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# 35<sup>TH</sup> DANUBIA ADRIA SYMPOSIUM ON ADVANCES IN EXPERIMENTAL MECHANICS

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# TABLE OF CONTENTS

<b>FOREWORD</b> .....	<b>1</b>
<b>SECTION I: STRUCTURAL ANALYSIS</b>	
EXPERIMENTING FOR KNOWING: EVOLUTION OF A CONCEPT IN TECHNICAL SCIENCE.....	5
<i>Alessandro FREDDI</i>	
EXPERIMENTAL AND NUMERICAL STUDY ON THE BENDING STRENGTH OF A T-CORE SANDWICH PANEL.....	9
<i>Adriana SANDU, Ștefan SOROHAN, Marin SANDU, Dan Mihai CONSTANTINESCU, Emil NUȚU</i>	
IMPACT ON A MICRO-REINFORCED UHPC: EXPERIMENTAL STUDIES VS. NUMERICAL MODELING.....	11
<i>Astrid KOWITZ, Cheng-Chieh WU, Falk HILLE, Rosemarie HELMERICH, Daniel KADOKE, Klaus-Peter GRÜNDER, Stephan HAUSER, Henrik SCHWARZINGER</i>	
A METHOD FOR STRAIN ANALYSES OF SURFACES WITH CURVED BOUNDARIES BASED ON MEASURED DISPLACEMENT FIELDS .....	13
<i>Thomas LEHMANN, Martin STOCKMANN, Jörn IHLEMANN</i>	
COMPARISON OF FRACTURE PROPERTIES OF STEEL PIPES .....	15
<i>Lubomír GAJDOŠ, Martin ŠPERL</i>	
EXPERIMENTAL INVESTIGATION OF RESTITUTION COEFFICIENT FOR HYBRID COMPOSITES.....	17
<i>Marcin OBSZAŃSKI, Marek MATYJEWSKI</i>	
DAMAGE MONITORING OF DIFFERENT CONCENTRATION CARBON NANOTUBE/EPOXY GLASS FIBER REINFORCED COMPOSITES UNDER QUASI-STATIC INCREMENTAL LOADINGS .....	19
<i>Iłona LAZARIDOU, Stavros K. KOURKOULIS, Nikolaos D. ALEXOPOULOS</i>	
DESIGN OF COMMERCIAL HEXAGONAL HONEYCOMBS OF EQUAL OUT-OF-PLANE SHEAR MODULI..	21
<i>Ștefan SOROHAN, Dan Mihai CONSTANTINESCU, Marin SANDU, Adriana SANDU</i>	
A SMALL-SCALE TEST BRIDGE FOR MEASUREMENT- AND MODEL-BASED STRUCTURAL ANALYSIS .	23
<i>Cheng-Chieh WU, Daniel KADOKE, Michael FISCHER, Harald KOHLHOFF, Sven WEISBRICH, Frank NEITZEL</i>	
FATIGUE DAMAGE PREDICTION OF NOTCHED SAMPLES.....	25
<i>Liviu Daniel PÎRVULESCU, Anghel CERNESCU</i>	
STIFFNESS DETERMINATION IN STEEL SPECIMENS ORIGINATING FROM NEW AND DISCARDED TRAMWAY RAILS BY MEANS OF NANOINDENTATION .....	27
<i>Valentin JAGSCH, Patricia HASSLINGER, Olaf LAHAYNE, Christian HELLMICH, Stefan SCHEINER</i>	
NUMERICAL AND EXPERIMENTAL INVESTIGATION OF CONTACT LENGTH DURING ORTHOGONAL CUTTING .....	29
<i>Szabolcs BEREZVAI, Tamas G. MOLNAR, Attila KOSSA, Daniel BACHRATHY, Gabor STEPAN</i>	
ROOT ITERATION METHOD FOR MODAL PARAMETER IDENTIFICATION.....	31
<i>Zoltan LOVASZ, Zoltan DOMBOVARI</i>	
APPRECIABLE CROSS SECTION REDUCTION UPON MODERATE INTRADOS BENDING STRESS INCREASE IN CURVED BEAMS.....	33
<i>Antonio STROZZI, Enrico BERTOCCHI, Sara MANTOVANI</i>	
EXPERIMENTAL APPROACH TO THE VERIFICATION OF NUMERICAL MODEL OF HYBRID MACHINE FOR CONSTRUCTION WORKS.....	35
<i>Jakub ANDRUSZKO, Damian DERLUKIEWICZ, Mariusz STAŃCO</i>	
NUMERICAL AND EXPERIMENTAL ANALYSIS OF THE RUBBER BUMPER STIFFNESS.....	37
<i>Mariusz STAŃCO, Paulina DZIAŁAK</i>	

IMPACT RESPONSE OF SANDWICH PANELS WITH POLYURETHANE AND POLYSTYRENE CORE AND COMPOSITE FACESHEETS .....	39
<i>Oana Alexandra MOCIAN, Dan Mihai CONSTANTINESCU, Marin SANDU, Ștefan SOROHAN, Dorin ROȘU, Michael FEUCHTER</i>	
MEASURING THE AXIAL FORCE ON TURBO-JET ENGINE ROTOR .....	41
<i>Nenad KOLAREVIĆ, Miloš STANKOVIĆ, Stevan CRNOJEVIĆ, Dušan MICKOVIĆ, Marko MILOŠ</i>	
METHODOLOGY OPTIMIZATION TESTS OF COMPOSITE ROTOR BLADES OF HELICOPTERS IN EXTREME CONDITIONS .....	43
<i>Časlav B. MITROVIĆ, Nebojša PETROVIĆ, Goran VOROTOVIĆ, Mirjana OPAČIĆ</i>	
EXPERIMENTAL STRESS ANALYSIS OF A CANTILEVER BEAM .....	45
<i>Ionuț Daniel GEONEA</i>	
<b>SECTION II: MATERIALS CHARACTERIZATION AND TESTING</b>	
EXPERIMENTAL DYNAMICAL ANALYSIS OF SPECIMENS' MATERIAL PROPERTIES MANUFACTURED BY ADDITIVE TECHNOLOGIES .....	49
<i>Bálint Ádám KOVÁCS, Peter FICZERE, Lajos BORBÁS</i>	
INVESTIGATION OF THE SHRINKAGE BEHAVIOR OF CONCRETE CONSIDERING THE MOISTURE CONTENT .....	51
<i>Stefan SMANIOTTO, Martin DREXEL, Günter HOFSTETTER</i>	
DAMAGE OBSERVATION IN GLASS FIBER REINFORCED COMPOSITES VIA M-TOMOGRAPHY .....	53
<i>Zvonimir TOMIČEVIĆ, Amine BOUTERF, Robert SURMA, François HILD</i>	
CHARACTERIZATION OF A CORK-RUBBER COMPOSITE USING ADVANCED MATERIAL MODELS.....	55
<i>Jiří KOCÁB, Radek KOTTNER, Attila KOSSA</i>	
YIELDING AND STRAIN LOCALIZATION EFFECTS IN GUM METAL - A UNIQUE TI ALLOY - INVESTIGATED BY DIGITAL IMAGE CORRELATION AND INFRARED THERMOGRAPHY .....	57
<i>Elżbieta A. PIECZYSKA, Karol GOLASIŃSKI, Michał MAJ, Maria STASZCZAK, Zbigniew L. KOWALEWSKI, Tadahiko FURUTA, Shigeru KURAMOTO</i>	
TOUGHNESS TESTS OF TOOL STEELS FOR WORK AT LOW TEMPERATURE.....	59
<i>Željko DOMAZET, Francisko LUKŠA, Petra BAGAVAC</i>	
MICRO- AND MACROSCOPIC CHARACTERIZATION OF GRANITE.....	61
<i>Josef EBERHARDSTEINER, Sophie SCHMID, Olaf LAHAYNE, Roland REIHSNER, Bernhard PICHLER</i>	
INFRARED THERMOGRAPHY OF STEEL STRUCTURE BY FFT .....	63
<i>Petra BAGAVAC, Lovre KRSTULOVIĆ-OPARA, Željko DOMAZET</i>	
MECHANICAL PROPERTIES OF COMPOSITE STRUCTURAL PARTS FOR MACHINE TOOLS .....	65
<i>Milan RŮŽIČKA, Viktor KULÍŠEK, Pavel VRBA, Jan SMOLÍK, Zdeněk POŠVÁŘ</i>	
DETECTION OF SURFACE DAMAGE USING RESISTANCE TOMOGRAPHY IN THIN GRAPHENE LAYER .	67
<i>Marek STEPNOWSKI, Paweł PYRZANOWSKI</i>	
WATER PERMEABILITY OF HOT MIX ASPHALT .....	69
<i>Daniel STEINER, Bernhard HOFKO</i>	
ON THE COMPRESSIBILITY OF RUBBER: EXPERIMENTS AND THEORETICAL CONSIDERATIONS .....	71
<i>Robert PLACHY, Stefan SCHEINER, Krzysztof W. LUCZYNSKI, Armin HOLZNER, Christian HELLMICH</i>	
EFFECT OF AS-CAST SURFACE LAYER ON ALUMINIUM ALLOY FATIGUE STRENGTH .....	73
<i>Sebastian POMBERGER, Martin LEITNER, Michael STOSCHKA</i>	
EARLY-AGE CHARACTERIZATION AND MULTI-SCALE MODELING OF POLYMER-MODIFIED CEMENT PASTES.....	75
<i>Luise GÖBEL, Markus KÖNIGSBERGER, Andrea OSBURG, Bernhard PICHLER</i>	
MICROMECHANICAL ANALYSIS OF FIBER SPATIAL DISTRIBUTION INFLUENCE IN UNIDIRECTIONAL COMPOSITE CROSS-SECTION ON OVERALL RESPONSE IN TERMS OF TENSILE CURVES .....	77
<i>Tomáš KROUPA, Hana ZEMČÍK, Robert ZEMČÍK</i>	

VALIDATION OF IDENTIFIED MATERIAL PARAMETERS OF RUBBER USING AN ARCAN SHEAR TEST . 79 <i>Radek KOTTNER, Jan HECZKO, Jan KRYSTEK</i>	
A NEW SURFACE PREPARATION METHOD FOR MICROSCOPIC DIGITAL IMAGE CORRELATION APPLICATIONS..... 81 <i>Edgar PERETZKI, Martin STOCKMANN, Thomas LEHMANN, Jörn IHLEMANN</i>	81
DYNAMIC TESTING OF A SPECIMEN SETUP FOR COMBINED HIGH PRECISION UNIAXIAL TENSION-COMPRESSION TESTS OF RUBBER ..... 83 <i>Lars KANZENBACH, Erik OELSCH, Thomas LEHMANN, Jörn IHLEMANN</i>	83
ELASTIC-PLASTIC CHARACTERIZATION OF 2024-T351 ALUMINUM MATERIAL BASED ON RING COMPRESSION TEST, BENDING TEST AND UNIAXIAL TENSION/COMPRESSION TESTS..... 85 <i>Attila KOSSA, Gabor STEPAN</i>	85
INVESTIGATING THE EFFECTS OF SEVERE SHOT PEENING ON PURE IRON ..... 87 <i>Sara BAGHERIFARD, Mauro Filippo MOLLA, Mario GUAGLIANO</i>	87
S-N CURVE OF COMPOSITE SPECIMENS DETERMINED IN TENSION-TENSION FATIGUE TESTING..... 89 <i>Ionel IACOB, Ionel CHIRICĂ, Elena-Felicia BEZNEA</i>	89
COMPARISONS BETWEEN SOME COMPOSITE MATERIALS REINFORCED WITH HEMP FIBERS ..... 91 <i>Cosmin Mihai MIRIȚOIU, Cristian Oliviu BURADA, Marius Marinel STĂNESCU, Dumitru BOLCU, Adriana PĂDEANU, Alexandru BOLCU</i>	91
STATIC AND DYNAMIC MECHANICAL PROPERTIES OF A NEW GREEN RESIN BASED ON DAMMAR .... 93 <i>Cosmin Mihai MIRIȚOIU, Marius Marinel STĂNESCU, Alexandru BOLCU, Dumitru BOLCU, Cristian Oliviu BURADA, Valeriu IONICĂ</i>	93
EXPERIMENTAL STUDIES ON UNIAXIAL AND ECHIBIAXIAL TENSILE TESTS APPLIED TO PLASTIC MATERIALS SHEETS ..... 95 <i>Adrian PASCU, Mihaela OLEKSIK, Nicolae ROȘCA, Eugen AVRIGEAN, Valentin OLEKSIK</i>	95
STATIC AND DYNAMIC TESTS FOR DETERMINING THE CHARACTERISTIC PERFORMANCE OF MECHANICAL SPLICES IN REINFORCED CONCRETE ..... 97 <i>Ovidiu VASILE, Oana TONCIU</i>	97
EXPERIMENTAL DETERMINATION OF FATIGUE PROPERTIES AND E-N CURVES FOR S355J2+N STEEL GRADE..... 99 <i>Vladimir MILOVANOVIĆ, Miroslav ŽIVKOVIĆ, Gordana JOVIČIĆ</i>	99
EXPERIMENTAL DETERMINATION OF STRAIN HARDENING EXPONENT FOR STRENX 700..... 101 <i>Aleksandar DIŠIĆ, Miroslav ŽIVKOVIĆ, Vladimir MILOVANOVIĆ</i>	101
DETERMINING THE EMISSIVITY FACTOR OF THERMOPLASTIC MATERIALS FOR A THERMOPLASTIC BENDING PROCESS ..... 103 <i>Martin KLINGENBRUNNER, Julia PLATZER, Friedrich BLEICHER</i>	103
THREE-POINT BENDING BEHAVIOUR OF ORGANIC MODIFIED COMPOSITES..... 105 <i>Cristian MUNTENIȚĂ, Marian Sebastian DRĂGHICI, Violeta SAVA, Vasile BRIA, Adrian CÎRCIUMARU, Iulia GRAUR</i>	105
<b>SECTION III: BIOMECHANICS</b>	
EVALUATION OF HUMAN KNEE FLEXION-EXTENSION ON INCLINED TREADMILL USING WEARABLE SENSORS ..... 109 <i>Alin PETCU, Daniela TARNIȚĂ, Ionuț Daniel GEONEA, Raluca MALCIU</i>	109
EXPLORING EXPERIMENTALLY THE POTENTIALITIES OF PLATELET RICH PLASMA IN TREATING PELVIC ORGAN PROLAPSE ..... 111 <i>Stavros K. KOURKOULIS, Eleftheria L. CHRYSANTHOPOULOU, Vasileios PERGIALIOTIS, Despina N. PERREA, Stergios K. DOUMOUCHTSIS, Chara SPILIOPOULOU</i>	111
BONE STRUCTURE INVESTIGATION IN A CASE OF AUTOSOMAL RECESSIVE OSTEOPETROSIS..... 113 <i>Francesca COSMI, Natalia MAXIMOVA</i>	113

DISPLACEMENT-ENCODED MRI REVEALS ALTERED STRAIN PATTERNS IN ENZYMATICALLY DEGRADED CARTILAGE DURING CYCLIC COMPRESSION .....	115
<i>Maria-Ioana PASTRAMĂ, Lianne ZEVENBERGEN, Nele FAMAHEY, Willy GSELL, Corey P. NEU, Uwe HIMMELREICH, Ilse JONKERS</i>	
NONLINEAR DYNAMICS OF HUMAN KNEE JOINT DURING JUMPS .....	117
<i>Daniela TARNIȚĂ, Dan MARGHITU, Alin PETCU</i>	
PERFORMANCE MEASUREMENT OF SAILORS WITH CUSTOM HIKING BENCH AND MOTION TRACKING SYSTEM.....	119
<i>Bernadett KISS, Rita KISS</i>	
ANALYSING HUMAN BALANCE RECOVERY ACTION USING CALCULATED TORQUES OF A DOUBLE PENDULUM MODEL .....	121
<i>Bernadett KISS, Balint PETRO, Rita KISS</i>	
INVESTIGATION OF THE DESIGN ASPECTS OF RUNNING SUITS APPLYING MOTION ANALYSIS .....	123
<i>Zsófia PÁLYA, Anna GULYÁS, Marianna HALÁSZ, Rita KISS</i>	
HUMAN BALANCING IN THE SAGITTAL PLANE .....	125
<i>Csenge A. MOLNÁR, Ambrus ZELEI, Tamás INSPERGER</i>	
3D-PRINTED ANKLE-FOOT ORTHOSIS: A DESIGN METHOD .....	127
<i>Alberto DAL MASO, Francesca COSMI</i>	
AUTOMATIC GUIDANCE OF BIOPSY CATHETER TO PERIPHERAL AIRWAYS TARGETS USING A NOVEL ROBOTIC SYSTEM.....	129
<i>Lucian Gheorghe GRUIONU, Cătălin CONSTANTINESCU, Andreea ȘOIMU-IACOB, Cătălin CIOBÎRCĂ, Anca UDRIȘTOIU, Ștefan Dan PASTRAMĂ, Gabriel GRUIONU</i>	
<b>SECTION IV: PRACTICAL APPLICATIONS/CASE STUDIES/ INSTRUMENTATION</b>	
OPTIMIZATION OF LASER BEAM CUTTING PARAMETERS OF HIGH DENSITY COMPOSITE FIBRE CEMENT FLAT BOARD .....	133
<i>László MOLNÁR, Tamás CSISZÉR, Lajos BORBÁS, Levente László BOGNÁR</i>	
DYNAMIC TEST OF A BRIDGE OVER THE DANUBE-BLACK SEA CHANNEL AT AGIGEA.....	135
<i>Cristian Lucian GHINDEA, Radu Iuliu CRUCIAT, Ionuț Radu RĂCĂNEL</i>	
SUPERSONIC TEST CASES AT HIGH ANGLES OF ATTACK .....	137
<i>Dijana DAMLJANOVIĆ, Đorđe VUKOVIĆ, Jovan ISAKOVIĆ, Marko MILOŠ</i>	
CONCEPT OF A GAS-SENSITIVE NANO AERIAL ROBOT SWARM FOR INDOOR AIR QUALITY MONITORING .....	139
<i>Patrick P. NEUMANN, Dino HÜLLMANN, Matthias BARTHOLMAI</i>	
PASSIVE RFID TRANSPONDER – LOW-POWER MULTI-SENSOR INTERFACE FOR STRUCTURAL HEALTH MONITORING IN CONCRETE .....	141
<i>Sergej JOHANN, Christoph STRANGFELD, Omid CHAHARDEHINEJAD, Matthias BARTHOLMAI</i>	
COMPARATIVE RESULTS OF MILLING STRATEGIES IMPLEMENTATION .....	143
<i>Adrian BUT, Radu CANARACHE</i>	
TOW TRUCK FRAME MADE OF HIGH STRENGTH STEEL UNDER CYCLIC LOADING.....	145
<i>Tadeusz SZYMCZAK, Adam BRODECKI, Katarzyna MAKOWSKA, Zbigniew L. KOWALEWSKI</i>	
STATIC TESTS ON A RAILWAY VEHICLE BODY BEFORE BOGIE REPLACEMENT.....	147
<i>Nicușor Laurențiu ZAHARIA, Dan Mihail COSTESCU, Elvis-Georgian ZIDARU, Ștefan Dan PASTRAMĂ</i>	
EXAMINATION OF THE INTERMODAL TRAILER FRAME IN ACCORDANCE WITH UIC 596-5 .....	149
<i>Jacek KARLIŃSKI, Paulina DZIAŁAK</i>	
STRENGTH OF BRIDGE STRUCTURES: A STUDY .....	151
<i>Mihai-Liviu BĂIAȘU, Diana-Ionela SANDU, Marilena MANEA, Andrei-Mădălin GRIGORE</i>	
1:60 SCALED EARTHQUAKE TESTING OF THE IMMERSSED TUNNEL OF THE HONG KONG-ZHUHAI-MACAO-BRIDGE .....	153
<i>Eva BINDER, Chong LI, Herbert MANG, Yong YUAN, Bernhard PICHLER</i>	



ASSESSMENT OF GRINDING WHEEL WEAR VIA MONITORING OF PROCESS POWER .....	155
<i>Clemens SCHWAIGER, Matthias HACKSTEINER, Friedrich BLEICHER</i>	
MULTI-INTERVAL LOAD CELL WITH STEPLESS AUTOMATIC RANGE TRANSITION ACCORDING THE WEIGHT.....	157
<i>Martin STOCKMANN, Thomas LEHMANN, Jörn IHLEMANN</i>	
CONTROL OF A SPHERICAL PARALLEL MANIPULATOR WITH THREE DEGREE OF FREEDOM .....	159
<i>Dino HÜLLMANN, Harald KOHLHOFF, Jessica ERDMANN, Patrick P. NEUMANN</i>	
APPLICATION OF AN ELECTRIC CONTACT SENSOR IN MACHINING .....	161
<i>David HAJDU, Daniel BACHRATHY, Tamás INSPERGER, Gabor STEPAN</i>	
COMPARISON OF COOLING SIMULATIONS OF INJECTION MOULDING TOOLS CREATED WITH CUTTING MACHINING AND ADDITIVE MANUFACTURING.....	163
<i>József Bálint RENKÓ, Dávid Miklós KEMÉNY, József NYIRÓ, Dorina KOVÁCS</i>	
CUTTING FORCE MEASUREMENT FROM ACCELERATION SENSOR IN MILLING OPERATION.....	165
<i>Adam KISS, Daniel BACHRATHY, Gabor STEPAN</i>	
IMPROVED SPINDLE SPEED MEASUREMENT BY ANALOGUE SENSOR.....	167
<i>Daniel BACHRATHY</i>	
DESIGN THINKING IN NUMERICAL AND EXPERIMENTAL EVALUATION OF THE STRUCTURE OF CONSTRUCTION ROBOT.....	169
<i>Damian DERLUKIEWICZ, Jakub ANDRUSZKO</i>	
EXPERIMENTAL AND NUMERICAL EVALUATION OF WAVE IMPACT STRESS ON A COMPOSITE BOAT HULL.....	171
<i>Adrian CARAMATESCU, Costel Iulian MOCANU</i>	
OPTICAL STUDY FOR SPRINGBACK PREDICTION, THICKNESS REDUCTION AND FORCES VARIATIONS ON SINGLE POINT INCREMENTAL FORMING .....	173
<i>Nicolae ROȘCA, Valentin OLEKSIK, Adrian PASCU, Mihaela OLEKSIK, Eugen AVRIGEAN</i>	
DYNAMIC TESTS PERFORMED ON FLAT FREIGHT WAGON.....	175
<i>Nicușor Laurențiu ZAHARIA, Alexandru Ionuț PĂTRAȘCU, Dan Mihail COSTESCU</i>	
EXPERIMENTAL STRESS ANALYSIS OF A RAILWAY CAR USING A DEDICATED TEST RIG .....	177
<i>Elvis-Georgian ZIDARU, Alexandru Ionuț PĂTRAȘCU, Nicușor Laurențiu ZAHARIA, Anton HADĂR</i>	
EXPERIMENTAL STRESS ANALYSIS ON RAILWAY VEHICLE BODY .....	179
<i>Alexandru Ionuț PĂTRAȘCU, Nicușor Laurențiu ZAHARIA, Elvis-Georgian ZIDARU, Anton HADĂR</i>	
EXPERIMENTAL STUDY OF THE DYNAMIC RESPONSE OF A CABLE UNDER WIND FLOW .....	181
<i>Vlad Daniel URDAREANU, Ionuț Radu RĂCĂNEL, Mircea DEGERATU, Costin Ioan COSOIU, Cristian Lucian GHINDEA, Radu Iuliu CRUCIAT</i>	
KEY FACTORS TOWARDS A HIGH QUALITY ADDITIVE MANUFACTURING (3D PRINTING) PROCESS WITH ABS MATERIAL .....	183
<i>Radu Emanuil PETRUSE, Samuel PUȘCAȘU, Adrian PASCU, Ioan BONDREA</i>	
STUDY REGARDING THE GEOMETRICAL DEVIATIONS FOR 3D PRINTED FUNCTIONAL PARTS.....	185
<i>Samuel PUȘCAȘU, Radu Emanuil PETRUSE, Adrian PASCU, Ioan BONDREA</i>	
EXPERIMENTAL STUDIES OF A BRIDGE MADE FROM REINFORCED CONCRETE BEAMS - BRIDGE OF TRANSILVANIA HIGHWAY .....	187
<i>Polidor BRATU, Ovidiu VASILE, Cătălin ZAHARIA</i>	
EVALUATION OF ELASTOMERIC STRUCTURAL BEARINGS PERFORMANCE BASED ON NATURAL SCALE TESTS.....	189
<i>Polidor BRATU, Ovidiu VASILE, Sorin POPA</i>	
ASSESSMENT OF SOIL STRENGTH AND DEFORMABILITY PARAMETERS IN LABORATORY CONDITIONS.....	191
<i>Cornelia-Florentina DOBRESCU, Oana TONCIU</i>	
SPECIALISED TESTS FOR THE ASSESSMENT AND CLASSIFICATION OF SAFES FOR THE VALUES PROTECTION, FROM THE SECURITY IN USE POINT OF VIEW.....	193
<i>Cristinel SEBE, Cătălin ZAHARIA, Sorin POPA</i>	

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HARDWARE IN THE LOOP SIMULATION FOR HOMING MISSILES .....	195
<i>Ivana TODIĆ, Vladimir KUZMANOVIĆ</i>	
<b>SECTION V: NUMERICAL METHODS</b>	
SEISMIC CALCULATION FOR GENERATOR PROTECTION PANEL.....	199
<i>Paweł MAŚLAK, Jerzy CZMOCHOWSKI, Tadeusz SMOLNICKI</i>	
ANISOTROPY OF PERIODIC MICROSTRUCTURE IN MODELS OF UNIDIRECTIONAL COMPOSITE MATERIALS.....	201
<i>Robert ZEMČÍK, Hana ZEMČÍK, Tomáš KROUPA</i>	
ESTIMATIONS OF THE SHIP HULL OSCILLATIONS .....	203
<i>Dumitru LUPAŞCU, Ionel CHIRICĂ, Elena-Felicia BEZNEA, Mihaela BARCAN (SAVIN)</i>	
SHIPS'S HULL STRUCTURAL SAFETY ESTIMATION.....	205
<i>Dumitru LUPAŞCU, Ionel CHIRICĂ, Liviu-Dan STOICESCU, Mihaela BARCAN (SAVIN)</i>	
FINITE ELEMENT STUDY ON THE STRESS STATE ACROSS THE THICKNESS OF A CURVED LAMINATE.....	207
<i>Marius Nicolae BABA</i>	
<b>AUTHOR INDEX.....</b>	<b>209</b>

## FOREWORD

Each year since 1984, the Danubia-Adria Symposium on Advances in Experimental Mechanics brings together internationally recognized experts and young researchers in an effort to exchange ideas in different topics having as common link Experimental Mechanics. Since the beginning, this Symposium was a platform for establishing connections between different research groups trying to establish future scientific collaboration and an agora where faculty members, students, scientists, researchers, engineers and industrial experts present and discuss the status and impact of modern technology and development in the field of experimental mechanics.

In 2018, the 35th Danubia Adria Symposium on Advances in Experimental Mechanics is to be held between September 25 – 28 in the wonderful mountain resort Sinaia, Romania.

The Book of Abstracts of the proceedings includes 97 papers, which have been selected and accepted after peer-review by the Scientific Committee, formed by the delegates of the eleven DAS member countries – Austria, Croatia, Czech Republic, Germany, Hungary, Italy, Poland, Romania, Serbia, Slovakia, and Slovenia.

The papers are organized in five sections:

- Structural analysis
- Materials characterization and testing
- Biomechanics
- Practical applications/case-studies/instrumentation
- Numerical methods

The present volume emphasizes the actual trends which are given to the development of methods and models that account for and integrate physical phenomena taking place on multiple scales. These include complex processes such as the evolution of the meso- and micro-structure of the material during loading, and if these phenomena could be accounted for, then their influence on the macroscopic constitutive behavior of materials could be also predicted, thus being able to create new, exceptional materials. While this perspective is fascinating, the current state-of-the-art falls short from attaining this goal. The better understanding of phenomena where large populations of defects - such as dislocations - interact in highly non-linear ways and the consideration of large deformations can lead to the creation of improved constitutive models of the materials' behavior to be observed macroscopically.

Finally, it is important to underline that, with the 2018 Romanian edition of the Symposium, the Danubia Adria Society on Experimental Methods proudly announces its 35th anniversary!

We wish all the participants to have a high level of scientific discussions and to enjoy the beauty of the Romanian mountains.

The Editors,

Professor Ștefan Dan Pastramă

Professor Dan Mihai Constantinescu

## EXPERIMENTAL DETERMINATION OF FATIGUE PROPERTIES AND E-N CURVES FOR S355J2+N STEEL GRADE

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### 1. Introduction

Today steels represent the most used group of mechanical materials. Steels are used in various branches of industry for construction of bridges, buildings, ships, cars, rail vehicles, railways. There are several thousand types of steel obtained by an appropriate combination of carbon and alloying elements of different characteristics. Because of the good mechanical properties, good cutting, forming (forging, rolling, extrusion, pressing), good weldability and low prices, structural steels are widely used in industry. The most commonly used steel for production of carrying parts of structures subjected to dynamic loads and low temperatures is medium-strength S355J2+N steel grade.

In this paper, fatigue properties and  $\varepsilon$ -N curves for S355J2+N steel grade were obtained experimentally.

### 2. Strain life ( $\varepsilon$ -N) fatigue approach

Strain life ( $\varepsilon$ -N) approach belongs to local fatigue approach and it can be used for low cycle and high-cycle fatigue. In  $\varepsilon$ -N approach loading is a combination of elastic and plastic deformation on the macro scale. In low cycle region, the plastic strain component is dominant, whereas in the high-cycle region the elastic strain component is dominant.  $\varepsilon$ -N approach uses cyclic strain-controlled tests because they better characterize fatigue behavior of a material than cyclic stress-controlled tests, particularly in the low cycle fatigue region. Mathematical model used to describe the fatigue behavior of material under cyclic strain-controlled tests to obtain cyclic stress-strain ( $\sigma$ - $\varepsilon$ ) curve is given by Ramberg-Osgood approach [1] presented by equation:

$$\varepsilon_a = \frac{\Delta\varepsilon}{2} = \varepsilon_{a,e} + \varepsilon_{a,p} = \frac{\sigma_a}{E} + \left( \frac{\sigma_a}{K'} \right)^{\frac{1}{n}}. \quad (1)$$

The total strain-life ( $\varepsilon$ - $N_f$  curve) is therefore expressed as the sum of Basquin's and Manson-Coffin's part by equation [2]

$$\varepsilon_a = \frac{\sigma_f'}{E} (2N_f)^b + \varepsilon_f' (2N_f)^c. \quad (1)$$

### 3. Strain controlled uniaxial tension-compression fatigue test

Uniaxial tension-compression fatigue tests of the S355J2+N steel grade were carried out according to the internal procedures of the Centre for engineering software and dynamic testing at Faculty of Engineering University of Kragujevac, based on the ASTM E468-90 [3] and ASTM E606-92 [4] standards.

Uniaxial tension-compression fatigue tests were performed by applying a sinusoidal wave in an universal servo-hydraulic machine SHIMADZU Servopulser EV101K3-070-0A. All specimens have been finely polished to minimize the surface roughness effects. The tests were strain controlled by means of a SHIMADZU DYNASTRAIN TCK-1-LH dynamic extensometer with a  $\pm 1$  mm working range.

The strain levels used to control the fatigue tests were chosen from the previously performed monotonic material characterization. The selection criteria was to obtain fatigue life cycles between  $10^4$  and  $10^6$  cycles. The uniaxial tension-compression test planning (loading ratio  $R=-1$ , i.e. mean strain amplitude  $\varepsilon_m=0\%$ ) is: five levels, three repetitions per level with a range of strain amplitude from 0.15% to 0.20%. The test frequency used in the characterization was in the range of 3–10 Hz, and the crack initiation criterion (failure criterion) was the quick stiffness loss (load amplitude loss of about 10%).

## 4. Results and discussion

Table 1 shows the results of the uniaxial tension–compression strain-controlled fatigue tests. The normal stress amplitude  $\sigma_a$  was calculated by means of the maximum load applied to the medium life cycle in stable conditions divided by cross sectional area of the specimen at the beginning of the test.

**Table 1.** Experimental uniaxial tension–compression strain-controlled fatigue test results of S355J2+N steel grade

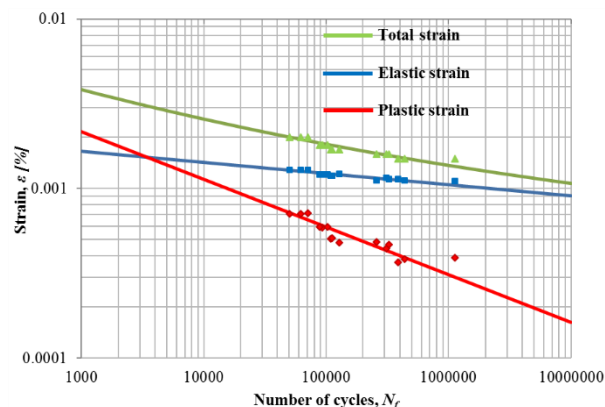
Specimen number.	$\epsilon_a$ [%]	$\sigma_a$ [MPa]	$N_f$
1-1	0.20	271.2	61900
1-2	0.20	270.5	50300
1-3	0.20	269.4	71000
2-1	0.18	254.1	92600
2-2	0.18	253.2	88300
2-3	0.18	253.2	103300
3-1	0.17	256.5	127600
3-2	0.17	250.4	109600
3-3	0.17	250.1	116000
4-1	0.16	243.1	310700
4-2	0.16	237.7	324700
4-3	0.16	234.3	257700
5-1	0.15	234.2	437500
5-2	0.15	233.0	1117200
5-3	0.15	238.2	389200

Based on the results shown in Table 1. and statistical analysis according to standard ASTM E739-91(2004) [5], uniaxial tension–compression strain controlled mechanical properties of S355J2+N steel grade have been shown in Table 2.

**Table 2.** Uniaxial tension–compression strain controlled mechanical properties of S355J2+N steel grade

Uniaxial cyclic properties	Value
Cyclic strength coefficient, $K'$	1470.45 MPa
Cyclic strain hardening exponent, $n'$	0.2344
Cyclic yield strength, $\sigma_y'$	342.65 MPa
Fatigue strength coefficient, $\sigma_f'$	575.25 MPa
Fatigue strength exponent, $b$	-0.0656
Fatigue ductility coefficient, $\epsilon_f'$	0.0182
Fatigue ductility exponent, $c$	-0.2087

Based on experimentally obtained uniaxial tension–compression strain controlled mechanical properties of S355J2+N steel grade, strain–life curve (log–log representation) has been determined and shown in Figure 1.



**Fig. 1.** Strain–life curve from uniaxial tension–compression strain-controlled fatigue test of S355J2+N steel grade

## 5. Conclusions

This study has presented an experimental determination of fatigue properties and  $\epsilon$ – $N$  curves for S355J2+N steel grade. The hysteresis loop behavior, cyclic stress–strain response and strain–life curve were determined by testing smooth specimens. A complete cyclic characterization of the material is obtained, including the new experimental  $\epsilon$ – $N$  fatigue curves for uniaxial tension–compression strain-controlled fatigue test. In order to determine fatigue properties of material S355J2+N, the testing procedure was performed with the help of special measurement device, servo-hydraulic SHIMADZU Servopulser EV101K3-070-0A.

## Acknowledgements

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## References

- [1] Ramberg W, Osgood WR., *Description of stress–strain curves by three parameters*, NACA TN-902. USA: National Advisory Committee for Aeronautics; 1943.
- [2] Stephens R., Fatemi A., Stephens R. and Fuchs H., *Metal Fatigue in Engineering*, John Wiley & Sons INC, New York, 2001.
- [3] ASTM: E486-90 Standard Practice for Presentation of Constant Amplitude Fatigue Test Results for Metallic Materials, 2004.
- [4] ASTM: E606-92 Standard Practice for Strain-Controlled Fatigue Testing, 1998.
- [5] ASTM: E739-91 Standard Practice for Statistical Analysis of Linear or Linearized Stress-Life (S-N) and Strain-Life (e-N) Fatigue Data, 2004.