MECHANICS AND MATERIALS IN DESIGN

Edited by

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PREFACE

M²D'2006 is the fifth international gathering of scientists and engineers interested in the fields of engineering mechanics, design and materials engineering planned for July 24-26, 2006 in the beautiful city of Porto, Portugal. This is a well-established meeting with followers from some 35 nations.

The first conference of this series was held in Toronto in 1996 and attracted over 150 delegates. The second was organized by Professors J.B. Hull and R. Gentle in Nottingham in 1998. The third was organized by Professor S.A. Meguid in Orlando in 2000. The fourth was organized by Dr. T. Mori and Professor H. Fujii in Nagoya, Japan in June 2002. These meetings resulted from the belief that of those disciplines associated with advanced product design and manufacture, engineering mechanics and materials engineering have made the most significant advance in recent years. Important and dramatic improvements in component design can be made by the use of the latest advances in mechanics and materials. Indeed, as a result of the activities in these three important fields: Mechanics, Materials and Design, the International Journal of Mechanics and Materials in Design was established in 2004. With Professor J.F. Silva Gomes being an important member of the Editorial Board and Professor Shaker A. Meguid being its Editor-in-Chief.

It is with this in mind that this ***Fifth International Conference on Mechanics and Materials in Design*** is organized. The purpose is to bring together scientists and engineers from the mechanics and materials communities to present their latest results and discuss new advances over a broad range of topics dealing with analytical, numerical and experimental techniques in mechanics and advances in materials' technology as well as case studies. We have done our best to provide the delegates with an environment conducive to exchange of knowledge, networking and making new friends.

We take this to thank our colleagues who contributed considerably to the event by organizing topical symposia and by helping us to launch this important meeting. We are truly grateful for their efforts. We also wish our overseas friends to have a great time in Portugal. We wish you all a happy and successful stay in Porto.

Shaker A. Meguid
J.F. Silva Gomes

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5TH INTERNATIONAL CONFERENCE ON MECHANICS AND MATERIALS IN DESIGN

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24-26 July 2006

Safe design is a design process that eliminates hazards, or minimizes potential risks, by involving decision makers and considering the life cycle of structures and materials. Safe design approach will generate a well-informed design option that should eliminate these potential problems to those who makes the product and to those who use it.

Structural and material safety in design will cover the design aspects of safe structures, using steel, concrete, timber and composite material elements. Accidental conditions should be carefully understood and considered according to the safety standards and regulations. Advances in standards and regulations should permanently ensure safety with the best practices and methods. Advanced analysis methods should be permanently improved and used to prevent such potential risk in structures and materials. Designers should guarantee structural integrity and prevent structural damage.

The papers presented in this Symposium will address different aspects in structural and material safety in design.

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ULTIMATE LIMIT STATE DESIGN FOR LATERAL TORSIONAL BUCKLING OF PARTIALLY ENCASED STEEL BEAMS

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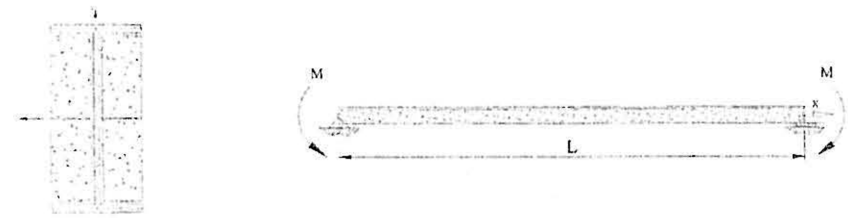
SYNOPSIS

Partially encased beams are composed structural elements widely used for industrial buildings with increasing significance. Composite beams may be designed for service load conditions without the collaborative contribution of slabs. Instability problems may occur because concrete may not have the age to resist and also because the concrete may slip over steel, crack or crush. Lateral torsional buckling is an instability limit state that may occur in these situations.

This paper presents a material and geometric non linear finite element model for the design of lateral torsional buckling resistance of partially encased steel beam without encasement reinforcements. The steel part of the composed section will be modelled by shell, concrete by three dimensional solids and the bond contact with non linear spring finite elements. Failure of concrete will also be predicted when the beam is subjected to a constant bending moment.

INTRODUCTION

Steel beams with partial encasement represents a composite section with two different materials, with distinct mechanical properties and mechanical behaviour, see figure 1.



(a) Composed cross section model. (b) Beam load model.

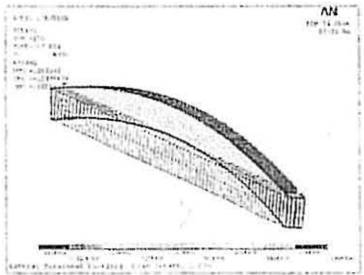
Fig. 1 – Partial encased steel beam with concrete.

Slabs may not transmit the stabilizing effect to prevent lateral torsional buckling (LTB). Also, concreting the steel beam within 7 or 8 days provides less torsional stiffness than after 28 days (Boissonade et al, 2004). This instability phenomenon is responsible for a simultaneous lateral displacement and cross-section rotation. This means that bending around the minor axis and torsion about the longitudinal axis of the element are involved.

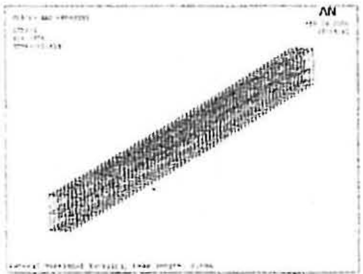
This work intends to be the preliminary phase of a full-scale test program in fire conditions, complemented with numerical research and intends to deal with the interaction between concrete and steel, finding failure of concrete that may occur during instability. Non linear numerical results of unrestrained partially encased steel beams in fire conditions will be presented for the uniform bending loading case, see figure 1. Non linear geometrical and material static analysis will address this ultimate limit state.

RESULTS

The real behaviour of steel partially encased steel beams is significantly different from the ideal. Buckling develops since the very beginning of the loading by equilibrium divergence. The ultimate LTB moment resistance corresponds to the maximum load bearing capacity, being the non-dimensional slenderness the governing parameter. The larger slenderness of a beam corresponds to a smaller ultimate LTB resistance.



a) Longitudinal stresses for the composite beam.



b) Partial failure of concrete elements.

Fig. 2 – Results for the ultimate limit state.

Figure 2 represents the ultimate limit state for the partially encased beam, representing stress field on both materials and the partial failure mode of concrete, produced by cracking.

CONCLUSIONS

Partially encased steel beams presents grater flexural and torsional resistance when compared to similar steel rolled beam. Load bearing capacity will be presented for this type of composite beam, for different beam lengths, compared to the simple design calculation method presented in Eurocode (CEN, 2004-2005).

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