

# THERMAL ANALYSIS OF WOOD-STEEL HYBRID CONSTRUCTION

E. M. M. Fonseca \*; H. M. E. Ramos; H. J. G. Silva; D. R. S. M. Ferreira



\* IDMEC, Polytechnic Institute of Bragança, Portugal

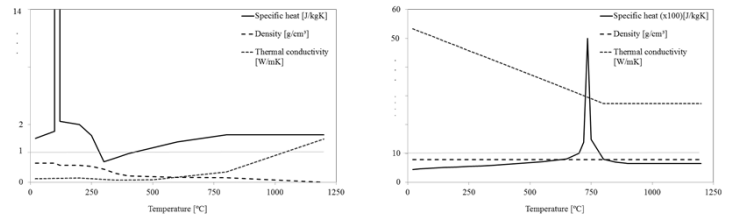
4th International Conference on INTEGRITY, RELIABILITY & FAILURE, Funchal, 23 - 27 June 2013

## KEYWORDS

- Wood-steel. Hybrid construction. Fire. Numerical model.



## 4- MATERIAL PROPERTIES

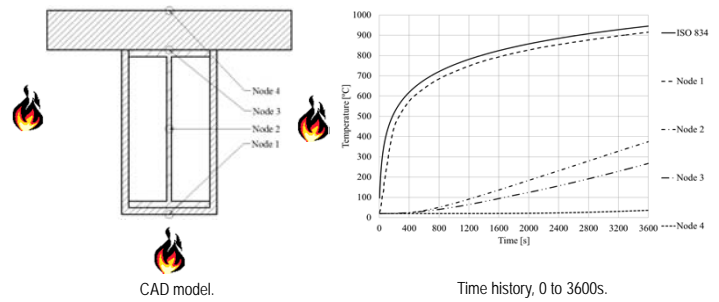


Wood and steel thermal properties.

## 1- INTRODUCTION

- The use of hybrid materials could increase the structural integrity of the construction elements.
- Steel material has many advantages over wood elements, strength, stability, resistance to woodworm, among others.
- Steel is incombustible and most of the times it can full recover strength after fire but, steel material conducts heat extremely well.
- Wood is a renewable resource, recently attracted by public attention.
- Wood is a natural material with good structural characteristics.
- The wood when exposed to accidental actions, such as fire conditions, has a surrounding charring depth.
- However, this layer can delay the heating process to the core section, acting as an insulating.

## 5- WOOD-STEEL HYBRID PROFILE AND FIRE SCENARIO



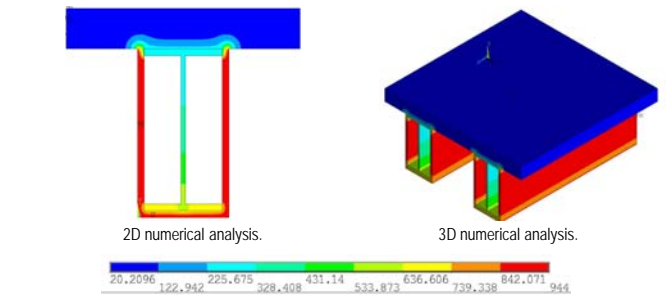
CAD model.

Time history, 0 to 3600s.

## 2- APPLICATIONS

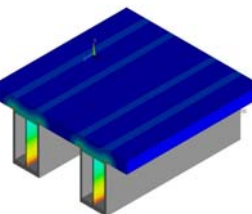


Wood-steel applications.



2D numerical analysis.

3D numerical analysis.

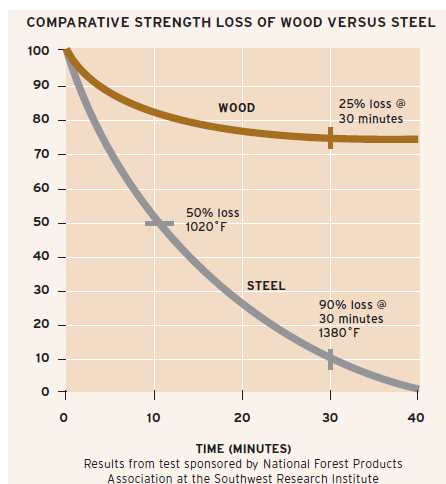


Charring layer of wood: 20°C-300°C.

- When wood material is externally applied to the steel profile, plays an important role as insulation, reducing the temperature inside steel.
- Wood has a good fire resistance even for three sides exposure, showing the ability to protect the steel.

## 3- OBJECTIVE AND WHY WOOD-STEEL MATERIAL?

- The main objective of this work is to provide the thermal analysis in wood-steel hybrid elements for building constructions under fire conditions.
- The use of wood-steel hybrid models has major advantages as increased fire resistance, improved high strength, leads to economic and ecologic benefits.
- The numerical modelling of these hybrid models, providing the analysis at high temperatures, is complicated due to the heat produced, to form a layer of carbonization surrounding the wood, and also the properties of both materials are nonlinear.
- The complexity of this analysis needs some numerical techniques with high performance, which is the case of the finite element analysis.
- Hybrid wood/steel material is used for new building projects, bridges, slabs, etc.



## 6- CONCLUSIONS

- Unprotected steel elements under fire condition may suffer serious damage.
- The use of hybrid wood/steel elements could increase both structural strength and stiffness.
- Wood could be considered as an insulating material, the core section could remain at low temperature, function of fire exposure time and element cross section size.

## REFERENCES

- EN 1995-1-2:2004. Eurocode 5: Design of timber structures, Part 1-2: General-Structural fire design, CEN, 2004.
- EN 1993-1-2:1995. Eurocode 3: Design of Structures - Part 1-2: General Rules - Structural Fire Design, CEN, 1995.
- EN 1991-1-2:2002. Eurocode 1: Actions on Structures - Part 1-2: General actions - Actions on Structures Exposed to Fire, CEN, 2002.



4th International Conference on INTEGRITY, RELIABILITY & FAILURE, Funchal, 23 - 27 June 2013

# IRF2013 PROGRAM

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## SUNDAY, 23 JUNE 2013

SUN, 14:00 - 18:30

EARLY-BIRD REGISTRATION

Lounge

Early-Bird Registration  
and  
Welcome Drink

## MONDAY, 24 JUNE 2013

MON, 09:00 - 09:30

OPENING SESSION

Main A.

Welcome to Participants  
(Conference Co-Chairs)  
Welcome Address  
(President of Regional Government / Dean of FEUP / Dean of U. Madeira)

MON, 09:30 - 10:15

PLENARY LECTURE I

Main A.

DYNAMIC CONTACT IN CONTINUA USING VARIATIONAL INEQUALITIES  
Professor Shaker A. Meguid  
(University of Toronto, Canada)  
Chair: Professor J.F. Silva Gomes (FEUP, Portugal)

MON, 10:15 - 11:00

PLENARY LECTURE II

Main A.

RECENT DEVELOPMENTS ON MPM AND ITS APPLICATION IN IMPACT AND EXPLOSION SIMULATION  
Professor Xiong Zhang  
(Tsinghua University, P. R. China)  
Chair: Professor Mário A.P. Vaz (FEUP, Portugal)

MON, 11:00 - 11:30

COFFEE-BREAK

Lounge

<b>MON, 11:30-13:00</b>		<b>SESSION 1A</b>	<b>Room A</b>
<b>Topic_A: ANALITICAL AND NUMERICAL TOOLS</b>			
<b>Chair:</b> <i>Xiong Zhang (Tsinghua University, China)</i>			
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3938	CHARACTERIZATION OF ALUMINIUM ALLOY CAPACITOR DISCHARGE JOINTS USING NON DESTRUCTIVE AND MECHANICAL TESTING. A.P. Carofalo, V. Dattoma, F. Palano, F.W. Panella.	61	
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3908	INFLUENCE OF SHOT PEENING ON THE FATIGUE RESISTANCE OF ALUMINUM ALLOY AA 7175-T74. Thiago A. Minto, Midori Y. Pitanga, Maria Odila H. Cioffi, Maria Cindra Fonseca, Herman J.C. Voorwald.	111	
4008	EVALUATION OF SHOT PEENING ON THE FATIGUE STRENGTH OF CUSTOM 465 STAINLESS STEEL FOR AERONAUTIC APPLICATION. Rafael G. Bonora, Herman J.C. Voorwald, Maria Odila H. Cioffi.	113	
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3964	STRESS REDISTRIBUTIONS PROVOKED BY THE USE OF EXPANSIVE SYSTEMS IN TIMBER STRUCTURES. Jose G. Fueyo, Manuel Dominguez, Jose A. Cabezas.	647	
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<b>Chair:</b> Jorge Lino (FEUP, Portugal)			
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4062	A FRAMEWORK FOR INTERACTING WITH ARTIFICIAL SYSTEMS. Peer M. Sathikh, S.G. Lee.	197	
3863	THE INFLUENCE OF CONTOURING ON THE TENSILE STRENGTH OF FUSED DEPOSITION MODELLING PROCESSED PARTS. Dario Croccolo, Massimiliano De Agostinis, Giorgio Olmi.	199	
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<b>MON, 13:00 - 14:00</b>	<b>LUNCH</b>	<b>REST</b>
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<b>MON, 14:00-15:30</b>	<b>SESSION 2A</b>	<b>Room A</b>
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<b>Topic_A: ANALITICAL AND NUMERICAL TOOLS</b>		
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3922	BUCKLING AND POST-BUCKLING ANALYSIS OF THIN-WALLED STRUCTURES BASED ON LARGE ROTATION FIRST-ORDER SHEAR DEFORMATION THEORY. S. Q. Zhang, R. Schmidt.	29
4000	RADIAL ACOUSTIC OSCILLATIONS OF HOLLOW ANISOTROPIC SPHERICAL SHELL SUBMERGED IN LIQUID. Valery A. Polyakov.	33
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<b>Chair:</b> <i>Yuri Kudryavtsev (SINTEC Inc., Canada)</i>		
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<b>Chair:</b> <i>Sergei Glavatskih (Machine Design, Sweden)</i>		
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4649	RESULTS OF THERMAL COMFORT EVALUATION WITH DIFFERENT CRITERIA. A. Quental Martins, Joana Guedes, J. Santos Baptista.	673	

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<b>Chair:</b> <i>Lino Maia (U. Madeira, Portugal)</i>			
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**TUESDAY, 25 JUNE 2013**

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<p><b>DESIGN FOR RELIABILITY AND MAINTAINABILITY</b>  <b>Professor E.A. Elsayed</b>                  (Rutgers University, USA)                  Chair: Professor Sergei T. Mileiko (Russian Academy of Sciences, Russia)</p>		

<b>TUE, 10:15 - 11:00</b>	<b>PLENARY LECTURE IV</b>	<b>A-101</b>
<p><b>ULTRA LOW FRICTION OF AMORPHOUS CARBON NITRIDE WITH CONTROLLING NANO SURFACE STRUCTURE</b>  <b>Professor Noritsugu Umehara</b>                  (Nagoya University, Japan)                  Chair: Professor Shaker A. Meguid (University of Toronto, Canada)</p>		

<b>TUE, 11:00 - 11:30</b>	<b>COFFEE-BREAK</b>	<b>Lounge</b>
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<b>Chair: Pedro Moreira (INEGI, Portugal)</b>		
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4758	UTILIZING RFM AND CONDITION MONITORING TO ENHANCING PROCESS SAFETY. Soliman A. Mahmoud.	103
4713	SIF DETERMINATION USING IMAGE PROCESSING TECHNIQUES. Paulo J. Tavares, Pedro M.G.P. Moreira.	105

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<b>Chair:</b> <i>Dario Croccolo (U. Bolonha, Italy)</i>			
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4077	ELASTIC AND INELASTIC PROPERTIES OF METAL-PORCELAIN COMPOSITES APPLIED TO FUNCTIONALLY GRADED METAL-CERAMIC DENTAL RESTORATIONS. Bruno Henriques, Delfim Soares, Filipe Silva.		267
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<b>TUE, 11:30-13:00</b>		<b>SESSION 4D</b>	<b>Room D</b>
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<b>Chairs:</b> <i>Álvaro Cunha (FEUP, Portugal), Elsa Caetano (FEUP, Portugal)</i>			
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<b>Chair:</b> <i>Mario Vaz (FEUP, Portugal)</i>			
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4040	AN APPROACH ON ARTHRITIS HIP SURFACE RESHAOING USING FINITE ELEMENT METHOD. Wei Li, Sarah Wayte, Damian Griffin, Derek Chetwynd, Ken Mao.		331
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<b>Chairs:</b> <i>Paulo Piloto (IPB, Portugal), Alberto Meda (U. Rome, Italy)</i>			
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4041	FIRE BEHAVIOUR OF COMPOSITE STEEL TRUSS AND CONCRETE BEAM. Paulo A.G. Piloto, Sérgio P.P.A. Roque, Paulo M.M. Vila Real, Giovanni A. Plizzari.	745
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4729	EXPERIMENTAL ANALYSIS OF REVERSE CHANNEL JOINT COMPONENT AT ELEVATED TEMPERATURES. Pedro Barata, Aldina Santiago, João P. Rodrigues.	749

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<b>Chair:</b> José Cirne (U. Coimbra, Portugal)			
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<b>TUE, 13:00 - 14:00</b>	<b>LUNCH</b>	<b>REST</b>

<b>TUE, 14:00-15:30</b>		<b>SESSION 5A</b>	<b>Room A</b>
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<b>Chair:</b> Paraskevas Papanikos (U. Aegean, Greece)			
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4064	DESIGN FOR ROBUSTNESS OF MULTI-STOREY REINFORCED CONCRETE FRAME STRUCTURES UNDER EXTREME LOADS. Ioan Petran, Mihai Senila.	231	

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<b>Chair:</b> Shaker A. Meguid (U. Toronto, Canada)			
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3984	HIGH TEMPERATURE AND HIGH PRESSURE NANOCCLAY MODIFIED DRILLING FLUIDS. Jamil Abdo, Danish Haneef, Abdullah Al-Shabibi.	307	
4032	MODELLING OF BUCKLING OF SINGLE-WALLED CARBON NANOTUBES BASED ON COSSERAT SURFACE THEORY. Yu Zhang, Carlo Sansour, Chris Bingham.	315	
4719	POLYVINYL ALCOHOL – CARBON NANOTUBE FIBERS RESPONSE UNDER PROGRESSIVE DAMAGE ACCUMULATION TENSILE TESTS. Stavros K. Kourkoulis, Nikolaos D. Alexopoulos.	323	

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3925	COMPARATIVE LINEAR AND NON-LINEAR TIME-HISTORY ANALYSIS OF AN EXPERIMENTAL PROTOTYPE STRUCTURE USING ADVANCED TECHNIQUES. Sebastian Crijanovschi, Gabriela M. Atanasiu.	593	
4039	PASSIVE-DAMPING DESIGN FOR STRUCTURAL VIBRATION CONTROL: A VELOCITY-FEEDBACK ENERGY-TO-PEAK APPROACH. Francisco Palacios-Quifonero, Josep M. Rossell, Josep Rubió-Massegú, Hamid R. Karimi.	595	
4028	LOCATING AND QUANTIFYING DAMAGES IN 3-D FRAME USING RESIDUAL ERROR METHOD AND NEURAL NETWORKS. Marília Marcy, Andrea Brasileiro, Gustavo Lima, Graciela Doz.	599	

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4066	OSSEOINTEGRATION OF DENTAL IMPLANTS IN rhBMP-2 INDUCED BONE AND STEM CELL-BASED INDUCED BONE: A HISTOLOGIC STUDY IN THE RABBIT PERI-IMPLANT DEFECT MODEL. Isabel Guerra, Helena Figueiral, Mário Vasconcelos, José R. Campos, Margarida Sampaio.	475	
4697	INDIRECT REPAIR OF METAL-CERAMIC RESTORATIONS: THE BONDING ISSUE. Paulo A. Guimarães, Paulo J. Almeida, Francisco Góis, João S. Fernandes.	479	
4653	PERI-IMPLANT BIOLOGICAL COMPLICATIONS AND OVERDENTURES. Margarida S. Fernandes, Paula Vaz, Patrícia Fonseca, José C. Reis Campos, Maria Helena Figueiral.	481	

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<b>TUE, 14:00-15:30</b>	<b>SESSION 5G</b>	<b>Room G</b>
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<b>Symp_12: VIBRATION AND STRUCTURAL ACOUSTICS ANALYSIS</b>		
<b>Chair:</b> César Vasques (INEGI, Portugal)		
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3981	COMBINING NEURAL NETWORKS FOR ONLINE DAMAGE DETECTION IN EULER-BERNOULLI BEAMS. Juliana Almeida, Hugo Alonso, Paula Rocha.	543
4082	THE INFLUENCE OF TEMPERATURE FIELD ON VIBRATION OF NANO, MICRO AND MINI BEAMS. Jurij Avsec.	545
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<b>TUE, 15:30 - 16:00</b>	<b>COFFEE-BREAK</b>	<b>Lounge</b>
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<b>TUE, 16:00-17:30</b>	<b>SESSION 6A</b>	<b>Room A</b>
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<b>Topic_H: MODES OF FAILURE</b>		
<b>Chair:</b> Volodymyr Hutsaylyuk (Military University of Technology, Poland)		
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4367	CORROSION STUDY OF SOME STAINLESS AND CARBON STEELS FOR STRUCTURAL APPLICATIONS. Rui A. Silva, Pedro R. Soares, António A. Crispim.	235
4720	TENSILE MECHANICAL BEHAVIOUR OF AERONAUTICAL 2024 AND 2198 ALUMINUM ALLOYS AFTER CORROSION EXPOSURE. Zoi S. Metaxa, Nikolaos D. Alexopoulos, Paraskevas Papanikos, Constantinos Stergiou.	237
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<b>Symp_5: BLOOD FLOW MECHANICAL BEHAVIOUR</b>		
<b>Chairs:</b> Catarina Castro (U. Porto, Portugal), Luisa Sousa (U. Porto, Portugal)		
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3898	STENOSED CAROTID BIFURCATION: HEMODYNAMICS AND WALL SHEAR STRESS. Luísa Sousa, Catarina Castro, Carlos C. António, Fernando Sousa, Rosa Santos, Pedro Castro, Elsa Azevedo.	463
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4776	NUMERICAL STUDY OF BLOOD FLOW IN A BIFURCATION WITH A STENOSIS: PULSATILE FLOW AND ELASTICITY OF THE FLUID. S.I.S. Pinto, E. Doutel, J.B.L.M. Campos, J.M. Miranda	469

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<b>Chair:</b> Andrey Nasedkin (Southern Federal University, Russia)			
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4721	FINITE ELEMENT MODELLING OF THE SHEAR STRESS DISTRIBUTION OF EMBEDDED POLYVINYL ALCOHOL – CARBON NANOTUBE FIBERS IN GLASS FIBER REINFORCED COMPOSITES. Paraskevas Papanikos, Ilias Tapeinos, Stavros K. Kourkoulis, Nikolaos D. Alexopoulos.	291	
3935	MODELLING THE PULLOUT OF HOOKED STEEL FIBERS FROM CEMENTITIOUS MATRIX. Edmunds Zile, Olga Zile.	293	
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<b>Chairs:</b> Humberto Varum (A. Aveiro, Portugal), Hugo Rodrigues (U. Aveiro, Portugal)			
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4754	RETROFIT OF RC COLUMNS CYCLICALLY LOADED IN BIAXIAL FLEXURE WITH AXIAL FORCE. J.P. Silva, P. Rocha, H. Rodrigues, N. Vila Pouca, A. Arêde.	613	
4755	CODE BASED DESIGN PROCEDURE AND ITS IMPACT ON REAL CONSTRUCTION PRACTICES IN NEPAL. Hemchandra Chaulagain, Hugo Rodrigues, Enrico Spacone, Humberto Varum.	615	
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<b>TUE, 16:00-17:30</b>		<b>SESSION 6E</b>	<b>Room E</b>
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<b>Chairs:</b> André Correia (FMDUP, Portugal), J.C. Reis Campos (FMDUP, Portugal)			
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4065	DENTAL IMPLANT PROSTHODONTIC REHABILITATION AND IL-1 GENE POLYMORPHISMS. Paula Vaz, João Fernandes, Ana Braga, António Felino, Maria Tavares.	485	
4043	RETROSPECTIVE EVALUATION OF THERAPEUTIC OUTCOMES OF FUNCTIONAL APPLIANCES COMBINED WITH HEADGEAR. Maria João Ponces, José P. Tavares, Eugénio Martins, Paula Vaz, Afonso Ferreira.	489	
4305	TOOTH GERMS IN PRENATAL ULTRASOUND – ITS IDENTIFICATION IS POSSIBLE?. Mariana Seabra, Paula Vaz, Francisco Valente, Ana Braga, António Felino.	493	

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<b>Chair:</b> Carlos C. António (FEUP, Portugal)			
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4622	STIFFENER LAYOUT OPTIMIZATION OF THE OVERALL BUCKLING OF THIN-WALLED STIFFENED PLATE. Lianchun Long, Yang Li .	517
4012	ADDRESSING GEOMETRICAL NONLINEARITY CONSIDERING PROBABLISTIC MATERIAL NONLINEARITY. Iffat Siddique.	521
4659	APPLICATION OF ANALYTICAL TARGET CASCADING TO THE DESIGN OF A RAILWAY VEHICLE SUSPENSION SYSTEM. Dário Silva, Hugo Policarpo, Miguel M. Neves, Virgínia Infante.	519

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<b>Chair:</b> César Vasques (INEGI, Portugal)			
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4733	NEW VIBRODYNAMIC PHENOMENA RELATIVE TO THE SPECIFIC VOLUME FORMS OF LOOSE/GRANULAR MATTER. Yuri Makov.	559	
4746	SOUND AND VIBRATION IN AN INTERDISCIPLINARY CONTEXT; SOME EXAMPLES FROM THE LAB. Jan Tro, Ulf Kristiansen.	561	
6001	SPACE QUALIFICATION OF AN ULTRA LOW-SHOCK NON-EXPLOSIVE ACTUATOR FOR HOLD-DOWN AND RELEASE MECHANISMS: INITIAL TESTS. O.M.F. Morais, C.M.A. Vasques, L.M.S. Guimarães, P.M.G. Salvado, C. Perestrelo, V. Pimenta, G. Baldesi.	NA	

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4750	X-RAYS TOMOGRAPHIC RECONSTRUCTION IMAGES OF MATERIALS USING INVERSE PROBLEM RESOLUTION BASED ON SPARSE REGULARIZATION METHOD. Aicha Allag, Redouane Draï.	439	
4634	DISPLACEMENT AND STRAIN FIELDS ASSESSMENT OF PDMS USING DIGITAL IMAGE CORRELATION. Bebiana Mendonça, João Ribeiro, Hernani Lopes, Pedro Martins, Mário A.P. Vaz, J.F. Silva Gomes.	447	
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4654	ON THE MECHANICAL FAILURE OF ARTERIAL PROSTHESES. Catarina F. Castro, Carlos C. António, Luísa C. Sousa.	465	
4045	MOUTHGUARD FOR ORTHODONTIC PATIENT TRUMPET PLAYER. Maria João Ponces, Saúl Castro, Maria Cristina Pollmann, Paula Vaz, Jorge Dias Lopes.	487	
4014	CONE BEAM COMPUTED TOMOGRAPHY AND PROSTHODONTIC REHABILITATION OF CLEIDOCRANIAL DYSOSTOSIS. Paula Vaz, Maria Ponces, Inês Corte-Real, Afonso Ferreira, José R. Campos.	491	
4306	PRENATAL ULTRASOUND SCREENING, TOOTH GERMS HISTOLOGY AND HYPODONTIA. Mariana Seabra, António Felino, Francisco Valente, Rosete Nogueira, Paula Vaz.	495	
4682	INOVATIVE HYBRID JOINT TECHNIQUE THROUGH FRICTION STIR WELDING AND ADHESIVE BONDING. Daniel F.O. Braga, Ana Silva, Miguel A.V. Figueiredo, L.F.M. Silva, Pedro M.G.P. Moreira.	533	
4715	STUDY OF ALTERNATIVE MANUFACTURING PROCEDURES FOR AN ALUMINIUM RAILWAY CAR PASSENGER UNDERFRAME. João P.A. Dias, Daniel F.O. Braga, Sérgio M.O. Tavares, Pedro M.G.P. Moreira, Paulo M.S.T. Castro.	535	
3952	A PARAMETRIC STUDY ON THE INFLUENCE OF VARIOUS PARAMETERS ON THE UNDERWATER NOISE LEVELS GENERATED BY OFFSHORE PILE DRIVING. Gargi Kaushik, Apostolos Tsouvalas, Andrei Metrikine.	541	
4092	MECHANICAL CONTROL OF INELASTIC CHARACTERISTICS, DEFECT NANOSTRUCTURE CHANGING OF SiO <sub>2</sub> + Si WAFER-PLATE, GeSi. A.P. Onanko, S.A. Vyzhva, Y.A. Onanko.	547	
4684	DYNAMIC RESPONSE OF LAYERED SATURATED SOIL SUBJECT TO SUBWAY TRAIN LOADS. Ding YuQin, Chen ChunLai, Gao ShuWei, Tao Rong.	555	

4751	DECONVOLUTION ALGORITHMS AND THEIR APPLICATIONS IN ULTRASONIC INSPECTION OF CFRP MATERIAL. Abdessalem Benammar, Redouane Draï.	563
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4689	A NONLINEAR SOIL CONSTITUTIVE MODEL BASED ON HYPERBOLIC TANGENT FUNCTION. YuQin Ding, YongXing Zhang.	611

<b>TUE, 19:00 - 23:00</b>	<b>BANQUET</b>	<b>Casino</b>
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**WEDNESDAY, 26 JUNE 2013**

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4651	MODEL FIRE OF TWO STOREY WOODEN - FRAME BUILDING. Linda Makovická Osvaldová, Anton Osvald, Martin Petho.	653
4102	A CONTRIBUTION TO ASSESS THE STRUCTURAL VULNERABILITY OF TRADITIONAL TIMBER PAVEMENTS. Marcos Teixeira, Débora Ferreira, Vítor Cunha, Artur Feio, José Lousada, Humberto Varum, João M. Guedes, Jorge Pinto.	655
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4090	THERMAL ANALYSIS OF WOOD-STEEL HYBRID CONSTRUCTION. Elza M.M. Fonseca, H.M.E. Ramos, H.J.G. Silva, Débora R.S.M. Ferreira.	659
4646	PROPOSAL OF A PATH TO SELECT A MATRICIAL METHOD FOR RISK ASSESSMENT. Cátia Ferreira, J. Santos Baptista.	669
4656	DEVELOPMENT AND MECHANICAL CHARACTERIZATION OF BIO-COMPOSITES FOR APPLICATION IN LIGHT-WEIGHT CONSTRUCTION. A. Alves, J. Velosa, S. Patinha, S. Rana, R. Fangueiro.	723
3924	A DSP SYSTEM APPLIED TO ELECTROMECHANICAL IMPEDANCE-BASED SHM ARCHITECTURE. Carlos A. Gallo, Antonio C. Oliveira Jr, Roberto M.F. Neto.	731
4736	PRACTICAL DETERMINATION OF A RELIABILITY TEST SCOPE. Zdenek VINTR.	761
4763	DIMENSIONAL CONTROL CASE STUDY IN A PUNCHING CELL. J.M. Herrera Olivenza, D. Rodríguez Salgado, I. Cambero Rivero, J. García Sanz-Calcedo.	767
4700	INFLUENCE OF AGEING OVER NON ACTIVE MEDICAL DEVICES. Maria José Abreu.	777
4054	ULTRASONIC PEENING IN INDUSTRIAL APPLICATIONS. Jacob Kleiman.	815
3967	ANALYTICAL AND NUMERICAL ASSESMENT OF FATIGUE PROPERTIES IN ROLLING BEARINGS. Paweł Romanowicz, Bogdan Szybiński.	809
4743	INFLUENCE OF COMPOSITE PATCH REPAIR ON FATIGUE CRACK GROWTH OF 6061 AL-ALLOY . Mustapha Benachour, Nadjia Benachour, Mohamed Bengueidba.	827

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<b>Chair:</b> <i>Aleksander Muc (Cracow U.T., Poland)</i>			
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3965	ON THE OPTIMAL CHOICE OF STRESS RELIEF GROOVES IN FLAT WELDED ENDS FOR PRESSURE VESSELS. Bogdan Szybiński.		807
3968	APPLICATION OF MULTIAXIAL HIGH-CYCLE FATIGUE CRITERIA IN ANALYSIS OF ROLLER BEARINGS. Paweł Romanowicz.		811
3975	MODELING OF FATIGUE DAMAGE EVOLUTION IN COMPOSITE STRUCTURES. Aleksander Muc, Piotr Kędziora, Zbigniew Krawiec.		813
4335	EFFECTS OF FATIGUE ON THE INTEGRITY OF A FRICTION STIR WELDED STRINGER-TO-SKIN LAP JOINT CONTAINING RESIDUAL STRESSES. Michael Bach, Ali Merati, Michael Gharghoury.		817

<b>WED, 09:30-11:00</b>		<b>SESSION 7B</b>	<b>Room B</b>
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<b>Chairs:</b> <i>Marek-Jerzy Pindera (U. Virginia, USA), Marcio A.A. Cavalcante (F.U. Alagoas, Brazil)</i>			
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4676	EVALUATION OF EFFECTIVE THERMAL CONDUCTIVITY OF PERIODIC COMPOSITES WITH THERMAL BARRIER. Romildo S. Escarpini Filho, Severino P.C. Marques.		787
4069	SOME APPROACHES FOR THE DETERMINATION OF EFFECTIVE PROPERTIES OF ACTIVE MULTIPHASE COMPOSITES. Andrey V. Nasedkin, Anna A. Nasedkina, Vladimir V. Remizov, Maria S. Shevtsova.		789
4308	FAILURE RESPONSE OF FIBER-EPOXY UNIDIRECTIONAL LAMINATE UNDER TRANSVERSE TENSILE/COMPRESSIVE LOADING USING FINITE-VOLUME MICROMECHANICS. Zhanwen Tang, Boming Zhang, Yalin Yu.		791
3894	A UNIFIED METHODOLOGY FOR THE HOMOGENIZATION OF PERIODIC MATERIALS WITH DAMAGE. Wenqiong Tu, Marek-Jerzy Pindera.		793

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<b>Symp_11: INNOVATIVE JOINING PROCESSES</b>			
<b>Chair:</b> <i>Pedro Moreira (INEGI, Portugal)</i>			
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4674	AA6082-T6 FRICTION STIR WELDED T JOINTS OPTIMIZATION. Ana C. F. Silva, Daniel F.O. Braga, M.A.V. Figueiredo, Pedro M.G.P. Moreira.		529
4675	AA6082-T6 FRICTION STIR WELDED BUTT JOINTS OPTIMIZATION. Ana C. F. Silva, Daniel F.O. Braga, M.A.V. Figueiredo, Pedro M.G.P. Moreira.		531

<b>WED, 09:30-11:00</b>		<b>SESSION 7D</b>	<b>Room D</b>
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<b>Chair:</b> <i>Rui C. Barros (U. Porto, Portugal)</i>			
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4006	DYNAMIC BEHAVIOUR OF A GUYED TOWER: DESIGN STUDY. Cecília Mendonça, Rui C. Barros.		569

4031	DESIGN OF LATTICE WIND TOWERS AND COMPARISON WITH THE TYPICAL SELF-SUPPORTED TUBULAR TOWERS. Jorge Henriques, Rui C. Barros.	571
4692	A DISPLACEMENT FORMULATION FOR CYLINDRICAL SHELLS UNDER RADIAL LOADS. Luísa Madureira, Elza M.M. Fonseca, Rui C. Barros.	573
4756	PASSIVE CONTROL OF CIVIL ENGINEERING STRUCTURES. Manuel Braz-César, Rui C. Barros.	575

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<b>Chairs:</b> <i>Marcelo Moura (U. Porto, Portugal), Nuno Dourado (UTAD, Portugal)</i>			
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4351	MODE II FRACTURE CHARACTERIZATION OF BOVINE BONE USING THE ENF TEST. F.A.M. Pereira, M.F.S.F. Moura, N. Dourado, J.J.L. Morais, F. Silva, M.I.R. Dias.	501	
4650	EFFECT OF BONE COMPOSITION AND APPARENT DENSITY ON LOCAL VARIATION IN ELASTIC AND PLASTIC MODULI OF CORTICAL BONE. N.K. Sharma, D.K. Sehgal, R.K. Pandey.	503	
4680	LOWER LIMB MATHEMATICAL MODELING WITH INERTIAL MOTION CAPTURE DURING NORMAL WALKING. Gennady Aryassov, Artem Kuznetsov, Victor Musalimov, Sergei Zhigailov.	505	

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<b>Topic_N: CASE STUDIES</b>			
<b>Chair:</b> <i>Jan Chvojan (VZU Plzen, Czech Rep)</i>			
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3909	SEISMIC EVALUATION OF A RC BRIDGE WITH MONOLITHIC CONNECTION OF MULTI-CELL CIRCULAR DECK AND PIERS. Omid Afsharian Zadeh, Araliya Mosleh.	389	
3931	A REVIEW ON CONSTRUCTION DETAILS THAT INFLUENCE THE STABILITY OF BRICK FAÇADES. Tiago T. Martins, Borja J. Salado, Suyapa Sánchez-Toscano, Ramón A. Cabal.	391	
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3971	FATIGUE SERVICE LIFE TEST OF THE TRIPPLE HYBRID HYDROGEN FUEL CELL BUS STRUCTURE. Jaroslav Václavík, Jan Chvojan.	395	

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<b>Chairs:</b> <i>Júlio C. Viana (Critical Materials, Portugal), Gustavo Dias (Critical Materials, Portugal)</i>			
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3911	IN-SITU STRUTURAL INTEGRITY EVALUATION FOR A HIGH POWER PULSED SPALLATION NEUTRON SOURCE. Masatoshi Futakawa, Takashi Wakui, Makoto Teshigawara, Takashi Naoe.	729	
3990	IMPACT & DAMAGE LOCATION IN COMPOSITE STRUCTURES BY SPATIAL SIGNAL CORRELATION ANALYSIS. Júlio C. Viana, Nelson J. Ferreira, Paulo J. Antunes, Gustavo R. Dias.	733	
4122	DEVELOPMENT OF INTELLIGENT HEALTH MONITORING SYSTEM FOR ROTATING MACHINERY AND STRUCTURAL COMPONENTS. A.A. Lakis, Ali Mahvash, M.H. Toorani.	735	
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<b>Chairs:</b> <i>Clito Afonso (U. Porto, Portugal)</i>			
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4049	THE EFFECT OF THERMAL BARRIER COATING ON THE LIFE EXTENTION OF A GAS TURBINE ROTARY BLADE. Reza Torabideh, Saeed A. Kouhanjani, Hamid M. Zoka, Maryam Torfeh, Reza Ghorbani.	363	
4112	OPTIMIZATION OF FUEL CONSUMPTION IN COMPRESSOR STATIONS. T.M. Elshiekh, H.A. El Mawgoud.	365	
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<b>Symp_32: FAILURE AND FATIGUE OF STRUCTURAL ELEMENTS</b>			
<b>Chair:</b> <i>Aleksander Muc (Cracow U.T., Poland)</i>			
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4677	ULTRASONIC MEASUREMENT OF RESIDUAL STRESSES IN WELDED ELEMENTS. Yuri Kudryavtsev.	821	
4705	UNDERWATER ULTRASONIC PEENING OF WELDED ELEMENTS AND STRUCTURES. Yuri Kudryavtsev, Jacob Kleiman, Alexander Lugovskoy.	823	
4711	CHARACTERIZATION OF X60 STEEL GRADE UNDER ULTRA LOW CYCLE FATIGUE LOADING. João Pereira, Abílio Jesus, José Xavier, António A. Fernandes.	825	

<b>WED, 11:30-13:00</b>		<b>SESSION 8B</b>	<b>Room B</b>
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<b>Chairs:</b> <i>Marcio A.A. Cavalcante (F.U. Alagoas, Brazil), Marek-Jerzy Pindera (U. Virginia, USA)</i>			
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4239	DISPERSION MONITORING ANALYSIS AND OPTIMISATION FOR EPOXY NANOREINFORCEMENT. Alkiviadis Paipetis, Giorgos Gkikas.	797	
3933	HOMOGENIZATION OF MAGNETORHEOLOGICAL ELASTOMERS CONSIDERING GEOMETRICAL NONLINEARITIES. George Chatzigeorgiou, Ali Javili, Paul Steinmann.	799	
3887	TARGETING THE RESPONSE OF BIOLOGICAL TISSUE VIA FINITE-VOLUME MICROMECHANICS. Wenqiong Tu, Marek-Jerzy Pindera.	801	

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<b>Chairs:</b> <i>Raúl Figueiro (U. Minho, Portugal), Sohel Rana (U. Minho, Portugal)</i>			
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4091	FLEXURAL BEHAVIOUR OF BRICK MASONRY RETROFITTED WITH BRAIDED TEXTILE MESHES. Graça Vasconcelos, Juan Mora, Raul Figueiro, Fernando Cunha, Andreia Martins.	713	

3940	DEVELOPMENT OF NEW BRAIDED FIBROUS MATERIALS FOR RETOFITING OF MASONRY WALLS. Fernando Cunha, Sérgio Patinha, Sohel Rana, Raul Fangueiro, Graça Vasconcelos.	715
4076	MICRO-STRUCTURE AND MECHANICAL PROPERTIES OF CARBON NANOTUBE/CEMENT NANOCOMPOSITES. Shama Parveen, Sohel Rana, Raul Fangueiro.	717
3999	COMPARATIVE ASSESSMENT OF FRP'S AND STEEL BARS APPLIED ON THE REINFORCEMENT OF CONCRETE STRUCTURES. Sérgio Patinha, Sara Neiva, Sohel Rana, Raul Fangueiro, Luís Bragança, Ricardo Mateus.	719
4011	VARIOUS CONTROL METHODS DEVELOPED FOR FIBRE- CONCRETE STRUCTURES. Leonard Hobst, Petr Bílek.	721

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4774	DETERMINATION OF THE CONCRETE COHESIVE LAW UNDER MODE I LOADING USING AN INVERSE METHOD. N. Dourado, F. Silva, J. Xavier, M.S.F.S. Moura	635	

<b>WED, 11:30-13:00</b>		<b>SESSION 8E</b>	<b>Room E</b>
<b>Symp_30: MEDICAL DEVICES AND HEALTHCARE MATERIALS</b>			
<b>Chairs:</b> <i>Maria José Abreu (U. Minho, Portugal), André Catarino (U. Minho, Portugal)</i>			
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4060	TEXTILE DESIGN OF STUCTURES WITH FUNCTIONAL PROPERTIES REPELLENCE FLYER OF MALARIA. Cláudia Pinheiro, Maria José Geraledes.	775	
4701	APPLICATIONS OF TEXTILE BASED ELECTRODES IN GAIT ANALYSIS – PROLIMB PROJECT. André Catarino, Ana M. Rocha, Maria José Abreu, José M. Silva, José C. Ferreira, Vítor G. Tavares, Miguel V. Correia, Fardin Derogarian, Ruben Dias.	779	
4752	NARROW BAND IMAGING TECHNIQUE FOR ENDOSCOPY IN THE SMALL BOWEL. M.F. Silva, S. Lamas, C. Costa, C. Lima, C. Silva, G. Minas, P.M. Mendes, J.P. Carmo, L.M. Goncalves, J.H. Correia.	781	

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<b>Chair:</b> <i>Jorge Lino (U. Porto, Portugal)</i>			
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4726	CELLULAR AUTOMATON METHOD APPLIED FOR MICROSTRUCTURE PREDICTION OF Al-Si CASTING TREATED BY LASER BEAM. Zenon Ignaszak, Paweł Popielarski, Jakub Hajkowski, Bartłomiej Dudziak, Marek Gościański.	401	
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4679	STRUCTURAL DESIGN OF A COMPOSITE VARIABLE-SPAN WING. Pedro D.R. Santos, Pedro V. Gamboa, Pedro M.B. Santos, José M.A. Silva.	407	

4708	MAINTENANCE ON CONDITION AND CORRECTIVE MAINTENANCE: EMPHASIS ON ASSET RELIABILITY IN INDUSTRIAL SECTOR. Eloi Dutra, Claudinei J. Oliveira, Gilmar Cordeiro, Thiago H.A. Souza.	409
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<b>WED, 11:30-13:00</b>		<b>SESSION 8G</b>	<b>Room G</b>
<b>Symp_1: SMART STRUCTURES AND MATERIALS</b>			
<b>Chair:</b> <i>Maria José Galdes (UBI, Portugal)</i>			
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4056	A MECHANICAL ANALYSIS OF MAGNETORHEOLOGICAL COMPOSITES USED FOR DAMPING OF THE VIBRATION. Anna Boczkowska, Stafan F. Awietjan, Danuta Miedzinska, Grzegorz Slawinski, Tadeusz Niezgoda.		417
4086	FUNCTIONAL KINITTING FOR CHILDREN SEGMENT: THE "DRY BABY" BODY. Ana Luiza Olivete, Maria José Galdes.		419
4626	STATIC AND DYNAMIC SHAPE CONTROL OF LAMINATED BEAMS WITH RESISTEVELY INTERCONNECTED PIEZOELECTRIC PATCHES. Juergen Schoeftner, Gerda Buchberger.		421
4671	CHARACTERIZATION OF THERMOPLASTIC-COMPATIBLE PIEZOCERAMIC MODULES FOR FUNCTION INTEGRATIVE COMPOSITE STRUCTURES. T. Heber, M. Gude, W. Hufenbach, M. Dannemann, A. Winkler, T. Weber.		423

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<b>Symp_20: THERMODYNAMICS AND THERMO-FLUID SYSTEMS</b>			
<b>Chairs:</b> <i>Clito F. Afonso (FEUP, Portugal) and Carlos C. António (FEUP, Portugal)</i>			
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4059	FLUID, NANOFLUID AND MAGNETIC FLUID SLIP FLOW IN RECTANGULAR AND CIRCULAR MICROCHANNELS AND MINICHANNELS. Jurij Avsec.		689
4084	INTEGRITY, RELIABILITY & FAILURE IN REFRIGERATION SYSTEMS FOR DRAUGHT DRINKS. Clito F. Afonso, João Faria, Armando Oliveira, Miguel Tavares, Ricardo Reis, Joaquim Gabriel, Armando Araujo, Jorge Dias Pires, Cristina Silva.		691
4118	OPTIMIZATION OF THE ANNUAL SOLAR IRRADIATION AVAILABILITY IN URBAN ENVIRONMENT. Carlos C. António, João B. Monteiro, Clito F. Afonso.		693
4773	THERMAL IMPROVEMENTS IN HOUSEHOLD REFRIGERATORS. Clito F. Afonso		695

<b>WED, 13:00 - 13:30</b>		<b>CLOSING SESSION</b>	<b>Room A</b>
<p><b>CLOSING SESSION</b> (Conference Organizing Committee)</p>			

<b>WED, 13:30 - 15:00</b>		<b>LUNCH</b>	<b>REST</b>
<p><b>LUNCH AND END OF CONFERENCE</b></p>			

# IRF2013 PROGRAM

FUNCHAL, 23-27 JUNE 2013

Time	SUNDAY ( JUNE 23 )	MONDAY ( JUNE 24 )	TUESDAY ( JUNE 25 )	WEDNESDAY ( JUNE 26 )	THURSDAY ( JUNE 27 )
08:00		REGISTRATION	REGISTRATION	REGISTRATION	<b>TECHNICAL VISITS AND CRUISE TO PORTO SANTO</b>
09:00	OPENING SESSION		POSTERS SESSION II Topics: H to N	POSTERS SESSION IV Symposia 16 to 32	
10:00	PLENARY SESSION I Prof. Shaker Meguid (U. Toronto, Canada)	PLENARY SESSION III Prof. E.A. Elsayed (Rutgers University, USA)	PLENARY SESSION III Prof. E.A. Elsayed (Rutgers University, USA)	Session 7A (Symp-32)	
	PLENARY SESSION II Prof. Xiong Zhang (U. Tsinghua, China)	PLENARY SESSION IV Prof. Noritsugu Umehara (Nagoya Univ., Japan)	PLENARY SESSION IV Prof. Noritsugu Umehara (Nagoya Univ., Japan)	Session 7B (Symp-31)	
11:00	COFFEE-BREAK	COFFEE-BREAK	COFFEE-BREAK	Session 7C (Symp-11)	
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	Session 1B (Topic-B)	Session 4B (Topic-B)	Session 4B (Topic-B)	Session 7E (Symp-7)	
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	Session 1D (Topic-D)	Session 4D (Symp-14)	Session 4D (Symp-14)	Session 7G (Symp-27)	
	Session 1E (Topic-E)	Session 4E (Topic-K)	Session 4E (Topic-K)	Session 7H (Topic-L)	
	Session 1F (Symp-18)	Session 4F (Symp-28)	Session 4F (Symp-28)		
	Session 1G (Topic-G)	Session 4G (Topic-M)	Session 4G (Topic-M)		
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14:00	Session 2A (Topic-A)	Session 5A (Topic-H)	Session 5A (Topic-H)	LUNCH & END OF CONFERENCE	
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	Session 2E (Symp-3)	Session 5E (Symp-6)	Session 5E (Symp-6)		
	Session 2F (Symp-19)	Session 5F (Symp-10)	Session 5F (Symp-10)		
	Session 2G (Symp-21)	Session 5G (Symp-12)	Session 5G (Symp-12)		
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16:00	Session 3A (Topic-A)	Session 6A (Topic-H)	Session 6A (Topic-H)		
	Session 3B (Topic-B)	Session 6B (Symp-5)	Session 6B (Symp-5)		
	Session 3C (Topic-I)	Session 6C (Topic-I)	Session 6C (Topic-I)		
	Session 3D (Topic-D)	Session 6D (Symp-15)	Session 6D (Symp-15)		
	Session 3E (Symp-4)	Session 6E (Symp-6)	Session 6E (Symp-6)		
	Session 3F (Symp-19)	Session 6F (Symp-10)	Session 6F (Symp-10)		
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17:00	POSTERS SESSION I Topics: A to G	POSTERS SESSION III Symposia: 1 to 15	POSTERS SESSION III Symposia: 1 to 15		
18:00	CONFERENCE RECEPTION	CONFERENCE BANQUET	CONFERENCE BANQUET		
19:00					
20:00					