International Journal of Automotive Technology, Vol. 23, No. 6, pp. 1537-1545 (2022)
DOI 10.1007/s12239–022–0134–7

pISSN 1229–9138/ eISSN 1976–3832

BEAM T-JUNCTION MODEL ACCURACY IMPROVEMENT BASED ON EXPERIMENTAL MODAL ANALYSIS

Francisco Badea[1)], JesusAngel Perez[2)] and JoseLuis Olazagoitia[1)*]

[1)] Industrial Engineering and Automotive Department, Universidad Nebrija, Polytechnic School, Madrid 28040, Spain
[2)] Industrial Engineering, Oviedo University, Polytechnic School, Gijón 33203, Spain

(Received 5 February 2021; Revised 6 December 2021; Accepted 30 December 2021)

ABSTRACT–For structural analysis of bus and coach tubular structures, finite element analysis with beam type elements is widely approved and utilized. These elements have an infinitely rigid behavior at the joint level, which represents an unrealistic stiffer estimation of the modeled structures. This cannot be neglected since it introduces stiffness variations when analyzing complex structures. To overcome this limitation, in this article an alternative beam T-junction model, in which 6 elastic elements are included at the joint level in order to improve the local stiffness behavior, is utilized. A new methodology to determine these 6 elastic constants is proposed, based on the analysis of the modal response differences between the beam model and the real prototype T-junctions. In this way, a completely new methodology for the determination of the rigidity of the elastic elements based on the analysis of the modal characteristics of these structures is presented. The methodology is validated against experimental modal analysis. The results show that using this methodology with the alternative beam T-junction model is possible to obtain a more accurate T-junction model with an average deviation from real models of less than 1.5%, and a maximum deviation among the studied modes of less than 4.

KEY WORDS : Modal analysis, Structural optimization, Elastic constants, FEM improvement, T-junction

1. INTRODUCTION

In most modern Finite Element Analysis (FEA) commercial packages, there are three main types of elements available for the mechanical analysis of structures: volume, shell, and beam. The selection of the appropriate element type for a certain analysis represents a fundamental part of the analysis process because it determines the outcome of the simulation and the quality of the results (Adams and Askennazi, 1999; Zienkiewicz *et al*., 2013; Hutton, 2004).

Despite the constant evolution of the FEA programs and the computational resources available, the beam type elements are still the most recommended and utilized when analyzing tubular structures. This fact is determined by practical aspects such as the simplicity of the modeling process and the reduced computational resources that these elements require for the analysis of relatively complex structures.

Consequently, many studies utilize regular beam type elements for the analysis and optimization of different kinds of structures (Eriksson, 2001; Lan *et al*., 2004; Gombor, 2005; Gauchia *et al*., 2010; Liang and Le, 2010; Milojevic and Pesic, 2012).

Unfortunately, the inherent simplification of the structural models constructed with beam type elements where the profiles junctions are represented as a single point, and as such, possible differences at the joint level cannot be taken into consideration, neither the global influence of each junction on the global behavior of the structure. Also, due to the common rigid node, when analyzing T-junctions, the beam modeled structures always predict a more rigid behavior than the original structures (Alcalá *et al*., 2013).

The finite element modelling of T-junctions of tubular elements can be carried out in different ways, and it is difficult to represent the real joint in a faithful way. We can cite for example (Shao *et al*., 2017) in which two methods were presented to predict the static rigidity of these joints at high temperatures as a function of the modification of the mechanical properties as the temperature increased. T-junctions modelling can be performed exclusively on a particular joint to take into account its fatigue behavior by predicting the destruction of stresses at its intersection (Liu *et al*., 2015), or it can be based on the dependence of welding parameters (Leitner *et al.*, 2011). For their characterization, experimental testing techniques can be used, such as that used in Moazed *et al.* (2010) to study the behavior of thin-walled square profile junctions. The deformation of this type of structures has been tried to predict through the use of sophisticated optimization algorithms such as support vector machine and genetic algorithms (Tian and Luo, 2020).

**Corresponding author*. e-mail: jolazago@nebrija.es