

INTEGRITY/ RELIABILITY/FAILURE

**IN AUTOMOTIVE, LOCOMOTIVE, AEROSPACE, CIVIL
ENGINEERING AND BIOMECHANICS**

**J.F. Silva Gomes
Shaker A. Meguid
*Editors***

*Proceedings of the 6th International Conference on Integrity, Reliability
and Failure, Lisbon/Portugal, 22-26 July 2018*

**FEUP-INEGI
(2018)**

IRF2018

INTEGRITY–RELIABILITY–FAILURE

IN AUTOMOTIVE, LOCOMOTIVE, AEROSPACE, CIVIL
ENGINEERING AND BIOMECHANICS

Editors

J.F. Silva Gomes and Shaker A. Meguid

FEUP-INEGI
(2018)

Published by

INEGI-Instituto de Ciência e Inovação em Engenharia Mecânica e Gestão Industrial
Rua Dr Roberto Frias, 4200-465 Porto - Portugal
Telefone: +351 22 9578710; Email: inegi@inegi.up.pt
<http://www.inegi.up.pt/>

July, 2018

ISBN: 978-989-20-8312-4
N. DL: 441087/18

Printed by:

LusoImpress S.A.
Rua Venceslau Ramos, 28 - 4430-929 Avintes, Portugal
Tel: +351 22 787 73 20; Fax: +351 22 787 73 29
www.lusoimpress.com

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic, mechanical, optical, recording, or otherwise, without the prior written permission of the Editors

TABLE OF CONTENTS

Preface	xxiii
International Scientific Committee	xxiv
Organizing Committee and Secretariat	xxv
Acknowledgments	xxvi
List of Tracks and Symposia	xxvii

INVITED KEYNOTE PAPERS

	1
7001 STRATEGIES FOR IMPROVED VEHICLE SAFETY: SURVIVABILITY OF OCCUPANTS. Shaker A. Meguid, Mohamed T.Z. Hassan.	3
7002 ENHANCEMENT OF FATIGUE LIFE AND ELONGATION OF METALLIC MATERIALS BY HIGH-DENSITY PULSED ELECTRIC-CURRENT. Yang Ju.	5
7003 SAFETY IN SPORTS: CHALLENGES AND OPPORTUNITIES. Veit Senner.	7

CONFERENCE MAIN TOPICS

	9
TOPIC-A: COMPOSITE AND ADVANCED MATERIALS	11
7096 THE IMPACT OF METAL REINFORCEMENT UPON THE PROPERTIES OF A COMPOSITE. Robert Szczepaniak, Pawel Przybylek, Aneta Krzyzak, Michal Micolajewski, Andrzej Komorek.	13
7097 INVESTIGATION INTO THE THERMAL RESISTANCE OF A POLYMER COMPOSITE WITH AEROGEL. Robert Szczepaniak, Pawel Przybylek, Arkadiusz Bartuzi.	15
7110 MECHANICAL PROPERTIES OF NiAl-TiB ₂ COMPOSITE MATERIALS. Masashi Yoshida.	17
7123 EFFECTS OF ACCELERATED AGEING ON THE TENSILE PERFORMANCE OF GFRP/EPOXY COMPOSITE AND THERMOSET EPOXY. Silviu Ivan, Matteo Cavasin, Stefanos Giannis, Ivo Dlouhy, Barry Thomson.	19
7129 SOME QUASI-ISOTROPIC LAMINATES ARE MORE ISOTROPIC THAN OTHERS. Mazen A. Albazzan, Ramy Harik, Zafer Gürdal, Jesse Hartzell.	21
7135 THERMO-PROTECTIVE PROPERTIES OF POLYMER COMPOSITES WITH NANO-TITANIUM DIOXIDE. Sylwester Stawarz, Natalia Bryła, Wojciech Kucharczyk, Mohamed Bakar, Magdalena Stawarz.	23
7137 THE MECHANICAL AND THERMAL BEHAVIOR OF EXPONENTIALLY GRADED SANDWICH PLATES IN BENDING TEST. Dongdong Li, Zongbai Deng, Shang-Chao Hung, Nai-Jen Cheng.	25
7150 NUMERICAL ANALYSIS OF A COMPOSITE LEG PROSTHESIS. João V.G. Santos, Vincent Wong, Vicente G. Neto, Luis C. Paschoarelli, Marcos A.R. Pereira, Carlos A. Fortulan, Cesar R. Foschini.	27

7186	MATERIAL CHARACTERISTICS OF GEOPOLYMERS BASED ON AN INDUSTRIAL WASTE PRODUCT. Jan Fořt, Eva Vejmelková, Zdeněk Soukup, Pavla Rovnaníková, Robert Černý.	29
7221	SURFACE MODIFICATION OF POLYSTYRENE BEADS WITH SULFONAMIDE DERIVATIVES AND APPLICATION TO WATER SOFTENING SYSTEM. Seong Ik Jeon, Cheol-Hee Ahn.	31
7228	MECHANICAL PROPERTIES AND MICROSTRUCTURE OF CARBON-FIBRE/ALUMINIUM-MATRIX AND CARBON-FIBRE/TITANIUM-MATRIX COMPOSITES. Alexander Rudnev, Rida Gallyamova, Andrew Gomzin, Andrew Kolchin, Sergei Galyshev, Fanil Musin, Sergei Mileiko.	33
7229	APPLICATION OF ZEOLITE IN CONCRETE MIXTURES FOR RADIONUCLIDE BARRIERS. Eva Vejmelková, Martin Keppert, Petr Bezdička, Robert Černý.	35
7238	DAMPING PROPERTIES OF CORK/FIBRE REINFORCED POLYMER COMPOSITES. Ali Daliri, Tahsin Anowar, José Silva.	37
7244	SILICATE-BASED FIBRES TO REINFORCE HIGH TEMPERATURE COMPOSITES. Sergei Mileiko, Andrew Kolchin, Natalia Novokhatskaya, Nelly Prokopenko, Olga Shakhlevich, Vladimir Chumichev, Sergei Abashkin. <i>(Invited Paper)</i> .	39
7251	EFFECT OF HOSTILE SOLUTIONS ON THE VISCOELASTIC BEHAVIOUR OF CARBON/EPOXY LAMINATES. M. Kamocka, Ana M. Amaro, Paulo N.B. Reis, Maria A. Neto, José Maria Cirne.	41
7254	THERMAL AND MECHANICAL ANALYSIS OF AN EPOXY FOAM SYNTHESIZED BY MEANS OF A CHEMICAL FOAMING AGENT. Matteo Cavasin, Marco Sangermano, Milena Salvo, Stefanos Giannis.	43
7277	ISOLATING VIBRATION BY PERIODIC COMPOSITE STRUCTURES. Hongping Hu, Yuantai Hu.	45
7291	SELF-ACTUATED MORPHING COMPOSITE WITH TUNABLE FREQUENCY AND DAMPING. Arnaldo Casalotti, Giulia Lanzara.	47
	TOPIC-B: COMPUTATIONAL MECHANICS	49
7084	CLUSTERING OF TRIBOLOGICAL FAULTS USING THE WARD METHOD. Antonio P.V. Pinto, Carlos E.F. Bezerra, Andreyvis S. Souza, Marco A.L. Cabral, Efrain P. Matamoros.	51
7098	MATHEMATICAL MODELING OF THE BLENDED WING BODY AIRCRAFT FLOW-OVER IN CRUISE MODE. Francheska Slobodkina.	53
7105	TIME-HARMONIC ANALYSIS OF LINEAR ANISOTROPIC ELASTIC SOLIDS WITH A BOUNDARY ELEMENT METHOD. Leonid Igumnov, Ivan Markov, Igor Vorobtsov, Mikhail Grigoryev.	55
7119	THREE-DIMENSIONAL DYNAMIC ANALYSIS OF A THREE-PHASE POROELASTIC MEDIUM USING THE TIME-DOMAIN BOUNDARY ELEMENT METHOD. Andrey Petrov, Leonid Igumnov, Igor Vorobtsov, Aleksandr Belov.	57
7120	NUMERICAL SOLUTION FOR A TRANSIENT PROBLEM OF A SANDSTONE LAYER ON A SOIL FOUNDATION UNDER VERTICAL LOAD USING BEM. Svetlana Litvinchuk, Akeksandr Ipatov, Aleksandr Boev.	59

7207	STRUCTURAL INTEGRITY ASSESSMENT OF CRACKED COMPOSITE PLATE UNDER AEROELASTIC LOADING BY MEANS OF XFEM. Nur Azam Abdullah, Jose L. Curiel Sosa, Nanda Wirawan, Mahesa Akbar.	61
7208	AEROFRACTUREELASTIC ON WING BOX OF MULTI-PURPOSE COMMUTER AIRCRAFT UNDER GUST LOAD BY MEANS OF XFEM. Nur Azam Abdullah, Nanda Wirawan, Jose L. Curiel Sosa, Mahesa Akbar.	63
7215	ASYMPTOTIC STOKES FLOWS USING AXIAL GREEN FUNCTION METHOD WITH REFINEMENT. Junhong Jo, Hong-Kyu Kim, Do Wan Kim.	65
7219	ANALYSIS OF THE COLD FORMING PROCESS. Sigitas Kilikevičius, Ramūnas Česnavičius, Povilas Krasauskas, Andrius Juodsnukis.	67
7223	NUMERICAL AND EXPERIMENTAL ANALYSIS OF AERONAUTICAL CFRP COMPONENTS SUBJECTED TO STRUCTURAL LOADS. Alessandro Castriota, Vito Dattoma, Riccardo Nobile, Francesco Panella, Alessandra Pirinu, Andrea Saponaro.	69
7232	NEW APPROACH TO SOLVING MATHEMATICAL EQUATION FOR DAMPED OSCILLATIONS BY SLIDING (COULOMB) FRICTION AT THE KARAKURI MECHANISM. Tomas Riegr, Ivan Masin.	71
7246	SIMULATION OF A VIBRATORY SYSTEM WITH SHAPE MEMORY ALLOY UNDER ROTATING UNBALANCE EXCITATION. Michel A. Silva, Vinicius Piccirillo, Carlos A. Andrade.	73
7307	FROM PERCOLATION OF FRACTURED MEDIA TO SEISMIC ATTENUATION: A NUMERICAL STUDY. Mikhail Novikov, Vadim Lisitsa.	75
TOPIC-C: EXPERIMENTAL MECHANICS AND INSTRUMENTATION		77
7052	DETERMINATION OF BURST PRESSURE FOR DEFECTED PIPES. Abdullah M. Al Shabibi, Majid Al Moharbi, Sultan Al Owaisi.	79
7060	MECHANICAL BEHAVIOR OF NEW POLYUREA ELASTOMERS: CONSTITUTIVE MODELLING. Nahuela Rull, Antoni Sanchez-Ferrer, M. Patricia Frontini.	81
7101	FATIGUE STRENGTH OF CARBON STEEL COVERED WITH PROTECTIVE LAYERS FOR CO ₂ ASSISTED SHALE GAS MINING. Marta Baran, Tomasz Brynk, Z. Pakiel.	83
7111	RESIDUAL STRESSES - NEUTRON DIFFRACTOMETER STRESS-SPEC @ FRM II. Joana Rebelo Kornmeier, Michael Hofmann, Weimin M. Gan, Jens Gibmeier, Jan Saroun.	85
7152	COMPARATIVE STUDY ON ACCELERATED FLUID DIFFUSION IN THERMOSET EPOXY AND GFRP FOR MARINE APPLICATIONS. Matteo Cavasin, Silviu Ivan, Stefanos Giannis, Marco Sangermano, Milena Salvo, Barry Thomson.	87
7156	CONDITION MONITORING OF AN INDUSTRIAL BUCKET ELEVATOR FOR BULK MATERIALS. Piotr Sokolski, Marek Sokolski.	89
7163	DIAGNOSIS OF BEARING FAULTS IN COMPLEX MACHINERY USING SPATIAL DISTRIBUTION OF SENSORS AND FOURIER TRANSFORMS. Aouni Lakis, Ali Mahvash, Mohammad Toorani.	91
7176	MECHANICAL PROPERTIES OF HYDROGELS AND AUTOMATED SYSTEM "KERN-DP". Anatolij P. Onanko, M.P. Kulish, Y.A. Onanko, S.A. Vyzhva, D.V. Charnyi, O.P. Dmitrenko, A.V. Shabatura, R.V. Homenko, A.N. Onischenko, T.O. Busko.	93

7182	EDDY CURRENT APPROACH FOR METALLURGICALLY CLAD PIPE INSPECTION. Cesar G. Camerini, João M.A. Rebello, Rafael W. Santos, João M. Santos, Gabriela R. Pereira.	95
7197	ADVANCED NDT PROCEDURES AND THERMAL DATA PROCESSING ON CFRP AERONAUTICAL COMPONENTS. Vito Dattoma, Riccardo Nobile, Francesco Panella, Alessandra Pirinu, Andrea Saponaro.	97
7220	STRENGTH AND MICROSTRUCTURE ANALYSIS OF SPOT WELDED JOINTS. Ramūnas Česnavičius, Sigitas Kilikevičius, Povilas Krasauskas, Vytautas Jurgaitis.	99
7222	DETERMINATION OF ALUMINUM ALLOY EN AW-1100 LIMITING DRAWING RATIO AT DIFFERENT TEMPERATURES THROUGH PRACTICAL EXPERIMENTS AND NUMERICAL SIMULATION USING FINITE ELEMENT METHOD. Gilmar C. Silva, Matheus M. Costa, João P.S. Carneiro, Jorge A.P. Rodrigues, José F.P. Vasconcelos, Daniel C. Maciel, Tiago A. Silva.	101
7224	MAGNETIC CHARACTERIZATION OF HEAT-RESISTANT AUSTENITIC STEELS BY USING AN OWN EDDY CURRENT SYSTEM. Mónica P. Arenas, Clara J. Pachecho, Artur L. Ribeiro, Helena G. Ramos, Carlos B. Eckstein, Laudemiro Nogueira Jr., Luiz H. Almeida, João M.A. Rebello, Gabriela R. Pereira.	103
7266	ANALYSIS OF HIGH TEMPERATURE PIPE INTEGRITY USING CUSTOMIZED EDDY- CURRENT SYSTEM. Fernando S. Crivellaro, Ana Peixoto, Miguel A. Machado, José P. Sousa, António Custódio, J. Pamies Teixeira, Telmo G. Santos.	105
TOPIC-D: FATIGUE AND FRACTURE MECHANICS		107
7074	FRACTURE MECHANICS ANALYSIS OF POROSITY EFFECT ON STRENGTH CHARACTERISTICS OF POROUS ALUMINA. Natsumi Miyazaki, Toshihiko Hoshide.	109
7080	CREEP FRACTURE OF PLATES IN UNSTEADY COMPLEX STRESS STATE IN THE PRESENCE OF AMBIENT MEDIUM. Alexander Lokoshchenko, Leonid Fomin.	111
7089	INVESTIGATION OF FATIGUE PROPERTIES OF SOME STEAM TURBINE BLADE MATERIALS. Jan Chvojan, Jaroslav Václavík.	113
7092	NEW CORROSION MODEL TO PREDICT STEEL STRENGTH. Rachid Dami.	115
7102	STUDY OF THE EFFECT OF STRESS CONCENTRATORS IN FATIGUE FAILURE ANALYSIS OF A CRANKSHAFT. José R.G. Carneiro, Leonardo C. Aguiar, Gilmar C. Silva, João P.S. Carneiro.	117
7166	THE EFFECT OF FRESH WATER CORROSIVE SOLUTION ON FATIGUE STRENGTH OF LOW CARBON STEEL. Marta Morgantini, Volodymyr Okorokov, Yevgen Gorash, Donald MacKenzie, Ralph van Rijswick.	119
7172	APPROACH TO FULL-SCALE FATIGUE TEST OF THE MIG-29 VERTICAL STABILIZER WITH REPAIR OF COMPOSITE STRUCTURES. Piotr Synaszko, Michał Sałaciński, Michał Dziendzikowski, Krzysztof Dragan, Andrzej Leski.	121
7230	PERIDYNAMIC MECHANO-CHEMICAL MODELING OF STRESS CORROSION CRACKING. Ziguang Chen, Siavash Jafarzadeh, Shumin Li, Florin Bobaru, Qin Qian.	123
7233	STRENGTH AND LIFE ANALYSIS IN THE PLASTIC STRAIN RANGE. NEUBER VERSUS STRAIN ENERGY CONSERVATION PRINCIPLE. Luciano Brambilla.	125

7240	ADVANCED NUMERICAL TECHNIQUES APPLIED TO THE STRENGTH PREDICTION OF STEPPED-LAP ADHESIVE JOINTS. Rui Machado, Raúl Campilho.	127
7241	MIXED-MODE FRACTURE OF BONDED JOINTS USING THE ASYMMETRIC TAPERED DOUBLE-CANTILEVER BEAM TEST. Filipe Nunes, Raúl Campilho.	129
7264	REAR SUSPENSION DEVELOPMENT: DURABILITY STUDY ON THE EFFECTS OF VARIATION OF VEHICLE AND SUSPENSION CHARACTERISTICS IN A TWIST BEAM REAR SUSPENSION. Guilherme Carneiro, Marco Anjos, Ernani S. Palma.	131
7292	COUPLED METHOD TO INVESTIGATE PLASTIFICATION OF HEAVY HAUL RAILWAY WHEELS. Pedro Picanço, Felipe Bertelli, Eduardo A. Lima, Thairon R. Costa, Auteliano A. Santos.	133
TOPIC-E: NANOTECHNOLOGIES AND NANOMATERIALS		135
7081	EFFICIENT FABRICATION METHOD OF METALLIC NANO/MICRO STRUCTURES FOR NANO DEVICES. Masahiko Yoshino, P. Potejanasak, Duc P. Truong, Motoki Terano.	137
7109	NANOINDENTATION INDUCED PLASTIC DEFORMATION IN NANOCRYSTALLINE ZrN COATING. Zhoucheng Wang.	139
7149	ALUMINA DOPING FOR IMPROVING PROPERTIES OF ZIRCONIA CERAMICS. Danil Belichko, Larysa Loladze, Tetyana Konstantinova, Alexandr Myloslavskyy.	141
7151	NEW CHALLENGES IN THE CREATION OF RELIABLE CERAMIC NANOCOMPOSITES. Igor A. Danilenko, Tetyana E. Konstantinova, Oxana A. Gorban, Irina I. Brukhanova, Larysa V. Loladze, Danil R. Belichko, Artyom V. Shylo.	143
7269	ZINC OXIDE MATERIAL FOR OPTOELECTRONIC APPLICATIONS. Irinela Chilbon.	145
7290	CARBON NANOTUBES BASED SENSORS FOR DAMAGE DETECTION. Erika Magnafico, Arnaldo Casalotti, Maryam Karimzadeh, Krishna C. Chinnan, Giulia Lanzara.	147
7296	IMPROVEMENT OF ADHESION STRENGTH OF THE COPPER NANOWIRE SURFACE FASTENER BY INVESTIGATING THE DIAMETER RATIO OF NANOWIRES. Motohiro Kato, Yuhki Toku, Yasuyuki Morita, Yang Ju.	149
7297	ELECTROMAGNETIC PERFORMANCE OF SPIRALLY DEFORMED COATED NANOWIRES. Yuhki Toku, Yuji Ueda, Yasuyuki Morita, Yang Ju.	151
TOPIC-F: TRIBOLOGY AND SURFACE ENGINEERING		153
7076	STRUCTURAL DEGRADATION OF LUBRICATING GREASES. AN ENERGY DRIVEN PROCESS. Erik Kuhn.	155
7177	CROSS-SECTIONAL MICROSTRUCTURE AND STRESS DISTRIBUTIONS IN THIN FILMS DURING INDENTATION REVEALED BY X-RAY NANODIFFRACTION. Josef Keckes, Rostislav Daniel, Juraj Todt, C. Krywka, M. Burghammer.	157
7194	EVALUATION OF RESEARCH OPPORTUNITIES OF A TRIBOLOGICAL TESTING TAPE MACHINE. Wojciech Żurowski, Wojciech Kucharczyk, Jarosław Zepchlo.	159
7265	FAULT DETECTION IN DIESEL ENGINE INJECTORS USING A VIBRATION AND SOUND PRESSURE LEVEL TECHNIQUE. Jarbas S. Medeiros, Daniel M. Lago, Antônio C. Moreira Filho, Efrain P. Matamoros, João T.N. Medeiros.	161

7304	MICROSTRUCTURE ANALYSIS OF RARE EARTH-MAGNESIUM ALLOY REPAIRED USING HIGH POWER SURFACE LASER CLADDING. Rongjuan Yang, Dongyun Ge, Xuan Zhao.	163
TOPIC-G: MECHANICAL DESIGN AND PROTOTYPING		165
7059	USING DESIGN S-N CURVES AND DESIGN STRESS SPECTRA FOR PROBABILISTIC FATIGUE LIFE ASSESSMENT OF VEHICLE COMPONENTS. Miloslav Kepka, Miloslav Kepka Jr.	167
7077	QUANTITATIVE ANALYSIS OF RELATIONSHIP BETWEEN EXTRUSION BLOW MOLDING PROCESS PARAMETERS AND DEFORMATION PROPERTIES. Esther R. Dorp, Berenika Hausnerova, Bernhard Möginger.	169
7082	MAIN EXPECTED PROBLEMS DURING THE IMPLEMENTATION OF "INDUSTRY-4.0" REFORMS AND THEIR PRACTICAL SOLUTIONS BASED ON IMPROVING THE EFFICIENCY OF USED MECATRONIC SYSTEMS. Raul Turmanidze, Vasili Bachanadze, Giorgi Popkhadze.	171
7189	A NUMERICAL AND EXPERIMENTAL STUDY OF THE ENERGY ABSORPTION CAPACITY OF AUXETIC STRUCTURES MANUFACTURED WITH ADDITIVE TECHNOLOGY. Filip Sarbinowski, Remigiusz Labudzki, Rafał Talar, Adam Patalas.	173
7270	DESIGN METHODOLOGY OF AN ALUMINIUM CHASSIS. Ana L. Ramos, Oscar Zapata, Tania Berber, Natalia Navarrete.	175
7301	COMPARISON OF UNIBODY AND FRAME BODY VERSIONS OF ULTRA EFFICIENT ELECTRIC VEHICLE. Wojciech Skarka, Tomasz Pabian, Michał Sosnowski.	177
7305	METHODOLOGY FOR THE OPTIMIZATION OF AN ENERGY EFFICIENT ELECTRIC VEHICLE. Wojciech Skarka.	179
TOPIC-H: BIOMECHANICAL APPLICATIONS		181
7050	KINEMATICS ANALYSIS OF MOZAMBICAN ATHLETES IN THE 100 METERS RACE. Ercilio Machanguan, Anicêncio Macitela, Alberto Graziano.	183
7051	ANALYSIS OF THE PERFORMANCE OF LOWER MEMBERS IN SUSPENSION SERVICE IN VOLLEYBALL. Anicêncio Macitela, Alberto Graziano.	185
7063	THE EFFECT OF MULTIPLE NEUROTRANSMISSION ON THE BIOMECHANICS OF THE HUMAN STOMACH. Saleh Alrowaili, Roustem Miftahof.	187
7066	BIOMECHANICS OF THE BOLUS PROPULSION IN THE COLON. Omar Al Qatrawi, Roustem Miftahof.	189
7067	BIOMECHANICS OF THE HUMAN STOMACH AFTER DIABETIC VAGOTOMY. Dareen Bash, Roustem Miftahof.	191
7071	MODELLING OF THE EFFECT OF METOCLOPRAMIDE ON THE BIOMECHANICS OF THE GASTROPARETIC HUMAN STOMACH. Fatima Alhayki.	193
7075	CONTRACTILE ACTIVITY OF THE HUMAN STOMACH UNDER COMPLEX STIMULATION. AIDana M. Zaid, Roustem Miftahof.	195
7094	MODELING OF LARGE GAUGE ARTERIES WITH A SOFT ELASTIC MEMBRANE PIPE FINITE ELEMENT. Francisco Q. Melo, António G. Completo, José L.S. Esteves.	197

7190	A MECHANICAL ANALYSIS OF CANCELLOUS BONE IN FEA SIMULATION RESEARCH AND EXPERIMENTAL TESTING WITH THE μ CT CONTROL. Adam Patalas, Remigiusz Labudzki, Filip Sarbinowski, Bartosz Gapiński, Rafal Talar.	199
7203	INFLUENCE OF BONE QUALITY IN THE BEHAVIOUR OF GRAFT FIXATION IN ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION. Covadonga Quintana, Cristina Rodriguez, Ines Peñuelas, Antonio Maestro.	201
7204	BIOMECHANICAL BEHAVIOUR CHARACTERIZATION OF THE MATERIALS INVOLVED IN ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION. Covadonga Quintana, Cristina Rodriguez, Ines Peñuelas, Antonio Maestro.	203
7267	IN VIVO CHARACTERIZATION OF MICRO ARCHITECTURE OF A HUMAN VERTEBRA BY MICRO-IMAGING. Hacene Ameddah, Hammoudi Mazouz.	205
TOPIC-I: CIVIL AND STRUCTURAL ENGINEERING APPLICATIONS		207
7057	AGGREGATE SIZE AND LATERAL DIMENSION EFFECTS ON CORE COMPRESSIVE STRENGTH OF CONCRETE. Adel Benidir, M'Hamed Mahdad, Ahmed Brara.	209
7068	EXPERIMENTAL STUDY OF THE MECHANICAL BEHAVIOR OF COMPRESSED STABILIZED EARTH BLOCKS AND WALLS. M'Hamed Mahdad, Adel Benidir, Ahmed Brara.	211
7083	SUBSTITUTION OF THE TRANSVERSE REINFORCEMENT WITH ENGINEERED CEMENTITIOUS COMPOSITE IN RC EXTERIOR BEAM-COLUMN JOINTS SUBJECTED TO CYCLIC LOADING. Shwan H. Said.	213
7085	THE EFFECTS OF SOIL CATEGORY ON THE SEISMIC RESPONSE OF CIRCULAR STEEL WATER TANKS WITH MEDIUM H/D RATIO USING LAGRANGIAN APPROACH. Armen Assaturians, Sohrab Fallahi.	215
7090	IDENTIFICATION OF HYSTERICALLY DEGRADING STRUCTURES USING THE BOUC-WEN-BABER-NOORI (BWBN) MODEL. Ying Zhao, M. Noori, Wael Altabay.	217
7108	PERFORMANCE OF AIR CURED CONCRETE TREATED WITH WATERPROOFING ADMIXTURES OR SURFACE TREATMENTS. Sirwan Kamal, Hsein Kew, Hamid Jahromi.	219
7112	NON-DESTRUCTIVE EVALUATION OF DETERIORATED REINFORCED CONCRETE SLAB USING EXPERIMENTAL AND NUMERICAL METHODOLOGIES. Norbert Renault, Jean-Louis Gallias, Christophe Barnes.	221
7118	STRAIN-RATE INFLUENCE ON A SHAPE MEMORY ALLOY BASED DAMPER. João Morais, Carlos Santos, Paulo Morais.	223
7121	PROBABILISTIC TRAFFIC LOAD IDENTIFICATION FOR CONCRETE BRIDGES. Sebastian Zorn, Jörg F. Unger.	225
7130	COST CONSEQUENCE-BASED RELIABILITY ANALYSIS OF BURSTING FAILURE IN SUBSEA PIPELINES. Bahram Mehrafrouz, Pedram Edalat, Mojtaba Dyanati.	227
7162	DAMDAMAGE1.0: A MATLAB 3DFE PROGRAM FOR NON LINEAR ANALYSIS OF ARCH DAMS. André Alegre, Sérgio Oliveira.	229
7165	RESILIENCY OF SLAB TRACK SYSTEMS SUBJECTED TO LONG-TERM DETERIORATION: NUMERICAL MODELLING WITH SUBSTRUCTURING TECHNIQUES. Samuel Matias, Patrícia Ferreira.	231

7167	INFLUENCE OF 4 BOLTS-PER-ROW CONNECTION ON A STEEL FRAME BUILDING SUBJECTED TO COLUMN LOSS. Daniel Nunes, I. Marginean, Adrian Ciutina, Florea Dinu.	233
7168	MODAL IDENTIFICATION METHODS IN TIME DOMAIN NUMERICAL TESTS AND APPLICATIONS IN CIVIL ENGINEERING. Ana Prior, Sérgio Oliveira, Matilde Freitas.	235
7170	MONITORING AND ANALYSIS OF CONCRETE DAMS BEHAVIOR OVER TIME CONSIDERING SWELLING EFFECTS. INTEGRATED USE OF FINITE ELEMENT MODELS AND MODELS FOR EFFECTS SEPARATION. Miguel Rodrigues, Sérgio Oliveira.	237
7171	OPTIMIZATION OF WEB STIFFENER IN COLD-FORMED STEEL CHANNEL BEAMS SUBJECTED TO PURE BENDING. Ayman R. Ahmed, Ahmad M. Abdullah, Sedky A. Tohamy, Amr Bakr Saddek.	239
7188	EVALUATION OF HYGRIC PROPERTIES OF CONTEMPORARY PLASTERS. Jan Fořt, Zbyšek Pavlík, Lukáš Balík, Robert Černý.	241
7191	ULTIMATE CAPACITY OF STEEL FRAMES WITH BOLTED CONNECTIONS UNDER COLUMN LOSS SCENARIOS. Ioan Marginean, Florea Dinu, Robert Kulcsár, Simina Sabău, Dan Dubina.	243
7192	APPLICATION OF A COMPLETE STRUCTURAL HEALTH MONITORING CHAIN ON THE CANADIAN RIVIÈRE-AUX-MULETS BRIDGE NUMERICAL MODEL SUBJECTED TO A SEISMIC LOAD. Farouk Frigui, Jean-Pierre Faye, Carmen Martin, Olivier Dalverny, François Pérès, Sébastien Judenherc.	245
7195	NUMERICAL STUDY OF THE ROBUSTNESS OF STEEL STRUCTURES WITH FRICTION JOINTS. Francisca Santos, Aldina Santiago, Gianvittorio Rizzano, Luís S. Silva, Massimo Latour.	247
7201	STATIC AND DYNAMIC ELASTICITY MODULE ANALYSIS OF CEMENT COATING MORTARS. Ana Isabel Marques, João Morais, Carlos Santos, Paulo Morais, Maria do Rosário Veiga.	249
7202	DEVELOPMENT OF ALTERNATE LOAD PATHS IN STEEL FRAMES WITH COMPOSITE BEAMS SUBJECT TO ACCIDENTAL EXPLOSIONS. Florea Dinu, Ioan Marginean, Ioan Petran, Mihai Senila, Calin Neagu, Dan Dubina.	251
7205	NUMERICAL STUDIES ON SEISMIC RESPONSE OF STEEL AND COMPOSITE ECCENTRICALLY BRACED FRAMES. Mihai Senila, Ioan Petran, Calin Neagu, Florea Dinu.	253
7209	NUMERICAL MULTI-SCALE APPROACH FOR MASONRY INFILLED FRAME. T.T.N. Nguyen, N.Q. Vu, S.T. Nguyen, N.H. Tran, M.N. Vu.	255
7212	FRAGILITY CURVES FOR RC BRIDGES USING GENERALIZED PUSHOVER ANALYSIS. Camilo Perdomo, Ricardo Monteiro.	257
7213	ANALYSIS OF THE GROWTH CURVE FOR THE USE OF THE REJECT OF GRANITE ROSA IRACEMA IN THE MANUFACTURE OF EXIT FUNNELS IN THE TEXTILE INDUSTRY. Joseanne Alves de Sousa, Jorge Luiz Cardoso, Cândido S. Lobo.	259
7216	STUDY OF THE PERFORMANCE OF R.C. WALLS WITH OPENINGS USING AN ANALYTICAL FINITE ELEMENT MODEL. Alaa Morsy, Youssef Ibrahim.	261
7217	INTEGRATING THREE INSPECTION/MONITORING METHODS FOR CIVIL ENGINEERING APPLICATIONS. Amir Nasrollahi, Piervincenzo Rizzo.	263

7227	ECODESIGN FOR DECONSTRUCTION IN THE LIFE CYCLE POST-OPERATIONAL STAGE TO IMPROVE CONCRETE RECYCLING IN BRAZIL. Silvia Leticia Vacelkoski, George Stanescu.	265
7236	INVESTIGATION INTO THE DOUBLE-LAYER BARREL VAULT SPACE STRUCTURE RESISTANCE TO PROGRESSIVE COLLAPSE. Karim Abedi, Shahram R. Kolachahi.	267
7248	IMPACT OF PREVENTIVE MAINTENANCE ON FLEXIBLE PAVEMENT SERVICE LIFE. Manuel Ruíz, Luis Ramirez, Fermín Navarrina, J.R. Fernández Mesa, David López-Navarrete, Mario Aymerich.	269
7250	USE OF STRUCTURAL MASONRY OF CONCRETE BLOCKS AND PROTECTED LABS WITH FENCED CORDOBA IN RESIDENTIAL BUILDINGS. Harlen Nunes, Roberto Carvalho.	271
7255	STRUCTURAL RECOVERY AND PROJECT MANAGEMENT: THE DESIGN DRAWS CONTRIBUTION. Giorgio Garzino.	273
7259	TIMBER SHEAR WALLS: NUMERICAL ASSESSMENT OF THE EQUIVALENT VISCOUS DAMPING. Giorgia Di Gangi, Cristoforo Demartino, Giuseppe Quaranta, Marco Vailati, Giorgio Monti.	275
7260	THERMAL EFFECT OF A LOCALIZED FIRE IN THE STEEL STRUCTURE OF AN OPEN CAR PARK. Paulo Piloto, Edson M.S. Júnior, Francisco A.A. Gomes.	277
7261	FIRE DYNAMICS IN OPEN COMPARTMENTS. Paulo Piloto, Ketlen Possoli, Luiz C.M. Júnior, Khadouma Nechab, Benarous Abdallah.	279
7271	DATA PROCESSING FOR DATA ACQUISITION SYSTEMS: ANALYSIS OF VIBRATIONS IN STRUCTURES. R.S. Gonçalves, Matheus S. Vieira, Thalyta L. Santos, J.G.S. Jesus.	281
7275	PERFORMANCE OF DUAL-SHOULDER-MOUNT-TRUSS WEATHERING-STEEL OVERHEAD SIGN STRUCTURES IN WEST VIRGINIA. Wael Zatar, Hai Nguyen.	283
7276	DEVELOPMENT OF A STRUCTURE VIBRATIONS MONITORING INSTRUMENT USING TRIAXIAL ACCELEROMETER. J.G.S. Jesus, Matheus S. Vieira, Thalyta L. Santos, R.S. Gonçalves.	285
7286	STABILITY EVALUATION OF MARBLE STONE CLADDING AFFECTED BY BOWING AND WIND PRESSURE - A CASE STUDY. Rui Sousa, Hipólito Sousa.	287
	TOPIC-J: IMPACT AND CRASHWORTHINESS	289
7131	A FINITE ELEMENT MODEL TO STUDY WELD AND GEOMETRIC IMPERFECTIONS IN AN IMPACT ATTENUATOR DEVICE. Jose A. López-Campos, Abraham Segade, E. Casarejos, Jose R. Fernandez, J.A. Vilán.	291
7132	STUDY OF A CRASH BOX DESIGN OPTIMIZED FOR A UNIFORM LOAD PROFILE. Abraham Segade, Alejandro Bolaño, Jose A. López-Campos, E. Casarejos, Jose R. Fernandez, J.A. Vilán.	293
7144	RESEARCH ON THE ANISOTROPIC PROPERTIES OF WOOD AT HIGH-RATE LOADING. Anatoly Bragov, Alexander Konstantinov, Andrey Lomunov.	295
7160	ESTIMATION OF DEFORMATION ENERGY DURING IMPACT DESTRUCTION OF ADHESIVE JOINT SAMPLES. Jan Godzimirski, Andrzej Komorek, Robert Szczepaniak.	297

7193	ANALYTICAL MODELING OF THE TRANSITION OF THE PROGRESSIVE FOLDING MODE OF THIN-WALLED TUBES AFTER FOAM-FILLING. Fan Yang, Shaker A. Meguid.	299
7198	OPTIMIZATION STRATEGIES FOR CRASH RELEVANT VEHICLE STRUCTURES. Ralf Sturm, Michael Schäffer, Marco Münster.	301
7226	USE OF COMPUTATIONAL METHODS TO EVALUATE DAMPING DEVICE EFFICIENCY DURING THE DESIGN OF NUCLEAR POWER PLANT EQUIPMENT. A.M. Bragov, O Yu. Vilensky, A. Yu. Konstantinov, D.A. Lapshin, M.G. Malygin, V.V. Petrunin.	303
7256	MECHANICAL STUDY OF ADDITIVE MANUFACTURED HONEYCOMB STRUCTURES. Piotr Dziewit, Paweł Płatek, Jacek Janiszewski.	305
TOPIC-L: INDUSTRIAL ENGINEERING AND MANAGEMENT		307
7055	CUTTING AND PASSIVE TIMES CALCULATION FOR TURNING PROCESS. Nivaldo L. Coppini, Gabriel N. Oliveira, Danilo E. Braga.	309
7070	CONDITION MONITORING WITH PREDICTION BASED ON OIL ENGINES OF URBAN BUSES - A CASE STUDY. Hugo Raposo, José T. Farinha, Inácio Fonseca, Luís A. Ferreira.	311
7087	BUSINESS SUSTAINABILITY THROUGH THE PRACTICE OF CSR: THE A. PETTI SPA EXPERIENCE. Maria R. Sessa, Ornella Malandrino, Daniela Sica, Stefania Supino.	313
7133	DEVELOPING THE BEST PREVENTIVE MAINTENANCE POLICY FOR FULLY AUTOMATED SHIP-TO-SHORE CRANE. Yassine Achhal, Hassan Samadi.	315
7148	COMMON CAUSE ANALYSIS OF CIRCULAR VARIABLE NACELLE INLET CONCEPTS FOR AERO ENGINES IN CIVIL AVIATION. Stefan Kazula, David Grasselt, Klaus Höschler.	317
7153	NEW APPROACH FOR THE JOINT OPTIMIZATION OF THE DESIGN AND MAINTENANCE OF MULTI-COMPONENT SYSTEMS BY INTEGRATION OF LIFE CYCLE COSTS. Oussama Adjoul, Khaled Benfriha, Améziiane Aoussat, Yacine Benabid.	319
7155	METHODOLOGICAL FRAMEWORK FOR IMPLEMENTATION OF A PREDICTION RELIABILITY MODEL FOR IGBT POWER MODULES USED IN RAILWAY APPLICATIONS. Essi Dabla, François Pérès, Carmen Martin, Claire Fournier, Michel Piton, Floran Andrianoelison.	321
7157	DEFINITION AND IMPLEMENTATION OF AN INTEGRATED MANAGEMENT PLAN (IMP) APPLIED TO THE EQUIPMENT AT PERIODICAL TECHNICAL INSPECTION (PTI) STATIONS. Julio Julio García-Cordonic, Pablo Izquierdo, José A. Vilán, Abraham Segade, E. Casarejos, M.L. Lago.	323
7159	PRELIMINARY SYSTEM-SAFETY-ANALYSIS AND COMPARISON BETWEEN TWO NEW BROADBAND NOISE ABSORBING ACOUSTIC-LINER CONCEPTS FOR CIVIL AVIATION. Marcel Mischke, Stefan Kazula, David Grasselt, Klaus Höschler.	325
7169	A MECHANICAL AND STATE ANALYSIS OF A GAS TURBINE. Suzana Lampreia, Vitor Lobo, José Requeijo.	327
7180	INTEGRATION OF MAINTENANCE SYSTEMS. Sarje Suhas.	329

SPECIAL SESSIONS		331
SYMPOSIUM-1: EXPERIMENTAL MECHANICS FOR RELIABILITY		333
7058	DRAG REDUCTION OF A SWEEP WING BY MEANS OF PLASMA ACTUATORS. Sergey Chernyshev, Marat Gamirullin, Andrey Kiselev, Aleksandr Kuryachii, Sergey Manuilovich, Dmitry Sboev.	335
7127	DUCTILITY OF TITANIUM ALLOYS IN A WIDE RANGE OF STRAIN RATES. Vladimir V. Skripnyak, Vladimir A. Skripnyak, Evgeniya G. Skripnyak.	337
7141	AN IN-SITU EVALUATION OF STRUCTURAL DAMAGE IN A HIGH POWER SPALLATION NEUTRON SOURCE. Masatoshi Futakawa, Tao Wan, Hiroyuki Kogawa, Takashi Naoe.	339
7199	INFRARED THERMOGRAPHY AND DIC USED TO INVESTIGATE GUM METAL LOCALIZATION EFFECTS. Elzbieta Pieczynska, K.M. Golasiński, M. Staszczak, M. Maj, T.O. Furuta, S. Kuramoto.	341
7274	APPLICATION OF THREE-AXIS ACCELEROMETER ON VIBRATION ANALYSIS IN MACHINING PROCESSES. R.S. Gonçalves, Thalyta L. Santos, J.G.S. Jesus, Matheus S. Vieira.	343
SYMPOSIUM-2: MODELING OF FRACTURE AND FRAGMENTATION OF SOLIDS UNDER STATIC AND DYNAMIC LOADING. DETERMINISTIC AND PROBABILISTIC APPROACHES		345
7078	PERIDYNAMICS ANALYSIS OF GLASS FRACTURE UNDER EXPLOSION LOAD. Jian Tu, Li-jun Zhao, Shan Yu, Chun-liang Xin.	347
7079	PROTECTION OF STRUCTURES AGAINST LONG PROJECTILES. Alexander Gerasimov, Sergey Pashkov, Roman O. Cherepanov.	349
7099	MODELLING POROUS STRUCTURES AND MECHANICAL BEHAVIOUR OF CERAMICS USING PROBABALISTIC APPROACH. Igor Yu. Smolin, Valentina A. Mikushina, Pavel V. Makarov, Mikhail O. Eremin.	351
7100	MATHEMATICAL MODEL OF GENERATION AND PROPAGATION OF SLOW DEFORMATION FRONTS. Pavel V. Makarov, A. Yu. Peryshkin, Mikhail O. Eremin.	353
7128	MODELLING OF THE MECHANICAL RESPONSE OF Zr-Nb AND Ti-Nb ALLOYS IN A WIDE TEMPERATURE RANGE. Vladimir A. Skripnyak, Vladimir V. Skripnyak, Evgeniya G. Skripnyak, Nataliya V. Skripnyak.	355
7134	EXPERIMENTAL STUDY AND NUMERICAL MODELLING OF FRACTURE PROCESS TRANSITION TO BLOW-UP MODE. Pavel V. Makarov, Igor Yu. Smolin, Alexey S. Kulkov, Mikhail O. Eremin, Vladimir A. Tunda.	357
7145	PROBABILISTIC FAILURE OF CERAMICS UNDER HIGH-VELOCITY IMPACT. Sergey A. Zelepugin, Vladimir F. Tolkachev, Alexey S. Zelepugin.	359
7147	NUMERICAL SIMULATION OF THE EXPLOSIVE COMPACTION OF MULTI- COMPONENT MIXTURES. Sergey A. Zelepugin, Oksana Ivanova.	361
7185	DISCRETE ELEMENTS SIMULATION OF GEOLOGICAL FAULT FORMATION. Vadim Lisitsa, Vladimir Tcheverda, Victoria Valyanskaya.	363

7225	PENETRATION OF STEEL AND ICE BARRIERS BY A PROJECTILE AT LOW INITIAL SPEEDS (<325 m/s). Maxim Yu. Orlov, Yuri N. Orlov, Viktor P. Glazyrin, Yu. N. Orlova.	365
7234	ANALYSIS OF THE PENETRATION OF BARRIERS BY IMPACTORS WITH AN EXPLOSIVE SUBSTANCE. Viktor P. Glazyrin, Maxim Yu. Orlov, Yuri N. Orlov.	367
7263	A METHOD FOR DETERMINING RELIABILITY OF A SELECTED STRUCTURAL COMPONENT OF AN AIRCRAFT FROM THE POINT OF VIEW OF FATIGUE PROCESSES. Mariusz Zieja, Mirosław Zieja, Mariusz Ważny.	369
SYMPOSIUM-3:FRACTURE BEHAVIOUR AND FATIGUE DAMAGE OF STRUCTURES: THEORY AND EXPERIMENTS		371
7095	FRACTURE FRAMEWORK OF PLASTIC PIPES: EXPERIMENTAL WORK AND FINITE ELEMENT ANALYSIS OF DOUBLE POLYETHYLENE CANTILEVER BEAM SPECIMENS. Federico Rueda, César Hernández, Patricia Frontini.	373
7142	INFLUENCE OF MICROSTRUCTURE ON THE MECHANICAL BEHAVIOUR OF STEEL IN EXTREME ENVIRONMENT. Valeriy Lepov, Albert Grigoriev, Afanasiy Ivanov, V. Achikasova, Anastassia Ivanova, Nikolay Balakleiskii, Boris Loginov, Artem Loginov.	375
7146	EFFECT OF GRAPHITE MORPHOLOGY ON COMPACTED GRAPHITE IRON THERMOMECHANICAL FATIGUE PROPERTIES. Edwin A. Lopez, S. Ghodrat, Leo Kestens.	377
7206	FATIGUE IMPROVEMENT OF WELDED ELEMENTS BY ULTRASONIC IMPACT TREATMENT. Yuri Kudryavtsev.	379
7210	ULTRASONIC MEASUREMENT OF RESIDUAL STRESSES IN WELDED JOINTS. Yuri Kudryavtsev, Jacob Kleiman.	381
SYMPOSIUM-4:RELIABILITY OF TRIBOLOGICAL SYSTEMS AT VARIED LENGTH SCALES		383
7091	EFFECT OF SURFACE ENERGY ON FRICTION COEFFICIENT OF CARBONACEOUS HARD COATINGS BY IN-SITU MEASUREMENT IN ESEM. Taichi Nakao, Makoto Terada, Noritsugu Umehara, Motoyuki Murashim.	385
7154	THE INFLUENCE OF MOLECULAR CLUSTERS ON LUBRICATING FILM FORMATION. Antoni Jankowski, Mirosław Kowalski, Andrzej Kulezyczny, Wojciech Dziegielewski, Jarosław Kaluzny, Jerzy Merkisz.	387
7247	A NEW STOCHASTIC MODEL FOR PARTICULATE MATTER AND DEBRIS EMITTED BY DIESEL ENGINES. Fábio Oliveira, Daniel Lago, Manoel Oliveira Filho, João Medeiros.	389
7302	PROPOSAL OF DEVELOPMENT GUIDLINE FOR LOW FRICTIONAL MATERIAL IN OIL LUBRICATION WITH HIGH PERMITTIVITY MATERIAL. Motoyuki Murashima, See-Jun Oh, Takaaki Miyachi, Noritsugu Umehara, Takayuki Tokoroyama, Kota Konishi, Tatsuya Okamoto.	391
7306	THE WEAR OF DIAMOND-LIKE CARBON BY MOLYBDENUM BASED PARTICLES UNDER BOUNDARY LUBRICATION. Takayuki Tokoroyama, Takahiro Nishino, Makoto Yamaguchi, Khairul Kassim, Noritsugu Umehara.	393

SYMPOSIUM-5: ADDITIVE MANUFACTURING AND RAPID PROTOTYPING		395
7064	3D PRINTING TECHNIQUES OF CERAMIC CORES USED FOR TURBINE BLADES MANUFACTURING. Rafał Cygan.	397
7124	RESISTANCE OF 3D PRINTED POLYMER STRUCTURES AGAINST FATIGUE CRACK GROWTH. Johannes Knöchel, Michael Kropka, Thomas Neumeyer, Volker Altstädt.	399
7125	FATIGUE RESPONSE OF AS BUILT DMLS PROCESSED MARAGING STEEL AND EFFECTS OF MACHINING, HEAT AND SURFACE TREATMENTS. Dario Croccolo, Massimiliano De Agostinis, Stefano Fini, Giorgio Olmi, Francesco Robusto, Snezana Ciric-Kostic, Aleksandar Vranic, Nusret Muharemovic, Nebojsa Bogojevic.	401
7126	EXPERIMENTAL STUDY ON THE SENSITIVITY OF DMLS MANUFACTURED MARAGING STEEL FATIGUE STRENGTH TO THE BUILD ORIENTATION AND ALLOWANCE FOR MACHINING. Dario Croccolo, Massimiliano De Agostinis, Stefano Fini, Giorgio Olmi, Francesco Robusto, Nusret Muharemovic, Nebojsa Bogojevic, Aleksandar Vranic, Snezana Ciric-Kostic.	403
7214	HOW BUILD ORIENTATION AND THICKNESS OF ALLOWANCE MAY AFFECT THE FATIGUE RESPONSE OF DMLS PRODUCED 15-5 PH STAINLESS STEEL. Dario Croccolo, Massimiliano De Agostinis, Stefano Fini, Giorgio Olmi, Nebojsa Bogojevic, Snezana Ciric-Kostic.	405
7262	EVALUATION OF DIFFERENT NDT TECHNIQUES FOR THE PRODUCTION OF COMPOSITE MATERIALS FABRICATED BY ADDITIVE MANUFACTURING. J.P. Oliveira, Patrick L. Inácio, Fernando Crivellaro, Carlos P. Simão, E. Camacho, Rosa M. Miranda, A. Velhinho, F.M. Braz Fernandes, Telmo G. Santos.	407
SYMPOSIUM-6: FASTENING AND JOINING TECHNOLOGY		409
7122	A NOVEL FINITE ELEMENT MODEL METHODOLOGY FOR THE GENERIC MODELLING OF ADHESIVE AGEING. Mathias Creyf, Pol Coudeville, Wim Desmet, David Seveno, Stijn Debryne.	411
7136	INFLUENCE OF THE STIFFNESS AND FRICTIONAL CHARACTERISTICS ON THE SHANK TORQUE OF SCREWS IN BOLTED JOINTS. Dario Croccolo, Massimiliano De Agostinis, Stefano Fini, Giorgio Olmi, Francesco Robusto, Omar Cavalli, Nicolò Vincenzi.	413
7235	MECHANICAL PERFORMANCE AND FRACTURE BEHAVIOR OF ADHESIVE-MULTI PIN JOINTS BETWEEN COMPOSITE AND METALLIC MATERIALS. Longquan Liu.	415
7237	STRUCTURAL VALIDATION OF INTRAMEDULLARY NAILS: FROM EXPERIMENTATION TO VIRTUAL TESTING. Dario Croccolo, Massimiliano De Agostinis, Stefano Fini, Silvia Funaioli, Giorgio Olmi, Francesco Robusto.	417
7242	DESIGN INFLUENCES OF PRELOAD RELAXATION BEHAVIOUR IN BOLTED JOINTS USING ALUMINIUM PARTS. Jens Peth, Christoph Friedrich.	419
SYMPOSIUM-7: INFLUENCE OF MANUFACTURING PROCESSES IN INTEGRITY OF MECHANICAL OR STRUCTURAL COMPONENTS		421
7053	RELIABILITY ASSESSMENT OF A SUBSEA ELECTRO-HYDRAULIC CONTROL SYSTEM. António H.M. Silva, Henrique da Hora, Rogrigo Fernandes.	423

7054	VALUE STREAM MAPPING IN OPTIMIZING TERRESTRIAL PIPELINES ASSEMBLY. Nivaldo L. Coppini, Luíz F.C. Cunha.	425
7072	EVALUATION AND CHARACTERIZATION OF WEAR BEHAVIOUR OF ROLLED STEELS FOR THE PRODUCTION OF A SCREW. Ricardo Paulo, Teresa Morgado, Alexandre Velhinho, Carla Machado, J. Pamies Teixeira.	427
7073	STUDY OF WEAR BEHAVIOR OF A HELICAL GEAR. Miguel Mousinho, Teresa Morgado, David Braga, Alexandre Velhinho, Carla Machado, J. Pamies Teixeira.	429
7239	EXPERIMENTAL STUDY OF LASER BEAM MACHINING IN Ti6Al4V ALLOY. Gabriela Belinato, Danielle M.D. Costa, Pedro P. Balestrassi, Pedro A.R.C. Rosa.	431
7314	INTERACTION BETWEEN LEAN PHILOSOPHY AND INDUSTRY 4.0: EXPLORATORY STUDY. Beatrice P. Santos, Fernando C. Santos, Tânia M. Lima.	433
SYMPOSIUM-8: SUSTAINABLE ENERGY SYSTEMS		435
7056	DATA CENTERS AND THEIR ENERGY CONSUMPTION FOR CLIMATIZATION. Clito F. Afonso, João Moreira.	437
7088	NUMERICAL INVESTIGATION OF FILM COOLING EFFECTIVENESS USING THE ANTI-VORTEX CONCEPTION. Fadéla Nemdili, Saliha Nemdili, Abbé Azzi.	439
7115	A METHOD FOR HEAT TRANSFER CALCULATION IN FOUR-STROKE SPARK IGNITION INTERNAL COMBUSTION ENGINES. Pedro Carvalheira.	441
7116	A METHOD FOR MASS BURNING RATE CALCULATION IN FOUR-STROKE SPARK IGNITION INTERNAL COMBUSTION ENGINES. Pedro Carvalheira.	443
7281	EXPERIMENTAL AND NUMERICAL STUDY OF DIFFUSER AUGMENTED WIND TURBINE - DAWT. Lino M. Paulo, Jorge Paulo, João E. Ribeiro, Luíz F. Ribeiro.	445
SYMPOSIUM-9: OPTIMIZATION AND UNCERTAINTY QUANTIFICATION		447
7069	UNCERTAINTY QUANTIFICATION USING A NEW NON INTRUSIVE STOCHASTIC APPROACH: APPLICATION TO THE ESTABLISHMENT OF INUNDATION MAPS DUE TO DAM BREAK FLOWS. Azzeddine Abdedou, Azzeddine Soulaïmani.	449
7093	EFFECTIVE ESTIMATION OF CONFIDENCE IN THE VULNERABILITY ASSESSMENT OF UNCERTAIN STRUCTURAL SYSTEMS. Marco Vailati, Giorgio Monti.	451
7104	THE RELIABILITY INDEX APPROACH WITH EVOLUTIONARY ALGORITHMS: APPLICATION TO THE RBRDO PROBLEM OF COMPOSITE STRUCTURES. Gonçalo N. Carneiro, Carlos C. António.	453
7106	MULTI-OBJECTIVE OPTIMIZATION AIMING THE SUSTAINABLE DESIGN OF FRP COMPOSITE STRUCTURES. Carlos C. António. <i>(Invited Paper)</i>	455
7107	RESEARCH AND VALIDATION OF GLOBAL MPP IN THE RELIABILITY ANALYSIS OF COMPOSITE STRUCTURES. Luísa N. Hoffbauer, Carlos C. António.	457
7280	THE USE OF RESPONSE SURFACE OPTIMIZATION METHOD TO MINIMIZE THE VIBRATIONS IN THE MILLING PROCESS. João E. Ribeiro, Manuel B. César, Ana I. Pereira.	459

7313	RELIABILITY SYSTEM ANALYSIS FOR AIRCRAFT COMPOSITE STRUCTURES. Paola Caracciolo.	461
SYMPOSIUM-10: BIOMECHANICS OF CARDIOVASCULAR AND ORTHOPAEDIC DISEASE		463
7158	FLUID-STRUCTURE INTERACTION FOR HEMODYNAMIC STUDY IN PATIENT CORONARY ARTERIES - VALIDATION. Nelson Pinho, Catarina F. Castro, Carlos C. António, Nuno Bettencourt, Luisa. C. Sousa, Sónia I.S. Pinto.	465
7161	CORRELATION BETWEEN GEOMETRIC PARAMETERS OF LEFT CORONARY ARTERY AND PLAQUE DEPOSITION IN LEFT ANTERIOR DESCENDING ARTERY. Nelson Pinho, Catarina F. Castro, Carlos C. António, Nuno Bettencourt, Luisa C. Sousa, Sónia I.S. Pinto.	467
7178	HEMODYNAMICS IN PATIENT-SPECIFIC CORONARY ARTERIES CONSIDERING BLOOD ELASTIC BEHAVIOR: NUMERICAL STUDY. Sónia I.S. Pinto, João B.. Campos.	469
7289	LATERAL LUMBAR FUSION, A MINIMALLY INVASIVE SURGICAL APPROACH FOR LUMBAR INTERBODY FUSION. Susana C. Caetano, Luisa C. Sousa, Marco Parente, Renato Natal, Henrique Sousa, João Gonçalves.	471
7293	VESSEL DETECTION IN CAROTID ULTRASOUND IMAGES USING ARTIFICIAL NEURAL NETWORKS. Catarina F. Castro, Carlos C. António, Luisa C. Sousa.	473
SYMPOSIUM-12: MECHATRONICS DESIGN: APPLICATIONS AND CASE STUDIES		475
7183	DESIGN OF A CONTROL SYSTEM FOR A MEDICAL WRIST REHABILITATION DEVICE. Eurico Seabra, Luis F. Silva, Valdemar Leiras, Ricardo Ferreira.	477
7184	DESIGN, DEVELOPMENT AND CONSTRUCTION OF A MEDICAL WRIST REHABILITATION DEVICE. Eurico Seabra, Luis Silva, Ricardo Ferreira, Valdemar Leiras.	479
7249	HAND TENSOR: A FULL MOTION HAND PROSTHESIS WITH MECHANISMS BY ONE SINGLE TRACTION ENGINE. João E. Polis, Cecília Amélia Zavaglia, Carlos A. Cimini Jr.	481
7252	ASBGO*: A MECHATRONIC IMPROVED SMART WALKER. Joana Alves, Cristina P. Santos, Eurico Seabra, Luis F. Silva.	483
7278	TGK DYNAMIC ANALYSIS OF A HUMANOID RESCUE ROBOT. Gerardo García, Enrique Vazquez, Pedro de J. García, Jonathan A. Soto, Isidro Sanchez, Juan G. Sandoval.	485
SYMPOSIUM-13: STRUCTURAL DYNAMICS AND CONTROL SYSTEMS: THEORY, EXPERIMENTS AND APPLICATIONS		487
7114	THE EFFICIENCY OF USING ADDITIONAL ISOLATED UPPER FLOOR (AIUF) IN SEISMIC UPGRADING OF RESIDENTIAL R.C. FRAME BUILDINGS IN ARMENIA. Armen Assatourians, Mohammad Reza Mehrdoust, Sohrab Fallahi.	489
7143	DETECTION OF DEFECTS IN COMPOSITE HELMETS USING ULTRASONIC IR THERMOGRAPHY. Monika Pracht, Waldemar Swiderski.	491
7187	MODAL DECOMPOSITION PROCEDURES FOR FE-BASED STRUCTURAL MODELS WITH NON-PROPORTIONAL DAMPING. Evgueni Stanoev.	493

7218	EVALUATION OF DYNAMIC WHEEL LOAD CONSIDERING BALLAST FOULING DURING TRAIN PASSAGE. Chayut Ngamkhanong, Keiichi Goto, Sakdirat Kaewunruen.	495
7282	DYNAMIC CHARACTERIZATION OF MAGNETORHEOLOGICAL DAMPER AND EXPERIMENTAL ADJUSTMENT OF MODIFIED BOUC-WEN NUMERICAL MODEL. Said Boukerroum, Nadhira Kheznadji, Nacer Hamzaoui.	497
7284	INFLUENCE OF STIFFNESS AND STRENGTH DEGRADATION OF AN INFILL WALL UPON THE PERFORMANCE OF A TMD. Pedro L.P. Folhento, Manuel T. Braz-César, António M.V. Paula, Rui C. Barros.	499
7285	STRUCTURAL CONTROL OF A SDOF FRAME WITH NON-LINEAR HYSTERETIC BEHAVIOR USING A TUNED MASS DAMPER. Pedro L.P. Folhento, Manuel T. Braz-César, António M.V. Paula, Rui C. Barros.	501
7287	NUMERICAL STUDY OF VIBRATIONS IN THE MILLING PROCESS. Ana Isabel Pereira, Manuel Braz-César, João E. Ribeiro.	503
7288	THERMAL-BRIDGE ASSESSMENT IN GLAZING AND ALUMINIUM FRAMES BY THERMO-IMAGES: A CASE STUDY. Thiago Laignier, Manuel Braz-César, João Ribeiro.	505
7308	SEISMIC ANALYSIS OF THE IRREGULAR FIRE STATION BUILDING OF L'AQUILA. Marco Scagnetti, Rui C. Barros, Marco Mezzi.	507
7309	ON THE USE OF RADAR INTERFEROMETRY FOR THE STRUCTURAL MONITORING OF BRIDGES. Rui C. Barros, Fábio M. Paiva.	509
7310	DYNAMIC STRUCTURAL HEALTH MONITORING OF A TRANSMISSION TOWER USING INTERFEROMETRIC RADAR. Fábio M. Paiva, Rui C. Barros, Luís Guerreiro.	511
SYMPOSIUM-14: NEW PRODUCT DEVELOPMENT - DESIGN RESEARCH, MATERIALS SELECTION, INNOVATION SYSTEMS		513
7065	RELIABILITY AND FAILURE OF POLICY IMPLEMENTATION OF INCLUSIVE DESIGN: CASE STUDIES OF OPEN SPACE IN BEIJING, TAIPEI, AND HONG KONG. Kin W.M. Siu, Yi Lin Wong, Jia Xin Xiao.	515
7173	FAILURE OF SOCIAL INCLUSION IN PUBLIC SPACE: A CASE STUDY OF CHILDREN'S INCLUSIVE PLAYGROUND AND THEIR ENGINEERING STANDARDS IN HONG KONG. Yi Lin Wong, Mei Seung Lam, Kin W.M. Siu.	517
7231	TECHNICAL CONTRADICTIONS SOLVING TECHNIQUE IN PLANT MAINTENANCE. Ivan Masin.	519
7245	GUIDELINES FOR THE ALIGNMENT OF THE INTEGRATED MANAGEMENT SYSTEM WITH THE BUSINESS STRATEGY IN INDUSTRIAL COMPANIES. Luis C. Barbosa, Gilberto Santos, Otávio J. Oliveira.	521
7253	THE CONTRIBUTION OF DESIGN TO THE SUSTAINABLE DEVELOPMENT BY THE TRANSFORMATION OF "NON-PLACES" IN URBAN GARDENS FOR PRACTICING URBAN AGRICULTURE. António Barroso, Maria João Félix, Gilberto Santos.	523
7257	MATERIALS SELECTION AND INNOVATION SYSTEMS IN PACKING DESIGN FOR HEALTHY FOOD. Verónica Duarte, Maria João Félix.	525
7295	LINKING MOULD FILLING AND STRUCTURAL SIMULATIONS. Carlos N. Barbosa, Julio C. Viana, Markus Franzen, Thomas Baranowski, Ricardo Simões.	527

SYMPOSIUM-15: QUALITY AND PROCESS MANAGEMENT. THEORY, APPLICATIONS AND CASE STUDIES		529
7086	FABRICATION LABORATORIES: WHERE NEW DIGITAL TECHNOLOGIES COME TO LIFE. Laura Bravi, Gilberto Santos, Federica Murmura.	531
7113	DOUBLE-SHEAR W-S-W CONNECTIONS AT AMBIENT TEMPERATURE, WITH DIFFERENT APPLIED TENSILE LOADS AND STEEL DOWELS DIAMETER. Ruben D.A.R. Martins, Elza M.M. Fonseca.	533
7117	W-W-W CONNECTIONS IN DOUBLE-SHEAR AT AMBIENT TEMPERATURE: EFFECT OF THE APPLIED TENSILE LOAD AND DOWELS DIAMETER. Abderrahim Aissa, Elza M.M. Fonseca, Alvear P.M. Daniel.	535
7164	USING DMAIC FOR AUTOMATED IDENTIFICATION OF CAUSES AND MEASURES. Patrick Drange, Klaus Seiffert, Roland Jochem.	537
7175	MAINTENANCE PLANS FOR KNOWN FAULTS EVENTS ADJUSTED WITH FUZZY LOGIC SUPPORT. Joaquin S. Herrera, Jhonny Rodrigues, Miguel Strefezza.	539
7181	STATISTICAL ANALYSIS OF MAJOR ACCIDENT HAZARDS DATA: LEARNING FROM THE PAST TO DEVELOP A SAFETY CASE. Nasser M. Blahareth, Soliman A. Mahmoud.	541
7196	ADAPTING KANO'S THEORY FOR WEIGHTING AND IMPLEMENTING CUSTOMER REQUIREMENTS ON A SOFTWARE TOOL FOR ASSESSING HUMAN RELIABILITY IN MANUAL ASSEMBLY. Christian Kern, Robert Refflinghaus.	543
7211	DEVELOPING AND VALIDATING A MODEL OF ISO 9001 EFFECTIVENESS GAP: EMPIRICAL EVIDENCE FROM CHINA. Xiaojing Sun, Decheng Wen, Dongwei Yan.	545
7258	THE ANALYSIS OF THE HELICOPTER TECHNICAL READINESS BY MEANS OF THE MARKOV PROCESSES. Józef Żurek, Mariusz Zieja, Jarosław Ziółkowski.	547
7268	HUMAN FACTOR INFLUENCE ON EDDY CURRENT NON-DESTRUCTIVE TESTINGS. Carlos E. Silva, Rita C. Ferreira, Yasmin S. Martins, Dalton G. Souza, Ana C. Santos.	549
7272	R&R STUDY FOR VALIDATION OF THE MEASUREMENT SYSTEM OF A PROCESS FOR THE MANUFACTURE OF WIRE COILS IN A TEXTILE INDUSTRY. Fabricio A. Almeida, Vinicius R. Paula, Rachel C. Sabioni, Daniel S. Cortez, José H. Gomes, Pedro P. Balestrassi.	551
7273	R&R STUDY FOR ANALYSIS OF THE MEASUREMENT SYSTEM OF A PUMP LABELING PROCESS. Vinicius R. Paula, Rachel C. Sabioni, Fabricio A. Almeida, Petra N. Leite, José H. Gomes, Pedro P. Balestrassi.	553
7279	THE JOURNEY OF MULTI NATIONAL ENTERPRISES INTO BUSINESS AND HUMAN RIGHTS. Pasquale Vetta.	555
7283	CLUSTER ANALYSIS FOR ENHANCING PROCESS QUALITY IN JOB SHOP PRODUCTION. Antonia Fels, Max Ellerich, Robert Schmitt.	557
7299	AN ANALYSIS OF QUALITY CONTROL GAME BETWEEN ONLINE SHOPPING PLATFORMS AND SELLERS UNDER COMPLETE INFORMATION. Yaping Li, Decheng Wen, Dongwei Yan.	559

SYMPOSIUM-16: NEW MATERIALS AND DESIGN PROCESSES IN DENTAL MEDICINE		561
7061	MATHEMATICAL MODELING OF TECHNOLOGIES FOR THE DESIGN OF INNOVATIVE FUNCTIONAL BIO-COATINGS FOR DENTAL IMPLANTS. Alla V. Balueva, Iliia N. Dashevskiy.	563
7294	SURFACE CHANGES (SCANNING ELECTRON MICROSCOPE) INDUCED BY ARTIFICIAL SALIVA IN TITANIUM-MOLYBDENUM ORTHODONTIC LOOPS. Saul Castro, Maria Ponces, J.C. Reis Campos, Jorge Lopes, Maria Pollmann.	565
7298	COMPARATIVE STUDY OF FLEXURAL STRENGTH IN THERMOFORMABLE DENTURE BASE RESINS. Tomás Pacheco, José M. Rocha, Nuno V. Ramos, J.C. Reis Campos, Maria H. Figueiral.	567
7300	MAXILLARY AND MANDIBULAR SUPERIMPOSITIONS IN THE ASSESSMENT OF ORTHODONTIC TREATMENT OUTCOMES. Berta Meireles, Ana C. Braga, Lucinda G. Faria, Saul Castro, Maria João Ponces.	569
7311	GROWTH PATTERN OF FETAL FACIAL STRUCTURES AND ULTRASOUND DIAGNOSIS MEANS FOR OROFACIAL ANOMALIES. Inês Côte-Real, Rosete Nogueira, Ana C. Braga, J.C. Reis Campos, Francisco Valente, César Silva, Paula Vaz.	571
7312	BIS-ACRYL RESIN COLOR EVALUATION BEFORE AND AFTER SURFACE TREATMENTS AND IMMERSION IN COLORING BEVERAGES. Susane L. Gras, Joseane Silva, Paula Vaz, César Silva, J.C. Sampaio Fernandes, Claudia Volpato.	573
7315	BIOMEDICAL RAPID PROTOTYPING OF FREE-FORM SURFACES BY PLANAR CONTOURS METHOD. Hacene Ameddah, Hammoudi Mazouz.	575
7316	FORENSIC IDENTIFICATION TOOL IN DENTAL REMOVABLE PROSTHODONTICS. Adélia Fernandes, André Correia, Ana Margarida Silva, Cristina Figueiredo.	577
AUTHOR INDEX		579

PREFACE

IRF2018 is the sixth international gathering of a prestigious series of Integrity-Reliability-Failure conferences coordinated by the International Scientific Committee of Mechanics and Materials in Design. This series of conferences are wholly devoted to advances in mechanics, materials, structural integrity and design. IRF2018 is jointly sponsored by the University of Porto, the University of Toronto and the Portuguese Society for Experimental Mechanics. The conference attracted over 200 participants with 258 accepted submissions involving 702 authors from 42 different countries around the world. The conference themes which address novel and advanced topics on Integrity, Reliability and Failure focused on Automotive, Locomotive, Aerospace, Civil Engineering and Biomechanics, including Computational Mechanics, Experimental Mechanics, Fracture and Fatigue, Composite and Advanced Materials, Tribology and Surface Engineering, Mechanical Design and Prototyping, Biomechanical Applications, Civil Engineering Applications, Energy and Thermo-Fluid Systems, and Industrial Engineering and Management, among other topics.

The conference also included an Open Forum on “*Can Professors Balance Scholarly Work, Teaching and Administration? The Challenges Going Forward*”, where an expert panel with many years of collective and active researchers and educators addressed the issue of balancing the activities of teaching, research and services within the universities.

We believe that the meeting offered our delegates a forum for the discussion and dissemination of their recent work in assessing the integrity, reliability and failure of engineering structures, components and systems, fostered research that integrates mechanics and materials in the design process, and promoted exchange of ideas and international co-operation among scientists and engineers in this important field of engineering.

We are particularly indebted to the authors and special guests for their presentations. Each of the 258 contributions offered opportunities for thorough discussions with the authors. Particularly, we acknowledge the excellent contributions of the participants, their innovative ideas and research directions, the novel modeling and simulation techniques, and the invaluable critical comments. We are also indebted to the outstanding keynote speakers who highlighted the conference themes with their contributions and covered the main topics of the conference. We also take this opportunity to thank the members of the International Scientific Committee and the reviewers for their time and helpful suggestions, the symposia organisers for their efforts and valuable contributions to the success of the event, and the local organising committee for an absolutely superb organization of the meeting in this magnificent city. To all of you, we offer our gratitude.

Given the rapidity with which science is advancing in all areas related to the topics discussed in the present meeting, the next conference in this series (Integrity-Reliability-Failure / IRF2020) will take place in the beautiful city of Funchal/Madeira, in July 2020. Undoubtedly, we expect IRF2020 to be as stimulating and interesting as IRF2018, as evidenced by the excellent contributions offered in this current event. We look forward to seeing all of you in Madeira in July 2020.

Shaker A. Meguid and J.F. Silva Gomes
Lisbon / Portugal, July 2018

International Scientific Committee

Aben, H. (Estonia)	Kaleta, Jerzy (Poland)	Semenski, D. (Croatia)
António, C.C. (Portugal)	Kepka, M. (Czech. Rep.)	Senner, Veit (Germany)
Banks-Sills, L. (Israel)	Kuhn, Erik (Germany)	Silva Gomes, J.F. (Portugal)
Barros, R.C. (Portugal)	Meda, Alberto (Italy)	Tröster, T. (Germany)
Bragov, A.M. (Russia)	Meguid, S.A. (Canada)	Turmanidze, Raul (Georgia)
Chvojan, Jan (Czech Rep.)	Mileiko, S.T. (Russia)	Umehara, N. (Japan)
Croccolo, D. (Italy)	Mines, R. (UK)	Van Hemelrijck, D. (Belgium)
De Agostinis, M. (Italy)	Ng, T.Y. (Singapore)	Van Tooren, M. (USA)
Goldak, J. (Canada)	Nowell, David (UK)	Wang, Changguo (China)
Guagliano, M. (Italy)	Olmi, Giorgio (Italia)	Weng, G. (USA)
Hess, Peter (Germany)	Owen, D.R.J. (UK)	Xu, H. (China)
Igumnov, L.A. (Russia)	Pieczyska, E. (Poland)	Yoshino, Masahiko (Japan)
Ju, Yang (Japan)	Reddy, J.N. (USA)	Zhang, X. (China)

Institutional Sponsors

FEUP

*University of Porto
Portugal*

MADL

*University of Toronto
Canada*

APAET

*Port. Soc. Exp. Mechanics
Portugal*

Co-Chairs

J.F. Silva Gomes (*U. Porto*)

Shaker A. Meguid (*U. Toronto*)

Organizing Committee

Carlos C. António, Catarina F. Castro, Clito F. Afonso, José M. Cirne

J. Reis Campos, Paulo G. Piloto, Teresa Morgado

Conference Secretariat

Angélica Ruivo, Nuno Pinto

With the support of

ABREU-PCO, Professional Congress Organizer (<http://abreuevents.com/>)

Mercatura Conference System (<http://www.mercatura.pt>)

PAPER REF: 7260

THERMAL EFFECT OF A LOCALIZED FIRE IN THE STEEL STRUCTURE OF AN OPEN CAR PARK

Paulo A.G. Piloto^{1(*)}, Edson M.S. Junior^{1,2}, Francisco A.A. Gomes²

¹LAETA-INEGI, Department of Applied Mechanics, Polytechnic Institute of Bragança (IPB), Portugal

²Mechanical Engineering Department, Federal Technological University of Paraná (UTFPR), Brazil

(*)Email: ppiloto@ipb.pt

ABSTRACT

Due to the recent fire events in open car parks and in order to increase the fire safety in this type of the building structures, simple calculation methods should be developed to estimate the thermal effects of a localized fire. This investigation deals with a parametric analysis, using different fire events (different car class), fire scenarios (relative position of the car with respect to the main element of the structure and dimensions of the compartment) and section factor of the main supporting element of the structure (dimensions of the beam cross section). The temperature was calculated for each fire scenario, around the beam (gas temperature) and also in the steel beam. The thermal effect on part of the structure was calculated by a mixed formulation, taking into consideration the Hasemi and Heskestad methods to evaluate the temperature of the gas and also the lumped thermal model for the calculation of the steel temperature.

Keywords: open car parks, localised fire, gas temperature, steel temperature.

INTRODUCTION

Fire events in car parks have been a major problem for buildings, vehicles and humans, since this kind of buildings starts to become more popular. Vehicles have combustible materials that are the main cause for fire propagation. Few events in open car parks have been reported, the last happened on January 1st of 2018, at Liverpool Echo Arena, when 1400 cars were destroyed due to a big fire event, where the temperature reached 1000 °C and the building presents a huge damage level on slabs and other structural elements. The estimate time for fire propagation between vehicles has been experimentally determined to be 12 minutes. In the same research (D. Joyeux *et al.*, 2002) statistics say that, approximately 98% of the fires were restricted to less than 4 cars and the New Zealand study (Li Yuguang *et al.*, 2007) revealed that approximately in 97% of the fires only 1 burning car was involved. The Building Research Establishment (BRE, 2010) developed a project to gather information on the nature of fires involving car parks, resulting that 51% of the fires started with the ignition of a car, but in most cases, no fire spread to other cars was identified.

The thermal model of the fire event was realized in accordance to the ECCS report (ECCS, 1993). A total of 720 fire scenarios were simulated, taking into consideration 5 different section factors, 2 heights for the compartment ($H=3; 5\text{m}$), 4 different car classes and 6 radial positions ($R=1,2,3,4, 5\text{m}$) between car and steel profile. A mixed formulation has been used to define the gas temperature, applying the Heskestad model when the flames are not touching the ceiling and applying the Hasemi model when the flames are touching the ceiling. Both models are applicable in accordance to EN1991-1-2 (CEN, 2002). The temperature of the steel beam was determined by the thermal lumped model (CEN, 2005).

RESULTS AND CONCLUSIONS

The maximum temperature of the beam (T_{steel}) increases with the car class, see Figure 1. This temperature also decreases with the increase of the relative position (R), see Figure 2. Similar conclusions can be taken with respect to the gas temperature. The results were also compared with the software ELEFIR-EN (Fransen, J.-M *et al.*, 2016).

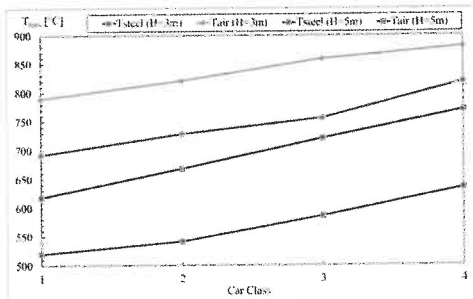


Fig. 1 - Maximum temperature for different car classes and H=3; 5m.

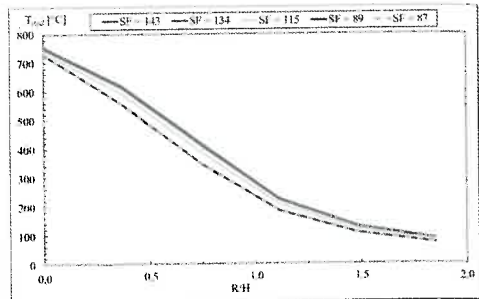


Fig. 2 - Maximum temperature for different section factors (SF), for car class 3.

The temperature of the element is an important design parameter to verify the stability of the beam and of the structure, by comparison to the limiting temperatures at which failure is expected to occur (620 °C for beams carrying floor slabs (Corus, 2004)).

REFERENCES

- [1] BRE, "Fire Spread in Car Parks". Building Research Establishment, Eland House Bressenden Place London, United Kingdom, 2010.
- [2] CEN. EN 1991-1-2 - Eurocode 1: Actions on structures - Part 1-2: General actions - Actions on structures exposed to fire. Brussels: CEN - European Committee for Standardization, pp. 59. 2002.
- [3] CEN. EN 1993-1-2 - Eurocode 3: Design of steel structures - Part 1-2: General rules - Structural fire design. Brussels: CEN - European Committee for Standardization, pp. 78. 2005.
- [4] Corus. "Steel-framed car parks". Corus Construction & Industrial, pp. 34. 2004.
- [5] D. Joyeux, J. Kruppa, L.-G. Cajot, J.-B. Schleich, P. van de Leur, L. Twilt, "Demonstration of real fire tests in car parks and high buildings", EU publications, technical steel research, ISBN 92-894-4234-4, Luxembourg, 2002, pp. 170.
- [6] ECCS, "Fire Safety in Open Car Parks", Modern Fire Engineering, Technical Committee 3, n°75, European Convention for Constructional Steelwork: Brussels, Belgium, 1993, pp. 90.
- [7] Fransen, J.-M. and Vila Real, P. (2016) The Computer Program "ELEFIR-EN", in Fire Design of Steel Structures: Eurocode 1-1-2: General Actions - Actions on Structures Exposed to Fire / Eurocode 3: Design of Steel Structures, Wiley-VCH Verlag GmbH & Co. KGaA, Weinheim, Germany. doi: 10.1002/9783433607008.
- [8] Li Yuguang, Spearpoint M J. Analysis of vehicle fire statistics in New Zealand parking buildings. Fire Technology, Vol. 43, No. 2, 2007, pp. 93-106.

About the Book:

This volume contains the extended Abstracts of papers accepted for presentation in the *IRF2018 - 6th International Conference on Integrity-Reliability-Failure* held in Lisbon/Portugal, 22-26 July 2018. The book is complemented by an accompanying USB-card containing the full length papers.

IRF2018 is the sixth international gathering of a prestigious series of Integrity-Reliability-Failure conferences coordinated by the International Scientific Committee of Mechanics and Materials in Design. This series of conferences is totally devoted to advances in mechanics, materials, structural integrity and design.

The organisation of IRF2018 was jointly sponsored by the University of Porto, the University of Toronto and the Portuguese Society for Experimental Mechanics. The conference attracted over 200 participants with 258 accepted submissions involving 702 authors from 42 different countries around the world.

The conference themes, which address novel and advanced topics on Integrity, Reliability and Failure focused on Automotive, Locomotive, Aerospace, Civil Engineering and Biomechanics, including Computational Mechanics, Experimental Mechanics, Fracture and Fatigue, Composite and Advanced Materials, Tribology and Surface Engineering, Mechanical Design and Prototyping, Biomechanical Applications, Civil and Structural Engineering Applications, Energy and Thermo-Fluid Systems, and Industrial Engineering and Management, among other topics.



ISBN: 978-989-20-8312-4