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Denis Chemezov
Vladimir Industrial College
M.Sc.Eng., Academician of International Academy of Theoretical and Applied Sciences, Lecturer, Russian Federation
https://orcid.org/0000-0002-2747-552X
vic-science@yandex.ru

Pavel Balabanov
Vladimir Industrial College
Student, Russian Federation

Alyona Kozlova
Vladimir Industrial College
Student, Russian Federation

Grigoriy Lushin
Vladimir Industrial College
Student, Russian Federation

Denis Kosolapov
Vladimir Industrial College
Student, Russian Federation

Aleksandr Popov
Vladimir Industrial College
Student, Russian Federation

Sergey Prokopenko
Vladimir Industrial College
Student, Russian Federation

COMPARISON OF THE STRESS AND STRAIN STATE OF LOADED I-BEAMS MANUFACTURED ACCORDING TO EUROPEAN STANDARDS

Abstract: *The results of a computer experiment to determine the stressed and deformed state of steel I-beams loaded statically are presented in the article. Loaded I-beams of the HEA, HEB, HEM, IPE and IPN series are characterized by the occurrence of maximum deformations in the area of the radial interface of flanges and web of the profile. It is noted that with the same height of profiles and the value of load, the I-beam of the IPE series is subjected to the maximum stress, and the I-beam of the HEM series is subjected to the minimum stress.*

Key words: *I-beam, von Mises stress, strain.*

Language: *English*

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Introduction

The widespread use of I-beams in construction is due to the high strength and rigidity of structural elements. European manufacturers produce I-beams in accordance with DIN 1025 [1-5]. This standard, which includes five parts, prescribes the dimensions and properties of hot-rolled I-beams of the HEA (wide-flange I-beam of light version), HEB (wide-flange I-beam of normal version), HEM (wide-flange I-beam of heavy version), IPE (profile I with parallel flanges) and IPN (profile I with tapered flange) series.

In a number of scientific papers [6-10], the authors considered the stress and strain state of loaded steel I-beams fixed cantilevered or on two supports. In paper [6], based on the static analysis of a loaded cantilever I-beam, the strength characteristics were determined and the calculated safety factor was compared with the maximum permissible coefficient. In paper [7], the stress states of I-beams of the same type were presented when loaded with the concentrated moment, concentrated and distributed forces. It is concluded that cantilever I-beams undergo deformation of greater intensity than I-beams fixed on two supports. In papers [8-10], the critical values of strains and stresses of material under loading conditions of I-beams of the same type were presented according to the schemes proposed in paper [7].

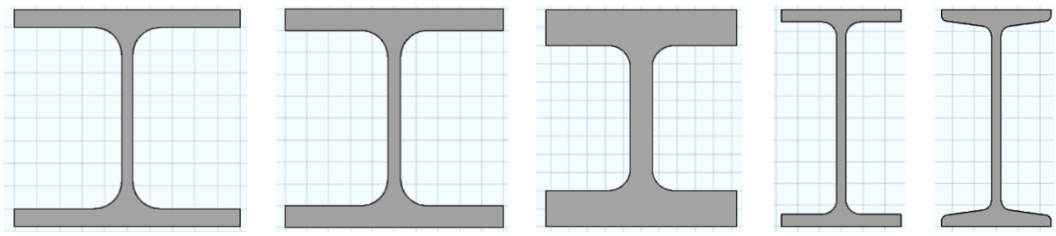
Comparison of the loaded state of material of I-beams of various types, based on the results of computer calculations, will reveal stress and strain gradients and draw a conclusion about the possible strength and rigidity of the configuration of the structural element under the same loading and fixing conditions.

Materials and methods

I-beams of the HEA, HEB, HEM, IPE and IPN series were subject to research. Two-dimensional profile models of the above-mentioned I-beams in the cross section were generated. The profile height of all models of I-beams was adopted 0.1 m. The remaining dimensions of elements of the I-beam models were calculated from the size of the profile height.

The stress and strain state of the I-beam models was calculated in the Comsol Multiphysics computer program. The I-beam models were given the properties of s355j2 steel in accordance with the EN 10025-2 standard [11]. A constant load of 0.5 kN was applied to the upper flange of each I-beam model. The lower flange of the I-beam models was rigidly fixed. The remaining conditions of the computer calculation were: displacement field – quadratic Lagrange, 2D approximation – plane stress, temperature – ambient, solid model – isotropic, geometric nonlinearity – force linear strains, load type – total force, element size – finer, study – stationary, solver – MUMPS, linear solver – direct, nonlinear method – Newton.

The studied profiles of I-beams of various series in the cross section are presented in the Fig. 1.



A ***B*** ***C*** ***D*** ***E***

Figure 1. The profiles of I-beams in the cross section: *A* – HEA; *B* – HEB; *C* – HEM; *D* – IPE; *E* – IPN.

Results and discussion

The simulation results were represented by the color contours of von Mises stress inscribed in the design areas of the I-beam models. The nature of strain of the I-beam models was graphically presented. On the graphs, along the abscissa axis, the values of the heights of the profile models of I-beams were postponed. The strain values were obtained from a slice passing through the middle of the profile web along the ordinate axis. The zero value on the graph along the *X*-axis is the coordinate on the models located in the middle of the outer end surface of the lower flange of each of the profiles. The calculated contours of von Mises stress of material of the I-beam models and the changes in strain of material of the I-beam models along the height of the profiles are presented in the Fig. 2.

On all models of I-beams, the surface layers on the side of the load application and the radii of the interface of flanges with web are subjected to the greatest von Mises stress. At the same time, the volume of distribution of maximum stresses in material of I-beams of the IPE and IPN series is less than in I-beams of other series. Maximum stress of 410000 N/m^2 was determined for the IPE series I-beam. This stress is approximately 5.3 times greater than stress to which the HEM series I-beam is subjected. The intensity of stress on the I-beam web of the HEM series is slightly greater than the intensity of stress on the webs of other I-beams.

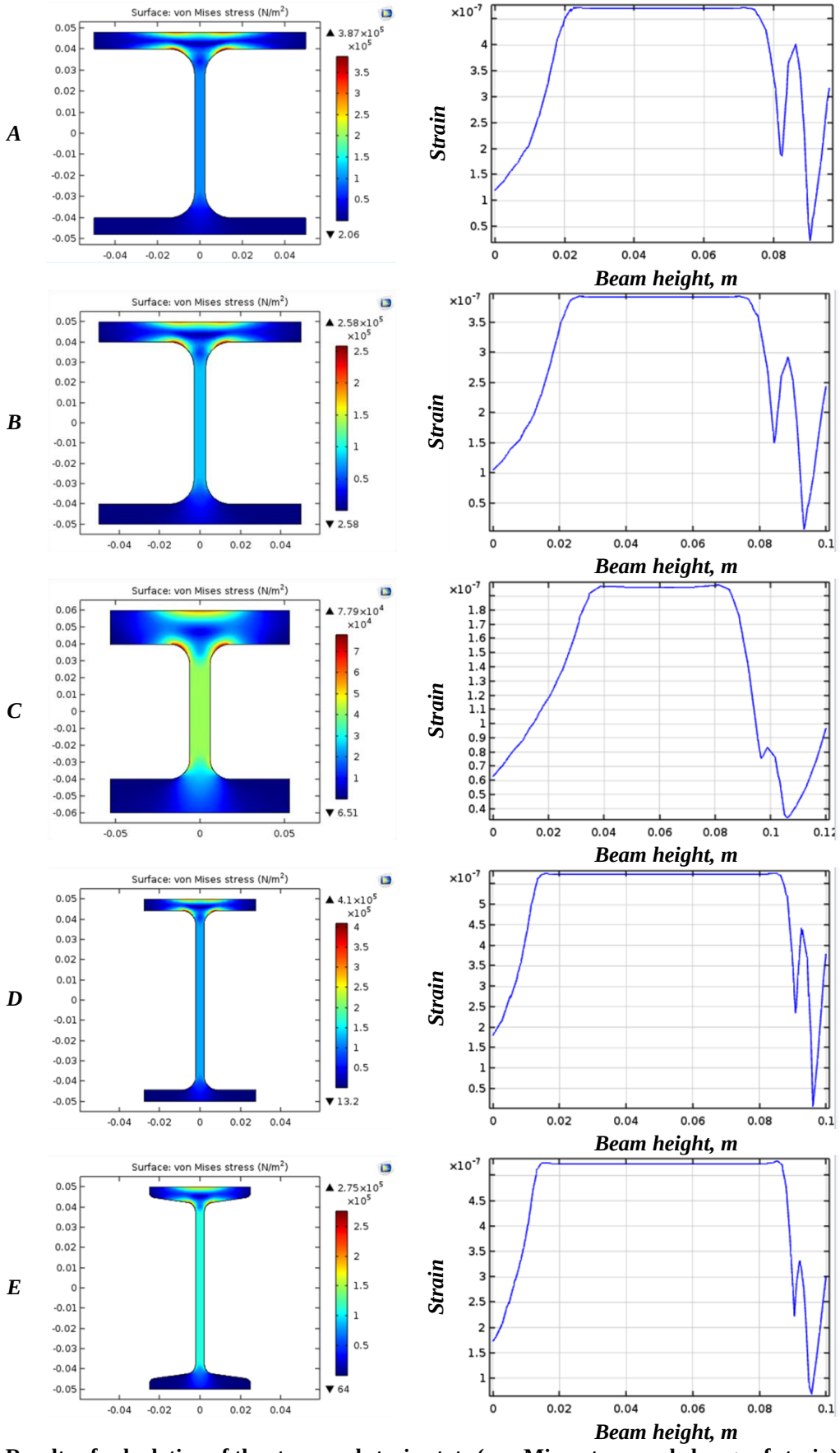


Figure 2. Results of calculation of the stress and strain state (von Mises stress and change of strain) of loaded I-beams: *A* – HEA; *B* – HEB; *C* – HEM; *D* – IPE; *E* – IPN.

Local zones where there is no strain exist for loaded I-beams of the HEB and IPE series. The value of strain of the web material of I-beams of the IPE and IPN series is the largest. Due to the lower web height and the greater thickness of the flanges of I-beam of the HEM series, strain of material occurs more evenly. The nature of strain of the webs and flanges is approximately the same for the other I-beams.

Conclusion

The wide-flange I-beam of the HEM series has the greatest strength and rigidity. At the same time, it is noted that for all the considered wide-flange I-beams, an increase in the size of the flanges and webs leads to a smaller difference in the stress values in material. On the other hand, the profile with tapered flanges of the IPN series showed better strength characteristics than the profile with parallel flanges of the IPE series. The best strength characteristics of I-beams were determined in descending order: HEM, HEB, IPN, HEA and IPE.

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