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Faculty of Engineering, University of Porto

**INTEGRITY
RELIABILITY
AND FAILURE
CHALLENGES AND
OPPORTUNITIES**

Editors:

J.F. Silva Gomes

Shaker A. Meguid

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IRF'2009

INTEGRITY, RELIABILITY AND FAILURE (CHALLENGES AND OPPORTUNITIES)

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J.F. Silva Gomes and Shaker A. Meguid

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S1706_A0432	PLASTICITY-INDUCED FATIGUE CRACK GROWTH IN HIGH-STRENGTH STEELS: NUMERICAL MODELLING AND EXPERIMENTAL VALIDATION. Jesus Toribio, V. Kharin, F.J. Ayaso, B. González, J.C. Matos, D. Vergara, and M. Lorenzo	499
S1707_A0531	PRACTICAL FRAMEWORK FOR PROCESS SAFETY MANAGEMENT BASED ON PLANT LIFE CYCLE ENGINEERING. Yukiyasu Shimada, Teiji Kitajima, and Kazuhiro Takeda	501
S1708_A0537	SAFETY CONTROL DESIGN FRAMEWORK. Hossam A.Gabbar	503
S1709_A0545	RELIABILITY BASED DESIGN OF NOVEL OFFSHORE STRUCTURES. Athanasios Kolios, and Feargal Brennan	505
CHAP. XVI	SELF-SENSING, SELF-HEALING, SELF-POWERING AND MULTIFUNCTIONAL MATERIALS	507
S1801_A0239	SHM OF CFRP-STRUCTURES WITH IMPEDANCE SPECTROSCOPY AND LAMB WAVES. Jürgen Pohl, and Gerhard Mook	509
S1802_A0272	DOMAIN WALL DYNAMICS IN FERROELECTRIC MATERIALS. Yu Su	511
S1803_A0292	NEURAL NETWORK SYSTEM USED TO DETECT FAULTS AND AUTOMATICALLY DIAGNOSE IN CONDITION-BASED MONITORING USING VIBRATION. Adyles Arato Junior, and Fabrício César Lobato de Almeida	513
S1804_A0313	ON THE KINETICS OF SELF-HEALING POLYMERS. T.C. Mauldin, and M.R. Kessler	515
S1805_A0383	ELECTRICAL RESISTANCE METHOD FOR SELF-SENSING DAMAGE IN CARBON FIBER-REINFORCED COMPOSITES UNDER FATIGUE LOAD. Y. Ngabonziza, C. Boldrini, J. Li, B.M. Liaw, F. Delale, and J.H. Chung	517
CHAP. XVII	COMPUTER SIMULATION IN BIOMEDICAL APPLICATIONS	519
S1901_A0225	FINITE ELEMENT DETERMINATION OF FACTORS LEADING TO PERIPROSTHETIC INTRAOPERATIVE FEMUR FRACTURE. Taylor G. Martin, Shaker A. Meguid, Cari M. Whyne, and Omri Lubovski	521
S1902_A0301	CONSTITUTIVE MODEL OF DEFORMATION-INDUCED DEGRADATION OF POLYMERS FOR APPLICATION IN BIODEGRADABLE STENT DESIGN. João S. Soares, James E. Moore Jr., and Kumbakonam R. Rajagopal	523
S1903_A0303	FINITE ELEMENT ANALYSIS OF MICROCRACK LOCALISATION AND PROPAGATION INSIDE CORTICAL BONE TISSUE. Dieter Kardas, and Udo Nackenhorst	525
S1904_A0345	HUMAN FEMUR ASSESSMENT USING ISOTROPIC AND ORTHOTROPIC MATERIALS DEPENDENT OF BONE DENSITY. E.M.M. Fonseca, M.J. Lima, and L.M.S. Barreira	527
S1905_A0377	NUMERICAL SIMULATION OF BLOOD FLOW IN A STENOTIC ARTERY. Luisa C. Sousa, Catarina F. Castro, and Carlos C. António	529
CHAP. XVIII	STRUCTURAL SAFETY	531
S2001_A0302	ASSESSMENT OF THE THERMAL RESPONSE OF HIGH RISE BUILDINGS UNDER NATURAL FIRES USING CFD AND FEM ANALYSIS. Jorge Capote, Daniel Alvear, Mariano Lázaro, and Jorge Crespo	533

S2002_A0385	FIRE DAMAGED R.C. COLUMNS REPAIRED WITH HIGH PERFORMANCE FIBER REINFORCED CONCRETE JACKET. Angelo Leonardi, Alberto Meda, and Zila Rinaldi	535
S2003_A0471	EFFICIENCY EVALUATION OF INTUMESCENT COATINGS USED FOR FIRE PROTECTION: COMPARISON BETWEEN NUMERICAL METHOD AND EXPERIMENTAL RESULTS. Luís M.R. Mesquita, Paulo A.G. Piloto, and Mário A.P. Vaz	537
S2004_A0472	INELASTIC BEHAVIOUR OF PARTIALLY ENCASED SECTIONS - NUMERICAL COMPARISON. P.A.G. Piloto, Ana Ramos Gavilán, L.M.R. Mesquita, and Alberto Meda	539
S2005_A0562	ROBUSTNESS STUDY OF TOP-HAT SECTIONS OF HIGH STRENGTH STEEL SUBJECTED TO AXIAL CRUSHING. Ø. Fyllingen, O.S. Hopperstad, and M. Langseth	541
S2006_A0316	CONTRIBUTION OF EXOGENOUS SUBSTANCES TO ALTERATION OF STONE SURFACES IN METROPOLITAN STATIONS. Carlos Alves, Carlos Figueiredo, António Maurício, Paula Figueiredo, and Luís Aires-Barros	543
S2007_A0317	AESTHETIC FAILURE OF LIMESTONES UNDER SALT CRYSTALLISATION TESTS. Carlos Alves, Carlos Figueiredo, Maria Amália Sequeira Braga, António Maurício, and Luís Aires-Barros	545
S2008_A0326	EROSION OF CARBONATE ROCKS UNDER WATER-FLOWING (FOUNTAIN) CONDITIONS. Carlos Alves	547
S2009_A0327	WIDESPREAD OCCURENCE OF WHITE COATINGS IN RECENT BUILDINGS. Carlos Alves	549
S2010_A0328	THE EFFECT OF ACCELERATED CORROSION EXPOSURE ON THE FRACTURE TOUGHNESS OF THE AIRCRAFT ALUMINUM ALLOY 2024. Nikolaos D. Alexopoulos	551
S2011_A0363	NUMERICAL MODELLING OF FATIGUE CRACK SHAPE EVOLUTION IN SHAFTS UNDER TENSION AND BENDING. R. Branco, F. V. Antunes, and J. Barbosa	553
S2012_A0364	INFLUENCE OF ELASTIC CONSTANTS ON CRACK SHAPE EVOLUTION IN AXLES. R. Branco, F. V. Antunes, and J. D. Costa	555
S2013_A0435	INFLUENCE OF CASTING DEFECTS ON THE FATIGUE LIMIT OF A STEEL CAST RAILWAY COMPONENT. Teresa Morgado, A. Sousa e Brito, and C. Moura Branco	557
S2014_A0436	COMPARISON OF FATIGUE LIFE EXTENSION RESULTS IN RAILWAY COUPLINGS OF CAST STEEL ASTM 148 90-60 USED IN FREIGHT TRAINS. Teresa Morgado, Carlos Moura Branco, and Virginia Infante	559
S2015_A0550	MEASUREMENT OF THE DYNAMIC FRACTURE TOUGHNESS WITH NOTCHED BRITTLE SPECIMEN UNDER IMPACT LOADING. S. Sahraoui, A. El Mahi, and B. Castagnède	561
CHAP. XIX	NOVEL ENERGETIC SYSTEMS: CHALLENGES AND OPPORTUNITIES	563
S2101_A0208	ALTERNATIVE SOURCES OF ENERGY. David M. Kennedy	565
S2102_A0365	TRANSIENT THERMAL BEHAVIOUR OF INSULATED AND NON INSULATED M3165 INTERNAL COMBUSTION ENGINE IN SHELL ECO-MARATHON PROTOTYPE VEHICLE. Pedro Carvalheira	567
S2103_A0366	DESIGN OF ENGINE PISTON OF M300 ENGINE. Pedro Carvalheira	569

CHAPTER XVIII

SYMPOSIUM

STRUCTURAL SAFETY

Coordinated by

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Introduction to Symposium on Structural Safety

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 safety in design will cover the design aspects of safe structures and components, using different materials. 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 reliability.

The following communications will present different aspects in Damage Analysis and Assessment, Fire Safety Engineering, Life Cycle Analysis, Natural and Man-Made Hazards, Performance-Based Design Methods, Prescribed Design Methods, Computational Methods and Simplified Methods for Structural Safety.

Paulo Piloto
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REF: S2004_A0472

INELASTIC BEHAVIOUR OF PARTIALLY ENCASED SECTIONS - NUMERICAL COMPARISON

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SYNOPSIS

Partially encased sections are made of composite steel and concrete casted between flanges. They present an attractive solution in comparison with bare steel or reinforced concrete counterparts. This paper intends to validate experimental results for bending and axial loading members at room temperature, (Elghazouli et al, 2008). The experiments were conducted at the Imperial College in London and aimed to provide essential data for validating future analytical and design studies. This numerical comparison is based on three dimensional finite element modelling, simulating bond contact and failure of concrete. The numerical results agree well with experimental results.

INTRODUCTION

The additional weight introduced by concrete is counterbalanced by the increasing stiffness. This advantage has enabled this section to be used into different types of construction, such as buildings or car parking, tested for natural and accidental conditions. In Europe, the use of partial rather than full encasement of steel profiles has proved more popular in recent years. Partially encased members have also been initially introduced as a means of improving fire behaviour.

This paper deals with the inelastic performance of partially-encased members at room temperature conditions, which are detailed according to conventional European practice (CEN-EN 1994-1-1, 2004). The model presented in figure 1 consists of an HEA200, high grade steel S460, with an equivalent C40/50 concrete. Concrete reinforcement used 8 [mm] rebar B500. The experiment referenced with C20Y0 was performed without axial load.

The experimental setup was designed with a hydraulic actuator for increasing vertical displacement under quasi-static loading conditions. The support and loading points were also used to provide out-of plane restraint for the experiments. Wide flexural cracks characteristic of pure bending behaviour were observed in the concrete portion, extending throughout most of the member depth.

An evaluation of the yield point of the member is required for assessing the effective stiffness, capacity and ductility of a member. For reinforced concrete members the first yielding of the reinforcement bars is assumed to represent this state. For steel members the first yield is not normally followed by significant increase in curvature, but the plastic hinge normally represents its ultimate limit state. For partially encased section, a plastic hinge may be attained with fully plastic steel section and with concrete completely damaged.

The numerical analysis is based on ANSYS three dimensional finite element model, (Ansys INC, 2008). One part of the mesh was generated with finite shell elements to represent the

steel profile and the other mesh part modelled with solid and link elements to represent reinforced concrete. These elements share common nodes, so that no movement between concrete and reinforcement was considered. These meshes were joined by non-linear finite spring elements used to simulate bond interface behaviour. The mechanical analysis required material and geometrical non-linear solutions to simulate large displacement with a maximum and minimum incremental displacements of 1,4 and 0.014 [mm], respectively.

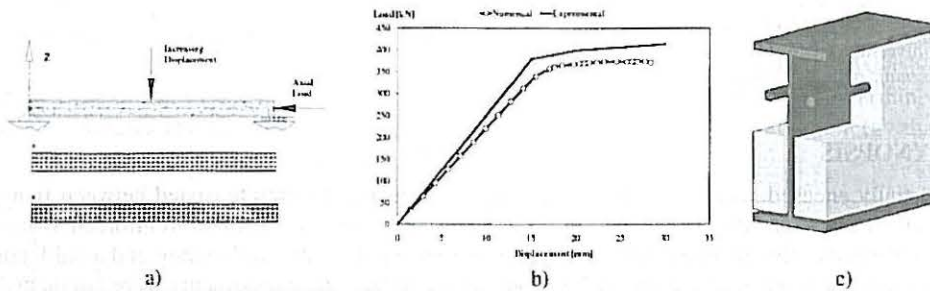


Fig. 1 Tested model C20Y0 (HEA 200). a) Prediction of concrete failure; b) Result comparison; c) Section.

An elastic - plastic model with strain hardening behaviour was considered for steel, using the suitable experimental values. Concrete being quasi brittle material was simulated with different behaviour for compression and tension, using stress relaxing model to improve numerical convergence. The presence of a crack at an integration point is represented through modification of the stress-strain relations by introducing a plane of weakness in a direction normal to the crack face. If the material, at an integration point, fails in uniaxial, biaxial, or triaxial compression, the material is assumed to crush at that point. In addition to cracking and crushing, the concrete may also undergo plasticity. In this case, the plasticity is verified before the cracking and crushing checks, (Ansys INC, 2008).

Triaxial confinement of concrete may produce direct influence in the behaviour of partially encased sections, by considerable improvement of mechanical properties, (Elghazouli et al, 2008). This phenomenon was considered during numerical simulations.

CONCLUSIONS

Numerical comparison is presented for experiments conducted at the Imperial College in London. Results agree well for the first yield point and ultimate limit state. The numerical model captures all the major and relevant state modification for partially encased sections.

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About the Book

As the engineering community continues to cross the boundaries of known practices, materials and manufacturing techniques into the frontiers of new functional materials, environments and applications, the opportunities for catastrophic failures will inevitably increase. If our knowledge of how to engineer systems, structures and components to minimize or prevent catastrophic failure is to keep pace with modern manufacturing technologies, the demanding applications, and the intolerance of a safety conscious society, we must continue our efforts to develop and use superior materials, apply reliable analytical techniques and validate these with sound experimental tools.

This book contains the Abstracts of papers presented at the 3rd International Conference on Integrity, Reliability and Failure, held at the Faculty of Engineering, University of Porto, Portugal, 20-24 July 2009. This is part of a prestigious series of Integrity Reliability and Failure conferences coordinated by the International Scientific Committee on Mechanics and Materials in Design. The conference attracted over 260 participants with 310 accepted academic and industrial submissions from 45 different countries around the world. These papers were presented in July 2009 in the magnificent city of Porto, Portugal, and the conference themes focused on design, nanotechnology, advanced materials, computational and structural mechanics, experimental mechanics, structural safety, energetic systems, and case studies.



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