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Professional paper

DIMENSIONING OF THE MAIN BRACKET FROM CONCRETE I PREMADE OF A MANUFACTURING FACILITY

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Abstract

Purpose: The development of small and medium-sized enterprises in the private sector as imperatives of the time for the construction of low buildings but with large spaces for the needs of small non-polluting industries in different environments, the demand of investors in the private social sector is the construction of the above-mentioned buildings but with large spaces for the needs required by the design task imposes the preparation of the main supports with large dimensions, in this paper the principle of dimensioning and calculation of beams up to 30m, which cannot be prepared with these dimensions in factories, is presented for the production of prefabricated products, but the one must be prepared in the place where the construction of the building-object takes place since the beam with a length of 30 m cannot be transported due to inadequate road infrastructure.

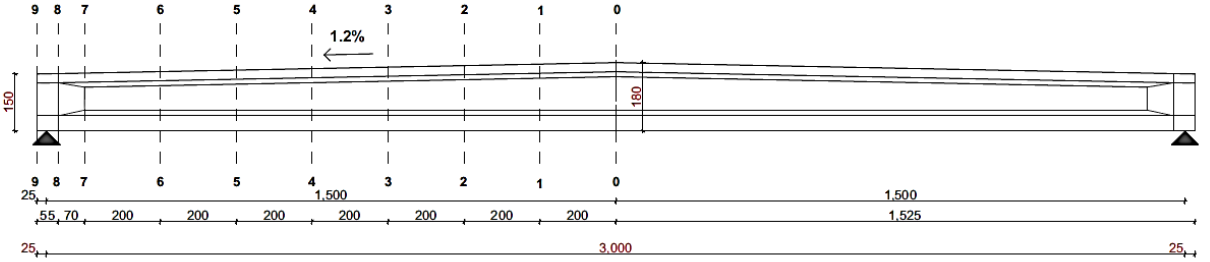
Methods: Dimensioning of the beam - the main supports for a space of 30m with prestressed concrete brand MB 30, MB 40, MB 50, MB 60 and with prestressing class 0.6; 0.8; 1.0 where the solution with the approximation method is used. Dimensioning of the Rigel-beam constructive element is done for cable prestressing, determination of the method for: - Filling-incorporation of concrete -Type of soft armor - The time of advance - Load according to the purpose of the object, the place where the construction takes place (altitude) - The part of the beam where the load is more pronounced, larger - the most unfavorable position - Shear forces in different cuts, at the beginning of the beam in the middle and other places. - Necessary measurements of honors, deformations, reductions, loss of prestressing seal about time, etc. -Parameters and geometric indicators of transverse and longitudinal sections.

Design: Analysis of the most meritorious cross-section of the Rigel-beam

Results: Results for the brands of prestressed concrete mentioned above, results for normal values, results from checking values indirectly (Fizo zone), results of reinforcement for acceptance of values from the tensile force, checking the coefficient of safety against fracture, control of tangential parts, value from the calculation of reinforcement in the area of application of the prestressing force, value - results from the calculation of deformations, the weight of the beam and the amount of material and details. Conclusions: After the dimensioning of cross-sections with different heights h=150cm, h=160cm, h=170cm, h=180cm with brands MB 30, MB 40, MB 50, and MB 60 for the same loads, it was found a conclusion of a beam with a height of h=180cm is acquired as the most meritorious for the given area, with cross-section "I", with the geometric characteristics given in the work, and with the mechanical characteristics, cable routing, loss of prestressing force and many other values that are necessary for this type of prestressed concrete beams.

***Keywords**: Prestressed concrete, anchors, cable, concrete grade, load, soft reinforcement.*

1 ACQUISITION OF CONSTRUCTIVE ELEMENTS



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1.1 *ADAPTATION OF DIMENSIONS AFTER PERFORMING THE ANALYSIS*

$$d = \frac{l}{15} \cdots \frac{l}{22}$$

$$d_{opt} = \frac{l}{16} \cdots \frac{l}{18}$$

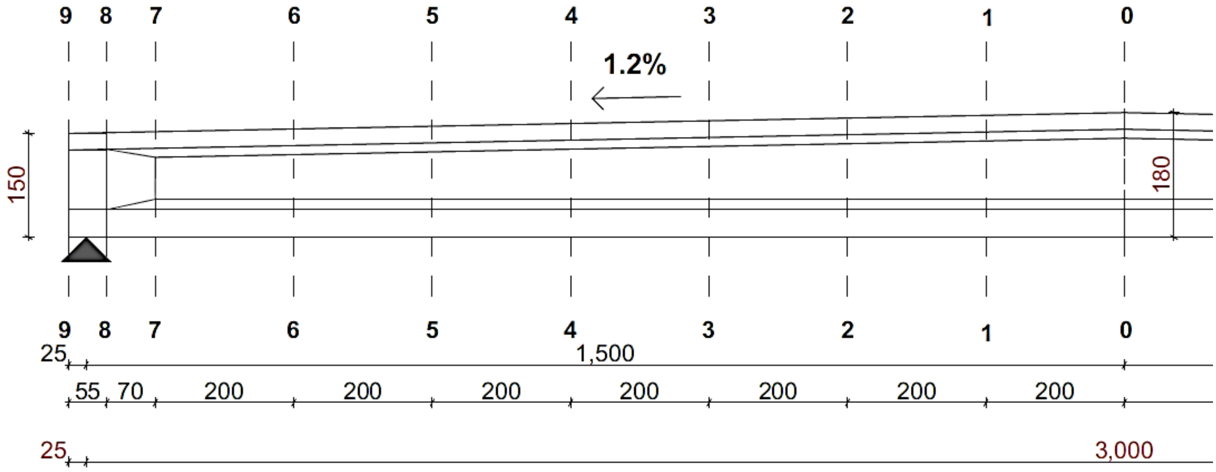
$$d_1 = (0.15 \div 0.20)d$$

$$d_2 = (0.15 \div 0.20)d$$

$$b = (0.20 \div 0.40)d \leq (4 \div 5)b_o$$

$$b_1 = (0.75 \div 1.0)b$$

$$b_o = (0.20 \div 0.25)b \geq (12 \div 15)cm$$



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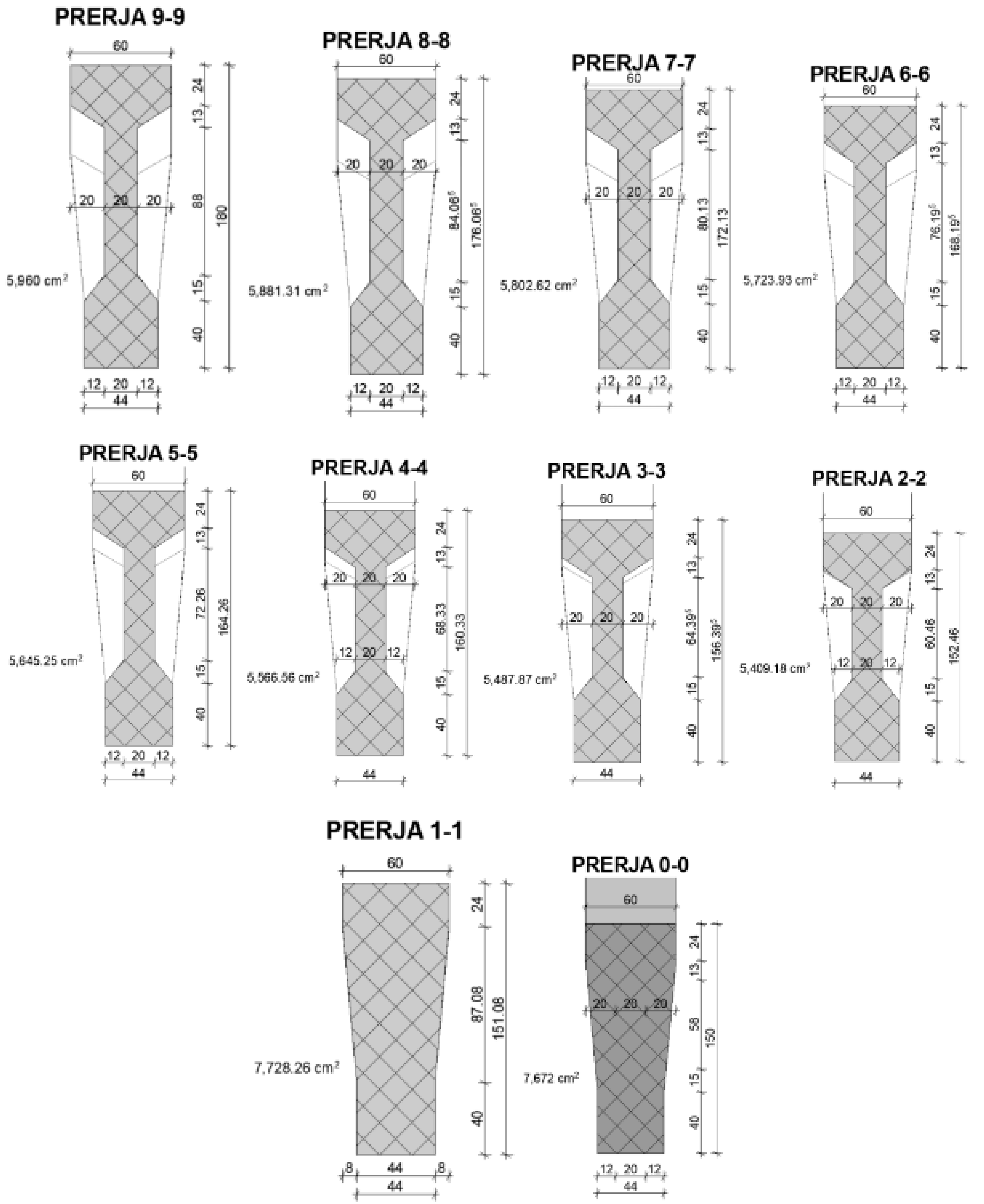
- **CROSS SECTION OF BEAM**



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- **Provided:**

$$d = \frac{l}{18} = \frac{30}{18} = 1.667m = 166.667cm$$

$$b \quad = 0.3d = 0.3 \cdot 1.667 = 0.5m = 50cm$$

$$\frac{F_b}{b \cdot d} = (0.3 \div 0.7) \rightarrow \frac{F_b}{b \cdot d} = 0.5$$

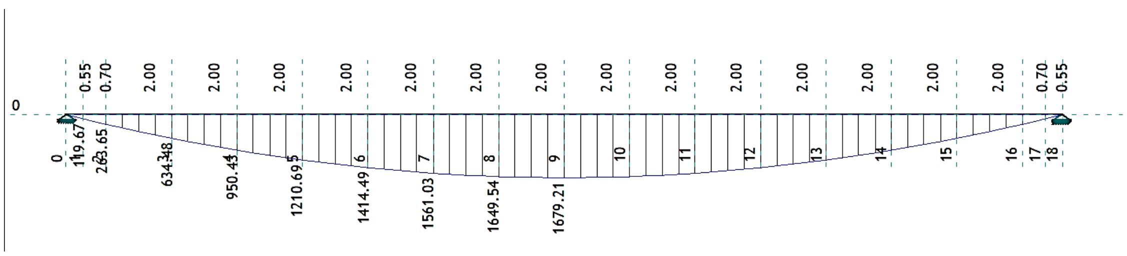
$$F_b = 0.5bd = 0.5 \cdot 35 \cdot 1.667 = 0.41667m2 = 4166.667cm2$$

- 2.1.1 Permanent loads
- Own weight : $2 \cdot \frac{1.65}{2} \cdot 9$.. 14.85 $kN/m^{`}$
- Fillings: $2 \cdot \frac{0.126}{2} \cdot 9$ …………………………………….. 1.134$kN/m^{`}$
- Waterproofing and Thermal Insulation : .... 0.10 $kN/m^{`}$
- Installations : $2 \cdot \frac{0.2}{2} \cdot 9$.. 1.80 $kN/m^{`}$
- $\underline{\boldsymbol{g_2 = 19.0\ kN/m^2}}$
-
- Self-weight of the beam
-
- own weight $F_b \cdot \gamma b = 0.41667 * 25.0$ .... 10.42 $kN/m^{`}$

$\underline{\boldsymbol{g_1 = 10.42\ kN/m^2}}$

- 2.1.2 Temporary load
- snow ……$2 \cdot \frac{0.9}{2} \cdot 9$…………………………………………….………… 8.10 $kN/m^{`}$
- the wind$2 \cdot \frac{0.3}{2} \cdot 9$……………………………………………...…..... 2.70 $kN/m^{`}$
- $\underline{\boldsymbol{p = 10.80\ kN/m^2}}$
- **2.2 STATIC EFFECTS**
- Moment diagrams in the beam

Mg1



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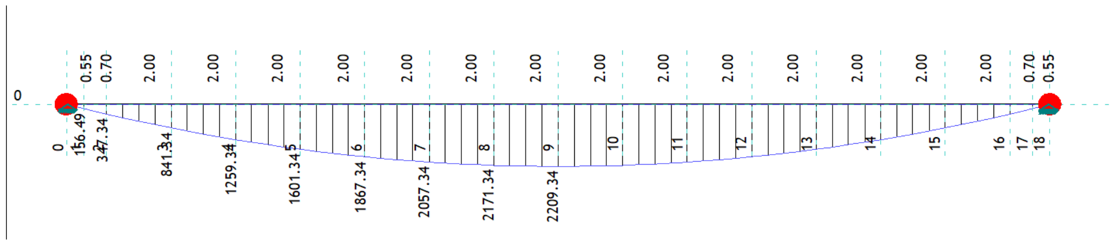
Mg2



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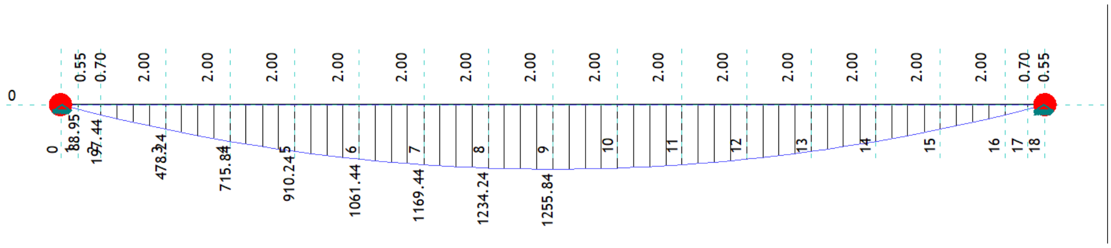
Mgp



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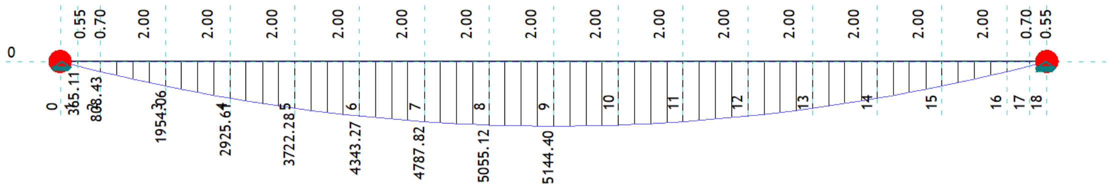
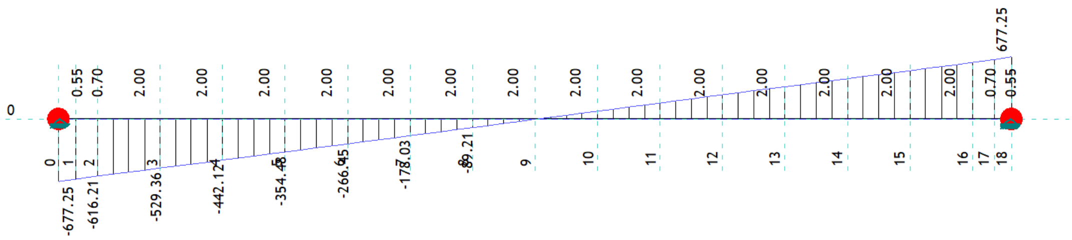
Mg1,g2,p

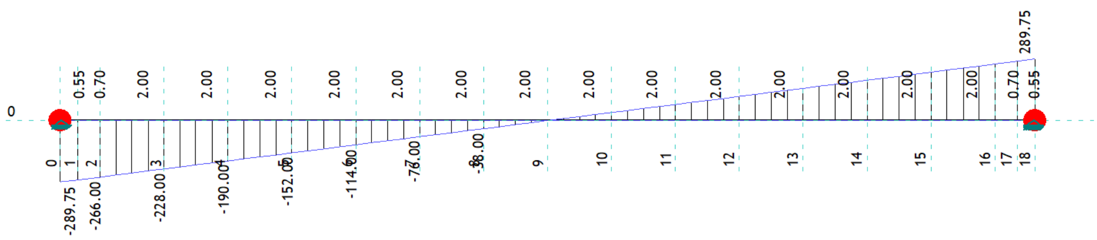


- - Diagrams of transverse forces

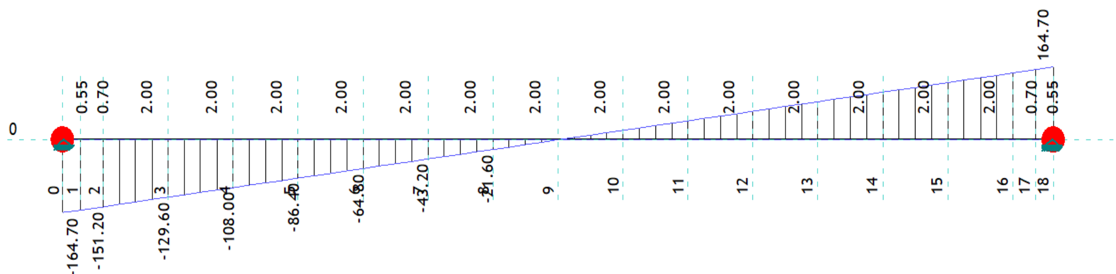
Tg1



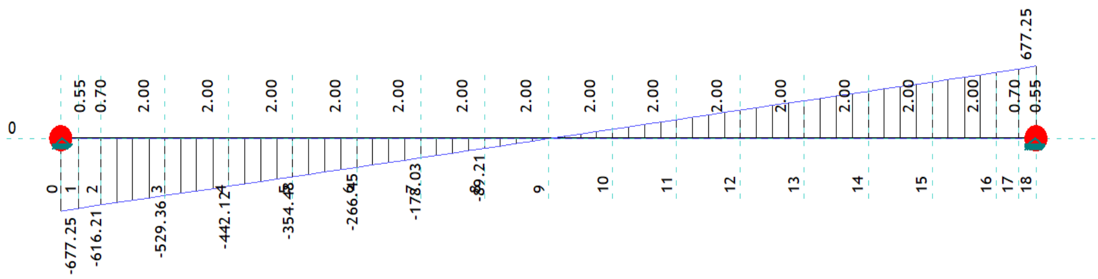
Tg2



Tp

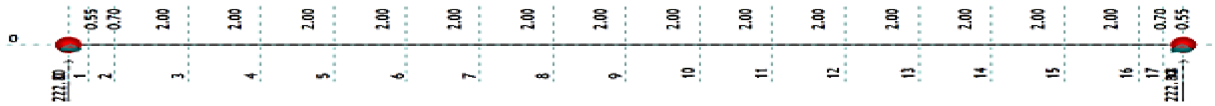


Tg1,g2,p

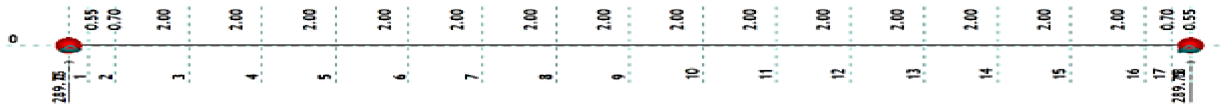


- Scheme of reactions in the support

Rg1

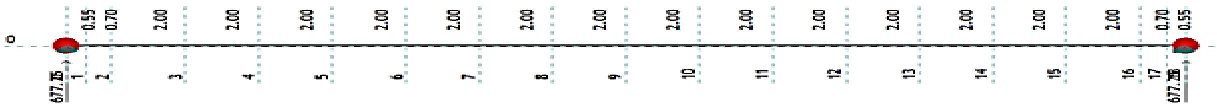


Rg2



Rp

Rg1,g2,p



$$M_{g1} = \frac{g_1 \cdot l^2}{8} = \frac{10.42 \cdot 30^2}{8} = 1171.88\ kNm$$

$$M_{g2} = \frac{g_2 \cdot l^2}{8} = \frac{19 \cdot 30^2}{8} = 2137.50\ kNm$$

$$M_p = \frac{p \cdot l^2}{8} = \frac{10.8 \cdot 30^2}{8} = 1215.00\ kNm$$

2.3 Preliminary dimensioning in the middle of the space according to guideline values

MB-40

Allowed honors (with absolute values)

a) During prestressing (t=0)

$[\sigma_{bdo}] = 19.5\ MPa$

$[\sigma_{bdzo}] = 3.0\ MPa$

b) During exploitation (t=∞)

$[\sigma_{bd\infty}] = 16.0\ MPa$

$[\sigma_{bdz\infty}] = 1.8\ MPa$

The necessary resisting moments (Wb1 and Wb2) are obtained from the condition of fulfilling the allowed values during the initial and final stages of prestressing.

$$W_{b1} \geq \frac{(1-\omega+\mu\cdot\omega)M_{g1}+M_{g2}+M_p}{\omega[\sigma_{bdo}]+[\sigma_{bdz\infty}]}$$

$$W_{b2} \geq \frac{(1-\omega+\mu\cdot\omega)M_{g1}+M_{g2}+M_p}{\omega[\sigma_{bdzo}]+[\sigma_{bd\infty}]}$$

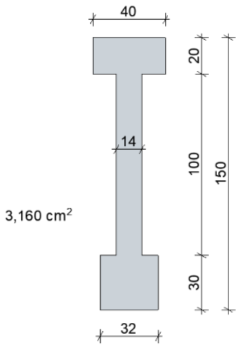
$$\frac{Y_{b2}}{d} = \frac{W_{b1}}{W_{b1}+W_{b2}}$$

It is predicted that losses of prestressing strength due to deformation time of concrete and relaxation of steel will be ~20%

$\omega = 1 - 0.2 = 0.8$

A) First approximation

It is assumed that the self-moment Mg1 can be below the lower point of the coefficient of friction is μ=0, which means that the coped with the descent of the resultant of the fins shear core for the required height:



μ=0→

$$W_{b1} \geq \frac{(1-0.8+0\cdot0.8)1171.88\cdot10^2+2137.5\cdot10^2+1215.0\cdot10^2}{0.8\cdot1.95+0.18} = 206142.241\ cm3$$

$$W_{b2} \geq \frac{(1-0.8+0\cdot0.8)1171.88\cdot10^2+2137.5\cdot10^2+1215.0\cdot10^2}{0.8\cdot0.3+1.6} = 194938.859\ cm3$$

$$\frac{Y_{b2}}{d} = \frac{206142.241}{206142.241+194938.859} = 0.51\ cm$$

$Y_{b1} = 1 - Yb2 = 1 - 0.51 = 0.49\ cm$

$b_1 = 0.8\cdot0.5 = 40cm \rightarrow 40cm$

$d_1 = 0.17\cdot d = 0.17\cdot1.667 = 0.283\ m \rightarrow 30\ cm$

$d_1 = d_2 = 20\ cm$

$b_o = 0.25\cdot b = 0.25\cdot0.5 = 12.5\ cm \rightarrow 14\ cm$

$$Y_{b2} = \frac{800 \cdot 140 + 1400 \cdot 80 + 960 \cdot 15}{800 + 1400 + 960} = 75.44cm$$

$$Y_{b1} = d - Y_{b2} = 150 - 75.44 = 74.56\ cm$$

$$J_b = 90{,}000 + 1{,}166{,}666.67 + 21{,}333 + 800 \cdot 59.56^2 + 1400 \cdot 0.44^2 + 960 \cdot 65.44^2$$
$$= 8{,}227{,}379.75\ cm4$$

$$W_{b1} = \frac{Jb}{Yb1} = \frac{8{,}227{,}379.75}{75.44} = 109054.2\ cm3$$

$$W_{b2} = \frac{Jb}{Yb2} = \frac{8{,}227{,}379.75}{74.56} = 110350.3\ cm3$$

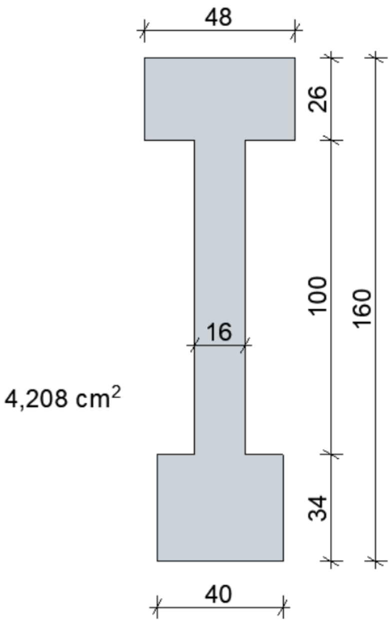
- We increase the dimensions of the cross section!

$$b_1 = 0.8 \cdot 0.5 = 40cm \rightarrow 48cm$$
$$d_1 = 0.17 \cdot d = 0.17 \cdot 1.667 = 0.283\ m \rightarrow 34\ cm$$
$$d_1 = 34\ cm$$
$$d_2 = 26\ cm$$
$$b_o = 0.25 \cdot b = 0.25 \cdot 0.5 = 12.5\ cm \rightarrow 16\ cm$$

$$F_b = 48 \cdot 26 + 40 \cdot 34 + 100 * 16 = 4208\ cm2$$

$$J_b = 70{,}304.0 + 1{,}333{,}333.33.0 + 131{,}103.0 + 1248 \cdot 65.97^2 + 1600 \cdot 2.97^2 + 1360 \cdot 64.03^2$$
$$= 12{,}555{,}894.77\ cm4$$

$$Y_{b2} = \frac{1248 \cdot 147 + 1600 \cdot 84 + 1360 \cdot 17}{1248 + 1600 + 1360} = 81.03\ cm$$



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$$Y_{b1} = d - Y_{b2} = 160 - 81.03 = 78.79\ cm$$

$$W_{b1} = \frac{Jb}{Yb1} = \frac{12{,}555{,}894.77}{81.03} = 154952.9\ cm3$$

$$W_{b2} = \frac{Jb}{Yb2} = \frac{12{,}555{,}894.77}{78.79} = 158996.6\ cm3$$

Correction of static effects

$$g_1 = 4208 \cdot 25.0 = 10.52\ \frac{kN}{m}`$$

$$M_{g1} = \frac{g_1 \cdot l^2}{8} = \frac{10.52 \cdot 30^2}{8} = 1183.5\ kNm$$

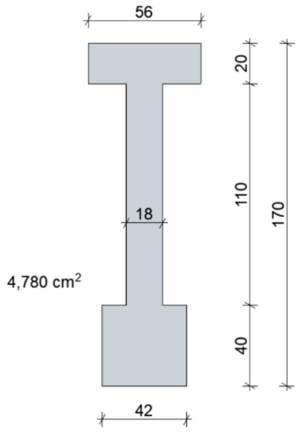
The central parts in concrete

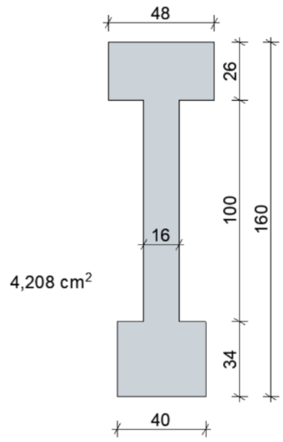
$$\sigma_{bco} = -[\sigma_{bdzo}] + \frac{y_{b2}}{d}([\sigma_{bd\infty} + \sigma_{bdo}]) = -0.3 + \frac{78.79}{160}(0.3 + 1.95) = 8.11\ MPa = 0.811kN/cm2$$

$$Nko = Fb \cdot \sigma_{bco} = 4208 \cdot 8.11 = 3410.63\ kN$$

Required initial prestressing force:

$$ebk = ([\sigma_{bdzo}] + [\sigma_{bco}])\frac{W_{b2}}{Nko} + (1-\mu)\frac{M_{g1}}{Nko} = (0.3+0.83)\frac{158996.6}{3410.63} + (1-0.0)\frac{1183.5}{3410.63} = 86.47\ cm$$





A) Second approximation

The position of the center of gravity of the gills is predicted to be:

$$ak = 0.11 \cdot d = 0.11 \cdot 150 = 17.6\ cm$$

$$ebk = y_{b1} - ak = 81.03 - 17.6 = 63.43\ cm$$

$$\mu = 1 - \frac{N_{ko} \cdot ebk - ([\sigma_{bdzo}] + [\sigma_{bco}])Wb1}{Mg1} = 1 - \frac{3410.63 \cdot 63.43 - (0.3+0.83) \cdot 154952.9}{1183.5} =$$

$$\mu = 0.626$$

A) Third approximation

$$\mu = 1 - \frac{N_{ko} \cdot ebk - ([\sigma_{bdzo}] + [\sigma_{bco}])Wb1}{Mg1} = 1 - \frac{4015 \cdot 64.76 - (0.3+0.84) \cdot 188{,}955.26}{134437.5} = 0.623$$

Taking into account that the necessary eccentricity of the pre-tensioning force is approximately the same as the assumed eccentricity, with the Nko force side the necessary number of bolts is determined, their alignment is done and the assumed ac is checked.

- We assume Y1860S7 type anchors, Class B, From the table IMS SPB SUPER is acquired:

1.7.2 Kablovi od užadi Ø 16,0mm

	Karakteristike \ Tip kabla		1 Ø16,0	2 Ø16,0	3 Ø16,0	4 Ø16,0	7 Ø16,0	12 Ø16,0
	Površina preseka A_{pk} (mm^2)		150	300	450	600	1050	1800
Klasa A, Y1770S7	Prekidna sila F_{pk} (kN)		265	531	797	1062	1859	3186
	Početna sila F_p (kN)	0,80 F_{pk}	212	425	637	850	1487	2549
		0,75 F_{pk}	199	398	597	797	1394	2390
		0,70 F_{pk}	186	372	558	743	1301	2230
Klasa B, Y1860S7	Prekidna sila F_{pk} (kN)		279	558	837	1116	1953	3348
	Početna sila F_p (kN)	0,80 F_{pk}	223	446	670	893	1562	2678
		0,75 F_{pk}	209	419	628	837	1465	2511
		0,70 F_{pk}	195	391	586	781	1367	2345

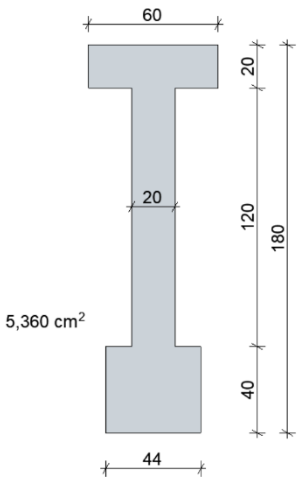
$\sigma_{ko} = 1327.7\ MPa$

Initial force in the throat

$Fkp = 1562\ kN$

The number of gills required

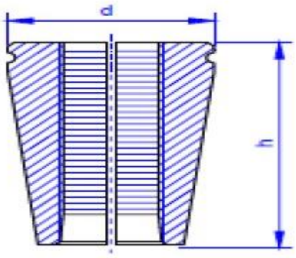
$\mu = \frac{Nko}{Fkp} = \frac{4382}{1562} = 2.8\ pcs$



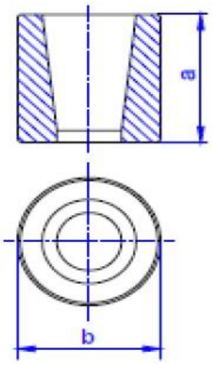
We adopt "3" anchors type Y1860S7, Class B, Fk=31.50 cm2

Tip kabla	Površina preseka A_{pk} (mm^2)	Klasa B,Y 1860S7			
		Prekidna sila F_{pk} (kN)	Početna sila 0,8 F_{pk}	Početna sila 0,75F_{pk}	Početna sila 0,7 F_{pk}
7Ø16	1050	1953	1562	1465	1367

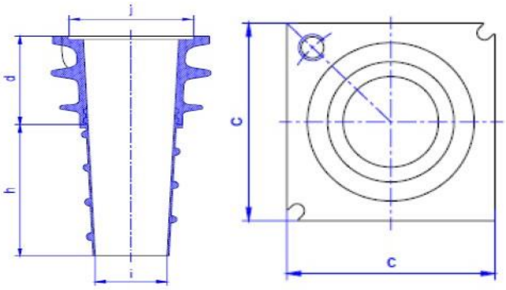
Zatezna čvrstoća Fpk N/ mm^2	Modulelastič. kN/ mm^2	Max.relaksacija (nakon 1000h) %	Koef.trenja μ Rad^{-1}	Slučajno odstup. K Rad/m
1860	195	2,5	0,22	$3 \cdot 10^{-3}$



Ø16	
d (mm)	33
h (mm)	50



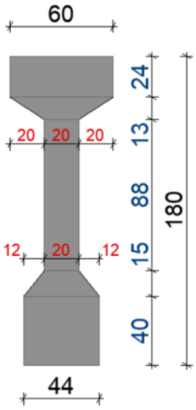
Tipkotve	a (mm)	b (mm)
S7/16	55	135

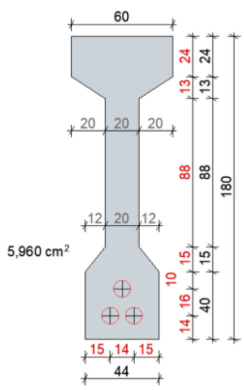


Tip kotve S7/16				
c (mm)	d (mm)	h (mm)	i (mm)	j (mm)
170± 1,8	200± 1,8	330± 3,0	69± 1,0	136± 0,4

"WE OBSERVE THE CROSS-CUT"

$$Fb = 60 \cdot 24 + 44 \cdot 40 + 116 \cdot 20 + 2 \cdot \frac{13}{2} \cdot 15 + 2 \cdot \frac{20}{2} \cdot 12 = 5960\ cm2$$





DEFORMATIONS DURING THE EXPLOITATION

$$\Delta\infty = \Delta Nko + \frac{1}{2}(\Delta Nko + \Delta Nk\infty)\varphi\infty + \Delta g + s(1+\varphi\infty) + \Delta p$$

Taking into account that the loads g1, g2, and p are uniformly distributed, as well as from the assumption that the effective coefficient of prestressing which is calculated for the cut in the middle of the space (w=0.805) is unchanged along the length of the beam, we obtain.

$$\Delta\infty = \omega \cdot \Delta Nko + \frac{1}{2}(1+\omega) \cdot \Delta Nko \cdot \varphi\infty + \frac{g+s}{g1} \cdot \Delta g1 \cdot (1+\varphi\infty) + \frac{p}{g1} \cdot \Delta g1$$

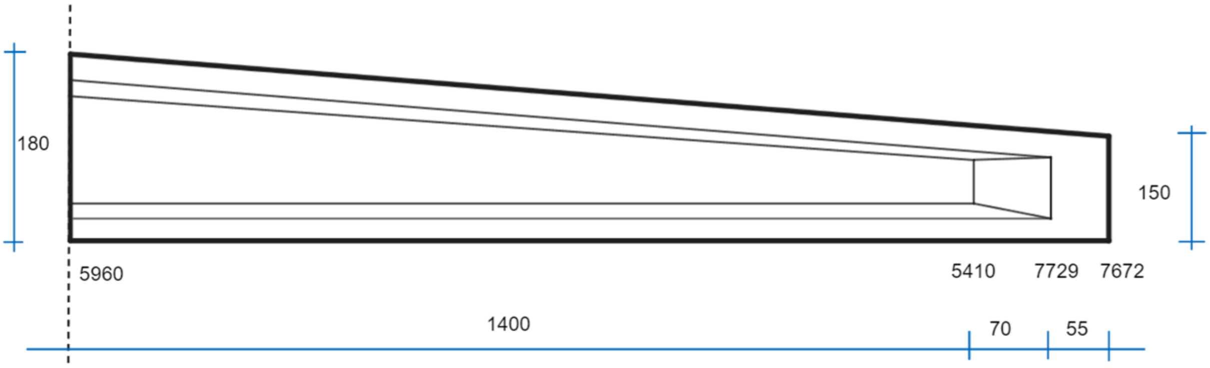
$$\Delta\infty = 0.836 \cdot (-3.68) + \frac{1}{2}(1+0.836) \cdot (-3.68) \cdot 2.2 + \frac{14.9+19}{14.9} \cdot 2.07 \cdot (1+2.2) + \frac{10.8}{14.9} \cdot 2.07$$
$$= 6.03\ cm \cong \Delta O = \frac{l}{500} = 6.0 \text{ cm}$$

Reduction of permanent loads without the temporary load.

$$\Delta p = \frac{10.8}{14.9} \cdot 2.07 = 1.5 \text{ cm}$$

$$\Delta = \Delta\infty - \Delta p = 6.0 - 1.5 = 4.5 \text{ cm} \cong \frac{l}{700} = 4.3 \text{ cm}$$

CALCULATION OF THE WEIGHT OF THE BEAM AND THE QUANTITY OF THE MATERIAL



$$V = 2 \cdot \left(\frac{5960+5410}{2} \cdot 1400 + \frac{5410+7730}{2} \cdot 70 + \frac{7730+7672}{2} \cdot 55\right) = 35.37\ m3$$

$$G = V \cdot \gamma b = 35.37 \cdot 25 = 364.5 \text{ kN}$$

- The amount of concrete in m2 of the base of the object (λ=9.15m)

$$g = \frac{G}{\gamma b \cdot \lambda \cdot l} = \frac{364.5}{25.0 \cdot 9.15 \cdot 30.0} = 0.1288 \frac{m3}{m2}$$

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