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Lateral Torsional Buckling of Selected Cross-Section Types

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Abstract

Currently used methods of solution of Lateral Torsion buckling which are implemented in design codes are based on solution of critical moment. This method can be correctly used only for minimally single symmetric cross sections. Also FEM based numerical models cannot be generally used because of problematic specification of all imperfections. Usually it is very difficult to define all boundary conditions and also effect of loading during the iteration process.
The goal of presented research is an experimental and theoretical analysis of selected types of cross-sections of elements subjected to bending with focus on lateral torsional buckling problems. Those experiments are focused on differences between real behaviour of single symmetric cross section and slightly non symmetric cross section.

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Keywords: Experiment; Bendig; Lateral Torsional Buckling; Stability

1. Introduction

The term lateral torsion stability of transversely loaded beam is a specific type of general buckling. In a case where the beam is loaded in the plane of main stiffness and together the transverse deflection along the beam length is not prevented, the deflection transverse to initial bending plane gradually rises. In principle it is a general stability problem of transversely loaded beam, which is characteristic by spatial deformation covering the flexural bending and the torsional displacement. The compressed part of the cross section is inclinable to deviate in the direction of minimal resistance. The tensioned part of the cross section stabilize the stiffness of cross section and inflicts the torsional displacement. This is similar to axially loaded beams.

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1.1. Problem definition

The problem of lateral torsional stability during the bending is a stabile problem, which can be described by two differential equations of fourth order [1]; [2]. The solution of these equations is the value of the critical bending moment. This critical bending moment is used in methods which are nowadays implemented in normative documents. These methods are useful only for cross sections which are at least single symmetric.

Often there is a need to use non symmetric cross section for bended member in practical steel structure design. Design methods implemented in normative documents it therefore difficult to use [3].

One of the possibility how to solve such transversely loaded beam with general non symmetric cross section is to use geometrically nonlinear solution of stability. All imperfections has to be implied in the solution. For example by substitution of initial imperfection [4].

Another way is the solution with the use of 3D numerical models. The use of this method is also difficult due to problematic implementation of imperfections. The differences between real structure and numerical model are often hard to describe. Modelling of real behavior of real boundary conditions, load position changes during the process of loading, and implementation of all imperfection is very difficult task.

1.2. Goal of analysis

This paper is focused on experimental analysis. Several experiments were realized to obtain the real measurable data which can be further compared to numerical models and theoretical studies. Geometry of all specimens was prepared with the idea to observe the difference in behavior of monosymmetric and slightly asymmetric cross section.

2. Experiments and comparison of results

The four point bending tests were prepared to observe the lateral torsional behavior of different cross section. Material used for all specimens was the steel S235. Laboratory verified characteristic of used steel are: yield strength $f_y = 327\ MPa$ and ultimate strength $f_u = 458\ MPa$. For each configuration, see Fig. 1 and Fig. 3(a) the number of five tests are planned (marked as H1A to H4E). So far only specimens marked as H1 (A to E) and H4 (A to E) were tested. Those results are described below.

2.1. Experiment configuration

Tested specimens were prepared according to geometry displayed in Fig.1. The beam is loaded in two points in the third of length. The length of specimens was 3000 mm and the distance between hinge joints in the loading system was 3170 mm. There were four strain gauges installed at both ends of both flanges (marked as T1, T2, T3 and T4).

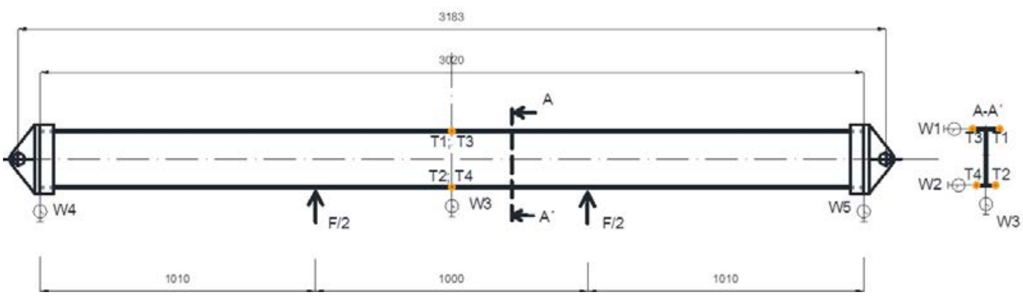

Fig. 1. Geometry of the specimen.