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MS4

Investigation of Buckling Behavior of Steel Beams Under the Effect of Lateral Buckling

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One of the important features in building design is the stability of building elements. In the elements, stability loss occurs depending on the slenderness, rigidity and geometry of the section. Depending on the slenderness of the section in the element, buckling occurs in the weak axis direction under the loading effect. Stability decreases with the occurrence of lateral buckling. In this study, the buckling behavior of I-section steel beams of different lengths and under the influence of different loads was investigated in case of lateral buckling. The behavior of steel beams under the effect of lateral buckling loading was evaluated using nonlinear finite element analysis method.

Anahtar Kelimeler— ANSYS, Analytical Study, Pressure, Buckling, Buckling Load Factor, Steel Beam

INTRODUCTION

Stability of the structure in steel structure design is one of the failure limit states. Steel codes and design standards examine three behavior states of steel elements. These are bending behavior, compressive behavior, bending and member behavior under pressure. Depending on the torsional rigidity, geometry and slenderness of the section, flexural buckling, torsional buckling or bending torsional buckling may occur in the element under pressure. Torsion occurs in the section when the element, which is subjected to bending in the strong direction of the section, bends in the weak axis of the section. This balance problem is called lateral torsional sprain. The axial force in the element under the effect of bending and pressure has the effect of increasing the bending. In addition, rotational and local buckling is one of the stability problems frequently encountered in non-compact sections. [1-3].

When the studies in the literature on lateral buckling were examined, the lateral displacement values of the beams were read as values less than 1 mm in the static analyzes made. It has been observed that the lateral displacement values vary independently of the section height and beam length [4]. By preventing lateral displacement, the buckling neck of cantilever beams, which is likely to buckling with lateral torsional buckling, is reduced. In addition, lateral buckling can be reduced by strengthening according to the weak axis in sections that will be exposed to lateral buckling [5]. Lateral torsional buckling is an important issue for I-shaped steel members under a linear moment gradient and the finite element analysis results are determined by the proposed function considering the methods and design codes and standards in the literature[6]. With this study, which will examine the buckling behavior in the change of load and element buckling length in lateral buckling, a clearer interpretation can be made about the buckling of the I-section element. In addition, steel beams generally reach their bearing capacity with nonlinear behavior. For this reason, the performance of the elements in the structure should be determined by nonlinear analysis. In order to observe the mentioned loss of stability during the analysis process, the behavior of steel beams under loading should be examined by using the nonlinear finite element analysis method with the ANSYS program.

For these reasons, in this study, I-section steel elements were modeled with the ANSYS finite element program and their buckling behavior was investigated.

MODEL

Steel beams with four different lengths were modeled with the Ansys 2022 R1 program. The cross-sectional properties of the steel beam are shown in Figure 1. I profile and S235 class are used as steel beam element. Modulus of Elasticity was determined as E=2.1E11 N/mm2 and Poisson ratio was determined as υ=0.3. One of the nodal points of the steel beams is modeled as a fixed support and the other side is empty.

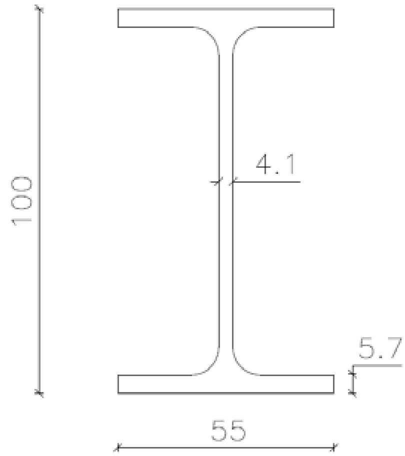

Figure 1. Dimensions of the beam section

It is desired to examine the relationship between the length of the steel beam element and the buckling load factor coefficient, with the lengths of the steel beam elements 3 m, 5 m, 7 m and 10 m. A load of 25 kN, 50 kN and 100 kN was loaded in the vertical direction, respectively, on the unsupported end of the steel beam element (Figure 2).

Figure 2. General Loading Status in Element

Yüklenen bu yük altında çelik kiriş elemanının burkulma yük faktöre ve gerilme dağılımları değerlendirilmiştir.

ANALYSIS RESULTS

3-meter-Length Beam Results

A load of 25 kN, 50 kN and 100 kN was loaded on the three-meter-long steel beam, respectively. Ansys results for beam loaded with 25 kN are given in Figure 3. The buckling load factor was calculated as 0.23, 0.11 and 0.05, respectively (25 kN, 50 kN and 100 kN) according to the Ansys program.

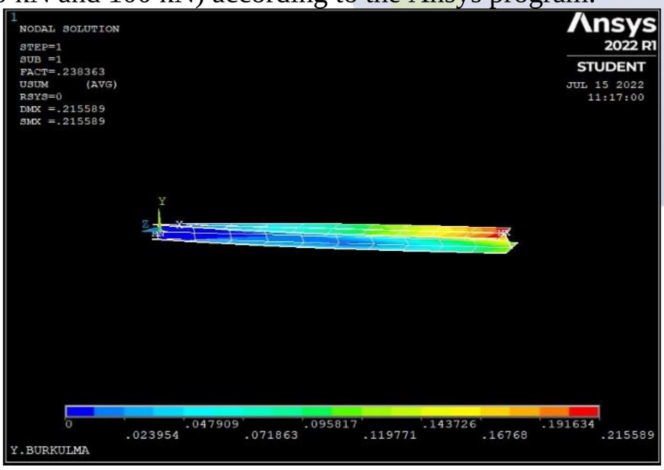

Figure 3. Displacement of a 3 meter long steel beam loaded with 25 kN

5-meter-Length Beam Results

A load of 25 kN, 50 kN and 100 kN was loaded on the steel beam, which has a length of five meters, respectively. Ansys results for a beam loaded with 25 kN are given in Figure 4. According to the Ansys program, the buckling load factor was calculated as 0.08, 0.04 and 0.02, respectively (25 kN, 50 kN and 100 kN).

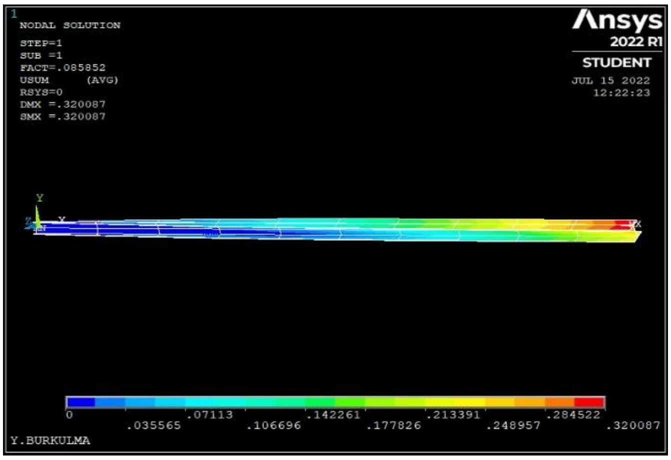

Figure 4. Displacement of a 5 meter steel beam loaded with 25 kN

7-meter-Length Beam Results

A load of 25 kN, 50 kN and 100 kN was loaded on the steel beam, which has a length of seven meters, respectively. Ansys results for beam loaded with 25 kN are given in Figure 5. The buckling load factor was calculated as 0.08, 0.04 and 0.01 respectively (25 kN, 50 kN and 100 kN) according to the Ansys program.

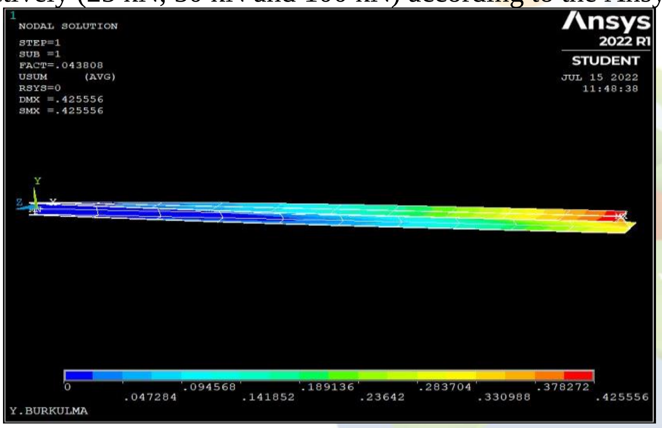

Figure 5. Displacement of a 7 meter long steel beam loaded with 25 kN

10-meter-Length Beam Results

A load of 25 kN, 50 kN and 100 kN was loaded on the steel beam, which has a length of ten meters, respectively. Ansys results for beam loaded with 25 kN are given in Figure 6. The buckling load factor was calculated as 0.02, 0.01 and 0.005, respectively (25 kN, 50 kN and 100 kN) according to the Ansys program.

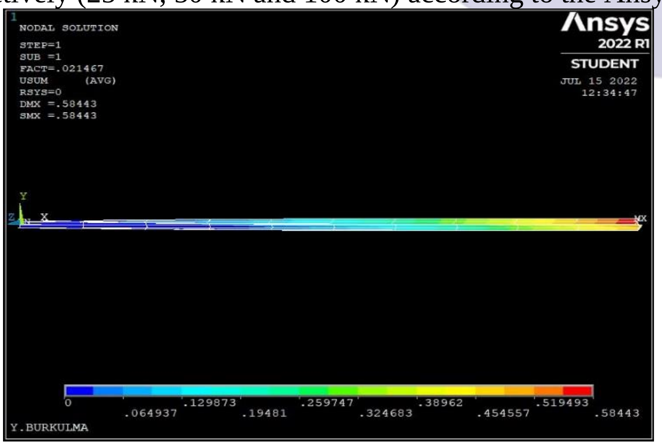

Figure 6. Displacement of a ten-meter steel beam loaded with 25 kN

discussion

In this section, the results of the steel beam elements modeled in the Ansys program are evaluated. The research was carried out with I profiles that have the same cross-sectional properties and different lengths and loads. The buckling load factors obtained from the Ansys program are given in Table 1.

TABLE I. Analysis Results

Element Lenght	Load (kN)	Ansys Result
3 m	25	0.23
3 m	50	0.11
3 m	100	0.05
5 m	25	0.08
5 m	50	0.04
5 m	100	0.02
7 m	25	0.04
7 m	50	0.02
7 m	100	0.01
10 m	25	0.02
10 m	50	0.01
10 m	100	0.005

When the buckling load factor values are examined, it has been determined that the buckling increases proportionally as the load increases in I profiles with the same profile and the same length. In addition, the increase in length also causes a decrease in the buckling load factor and a significant increase in buckling.

When the stress results are examined, the increase in the load and length causes the buckling to increase. Ansys program divided the element into small pieces and used the finite element method with small pieces. When using the finite element method, dividing the elements into smaller pieces provides more accurate results. When the results are examined, buckling has occurred in all of the elements since the buckling load factor is between 0<BYF<1. The buckling load factors decreased as the length of the members increased. In this case, it is seen that the length and slenderness are directly proportional. For this reason, using segmented elements instead of using a monolithic element will help reduce the slenderness effect.

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