Short presentation of research projects supported by the Croatian Science Foundation.

- **Research projects that are running at the Faculty of Engineering, University of Rijeka**

Principal investigator: Josip Brnić

- 6876 ASSESSMENT OF STRUCTURAL BEHAVIOUR IN LIMIT STATE OPERATING CONDITIONS

Principal investigator: Marina Franulović

- DEVELOPMENT OF EVOLUTIONARY PROCEDURES FOR CHARACTERIZATION OF BIOLOGICAL TISSUES BEHAVIOR- BIOMAT

Principal investigator: Tihana Galinac Grbac

- 7945 EVOLVING SOFTWARE SYSTEMS: ANALYSIS AND INNOVATIVE APPROACHES FOR SMART MANAGEMENT (EVOSOFT) – FIRST YEAR STATUS REPORT

Principal investigator: Jasna Prpić–Oršić

- 8722 GREENER APPROACH TO SHIP DESIGN AND OPTIMAL ROUTE PLANNING – GASDORP

Principal investigator: Božo Smoljan

- 5371 OPTIMISATION AND MODELLING OF THERMAL PROCESSES OF MATERIALS (OMOTPOM) – SECOND YEAR REPORT

- **Research projects that are running at the Faculty of Civil Engineering, University of Rijeka**

Principal investigator: Gordan Jelenić

- 1631 CONFIGURATION-DEPENDENT APPROXIMATION IN NON-LINEAR FINITE-ELEMENT ANALYSIS OF STRUCTURES

Principal investigator: Ivica Kožar

- 9068 MULTI-SCALE CONCRETE MODEL WITH PARAMETER IDENTIFICATION – CONCRETEMUSCID

This research has been fully supported by Croatian Science Foundation under the project 6876.

ASSESSMENT OF STRUCTURAL BEHAVIOUR IN LIMIT STATE OPERATING CONDITIONS – *STRUBECON*

Principal investigator: Prof. Josip Brnić, D. Sc., Faculty of Engineering, University of Rijeka, Croatia

Team members

Prof. Goran Turkalj, D. Sc., Faculty of Engineering, University of Rijeka, Croatia
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Assoc. Prof. Domagoj Lanc, D. Sc., Faculty of Engineering, University of Rijeka, Croatia
Assist. Prof. Marino Brčić, D. Sc., Faculty of Engineering, University of Rijeka, Croatia
Assist. Prof. Goran Vukelić, D. Sc., Faculty of Maritime Studies, University of Rijeka, Croatia
Igor Pešić, D. Sc. (postdoc), Faculty of Engineering, University of Rijeka, Croatia
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Neven Munjas, D. Sc. (postdoc), Faculty of Engineering, University of Rijeka, Croatia
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Edin Merdanović, D. Sc. candidate, Euro Façade Tech, Kuala Lumpur, Malaysia

Project summary

The project aims to describe the structures operating in limit state conditions. The studies are performed by experimental and numerical research methods. Therefore, the main objective is to provide an assessment of structure behaviour, by comparing of the parameters such as stress, strain, crack occurrence, etc., caused by certain load level and temperature at this unexpected limit state with those allowed by material properties. The following research sub-objectives should be accomplished: testing of material properties; impact energy; the determination of the crack driving force and life assessment of structural elements; evaluation of the semi-rigid structural joints/connections behaviour; buckling simulations of composite beam-type structures; proper constitutive modelling at limit operating conditions, etc. Although many journal papers were published, omly some of them are mentioned here.

Some of journal papers related to CC and Q1 published in 2015./2016.

1. Lanc, D., Turkalj, G., Vo, T. P., Brnić, J.: Nonlinear buckling behaviours of thin-walled functionally graded open section beams, Composite structures, 152 (2016) ; 829-839.
2. Brnić, J., Turkalj, G., Čanađija, M., Lanc, D., Kršćanski, S., Brčić, M., Li, Q., Niu, J.: Mechanical Properties, Short Time Creep and Fatigue of an Austenitic Steel, Materials, 9 (2016) , 4; 298-1-298-19.
3. Vukelić, G., Brnić, J.: Predicted Fracture Behavior of Shaft Steels with Improved Corrosion Resistance, Metals, 6 (2016) , 2; 40-1-40-9.
4. Brnic J., Turkalj G., Canadija M., Krscanski S., Brcic M., Lanc D., .: Deformation Behavior and Material Properties of Austenitic Heat - Resistant Steel X15CrNiSi25-20 Subjected to High Temperatures and Creep, Materials and Design, 69 (2015), 219-229.
5. Vukelic G., Brnic J.:Prediction of Fracture Behavior of 20MnCr5 and S275JR Steel Based on Numerical Crack Driving Force Assessment, Journal of Materials in Civil Engineering, 27 (2015), 3, 04014132-1 - 04014132-5.
6. Turkalj, G., Lanc, D., Brnić, J., Pešić, I.: A beam formulation for large displacement analysis of composite frames with semi-rigid connections, Composite structures, 134 (2015), 237-246.

This research has been fully supported by Croatian Science Foundation under the project 4982.

DEVELOPMENT OF EVOLUTIONARY PROCEDURES FOR CHARACTERIZATION OF BIOLOGICAL TISSUES BEHAVIOR- BIOMAT

Principal investigator: Assoc. Prof. Marina Franulović, D. Sc., Faculty of Engineering, University of Rijeka

Team members

Assoc. Prof. Robert Basan, D. Sc., Kristina Marković, D. Sc. (postdoc), Tea Marohnić, PhD student, Faculty of Engineering, University of Rijeka

Prof. Ivan Prebil, D. Sc., Ana Trajkovski, D. Sc. (postdoc), Senad Omerović, PhD student, Simon Krašna, D. Sc. (postdoc), Faculty of Mechanical Engineering, University of Ljubljana

BIOMAT accomplishments in the first year of research

The first year of the research activities on the project BIOMAT were mainly oriented to achieve the strong foundation of the research, on one hand to make possible the cooperation among team members, and on the other to provide the purchase of the material goods. The activities were performed with the goal to expand the opportunities for further exploration of innovative materials and to make possible publication and presentation of the research at an international level. The specific accomplishments were achieved, as follows.

Material behavior modelling

The observation and understanding of the influence of strain rate and the load on the stress and stretch of materials and damage to the ligaments on the macro level was performed at the Faculty of Mechanical Engineering, Department for Modeling in Technics and Medicine in Ljubljana. Collected data represent the material response to the specified load, or data set stress - stretch from the start of the loading to the fracture of the sample in two parts. Through the process, the knowledge of the input parameters for embroidered patterns is assured, relating to the definition of their length and cross-section. In order to use data in the process of developing a genetic algorithm procedure for identification of material parameters, it is further necessary to create software application for data manipulation and control of materials behavior.

Acquisition and systematization of underlying knowledge and data on constitutive models of materials behavior

Available information on existing more conventional constitutive models of materials behaviour has been acquired. Systematic overview of fundamentals of constitutive modeling and material behavior along with classification of real material behavior is given, and described in brief. Further on, plastic behavior of materials is described in more detail as well as fundamentals of elastoplastic material behavior modeling. So far, nonlinear materials models dealing with rate-independent plasticity are covered, with the aim of expanding the content to materials other than metals during the second year of the project. Report is made publicly available on the BIOMAT project webpage.

Presentation

The working group members already participated in prominent international conferences and published research results achieved in the proposed project in order to promote the excellence of own research and thus ensure the continuation of their careers and international recognition.

This research has been fully supported by Croatian Science Foundation under the project UIP-2014-09-7945.

EVOLVING SOFTWARE SYSTEMS: ANALYSIS AND INNOVATIVE APPROACHES FOR SMART MANAGEMENT (EVOSOFT) – FIRST YEAR STATUS REPORT

Principal investigator: Assistant Professor Tihana Galinac Grbac, D. Sc., Faculty of Engineering, University of Rijeka

Research summary

This installation research project led by the young researcher Tihana Galinac Grbac has the main goal to establish her independent research career and her own laboratory and research group. For this project she received institutional support of the Faculty of Engineering at the University of Rijeka. Detailed summary can be found at web page: http://www.seiplab.riteh.uniri.hr/?page_id=712&lang=en.

EVOSOFT accomplishments in the first year of research

Majority of activities were focused on establishing the research infrastructure needed for executing research within the project. Principal Investigator Tihana Galinac Grbac granted additional funding from Croatian Science Foundation to employ PhD researcher. She visited prof. Per Runeson, the leader of the Software Engineering Research Group at Lund University, Sweden and established collaboration. She initiated a collaboration projects with the leading industries in the region Ericsson Nikola Tesla that is directly financially supporting the research activities of this project in the amount of 15% of the total project value. She established new collaborations: CEEPUS project *International Cooperation in Computer Science* with 16 universities in region and ERASMUS project with two research groups. Software Engineering and Information Processing Laboratory (SEIPLab - http://www.seiplab.riteh.uniri.hr) infrastructure is established to become a platform for strengthening knowledge and innovation as drivers for future development. New web page, equipment, software, services, literature, and subscriptions have been purchased and provided on SEIPLab Cloud to students. Over 50 student projects have been finalized by using this infrastructure resulting with several research publications. Experimental base with systematical procedures and collected datasets are prepared from open source and real industry projects. A number of project presentations and invited talks were given in public, at the University of Rijeka, within equivalent European projects funded by the program Cooperation in Science and Technology named *Autonomous Control for a Reliable Internet of Services (ACROSS)* and *Behavioural Types for large-scale reliable systems (BETTY)*, and international conferences MIPRO and SQAMIA. With thanks to the funds a workshop on *Future Networks and Services* and a summer school on *Autonomous Control for Reliable Future Networks and Services* were organized.

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Selected research group's publications related to the project in 2015/2016.

1. Hržić F., Poljančić D., Galinac Grbac T.. *Secure Operations as Congestion Control Mechanism Within OpenStack Based Cloud Laboratory*, Int. Conf. on Smart Syst. and Technologies (SST), Croatia, 2016.
2. Galinac Grbac T., Runeson P: 'Plug-in' Software Engineering Case Studies, CESI – ICSE 2016 Workshop, USA
3. Mauša, G., Galinac Grbac, T., Dalbelo Bašić, B.: A Systematic Data Collection Procedure for Software Defect Prediction. *Computer Science and Information Systems Journal*, Vol. 13 (1), 2016, pp. 173–197
4. Grbac Babić S, Galinac Grbac T: Graph-Based Analysis and Metrics of Evolving Open-Source Software Systems, proc. of IS CSS, Ljubljana, Slovenia.
5. Rubinić, E; Mauša, G; Galinac Grbac T; Software Defect Classification with a Variant of NSGA-II and Simple Voting Strategies, SSBSE2015 Graduate Student Track, Bergamo, Italy.
6. Galinac Grbac T, Car Ž, Vuković M.; Software Engineering Education on Requirements and Architecture Modeling, ECSA Workshops 2015, Cavtat, Croatia.

This research has been fully supported by Croatian Science Foundation under the project 8722.

GREENER APPROACH TO SHIP DESIGN AND OPTIMAL ROUTE PLANNING – GASDORP

Principal investigator: Prof. Jasna Prpić–Oršić, D. Sc., Faculty of Engineering, University of Rijeka

Project summary

The accurate calculation of attainable ship speed at actual sea is essential from economical and also environmental aspects. Reliable ship speed loss estimation under real environmental conditions allows a more accurate prediction of the power increase and fuel consumption as well as gas emissions from ships. Nowadays this second issue becomes very important because of the problem of global warming. Following the increasing awareness of the environmental and human health concerns of shipping, legislative actions have been taken on global and national levels making mandatory (from January 1st 2013) that new ships over 400 gross tonnage, to comply with the regulations, should have emissions of CO_2 under limiting value. Technological enhancement to ships like improved hull designs as well as improvement in power and propulsion systems could potentially reduce CO_2 emission up to 35 %. These measures could effectively be combined with several other operational measures, such as weather routing and voyage planning, in order to ensure that fuel consumption and CO_2 emissions from ships are minimized on every voyage.

References of project second year

1. Prpić-Oršić, J., Vettor, R., Faltinsen, O. M., Guedes Soares, C.: Route choice and operating conditions influence on fuel consumption and CO_2 emission, Journal of Marine Science and Technology, Vol. 21, No. 3, pp 434-457, ISSN 0948-4280, Springer, 2016.
2. Valčić, M., Prpić-Oršić, J.: Methodology of wind loads estimation on marine objects based on elliptic Fourier descriptors and neural networks hybrid method, Ocean Engineering, Vol. 122, No 1, pp. 222-240, ISSN 0029-8018, Elsevier Science Ltd, Oxford, United Kingdom, USA 2016.
3. Prpić-Oršić, J, Faltinsen, O.M., Parunov, J.: The effect of voluntary speed reduction criteria on attainable ship speed, International Congress of the International Maritime Association of the Mediterranean -IMAM 2015 - Towards Green Marine Technology and Transport, pp. 143-149, Pula, 2015.
4. Vettor, R., Prpić-Oršić, J., Guedes Soares, C.: The effect of wind loads on attainable ship speed on seaway, International Congress of the International Maritime Association of the Mediterranean -IMAM 2015 - Towards Green Marine Technology and Transport, pp.867-875, Pula, 2015.
5. M. Valčić, J. Prpić-Oršić: Wind loads estimation method based on elliptic Fourier descriptors, International Congress of the International Maritime Association of the Mediterranean -IMAM 2015 - Towards Green Marine Technology and Transport, pp. 883-891, Pula, 2015.
6. Legović, D., Dejhalla, R., Numerical Hydrodynamic Optimization of a Tanker Hull Form, 16th International Congress of the International Maritime Association of the Mediterranean -IMAM 2015 - Towards Green Marine Technology and Transport, Pula, 2015.
7. Bukša. T., Pavletić, D., Forempoher-Škuver, M., Bukša J., Analysis of Quality Improvement Models Applied in Shipbuilding Projects, IMAM 2015 - Towards Green Marine Technology and Transport, Pula, 2015.
8. Valčić, M., Dejhalla, R., 2015. Neural Network Prediction of Open Water Characteristics of Ducted Propeller, Pomorski zbornik - Journal of Maritime & Transportation Sciences 49-50, pp. 101-115.
9. Bukovac, O., Medica, V., Mrzljak, V.: "Steady state performances analysis of modern marine two-stroke low speed diesel engine using MLP neural network model", Brodogradnja: Teorija i praksa brodogradnje i pomorske tehnike, Vol. 66, No. 4, 2015.
10. Mrzljak, V., Mrakovčić, T.: Comparison of COGES and diesel-electric ship propulsion systems, 6th Conference on Marine Technology, Faculty of Engineering, 2015.
11. Mrzljak, V., Mrakovčić, T., Medica-Viola, V.: Quasi-dimensional numerical model of fuel evaporation and combustion in diesel engine, Pomorstvo, Vol. 29, No. 2, 2015.

This research has been fully supported by Croatian Science Foundation under the project 5371.

OPTIMISATION AND MODELLING OF THERMAL PROCESSES OF MATERIALS (OMOTPOM)

Principal investigator: Prof. Božo Smoljan, D. Sc., Faculty of Engineering, University of Rijeka

Summary of second year of Optimisation and Modelling of Thermal Processes of Materials

Main objective of the project is development of models and computer simulations of thermal processes and study of optimizing the application of tools and dies in thermal processing of materials. In the second year of research, main focus was on heat treatment, casting and welding. Extensive research has been done regarding the mentioned thermal processes. Computer models and programs for simulation of mechanical properties and microstructure distribution after thermal processing have been developed.
Besides computer modelling of mentioned thermal processes, great effort was put into developing and improving the thermal process for increasing the adhesiveness of electroless Ni-P coatings on substrates made of stainless steel. Processing parameters for application of coatings on stainless steel have been defined regarding to results of testing of adhesiveness.

Accomplished results have been published in the following book chapter:

1. B. Smoljan; Quench Processing: Multiple. In Encyclopedia of Iron, Steel, and Their Alloys; Taylor and Francis: New York, 31 March 2016; 2683-2705,

in the following scientific journal:

1. B. Smoljan, D. Iljkić, G. E. Totten; Mathematical Modelling and Simulation of Hardness of Quenched and Tempered Steel; Metallurgical and Materials Transactions B (46) 6; Springer, USA; 2015.; 2666-2673,

as well as on 10 conferences and their proceedings. Some of them are:

1. B. Smoljan; D. Iljkić; L. Štic; L. Pomenić; S. Smokvina Hanza; Numerical modelling of case hardening of steel; Proceedings of the International Conference MTSM 2016; Split, Croatia,
2. B. Smoljan; D. Iljkić; L. Štic; Computer modelling of quenching of steel die for industrial purpose; Proceedings of the International Conference HTDC 2016., Venice, Italy,
3. B. Smoljan; D. Iljkić; L. Štic; N. Tomašić; S. Smokvina Hanza; Mathematical modelling of mechanical properties and microstructure of welded joint; Proceedings of the 41st International Conference WELDING 2016; Opatija, Croatia,
4. B. Smoljan; D. Iljkić; L. Štic; Mathematical Modeling and Computer Simulation of Non-monotonic Quenching; Proceedings of the 23rd IFHTSE Congress; Savannah, USA.

Conclusion

Following the working plan, models for prediction of mechanical properties of specimens after heat treatment, casting and welding have been developed. Processing parameters for application of electroless Ni-P coatings on stainless steel substrate have also been defined. All accomplished results have been published in a book chapter, scientific journal and conference proceedings. Next step in optimisation and modelling of thermal processes of materials is verification of models that have been developed.

This research has been fully supported by Croatian Science Foundation under the project 1631.

CONFIGURATION-DEPENDENT APPROXIMATION IN NON-LINEAR FINITE-ELEMENT ANALYSIS OF STRUCTURES

Principal investigator: Prof. Gordan Jelenić, D. Sc., Faculty of Civil Engineering, University of Rijeka

Project summary

This research explores configuration-dependent interpolation as a novel and promising concept in non-linear finite-element analysis, in which shape functions do not depend only on the material co-ordinates, but also on the problem unknowns. In the limiting case where the non-linear mechanical problem becomes linear, the configuration-dependent approximation is expected to coincide with a known exact solution or, where this does not exist, with a known reference solution (reference linear solution – RLS). In a general non-linear situation, the configuration-dependent approximation is designed so that it should preserve all or some of the existing mathematical or physical properties of the problem analysed (property preservation – PP).

Principal investigator and team members (University of Rijeka, Faculty of Civil Engineering)

Academic staff:	Gordan Jelenić, Nenad Bićanić (deceased), Dragan Ribarić, Edita Papa Dukić, Leo Škec, Paulo Šćulac, Maja Gaćeša
Post-doctoral Research Associate:	Maryam Tabatabaei
Doctoral students / Research Assistants:	Sara Grbčić, Nina Čeh, Miran Tuhtan

Project work-packages

WP1. Configuration-dependent interpolation for homogeneous straight and curved 3D beams.
WP2. Configuration-dependent interpolation for homogeneous plates as well as flat and curved shells.
WP3. Configuration-dependent interpolation for straight layered 2D beams including discontinuities.
WP4. Configuration-dependent integration of equations of motion.

Outline of 2. year project results

The core project research topics involving layered beams and damage as well as the fixed-pole approach and higher-order linked interpolation in beams and Mindlin plates have been studied further and presented at a number of international conferences. Research collaboration with Brunel University (through a prestigious MSCA Individual Fellowship) and Universite de Technologie Compiegne (through a Ph.D. scholarship awarded by the French Government) have been established and a new CSF Research Project has been submitted. The project aims have been extended to include dynamic analysis, with particular reference to configuration-dependent time integration and dynamics of discrete multi-block structures, as well as micro-polar continuum theory and implementation. A new research assistant and a research associate have been employed to strengthen the research in rigid-body dynamics and elasto-dynamics of simple continua with rotational degrees of freedom.

This research has been fully supported by Croatian Science Foundation under the project 9068.

MULTI-SCALE CONCRETE MODEL WITH PARAMETER IDENTIFICATION – *CONCRETEMUSCID*

Principal investigator: Prof. Ivica Kožar, D. Sc., Faculty of Civil Engineering, University of Rijeka.

Objective

The shortest description of the project goal would be: development of the new numerical model for steel-fibre reinforced concrete under static and dynamic loading. Fibre reinforced concrete consists of cement matrix, aggregate and steel fibres, as could be seen in Fig. 1.

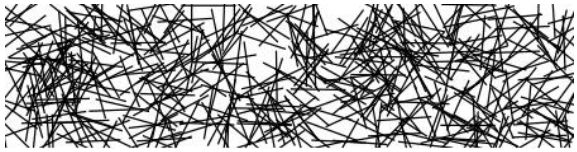
a)  b) 

Figure 1.: a) X-Ray image of steel-fibre reinforced concrete specimen, b) steel-fibre distribution generated by computer program developed within the Project.

Numerical model

Numerical model is based the lattice model applied on the Voronoi tesselation as presented in Fig. 2

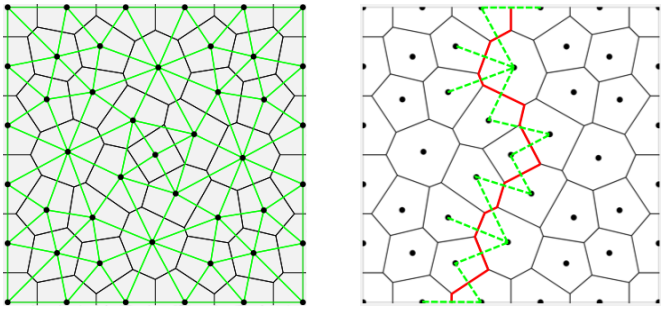


Figure 2.: a) Voronoi tesselation with cohesive links (Delaunay triangulation), b) crack propagation due to failure of single elements.

Parameter Identification

One of the important model parameters is the steel fibre behaviour characterised with a pull-out resistance whose testing is depicted in Fig. 3.

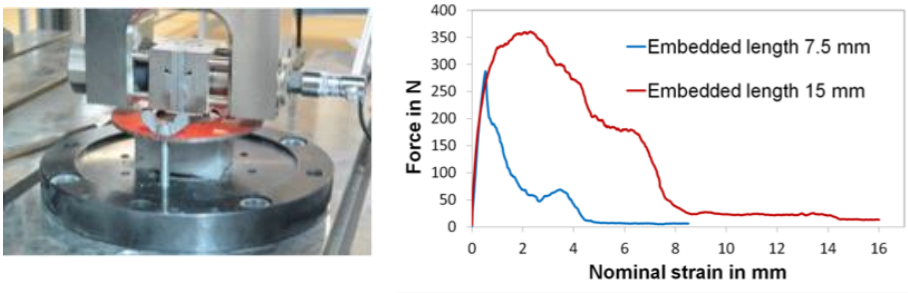


Figure 3.: Single fibre pull-out tests. a) experimental setup, b) test result.

Additional aspects

In addition, the aspects of corrosion in concrete will be dealt with. The corrosion is described using transport equations but coupled with mechanical equations so that the damage of concrete cover due to expansion of corrosion products and transport of rust through concrete pores and cracks could be computed.