Rigorous non-linear theory for buckling analysis of thin-walled restrained beam

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ABSTRACT

A beam theory has been developed for the stability analysis of restrained beam in which shear deformation and warping of the cross-section are included. Constitutive equations relating the kinematics quantities that arise in the theory to the force quantities has been developed and equilibrium equations have been obtained by the principle of potential work. *A new term of additional moment due to shear and bi-moment which has been neglected in previous theory of thin walled structures is introduced in this work.* This term take into account the exact distribution of shear stresses. It can have a considerable influence for the short beams out of steel, aluminum or composite.

Flexural-torsional buckling is an important limit state that must be considered in structural steel design. This type of instability phenomena occurs when a structural member undergoes significant out-of plane bending and twisting. The failure occurs suddenly in members with a much greater in-plane bending stiffness than torsional or lateral bending stiffness. Tomshenko and Gere [1] established buckling equations through considering equilibrium of finite segment of thin-walled structure, while Vlassov used fictitious load method in which second order effects of stresses in an infinitesimal plate element was regarded as fictitious loads acting on the thin-walled cross-sections. After these pioneer works, the problem of lateral torsional buckling of steel beam has been studied extensively by many authors. However, these investigations are mainly focused on the buckling of an isolated beam without considering secondary structural members (such as sheeting, steel deck). A beam is often connected to other elements which participate in the buckling actions and significantly influence the structure's buckling resistance. This configuration is encountered very frequently in practice, as the case of purlins supporting a steel deck cover, and also in that of cross bars of a portal frame with purlins. B. Larue and A. Khelil [2] developed a simple model of the elastic buckling of steel beams with continuous lateral restraints, in this research the effects of moment distribution and continuous restraints on the elastic flexural-torsional buckling of beams are also studied and design approximations and procedures developed, they concluded that the restraint of tensioned part of the beam is not sufficient to limit lateral buckling. The purpose of this work is to present the theoretical bases allowing the study of the stability analysis of restrained beam in which shear deformation and warping of the cross-section are included. The theoretical development is based on the determination of the expression of total potential. The system of differential equilibrium equations of beam laterally restrained is obtained by using Euler-Lagrange principal. For a simple case, this approach yielded a semi analytical formula for the calculation of the critical buckling moment for bisymmetric section. The solution has been verified by finite-element analysis.

REFERENCES

[1] Timoshenko, S.P., and Gere, J.M. Theory of elastic stability.2nd ed. McGraw-Hill Book Company,
[2] A. Khelil, B. Larue. Simple solutions for the flexural-torsional buckling of laterally, Engineering Structures 30 (2008) 2923–2934