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Analytical Study of Prestressed I-Section Beam with Varying Flange Widths

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Abstract—*I- Section beams are one of the most widely preferred beam components owing to the advantage of reduced cross sectional area, and hence, reduced self weight in comparison with a rectangular sectionof equal depth. Prestressing the same adds to the benefits of permitting further reduction in the dimensions of the beam section, which can be favourable in increasing the spaciousness and lessening the deadload furthermore. This analytical study presents the effect of variation of the width of the bottom flange of an I-section beam under various conditions of imposed loading and to identify the limiting dimensions that could safely carry the loads without permitting tensile stresses.*

1. INTRODUCTION

Concrete, the very important nevertheless inevitable composite of the construction industry is taken into account to be ever evolving, so being the matter of constant analysis and development. varied techniques are adopted to reinforce the behavior of the structural elements amongst that Prestressing the members may be a reliable possibility. Prestressing of concrete, in spite of not being a recent advancement, still holds a huge share of research with regards to the endless advantages that it can give. Prestressing will vary from easy procedure with the least instrumentality to complicated procedures.

Prestressed Concrete (PC) is an amalgamation of concrete and steel tendons that are stressed prior to the action of imposed loads to lessen the extent of tensile stresses induced during its service. Depending upon when the t=tendons are stresses, i.e., before or after the placement of fresh concrete, the prestressing methods may be distinguished as pre tensioning or post tensioning.

The well-known phenomenon of flexure is that the bottom fibre undergoes compressive stress and the top fibre undergoes tensile stress. When an I- section beam is considered with this regard, it is obviously seen that the same principle of flexure yields tensile stresses at the bottom most fibre. This case is particularly true for simple TCC sections that are subjected to heavier loads. But with the case of beams that are prestresses to provide for better load carrying capacities, it is possible to eliminate the development of tensile stresses, even at the bottom most fibre, thereby adding to the safety of the structure.

The prime objective of this study is to identify the beam sections that would be economical for different loading conditions by gradually reducing the width of the bottom flange of the I-section beam, without permitting the development of tensile stresses in the bottom fibre..

2. LITERATURE STUDY

Chen *et al.*[6]has studied and concluded that, between beams externally prestressed and that not prestressed, the former was found to have a greater effective depth than the latter.

Abhinav S. Kasat*, et al* has analyzed prestressed concrete beams using finite element analysismethod using ANSYS 12.1 and has investigated on the structural properties such as deflection, stress distribution using a rectangular beam

Husain et al. [8] has conducted aparametric study to analyse the effects of variation in the ratio of prestressing reinforcement, concrete strength, and level of initial pre-stressing on the behaviour of the pre-stressed concrete modelsIt is stated that cables can be as effective as steel cables.

Rajesh *et al*.[9] investigated the displacement behavior of single span prestressed concrete beams, with a comparison towards the analytical and experimental results. The friction losses were found to remain constant whereas, the anchorage losses were found to be varying.

Nimiya Rose *et al.*s has tudied the response of reinforced and PS Cbeams to vertical load using the finite element software package ANSYS 12.0. It was seen that the PSC beam could withstand higher service loads.

3. ANALYTICAL WORK

The analytical work of PSC single span beam has been carried out using STAAD. Pro software.

3.1 Section Properties

The span of the beam (l) considered is 10000mm in length with overall depth (D) of 1500mm. The top flange has a width (b_1) of 1000mm and a thickness (t_1) of150mm. The web is designated with a width (b_2) of 200mm and depth (t_2) of 1200 mm. The thickness of the bottom flange (t_3) is taken as 150 mm and the width (b_3) is kept varying at 1000mm, 800mm, 600mm, 400mm and 200mm..

Figure1 depicts the sectional view of the beam with the first configuration, i.e., bottom flange width of 1000mm.Assigning Section Property.

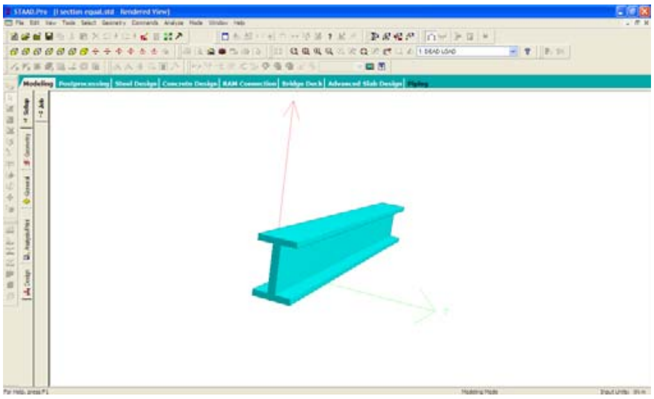

Figure 1:3D View of I-Section Beam.

3.2 Material Properties

The material properties for the PSC beam (I-section) are Characteristic compressive strength of concrete, fck is 35 N/mm2 and with reference to IS 1343-1980/clause 5.2.3.1, Young's modulus of elasticity, E is $5700\sqrt{f_{ck}}$= 33721.65 N/mm2 . The unit weight of concrete, γ is 25 kN/m3

3.3 Support Conditions

The beam is considered restrained against both translation and rotation at both the ends. Fixed supports are said to resist vertical and horizontal forces as well as a moment. Since they restrain both rotation and translation, they are also known as rigid supports

3.4 Loading Criteria

The following load and load combinations have been considered for the stress analysis of the Prestressed Cncrete beam. Table I shows the primary load cases considered and the corresponding legends used.

Table 1: Primary Load Cases

Loading Condition	Legend
Self Weight	DL
Prestressing Force	PS
Imposed Load	L

The imposed loads are taken in the order of 5kN/m till 65kN/m with an incremental increase of 10kN/m for every stage. Also, a prestressing force of 250kN is applied to the section. The load combinations have been considered as per IS: 1343-2012. The Table 2 shows the chosen load combinations considered for this analysis

TABLE 2. Load Combinations

S. No.	Factor F1	Load	Factor F2	Load	Factor F3	Load kN/m	
1	1	DL	1	PS	1	L	5
2	1.5	DL	1	PS	1.5	L	5
3	1.5	DL	1.5	PS	1.5	L	5
4	1	DL	1	PS	1	L	15
5	1.5	DL	1	PS	1.5	L	15
6	1.5	DL	1.5	PS	1.5	L	15
Note	Load Combination is considered as [(F1 × DL) + (F2 × POST) + (F3 × L)]						

3.5 Processing and Extraction of Results

After the material properties, section properties and the load cases are fed, analysis of the section is performed and the results are extracted. The stresses at the top and bottom flanges of the section are studied at the midspan of the beam. The resultant stress diagrams of I-section beam with varying the widths of the bottom flange for various levels of load are obtained and those for the loads for which the bottom fibre falls in the tensile zone are presented from Figure 2-6.

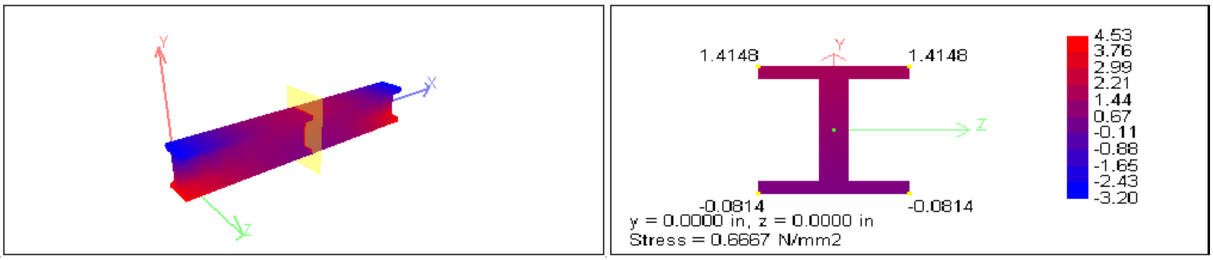

Figure 2 Resultant stress diagram of the section with 1000mm bottom flange at 55kN/m

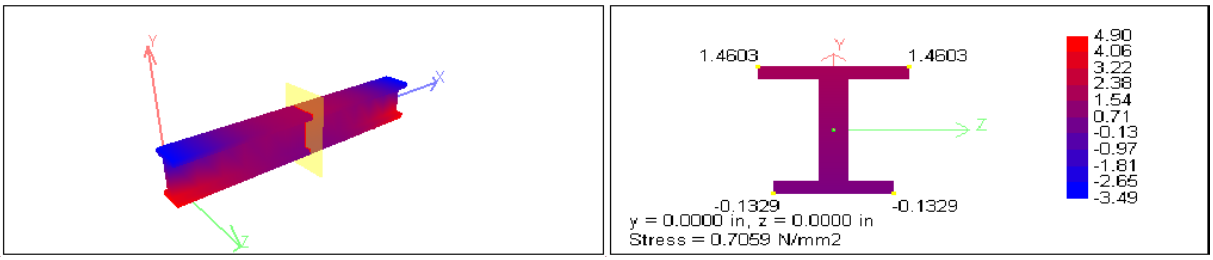

Figure 3 Resultant stress diagram of the section with 800mm bottom flangeat 55 kN/m

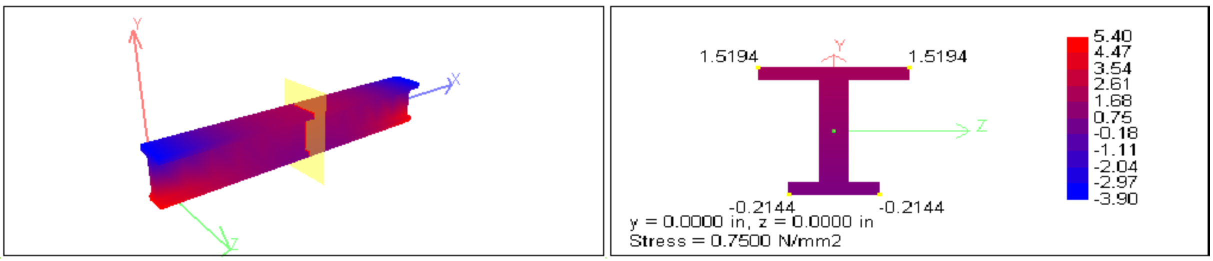

Figure 4 Resultant stress diagram of the section with 600mm bottom flangeat 55kN/m

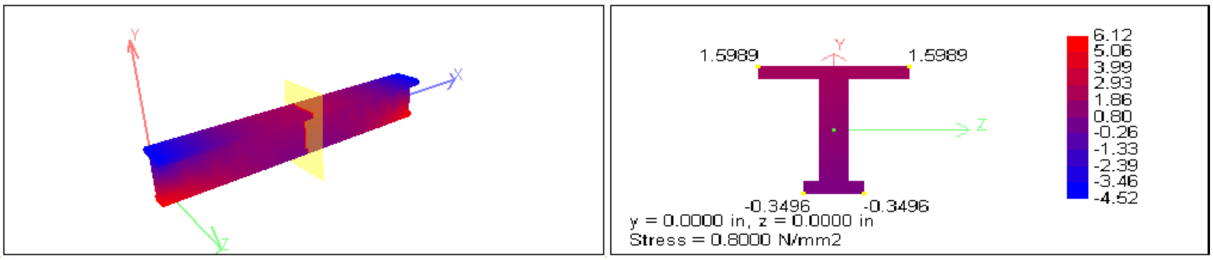

Figure 5 Resultant stress diagram of the section with 400mm bottom flangeat 55kN/m

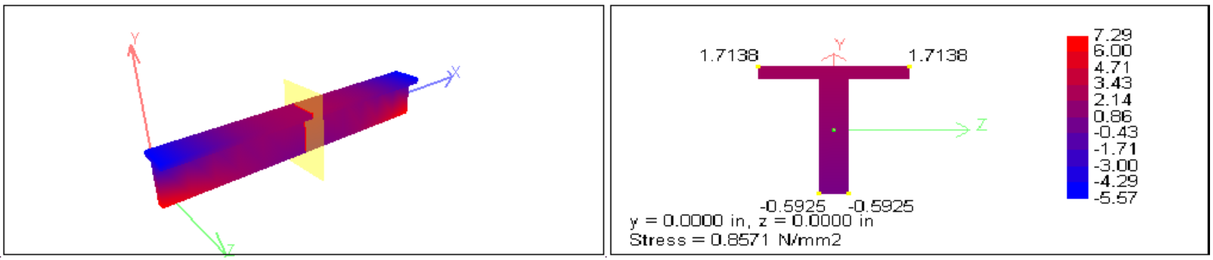

Figure 6 Resultant stress diagram of the section with 200mm bottom flangeat 55kN/m

3.6 Interpretation of Results

From the above results it is evident that the tensile stresses do not surface until the imposed load ranges to 45kN/m, but occurs once it reaches higher loads.

4. RESULTS AND DISCUSSION

The graphical representation of the results obtained are as depicted in Figure 7 – 11, showing the resultant stress at bottom fibre in varying section and their corresponding magnitude of load. corresponding width of the bottom flange of the section.

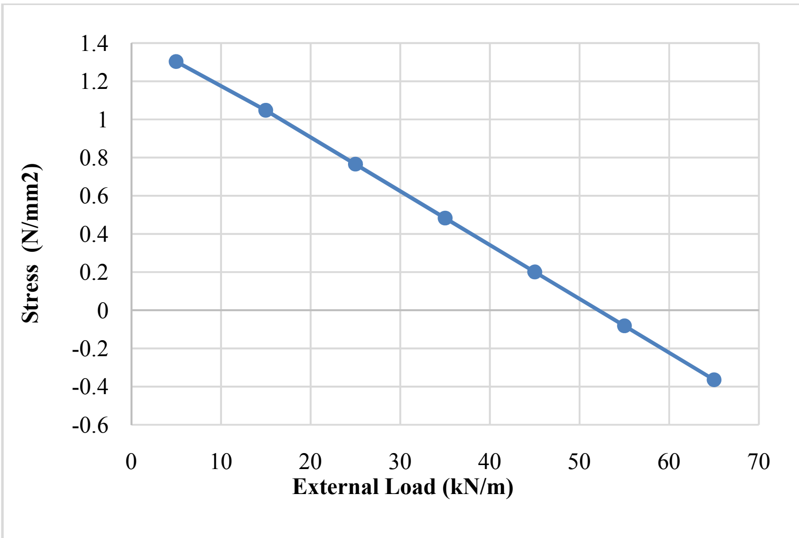

Figure 7 Stress vs external load for a flange width of 1000mm

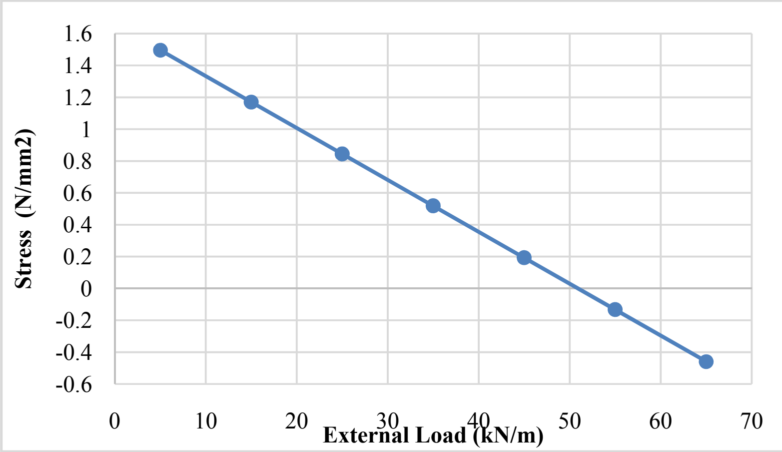

Figure 8 0Stress vs external load for a flange width of 800mm

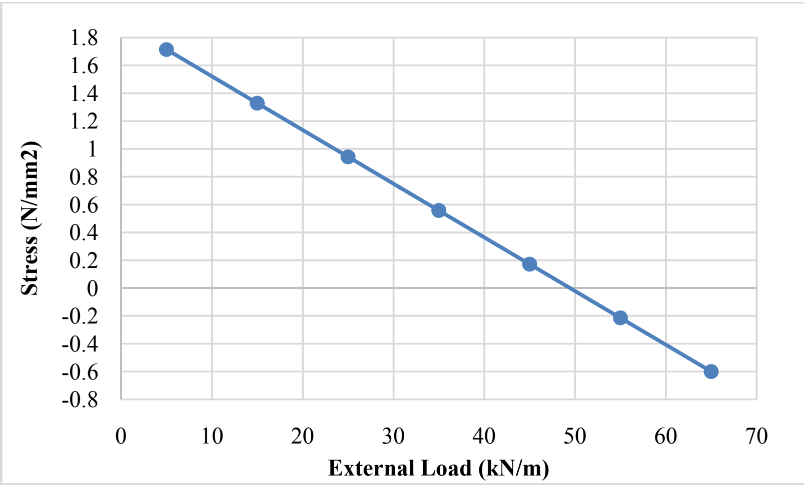

Figure 9 Stress vs external load for a flange width of 600mm

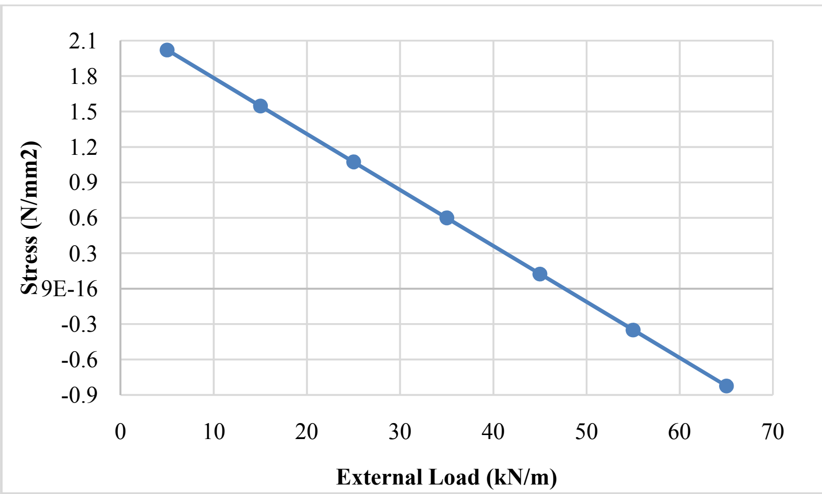

Figure 10 Stress vs external load for a flange width of 400mm

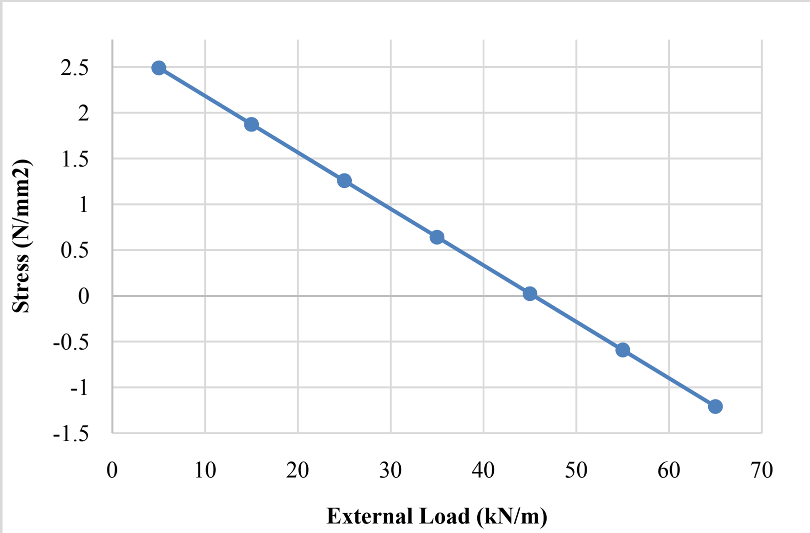

Figure 11 Stress vs external load for a flange width of 200mm

5. CONCLUSION

1. From the displayed graphical data, it is evident that in the event of prestressing, tensile stresses are not induced even in the bottom fibre at normal service loads, hence promoting safety.
2. The application of prestressing force to the beam can thus help in reducing the dimensions of the member, without losing out on the load carrying capacity.
3. Though loads as high as 55kN/m would not be practically imposed on structures, this study gives an insight as to the safe carrying capacity of the analysed section.

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