.

$$= (0,5 \dots 1,5) = (5 \dots 15) ,$$

$$= (2 \dots 3) = (20 \dots 30) .$$

6.3.4. , 2 , 3 ,  
 ( .6.3),  
 . 6.2 ( ).

6.3.5. -  
 . 6.2 ( ).

6.3.6. -  
 ,  
 . 6.2. -  
 . 6.2 . 6.4.

6.3.7. 6.3.2 - 6.3.6 . 6.3 . 6.4.

6.3.8. (6.1) (6.2)

6.3.9. (6.3) . 6.4. -  
 . 6.4.

6.3.10. -

:  

$$\delta_{\lambda} = \frac{|\lambda - \lambda|}{\lambda} \cdot 100\%; \quad \delta_c = \frac{|C - C|}{C} \cdot 100\%.$$
 . 6.4.

6.3.11.

6.3.12.  $\lambda$  . 6.4.  
 6.4.

6.4.1. :  
 6.4.2. ( .6.3).  
 6.4.3. 6.1

		1	2
1			
2	$D ( \quad )$		
3	$D ( \quad )$		
4	$D ( \quad )$		
5	$d ( \quad )$		
6	$n$		

6.2

1

	( , )				
		( )	( )	( )	( )
0					
1					
2					
3					
		$\lambda_1 = \Delta =$		$\lambda_2 = \Delta =$	
		$\lambda = \frac{\lambda_1 + \lambda_2}{2}$			

6.3

2

	( , )				
		( )	( )	( )	( )
0					
1					
2					
3					
		$\lambda_1 = \Delta =$		$\lambda_2 = \Delta =$	
		$\lambda = \frac{\lambda_1 + \lambda_2}{2}$			

- 6.4.4.  
1 2 ( (6.1) (6.2)).
- 6.4.5.  
2 ( (6.3)).
- 6.4.6.

1

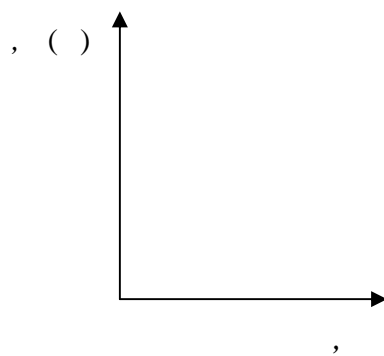
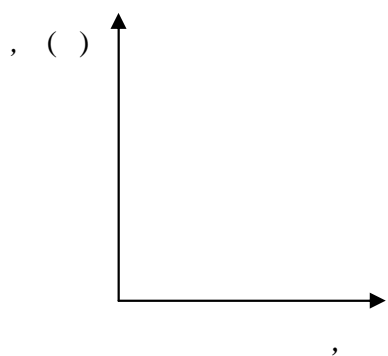
6.4

-	1			2		
	.	.	%	.	.	%
-						
( )						
<i>C</i> ( / , / )						

6.4.7.

1

2



6.4.8.

\_\_\_\_\_:

"\_\_\_\_" \_\_\_\_\_200\_\_ .  
:  
;  
;

6.5.

1.

( ) ?

2.

?

3.

-

4.

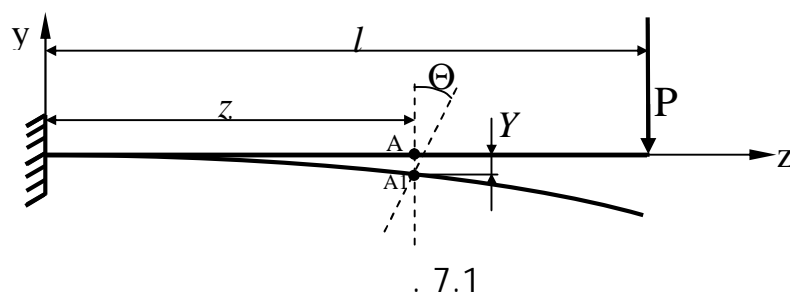
,

( )?

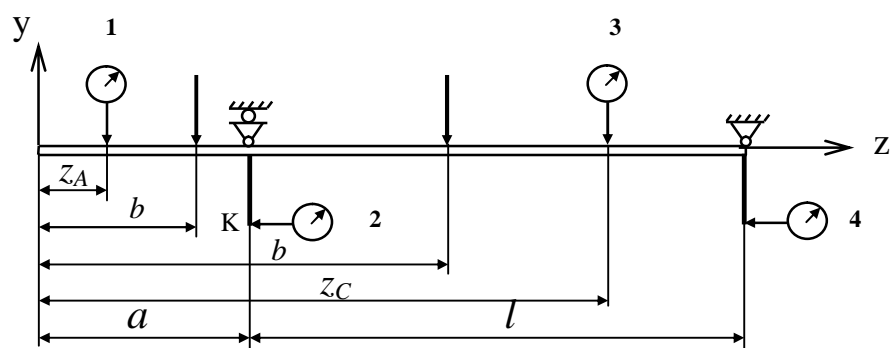
?

7.1.

«Y»

« $\Theta$ » ( 7.1).

7.2.

 $z_A$  $z_C$ 

7.2

$$\begin{aligned}
1. \quad & (0 \leq b \leq a) \\
Y_A &= \frac{P}{6EJ_x} [(a-b)^3 - 3(a-b)^2 \cdot a - 2(a-b)al]; \\
Y_C &= \frac{P(a-b)l^2}{16EJ_x}; \\
\theta_b &= \frac{P(a-b)l}{3EJ_x}; \\
\theta_E &= -\frac{P(a-b)l}{6EJ_x}.
\end{aligned} \tag{7.1}$$

$$\begin{aligned}
2. \quad & (a \leq b \leq a+l) \\
Y_A &= -\frac{Pa}{6EJ_x l} [(a-b)^3 + 3(a-b)^2 l + 2(a-b)l^2]; \\
Y_C &= \begin{cases} \frac{P}{48EJ_x} [-4(a-b)^3 + 3(a-b)l^2] & b \leq Zc \\ \frac{P}{48EJ_x} [4(a-b)^3 + 12(a-b)^2 l + 9(a-b)l^2 + l^3] & b \geq Zc \end{cases} \\
\theta_B &= \frac{P}{6EJ_x \cdot l} [(a-b)^3 + 3(a-b)^2 l + 2(a-b)l^2]; \\
\theta_E &= \frac{P}{6EJ_x \cdot l} [(a-b)^3 - (a-b)l^2],
\end{aligned} \tag{7.2}$$

$b -$   $P,$   $-$   
 $0 \leq b \leq a+l;$   
 $E -$  ;  
 $J_x -$  .

7.2.

. 7.3.

1, 2, 3, 4, 5, 6, 7, 8.  
 (  $E=2 \cdot 10^5$  )  
 (  $H=7$  )  $B=40$  ,  
 $l=700$  ,  $a=300$  .  
 $(l+a = 1000)$  .

$b$

(

)

$b = 0, 100, 200$

(

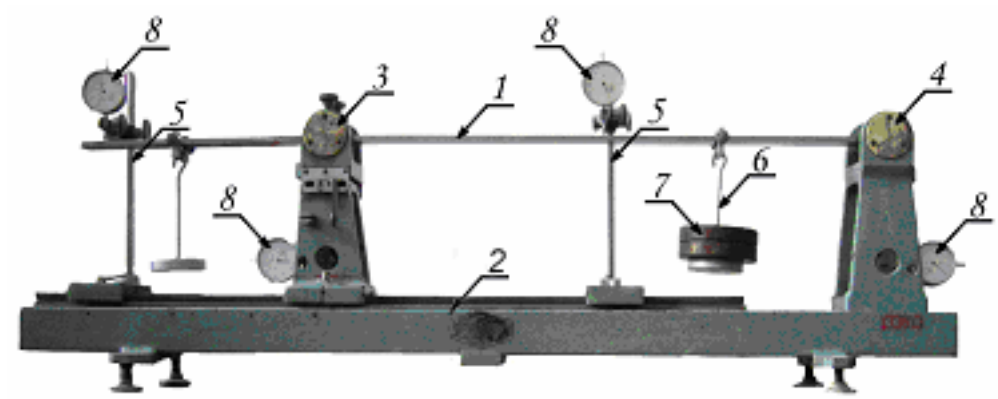
$b = 400, 500, 600, 700, 800, 900$   
40, 50, 60, 70, 80, 90

(

) –

0, 10, 20,

$b$



.7.3

0,01

( . 7.2. 7.4.).

$\theta$ ,

( . 7.4.).

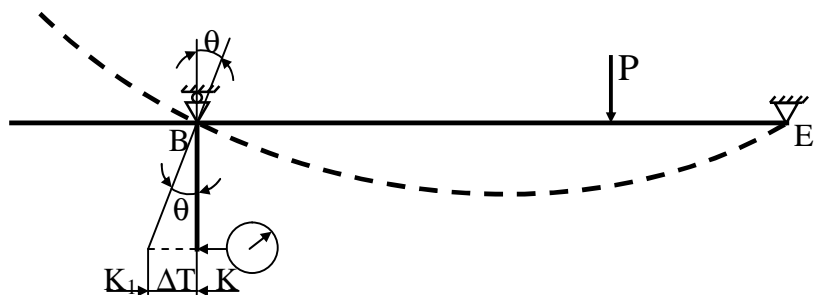
$=L=150$

$$I = \Delta I = L \cdot \tan \theta$$

$$\tan \theta \approx \theta$$

$$\theta \approx \frac{\Delta T}{L}$$





. 7.4

7.3.

7.3.1.

$b$

( ).

7.3.2.

«0»

0

7.1.

1

3

2

4 –

7.3.3.

$= 20$  ,

7.3.4.

. 7.1.

7.3.5.

7.3.6.

$b$ ,

. 7.3.2. – 7.3.5.

( . 7.1.

).

7.3.7.

$\Delta$

$$Y = \Delta_1, \quad Y = \Delta_3,$$

$$\theta = \frac{\Delta T_2}{L}, \quad \theta = \frac{\Delta T_4}{L}.$$

. 7.2.

. 7.2.

. 7.1.

7.3.8.

(7.1) (7.2)

( .

.7.4).

. 7.2.

7.3.9.

$$\delta = \left| \frac{Y' - Y}{Y} \right| \cdot 100\%,$$

$$\delta_\theta = \left| \frac{\theta' - \theta}{\theta} \right| \cdot 100\%,$$

$Y, \theta$  –

;

$Y', \theta'$  –

. 7.2.

7.3.10.

(

$b_i$ ).

7.3.11.

( . . 7.5.).

7.4.

(7.1.) (7.2.)

$a, l$

$a+l=1000$  .

- 10.

(

A

)

(Y , Y ,  $\theta$  ,  $\theta$  )

10

«Windows».

7.4.1.

7.4.2.

«

», «Mechanics», «Sopromat», «lab 07».

7.4.3.

«lab 07»

«lab 07.exe».

«

».

«

».

7.4.4.

$b_1=0$ ,  $b_2=100$  ,  $b_3=200$  ,  $b_4=400$  ,  $b_5=500$  ,  $b_6=600$  ,  $b_7=650$  ,  
 $b_8=700$  ,  $b_9=800$  ,  $b_{10}=900$  .  $a, l, Z_A, Z_C$

$b_i$

7.4.5.

«

».

$b_i$  ( $i=1,2,\dots,10$ ).

Y Y  $\Theta$   $\Theta$  -

7.4.6.  $b_i$  , -

7.2. -

7.4.7. .

7.4.8. « Y b». Y ( ) Y ( -

7.4.9.  $b_i$   $\Theta$  b».  $\Theta$   $\Theta$   $b_i$

7.4.10. .

## 7.5.

7

7.5.1. :

7.5.2. ( . 7.2)

7.5.3. .

7.1

		1			2			3			4		
/	$b_i$ ,	0		$\Delta$	0		$\Delta$	0		$\Delta$	0		$\Delta$
1	0												
2	100												
3	200												
4	400												
5	500												
6	600												
7	650												
8	700												
9	800												
10	900												

7.5.4.

7.2

	Y ,			θ ,			Y ,			θ ,		
$b_{i'}$	.		% '	.		% '	.		% '	.		% '
0												
100												
200												
400												
500												
600												
650												
700												
800												
900												

7.5.5.



7.5.6. :

«\_\_\_\_\_» \_\_\_\_\_ 200\_\_\_\_\_ .

\_\_\_\_\_ :

) \_\_\_\_\_ :

) \_\_\_\_\_ ;

) \_\_\_\_\_ .

7.6.

1. ?
2. ?
3. ?

4. ?

5.

?

6.

?

8

:

-

;

-

8.1.

-

$b(z)$  ( 8.1).

-

.

A-A

Z

:

$$\sigma(z) = \frac{M_x(z)}{W_x(z)} \quad , \quad (8.1)$$

$M_x(z)$  -

A-A:

$$M_x(z) = P \cdot z \quad ; \quad (8.2)$$

$W_x(z)$  -

-

X:

$$W_x(z) = \frac{b(z) \cdot h^2}{6} \quad ; \quad (8.3)$$

$b(z)$  -

;

Z

:

$$b(z) = \frac{b}{l} \cdot z \quad ; \quad (8.4)$$

$h(z)$  -

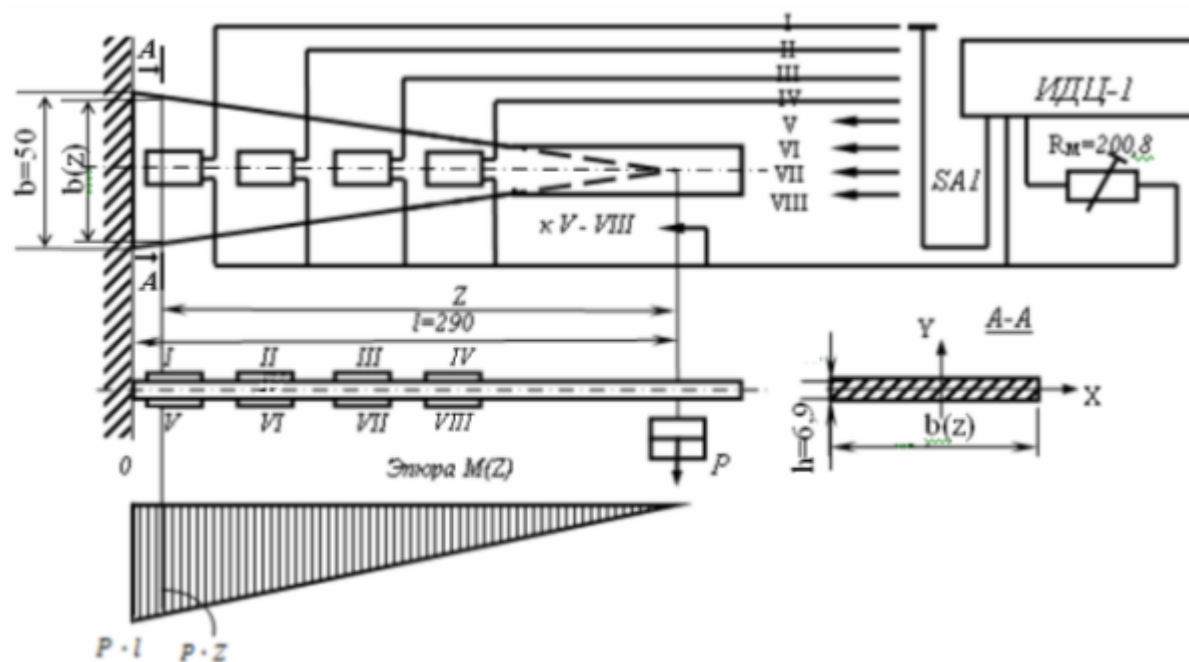
(8.2), (8.3), (8.4) (8.1),

-

:

$$\sigma = P \cdot \frac{6 \cdot l}{b \cdot h^2} \quad (8.5)$$

(8.5)



8.1

8.2.

8

8.1.

(I-IV)

(V-VIII) –

SA1

$R = 200,8$

-I.

( )



8.3.8. (8.6) . 8.1 -

8.3.9. (8.10) -

. 8.2 .

8.3.10. (8.5)

$P=5$   $P=10$  . 8.2.

8.3.11. -

$$\delta_{max} = \left| \frac{\sigma - |\sigma^{max}|}{\sigma} \right| \cdot 100\%$$

. 8.2. -

8.3.12. -

8.5.

8

8.5.1. :

8.5.2. ( 8.1).

8.5.3. 8.1

	( )				
	=0	=5	=50	=10	=100
	$\theta$				
I					
II					
III					
IV					
V					
VI					
VII					
VIII					



8.5.4. \_\_\_\_\_ :

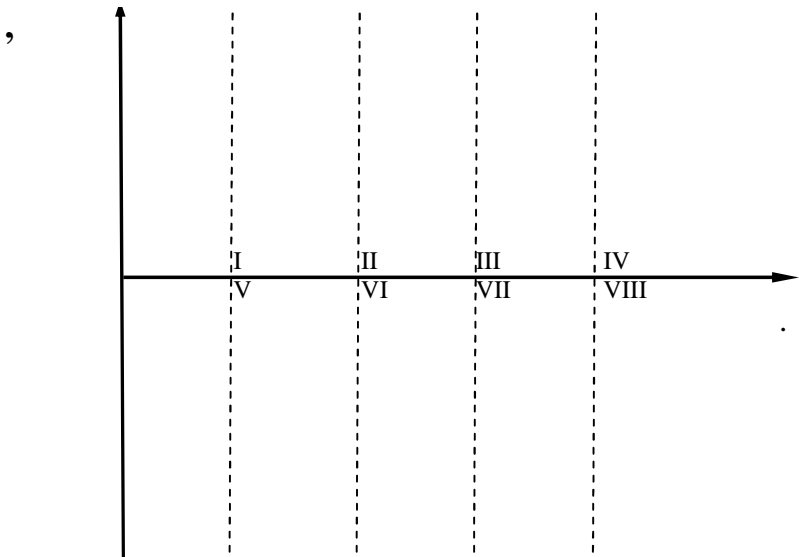
$$\sigma = \cdot \frac{6 \cdot l}{b \cdot h^2}$$

$$i = 0,19 \cdot i ( \quad ) = 1,9 \cdot i ( \quad / \quad ^2 ).$$

8.2

										max, %
	-									
	-									
	$\sigma$	$\sigma_I$	$\sigma_{II}$	$\sigma_{III}$	$\sigma_{IV}$	$\sigma_V$	$\sigma_{VI}$	$\sigma_{VII}$	$\sigma_{VIII}$	
50										
100										

8.5.5



8.5.6 \_\_\_\_\_ :

«\_\_» \_\_\_\_\_ 20\_\_ .

\_\_\_\_\_ :

:

;

P;

8.6.

1.

?

2.

?

3.

?

4.

-I ?

5.

-I ?