Oct 30th, 3:00 PM - 4:30 PM

Application of prestressing with pretension and post-tension in precast beams

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Application of prestressing with pretension and post-tension in precast beams

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Abstract. In Nowdays, prestressed concrete founds wide application in the construction of engineering structures. Where concrete elements are subjected to mandatory stresses to gain more favorable behaviors. This can be realized by applying prestressing force with system of pre-tension and post-tension.
Analysis of precast beams elements with different sections by applying these prestressing methods, will help us to determine which method of force application is going to be more favorable for realization.
Analysis of precast beams elements for different shapes of sections for two methods of prestressing, that with pretensioned and post-tension, by checking the basic condition criteria of servisability limit state.

Keywords: Prestressing, Pretension, Post-tension, Shapes, Servisability limit state

1 Introduction

For the construction of mankind's infrastructure, reinforced concrete is the most widely used structural material [1]. As is well known, concrete is very strong in compression, but it is very weak in tension, with a tensile strength approximately only 10% of compressive strength [2]. Because the tensile strength of concrete is low, steel bars are embedded in the concrete to carry the internal tensile forces. Tensile forces may be caused by imposed loads or deformations, or by load-independent effects such as temperature changes and shrinkage [1].
However, this does not solve all the problems associated with low concrete tensile strength. Vertical cracks develop due to tensile stress caused by bending and inclined cracks due to shear stresses. If concrete can be subjected to external compressive forces so as to neutralize tensile stresses caused by applied loads [2].
Normal force applied in advance is known as prestressing force while the state of stresses caused is known as prestressing [3].
Prestressing involves the application of an initial compressive load to the structure to reduce or eliminate the internal tensile forces and thereby control or eliminate cracking. The initial compressive load is imposed and sustained by highly tensioned steel reinforcement (tendons) reacting on the concrete. With cracking reduced or eliminated, a prestressed concrete section is considerably stiffer than the equivalent (usually cracked) reinforced concrete section. Prestressing may also impose internal

forces that are of opposite sign to the external loads and may therefore significantly reduce or even eliminate deflection [1].

2 Methods of prestressing

2.1 Pretensioning

The prestressing tendons are initially tensioned between fixed abutments and anchored. With the formwork in place, the concrete is cast around the highly stressed steel tendons and cured. When the concrete has reached its required strength, the wires are cut or otherwise released from the abutments. As the highly stressed steel attempts to contract, it is restrained by the concrete and the concrete is compressed. Prestress is imparted to the concrete via bond between the steel and the concrete. [1]. The tendon extension is with constant eccentricity, straight tendon.

2.2 Post-tensioning

The prestress force is applied in this case by jacking steel tendons against an already cast concrete member. Nearly all in situ prestressing is carried out using this method. The tendons are threaded through ducts cast into the concrete, or in some cases pass outside the concrete section. Once the tendons have been tensioned to their full force, the jacking force is transferred to the concrete through special built-in anchorages [4]. The tendon extension is with various eccentricity, parabolic tendon.

3 Data and Methods

Prestressed concrete usually is applied in bridge holder elements like beams, but in our contry (Kosovo) the prestressing methods and shape of cross section that are applied in most cases they are used the same for different locations and spans. Static scheme is simply supported beam with span from 15 – 38 m.

(a) (b)

Fig 1. Type of cross section shape used, (a) Overpass on highway Arber Xhaferi R6 type of cross section used is "T" and static scheme is simply supported beam. (b) National road Prishtinë – Pejë type of cross section used is "T" and static scheme is simply supported beam.

Since, in some locations is used the same shape of cross section for different spans. Most commonly shapes used are "I" and "T".
Method of assessment is based on comparison of this two shapes of cross section. The comparison of method of prestressing for this shapes and for different span starting from 21m, 28m, 35m and 42m of simply supportet beam. Which method of presstresing is more suitable for this spans and which shape of cross section is more rational in term of cross section area in base of minimum section modulus. Concrete class assumed is C45/55, whereas for serviceability limit state (to provide uncracked cross section), the concrete stress limits are $f_{cc,0}$=$f_{cc,t}$= 28 N/mm^2 and $f_{ct,0}$=$f_{ct,t}$= 3.8 N/mm^2. Assument loads are, permanent load G_k= 57 KN/m', service load Q_k =43 KN/m'.

4 Results

According to the data presented above, the bending moment M_T (moment from total service loads), M0 (moment during transfer) is calculated for characteristic combination of serviceability limit state (SLS).
The calculations were done for each span, method of prestressing and shape of cross section. Consequently from bending moment, the minimum section modulus is determined then for each element.
For post-tension elements, the minimum section modulus is determined form equations:

$$Z_{btm,min} = M_T - \Omega M_0 / f_{ct,t} - \Omega f_{cc,0} \quad \textbf{(1)}$$

$$Z_{top,min} = M_T - \Omega M_0 / \Omega f_{ct,0} - f_{cc,t} \quad \textbf{(2)}$$

For pretension elements, the minimum section modulus is determined form equation:

$$Z_{btm,min} = M_T - \Omega M_0 / f_{ct,t} - \Omega f_{cc,0} \quad \textbf{(3)}$$

From the above equations, minimum section modulus for each method of prestressing and for each shape of cross section is presented below.

Table 1. Minimum section modulus for post-tensioned elements with 'I & T' cross section.

Length [m]	21	28	35	42
$Z_{btm,min}$ cm^3	214979.5	386627.9	611107.5	889779.9
$Z_{top,min}$ cm^3	187415.3	337055.2	532752.5	775694

Table 2. Minimum section modulus for pretensioned elements with 'I' cross section.

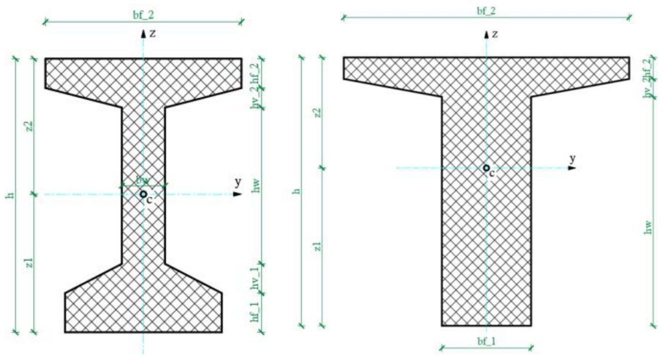
Length [m]	21	28	35	42
$Z_{btm,min}$ cm^3	267710.6	508331	855879.3	1354200

Table 3. Minimum section modulus for pretensioned elements with 'T' cross section.

Length [m]	21	28	35	42

$Z_{btm,min}$ cm^3	288572.7	566306.8	981570.6	1565915

Based on the results for minimum section modulus of cross section are determined the dimensions of cross section and area for each element.



(a) (b)

Fig 2. Shape of cross section of elements, (a) cross section ‘I’, (b) cross section ‘T’.

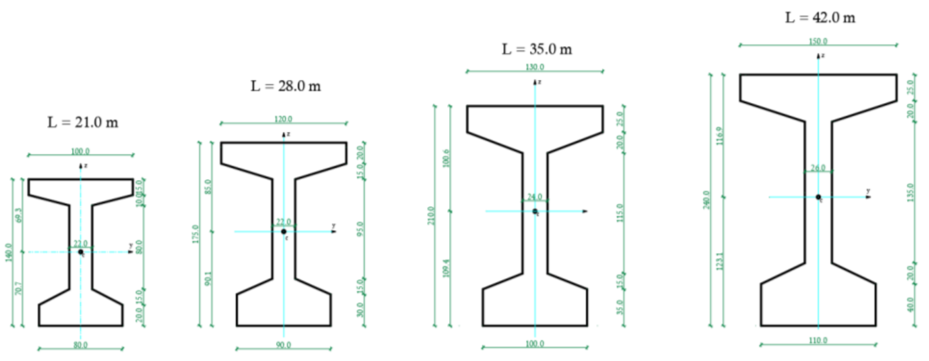
After assigned of minimum section modulus and dimensions of cross section is determined the area of cross section. Results of each cross section are presented below.

Table 4. Cross section area for post-tensioned elements.

Length [m]	21	28	35	42
Area cm^2 ‘I’	6235	9095	11980	14780
Area cm^2 ‘T’	9370	13350	17462.5	20487.5

Table 4. Cross section area for pretensioned elements.

Length [m]	21	28	35	42
Area cm^2 ‘I’	6730	9910	13780	19090
Area cm^2 ‘T’	10370	15600	21675	28325



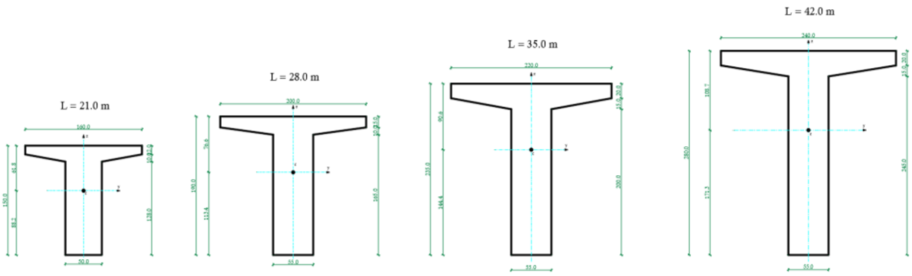


Fig 3. Dimensions of post-tension elements for ‘I’ and ‘T’ cross section.

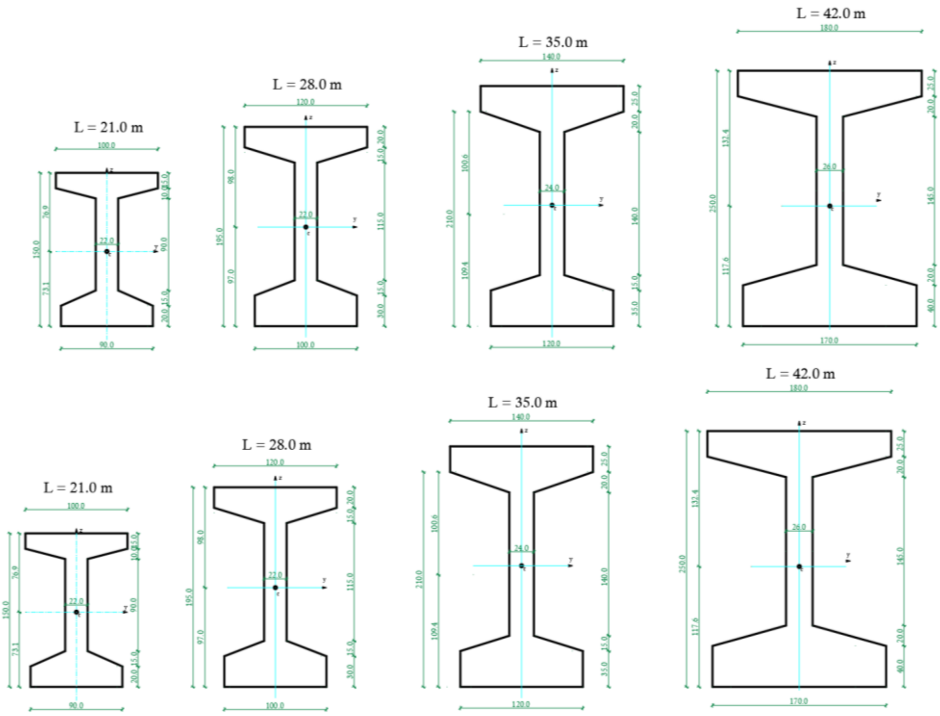


Fig 4. Dimensions of pretension elements for ‘I’ and ‘T’ cross section.

5 Discussion

From the obtained results, it can be clear that the method of prestressing has a significant role in satisfying minimal requirement of second modulus of cross section. This is related with extension of tendons. Where for pretension method of elements the extension of tendons is with constant excenticity and critical cross section is at suport where is acting only prestressing force with excentricity and cause a bending moment of section. While for method of post-tension critical cross section is at midspan where excentricity of prestressing force is maximal while at supporter excentricity is almost zero.

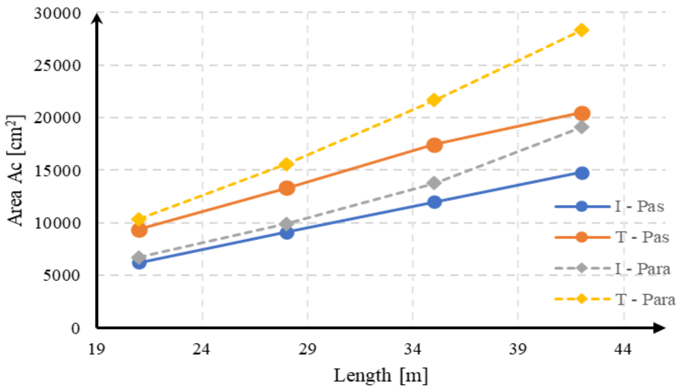


Fig 5. Graphic presentation of comparison of prestressing methods for required area of cross section, dashed line (- - -) pretension method, solid line (___) post-tension method.

6 Conclusion

Method of prestressing with post-tension is suitable for short span and also for long spans, but for spans until 28 m can be used also and method of pretension because there is a small differenc between the methods of prestressing. However, shape of cross section 'I' is more siutable for both methods of prestressing in relation with 'T' cross section wich requires more cross section area.

7 Reference

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