



UNIVERSITY OF EAST SARAJEVO  
FACULTY OF MECHANICAL  
ENGINEERING



7<sup>th</sup> INTERNATIONAL SCIENTIFIC CONFERENCE



***COMETa 2024***

***„Conference on Mechanical Engineering  
Technologies and Applications“***

***PROCEEDINGS***

14<sup>th</sup>-16<sup>th</sup> November East  
Sarajevo, RS, B&H

# COMET<sub>a</sub> 2024

7<sup>th</sup> INTERNATIONAL SCIENTIFIC CONFERENCE

14<sup>th</sup> - 16<sup>th</sup> November 2024

Jahorina, B&H, Republic of Srpska



University of East Sarajevo

Faculty of Mechanical Engineering

Conference on Mechanical Engineering Technologies and Applications

---

## ***PROCEEDINGS***

*East Sarajevo, B&H, RS  
14<sup>th</sup> – 16<sup>th</sup> November, 2024*

PROCEEDINGS OF THE 7<sup>th</sup> INTERNATIONAL  
SCIENTIFIC CONFERENCE  
"Conference on Mechanical Engineering  
Technologies and Applications"  
COMETA2024, East Sarajevo, 2024

---

*Organization:* University of East Sarajevo  
Faculty of Mechanical Engineering East Sarajevo

*Publisher:* University of East Sarajevo  
Faculty of Mechanical Engineering East Sarajevo

*For publisher:* PhD Saša Prodanović, associate professor

*Editors:* PhD Biljana Marković, full professor  
PhD Miroslav Milutinović, full professor  
PhD Davor Milić, assistant professor

*Technical treatment  
and desing:* MSc Jelica Anić, senior assistant  
MSc Jovana Blagojević, senior assistant  
MSc Krsto Batinić, senior assistant  
MSc Srđan Samardžić, assistant

*Printing:* 1<sup>st</sup>

*Register:* ISBN 978-99976-085-2-9  
COBISS.RS-ID 141688065

## REVIEWERS

PhD Aleksandar Košarac, FME UES (B&H)  
PhD Aleksandar Živković, FTS Novi Sad (Serbia)  
PhD Aleksije Đurić, FME UES (B&H)  
PhD Angela Fajsi, FTS Novi Sad (Serbia)  
PhD Biljana Marković, FME UES (B&H)  
PhD Bogdan Marić, FME UES (B&H)  
PhD Borislav Savković, FTS Novi Sad (Serbia)  
PhD Branimir Grgur, FTM Belgrade (Serbia)  
PhD Branimir Krstić, University of Defence, Military Academy (Serbia)  
PhD Cvijetin Mladenović, FTS Novi Sad (Serbia)  
PhD Davor Milić, FME UES (B&H)  
PhD Dejan Jeremić, FME UES (B&H)  
PhD Dragan Milčić, FME Nis (Serbia)  
PhD Dragan Pršić, FMCE Kraljevo (Serbia)  
PhD Dušan Golubović, FME UES (B&H)  
PhD Dušan Gordić, FE Kragujevac (Serbia)  
PhD Goran Orašanin, FME UES (B&H)  
PhD Jasmina Pekez, TF "Mihajlo Pupin" Zrenjanin (Serbia)  
PhD Jelena Jovanović, FME Podgorica (MNE)  
PhD Milan Banić, FME Niš (Serbia)  
PhD Milan Rackov, FTS Novi Sad (Serbia)  
PhD Milan Rapajić, FTS Novi Sad (Serbia)  
PhD Milan Tica, FME Banja Luka (B&H)  
PhD Milan Zeljković, FTS Novi Sad (Serbia)  
PhD Milija Krašnik, FME UES (B&H)  
PhD Milomir Šoja, FEE UES (B&H)  
PhD Miloš Matejić, FE Kragujevac (Serbia)  
PhD Miloš Milovančević, FME Nis (Serbia)  
PhD Mirko Blagojević, FE Kragujevac (Serbia)  
PhD Miroslav Milutinović, FME UES (B&H)  
PhD Miroslav Stanojević, FME Belgrade (Serbia)  
PhD Mladen Tomić, FTS Novi Sad (Serbia)  
PhD Mladomir Milutinović, FTS Novi Sad (Serbia)  
PhD Nebojša Radić, FME UES (B&H)  
PhD Nenad Grahovac, FTS Novi Sad (Serbia)  
PhD Nikola Tanasić, FME Belgrade (Serbia)  
PhD Nikola Vučetić, FME UES (B&H)  
PhD Radoslav Tomović, FME Podgorica (MNE)  
PhD Ranka Sudžum, FME UES (B&H)  
PhD Saša Prodanović, FME UES (B&H)  
PhD Saša Živanović, FME Belgrade (Serbia)  
PhD Silva Lozančić, Faculty of Civil Engineering Osijek (Croatia)  
PhD Slaviša Moljević, FME UES (B&H)  
PhD Slobodan Lubura, FEE UES (B&H)  
PhD Slobodan Tabaković, FTS Novi Sad (Serbia)  
PhD Snežana Nestić, FE Kragujevac (Serbia)  
PhD Spasoje Trifković, FME UES (B&H)  
PhD Srđan Vasković, FME UES (B&H)  
PhD Stojan Simić, FME UES (B&H)  
PhD Uroš Karadžić, FME Podgorica (MNE)  
PhD Vladimir Milovanović, FE Kragujevac (Serbia)

PhD Vladimir Stojanović, FMCE Kraljevo (Serbia)  
PhD Vlado Medaković, FME UES (B&H)

## INTERNATIONAL SCIENTIFIC COMMITTEE

### **PhD Biljana Marković, FME UES (B&H) – president**

PhD Adisa Vucina, FMCE Mostar (B&H)  
PhD Aleksandar Aleksic, FE Kragujevac (Serbia)  
PhD Aleksandar Jovovic, FME Belgrade (Serbia)  
PhD Aleksandar Košarac, FME UES (B&H)  
PhD Aleksija Đurić, FME UES (B&H)  
PhD Bogdan Maric, FME UES (B&H)  
PhD Borut Kosec, NTF Ljubljana, (Slovenia)  
PhD Branimir Krstic, Military academy, University of Defence in Belgrade (Serbia)  
PhD Budimirka Marinović, FPM UES (B&H)  
PhD Balasaheb M. Patre, SGGS IET (India)  
PhD Vladimir Popović, FME Belgrade (Serbia)  
PhD Vladimir Stojanović, FMCE Kraljevo (Serbia)  
PhD Vladimir Milovanović, FE Kragujevac (Serbia)  
PhD Vlado Medaković, FME UES (B&H)  
PhD Vlatko Cingoski, FEE "Goce Delcev" University (North Macedonia)  
PhD George Nenes, UOWM (Greece)  
PhD Goran Janevski, FME Niš (Serbia)  
PhD Goran Šimunović, MEFSB (Croatia)  
PhD Grigor Stambolov, TU FIT (Bulgaria)  
PhD Davor Milić, FME UES (B&H)  
PhD Damjan Klobcar, FME Ljubljana (Slovenia)  
PhD Danijela Tadić, FE Kragujevac (Serbia)  
PhD Darko Knezevic, FME Banja Luka (B&H)  
PhD Dejan Jeremić, FME UES (B&H)  
PhD Dragan Milcic, FME Niš (Serbia)  
PhD Dragan Pršić, FMCE Kraljevo (Serbia)  
PhD Dragan Spasic, FTS Novi Sad (Serbia)  
PhD Dušan Golubović, FME UES (B&H)  
PhD Zdravko Krivokapić, FME (MNE)  
PhD Zlatko Nedelkovski, FTS MTU (North Macedonia)  
PhD Zoran Trifunov, FTS MTU (North Macedonia)  
PhD Zorana Tanasic, FME Banja Luka (B&H)  
PhD Ibrahim Plančić, FME UZ (B&H)  
PhD Ivan Bajsić, University of Novo mesto (Slovenia)  
PhD Ivan Samardžić, MEFSB (Croatia)  
PhD Izet Zekiri, MTU (North Macedonia)  
PhD Indiran Thirunavukkarasu, Manipal Institute of Technology (Indija)  
PhD Isak Karabegovic, FTS Bihać (B&H)  
PhD Jozsef Nyers, The Obuda University Budapest (Hungary)  
PhD Kyros Yakinthos, Aristotle University of Thessaloniki (Greece)  
PhD Lozica Ivanovic, FE Kragujevac (Serbia)  
PhD Ljubiša Dubonjić, FMCE Kraljevo (Serbia)  
PhD Mathias Liewald, IFU (Germany)  
PhD Megan Cordill, ESI MS, AAS (Austrian)  
PhD Milan Rakita, Purdue University (SAD)  
PhD Milan Rackov, FTS Novi Sad (Serbia)  
PhD Milan Tica, FME Banja Luka (B&H)

PhD Mile Savkovic, FMCE Kraljevo (Serbia)  
PhD Milosav Ognjanović, FME Belgrade (Serbia)  
PhD Miklos Imre Zsolt, PU Timisoar, (Romania)  
PhD Mirko Blagojević, FE Kragujevac (Serbia)  
PhD Mirko Ficko, UM FME (Slovenia)  
PhD Miroslav Zivkovic, FE Kragujevac (Serbia)  
PhD Mladen Tomic, FTS Novi Sad (Serbia)  
PhD Mladimir Milutinović, FTS Novi Sad (Serbia)  
PhD Monika Lutovska, FTS MTU (North Macedonia)  
PhD Nebojsa Lukić, FE Kragujevac (Serbia)  
PhD Nebojša Radić, FME UES (B&H)  
PhD Nenad Pavlović, FME Niš (Serbia)  
PhD Neritan Turkishi, FE, MTU (North Macedonia)  
PhD Nikola Vučetić, FME UES (B&H)  
PhD Nina Andjelić, FME Belgrade (Serbia)  
PhD Obrad Spaić, FPM UES (B&H)  
PhD Radivoje Mitrović, FME Belgrade (Serbia)  
PhD Radovan Radovanović, The Academy of criminalistic and police studies  
Belgrade (Serbia)  
PhD Radoslav Tomović, FME Podgorica (MNE)  
PhD Ranislav Bulatović, FME Podgorica (MNE)  
PhD Ranka Sudžum, FME UES (B&H)  
PhD Ranko Antunović, FME UES (B&H)  
PhD Saša Randelović, FME Niš (Serbia)  
PhD Sergej Alexandrov, Institute for Problems in Mechanics (Russia)  
PhD Slavisa Moljević, FME UES (B&H)  
PhD Slobodan Morača, FTS Novi Sad (Serbia)  
PhD Snežana Nestić, FE Kragujevac (Serbia)  
PhD Spasoje Trifković, FME UES (B&H)  
PhD Srdjan Vasković, FME UES (B&H)  
PhD Sreten Peric, Military Academy, University of Defence in Belgrade (Serbia)  
PhD Stanislav Karapetrovic, University of Alberta (Canada)  
PhD Stanislaw Legutko, PUT (Poland)  
PhD Stevan Kjosevski, FTS MTU (North Macedonia)  
PhD Stevan Stankovski, FTS Novi Sad (Serbia)  
PhD Stojan Simic, FME UES B&H  
PhD Tamara Aleksandrov Fabijanić, UZ FMENA (Croatia)  
PhD Uroš Karadžić, FME Podgorica (MNE)  
PhD Fuad Hadžikadunić, FME UZ (B&H)

#### **ORGANIZING COMMITTEE**

**PhD Milija Kraišnik, FME UES – president**

PhD Miroslav Milutinović, FME UES  
PhD Saša Prodanović, FME UES  
PhD Nebojša Radić, FME UES  
PhD Goran Orašanin, FME UES  
PhD Aleksije Đurić, FME UES  
Jovana Blagojević, ma, FME UES  
Jelica Anić, ma, FME UES  
Krsto Batinić, ma, FME UES - Technical Secretary  
Srđan Samardžić, ma, FME UES - Technical Secretary  
Stanišić Vera – Secretary

## GENERAL SPONSOR

Ministry of Scientific and Technological  
Development and Higher Education  
Republic of Srpska



## SPONSORS



**MAHLE®**



**DINECO**







The conference has been supported by:



*International Federation for  
the Promotion of Mechanism  
and Machine Science*



*Association  
for Design, Elements  
and Constructions*



UNIVERSITETI NËNË TEREZA  
УНИВЕРЗИТЕТ МАЈКА ТЕРЕЗА  
MOTHER TERESA UNIVERSITY



*Union of Mechanical Engineers and  
Technicians of Republic of Srpska*

**Countries from which conference participants come**



## PREFACE

Mechanical engineering, as one of the basic engineering disciplines, represents the key to understanding and improving many aspects of modern society. From the development of energy-efficient systems, through advanced materials and production technologies, to robotics and automation, mechanical engineering is at the very heart of innovation, which drives the global economy and contributes to a better quality of life. Contemporary trends in mechanical engineering, such as the application of artificial intelligence, additive technology, digital transformation, minimizing the impact of industrial processes on the environment, etc. widely open new horizons and opportunities for our profession. Through mutual cooperation, interdisciplinary approaches and the integration of new technologies, we can find solutions that will shape the future of industry and society. Today, our profession faces numerous challenges, which are the result of accelerated technological development. They are at the same time extremely complex, but also very inspiring and require not only technical expertise, but also creativity, cooperation and a constant desire for new scientific achievements. Therefore, we must be able to recognize and implement new approaches, methodologies and technologies. Moreover, only a holistic approach in the application of knowledge in various engineering fields, and especially in the field of mechanical engineering, is a safe way into the future. Finally, in today's world, which is rapidly changing under the influence of global economic, environmental and social factors, it is important that all of us, who deal with the field of mechanical engineering from various aspects, do not forget our responsibility. In this context, engineering ethics, quality of work and continuous education play a crucial role.

Although the scientific research process is crucial for economic progress, we must not forget the importance of educating new generations of mechanical engineers. The conference COMETA 2024 is precisely an extraordinary opportunity to further encourage young researchers and students to actively engage in scientific activities through the development of their ideas. In this sense, academic institutions have a great responsibility to provide quality education and research programs to future generations.

Recognizing the importance of the broad field of mechanical engineering for the overall industrial development of society, the work of the conference will take place through 5 sections. The program is focused on the following thematic areas:

- Manufacturing technologies and advanced materials,
- Applied mechanics and mechatronics,
- Machine design, simulation and modeling,
- Product development and mechanical systems,
- Energy and thermotechnic,
- Renewable energy and environmental,
- Maintenance and technical diagnostics,
- Quality, management and organization.

Also, as part of the conference program, one round table and two workshops will be held, whose topics relate to the generation of ideas and proposals for future project activities that must inevitably be based on innovation, quality, and upcoming machine technologies, which is actually in accordance with the Development strategy of

science and technology of the Republic of Srpska for the period 2023-2029, in which education, science, technology, research, innovation, and digitization are recognized as key prerequisites for achieving a sustainable economy.

Many experts, researchers, university professors, businessmen and students from various fields of mechanical engineering have registered to participate in this edition of conference COMETa 2024. The topics that will be discussed by the scientific and professional public will certainly contribute to the acquisition of new knowledge and open up a lot of space for future innovations. 77 papers will be published in the Conference proceedings, including 3 plenary lectures. The fact that numerous participants from abroad have been registered for the conference COMETa 2024 this year is especially pleasing.

Namely, 262 authors come from 16 countries. The review team is composed of 53 colleagues from the country and abroad. This is certainly the result of strenuous activities that were aimed at raising the international reputation and visibility of the conference in the regional, but also in the wider academic and scientific research area, which will be one of our primary goals in the future.

We are sure that the work at the conference COMETa 2024 will be fruitful and that each of you, after its end, will leave with new ideas, knowledge and contacts that will contribute to your further professional development. This is an opportunity not only to learn from each other, but also to build the foundations for future research projects and industrial innovations together. In addition, we believe that in the coming days we will have the chance to get to know each other better, discuss common challenges and establish new forms of cooperation. In this sense, we would like to point out that all your proposals and suggestions are more than welcome and will be carefully considered by the Organizing and Scientific Committee in order to improve the organization of the next conferences.

Finally, on behalf of the Organizing and Scientific Committee of the conference COMETa 2024, we express our great gratitude to all authors, reviewers, universities and faculties, business entities, and national and international institutions and organizations that supported the organization of the conference. Special thanks go to the Ministry of Scientific and Technological Development and Higher Education of the Republic of Srpska, the City of East Sarajevo, the Municipalities of East New Sarajevo, East Ilidža and Pale, without whose help the organization and work of the conference certainly could not be at the level that its status deserves.

East Sarajevo, November 13<sup>th</sup>, 2024.

President of the Scientific  
Committee

PhD Biljana Marković,  
full professor



President of the Organizing  
Committee

PhD Milija Krašnik,  
Associate Professor



# CONTENT

## PLENARY LECTURES

1. **Marcin Kamiński**  
PROBABILISTIC ENTROPIES IN MECHANICAL ENGINEERING 2
2. **Primož Podržaj**  
MODERN APPROACHES IN RESISTANCE SPOT WELDING CONTROL 10
3. **Mladimir Milutinović, Dejan Movrin, Saša Randelović**  
SMART TOOLS AND TOOLING DESIGN STRATEGIES FOR IMPROVED PROCESS CONTROL AND PART ACCURACY IN METAL FORMING 22

## MANUFACTURING TECHNOLOGIES AND ADVANCED MATERIALS

4. **Mirza Imširović, Uroš Trdan, Damjan Kločar, Drago Bračun, Aleš Nagode, Laurent Berthe, Matija Bušić, Miodrag Milčić, Dragan Milčić, Nataša Zdravković, Aleksija Đurić**  
ENHANCING DIRECTED ENERGY DEPOSITED AL5356 THROUGH IN SITU WORKPIECE VIBRATIONS 43
5. **Tatjana Lazović, Pavle Ljubojević, Snežana Čirić-Kostić, Nebojša Bogojević, Marina Dojčinović, Milan Stojanović**  
SAMPLE PREPARATION FOR CAVITATION EROSION TESTING OF 3D-PRINTED METAL 51
6. **Aleksandar Vujović, Janko Jovanović, Jelena Šaković-Jovanović, Marko Mumović**  
TESTING OF THE MECHANICAL PROPERTIES OF PARK FURNITURE ELEMENTS OBTAINED FROM RECYCLED PLASTIC 59
7. **Marija Matejic, Jovana Markovic, Dragan Lazarevic, Jasmina Skerlic, Milan Radenkovic**  
THEORETICAL ANALYSIS OF STATIC AND DYNAMIC STIFFNESS OF THE SUPPORTING STRUCTURE OF MODULAR CLAMPING FIXTURES 65
8. **Jelena Jovanović, Nikola Mitrović, Sandra Gajević, Slavica Miladinović, Jasmina Blagojević, Blaža Stojanović**  
INVESTIGATION OF THE IMPACT OF ABRASIVE ACTION ON SURFACE ROUGHNESS AND WORN MASS OF LAMINATED COMPOSITES 74
9. **Miloš Pjević, Mihajlo Popović, Goran Mladenović, Radovan Puzović**  
THE POST-PROCESSING METHOD FOR LARGE-SIZED PARTS PRODUCED USING SLA/mSLA TECHNOLOGY 83
10. **Nikola Vorkapic, Branko Kokotovic, Sasa Zivanovic**  
CHATTER DETECTION USING SUPPORT VECTOR MACHINE 90
11. **Tatjana Stanivuk, Miroslav Dujmović, Nikola Muslim, Branko Lalić**  
ELECTRIC MOTOR STARTERS AND DRIVES 98
12. **Miloš Milovančević, Srđan Stojičić, Mirjana Miljanović, Nikola Simonović, Dragana Trnavac**  
OPTIMAL PREDICTORS FOR ABLATION DEPTH IN MICROMACHINING USING EXCIMER LASER BY ADAPTIVE NEURAL FUZZY LOGIC 105

|     |   |     |
|-----|---|-----|
| 13. | <b>Srđan Stojičić, Milos Milovancevic, Mirjana Miljanović, Nikola Simonović, Dragana Trnavac</b><br>ASSESSMENT OF CHIP-TOOL INTERFACE TEMPERATURE USING AN ADAPTIVE NEURAL FUZZY INFERENCE SYSTEM                     | 117 |
| 14. | <b>Strahinja Djurovic, Dragan Lazarevic, Bogdan Cirkovic, Zivce Sarkocecic, Milan Misic, Marija Matejic</b><br>PREDICTION OF SURFACE ROUGHNESS WITH MULTIPLE REGRESSION ANALYSIS IN MACHINING PROCESS OF POM MATERIAL | 132 |
| 15. | <b>Katarina Pejić, Lana Šikuljak, Aleksandar Košarac</b><br>ADVANCED PARAMETRIC PROGRAMMING OF CNC MACHINES USING CUSTOM MACRO B LANGUAGE   | 141 |
| 16. | <b>Radomir Pojužina, Lana Šikuljak, Aleksandar Košarac</b><br>SURFACE QUALITY OPTIMIZATION IN MILLING Ti6Al4V TITANIUM ALLOY  | 149 |
| 17. | <b>Selver Smajic</b><br>ANALYSIS OF DIFFERENT PROCEDURES DURING SAWING LOGS INTO SAWN TIMBER  | 156 |

### **APPLIED MECHANICS AND MECHATRONICS**

|     |   |     |
|-----|---|-----|
| 18. | <b>Vladimir Stojanovic, Vladimir Djordjevic, Ljubisa Dubonjic, Sasa Prodanovic</b><br>OPTIMAL CONTROL OF A TWO-WHEELED SELF-BALANCING MOBILE ROBOT BASED ON ADAPTIVE DYNAMIC PROGRAMMING                      | 164 |
| 19. | <b>Stevan Stankovski, Gordana Ostojić</b><br>DEVELOPMENT OF TASKS FOR TRAINING IN PLC PROGRAMMING USING GENERATIVE ARTIFICIAL INTELLIGENCE  | 173 |
| 20. | <b>Janani Rajaraman, Saša Prodanović, Sai Phani Chandra Chittaluri, Ljubiša Dubonjić, Vladimir Stojanović</b><br>ANALYZING AND OPTIMIZING PI CONTROLLER METHODS FOR TWO TANK SYSTEM: A LABORATORY-BASED STUDY | 181 |
| 21. | <b>Marjan Dodić, Branimir Krstić</b><br>A LOW FIDELITY MATHEMATICAL MODEL OF A SINGLE ROTOR HELICOPTER IN FORWARD FLIGHT  | 189 |
| 22. | <b>Aleksandar Bodić, Snežana Vulović, Milan Bojović, Jelena Živković, Miroslav Živković</b><br>IMPROVED STRUCTURAL FATIGUE ANALYSIS USING FEM: DEVELOPMENT OF API SCRIPTS FOR STRESS RANGE CALCULATION        | 200 |
| 23. | <b>Snežana Vulović, Miloš Pešić, Aleksandar Bodić, Marko Toplavić, Miroslav Živković</b><br>FINITE ELEMENT ANALYSIS OF CYLINDRICAL SURFACE CONTACT  | 208 |
| 24. | <b>Nikolina Dakić, Vule Reljić, Slobodan Dudić, Vladimir Jurošević, Filip Damjanović</b><br>DESKTOP APPLICATION FOR PNEUMATIC DIDACTIC COMPONENT RECOGNITION  | 214 |
| 25. | <b>Nikola Vučetić, Ranko Antunović, Dejan Jeremić, Nebojša Radić, Imre Zsolt Miklos</b><br>ALGORITHM FOR ASSESSING THE INTEGRITY OF THE CYLINDER ASSEMBLY   | 222 |

26. **Isak Karabegović, Raul Turmanidže, Predrag Dašić**  
THE AUTOMOBILE AND ELECTRO/ELECTRONIC INDUSTRY AS  
WORLD LEADERS IN THE IMPLEMENTATION OF INDUSTRY 4.0 228  
TECHNOLOGIES IN PRODUCTION PROCESSES: REVIEW OF  
ROBOT TECHNOLOGY
27. **Dragan Rakić, Vukašin Slavković, Aleksandar Bodić, Milan  
Bojović, Miroslav Živković**  
USER INTERFACE DEVELOPMENT FOR IDENTIFYING CDP 241  
CONSTITUTIVE MODEL PARAMETERS
28. **Cvijetin Mladenović, Aleksandar Živković, Miloš Knežev, Dejan  
Marinković, Dejan Lukić**  
STABILITY LOBE DIAGRAM OF THE MILLING MACHINING SYSTEM 249  
WITH MULTIPLE DOMINANT VIBRATION MODES
29. **Andjela Mitrović, Slobodan Savić, Mladen Josijević, Nebojša  
Hristov, Damir Jerković, Djordje Ivković**  
DETONATION WAVE CONTOURS IN EXPLOSIVELY FORMED 258  
PROJECTILE
30. **Alma Čosić, Adis Dedić, Emir Nezirić, Dejan Jokić**  
EXPERIMENTAL ANALYSIS OF KINEMATIC PARAMETERS IN 270  
PLANAR MECHANISMS

### ***MACHINE DESIGN, SIMULATION AND MODELING***

31. **Stevan Kjosevski, Monika Lutovska, Zoran Trifunov**  
CAPACITY OF CONTRIBUTING TO SUSTAINABLE DEVELOPMENT 275  
OF CARS WITH DIFFERENT PROPULSION SYSTEMS – WESTERN  
BALKAN STUDY
32. **Saša Živanović, Ljubomir Nešovanović, Zoran Dimić, Radovan  
Puzović**  
SIMULATION OF PARALLEL KINEMATIC MACHINE WITH SPECIFIC 284  
SOLUTIONS OF THE PASSIVE TRANSLATORY JOINT
33. **Biljana Marković, Miljan Savić**  
ARTIFICIAL INTELLIGENCE (AI) MANAGEMENT SYSTEM, KEY 291  
ELEMENTS
34. **Goran Pavlović, Mile Savković, Nebojša B. Zdravković, Goran  
Marković, Marko Todorović, Predrag Mladenović**  
OPTIMAL DESIGN OF THE HYBRID I-GIRDER OF THE SINGLE- 300  
BEAM BRIDGE CRANE
35. **Miloš Josimović, Gordana Bogdanović, Milan Vasić, Mirko  
Blagojević**  
THE USE OF THE CYCLOIDALDRIVE BLOCK IN THE ANALYSIS OF 308  
CYCLOIDAL REDUCER EFFICIENCY
36. **Nikola Babić, Milan Tica**  
RESULTS COMPARATION OF ANALYTICAL AND SOFTWARE 316  
METHODS OF STEEL STRUCTURE STATIC CALCULATION
37. **Dejan Landup, Eleonora Desnica, Ivan Palinkaš, Luka Đorđević,  
Borivoj Novaković**  
EXAMPLES OF THE PRACTICAL APPLICATION OF 3D SCANNERS 325  
IN PARTS QUALITY CONTROL IN THE AUTOMOTIVE INDUSTRY
38. **Aleksija Djuric, Srđan Samardžić, Biljana Marković, Dragan Milčić,  
Damjan Klobčar, Nataša Zdravković, Miodrag Milčić**  
EXPERIMENTAL ANALYSIS OF THE BEHAVIOR OF ADHESIVELY 334  
BONDED CFRP-ALUMINUM ALLOY AW 5754 H22 JOINTS UNDER  
TENSILE-SHEAR LOAD

39. **Nina Anđelić, Vesna Milošević-Mitić, Ana Petrović, Đorđe Đurđević**  
A VIEW OF THE INFLUENCE OF CONSTRAINED TORSION ON  
BEHAVIOUR OF THIN-WALLED CANTILEVER CHANNEL-SECTION  
AND Z-SECTION BEAMS 342
40. **Srđan Samardžić, Mersida Manjgo, Aleksija Đurić, Biljana  
Marković, Miroslav Milutinović, Spasoje Trifković**  
INFLUENCE OF FIBER ORIENTATION AND MOISTURE ON THE  
STRENGTH OF SINGLE-LAP ADHESIVE JOINTS OF PA6 GF  
COMPOSITE 351
41. **Rade Vasiljević**  
ANALYSIS OF NODAL LOADS OF THE COLUMN OF A MECHANICAL  
LIFTS 359
42. **Nikola Milošević, Spasoje Trifković, Miroslav Milutinović, Kulwant  
Singh**  
APPLICATION OF 3D PRINTING IN METAL CONSTRUCTIONS 367

### ***PRODUCT DEVELOPMENT AND MECHANICAL SYSTEMS***

43. **Milan Rackov, Siniša Kuzmanović, Ivan Knežević, Waldemar  
Matysiak, Jakub Hajkowski, Mateusz Barczewski, Mirjana Bojanić  
Šejat** 378  
THE IMPACT OF EFFICIENCY ON THE SELECTION OF  
UNIVERSAL GEAR MOTOR REDUCERS
44. **Radoslav Tomović, Aleksandar Tomović, Samir Dizdar** 386  
REPLICA OF CRNOJEVIC PRINTING PRESS - THE FIRST  
PRINTING MACHINE IN THE BALKANS
45. **Nenad Kostic, Vesna Marjanovic, Nenad Petrovic, Zivana  
Jovanovic Pesic** 394  
PREDICTING STRESS CONCENTRATION FACTORS IN TENSION-  
LOADED SHAFTS USING ARTIFICIAL NEURAL NETWORKS
46. **Miloš Matejić, Anđela Perović, Ivan Miletić, Ljubica Mudrić-  
Staniškovski, Lozica Ivanović** 402  
DESIGN AUTOMATION OF SET SCREW CONNECTION
47. **Milica Radovanović, Brankica Čomić, Snežana Dostinić,  
Budimirka Marinović, Obrad Spaić, Dejan Božić, Dejan Lukić,  
Mijodrag Milošević** 409  
THE INFLUENCE OF CNC TECHNOLOGY ON PRODUCTION TIME  
AND PROCESSING QUALITY

### ***ENERGY AND TERMOTECHNIC***

48. **Valentino Stojkovski, Marija Lazarevikj, Zoran Markov** 419  
MODEL FOR PROSPECTING HIDDEN HYDROPOWER AT  
EXISTING WATER SUPPLY SYSTEMS
49. **Vuko Kovijanić, Uroš Karadžić, Anton Bergant, Igor Aleksić** 431  
TRANSIENT FLOW DURING RAPID FILLING OF HORIZONTAL  
PIPES WITH TRAPPED AIR
50. **Ruzena Kralikova, Ervin Lumitzer, Elena Lukač Jurgovska** 439  
DRONE THERMAL IMAGING: NEW TRENDS AND PERSPECTIVES
51. **Djordje Manojlovic, Vesna Jevtic** 446  
FLUE GAS DESULPHURIZATION PLANT WORKING EFFECTS IN  
THE THERMAL POWER PLANT



- 52 **Ivan Popović, Milan Djordjević, Jasmina Skerlić, Vladan Jovanović**  
 DETERMINING THE RELIABILITY FUNCTION OF THE THERMAL POWER SYSTEM IN POWER PLANT "KOSTOLAC, BLOCK A2" USING THE WEIBULL DISTRIBUTION 454

### **RENEWABLE ENERGY AND ENVIRONMENTAL PROTECTION**

- 53 **Danijela Nikolić, Minja Velemir Radović, Saša Jovanović, Zorica Đorđević**  
 ENERGY ANALYSIS OF SERBIAN BUILDING WITH PV PANELS AND DIFFERENT HEATING SYSTEMS 463
- 54 **Branislav Dudić, Alexandra Mittelman, Branko Štrbac, Borislav Savković**  
 SUSTAINABILITY OF GLOBAL LITHIUM-ION BATTERIES 472
- 55 **Srđan Vasković, Gojko Krunić, Aleksandar Anđelković, Mladen Tomić, Marko Romović**  
 ASPECTS OF LPG FUEL APPLICATION IN CARS 478
- 56 **Goran Orašanić, Budimirka Marinović, Stojan Simić, Davor Milić, Jovana Blagojević**  
 SUSTAINABLE WATER SUPPLY IN THE CONTEXT OF THE GREEN AGENDA FOR THE WESTERN BALKANS 484
- 57 **Jela Vorotović, Goran Vorotović, Đorđe Novković, Milan Lečić, Miloš Januzović**  
 TURBULENCE ANISOTROPY IN A COUNTER-FLOW VORTEX TUBE FLOW 491
- 58 **Minja Velemir Radović, Danijela Nikolić, Saša Jovanović**  
 ENERGY EFFICIENCY IN THE BUILDING SECTOR IN SERBIA - AN OVERVIEW 499
- 59 **Vesna Mihajlov, Jasmina Pekez, Uroš Šarenac, Ljiljana Radovanović, Mića Djurdjev, Aleksandar Ašonja**  
 JUSTIFICATION OF THE APPLICATION OF PHOTOVOLTAIC TRANSFORMATION OF SOLAR RADIATION FOR THE PRODUCTION OF ELECTRICITY FOR THE NEEDS OF PUBLIC INSTITUTIONS 507
- 60 **Milica Kašiković, Uroš Karadžić**  
 SELECTION OF THE WATER TURBINE BASED ON ELECTRICITY GENERATION ON SUTJESKA RIVER 515
- 61 **Zaga Trišović**  
 RENEWABLE ENERGY EQUIPMENT IN BIOGAS PLANTS 521

### **MAINTENANCE AND TECHNICAL DIAGNOSTICS**

- 62 **Rodoljub Vujanac, Nenad Miloradovic, Snezana Vulovic**  
 SOME EXPERIENCES FROM THE PRACTICE ABOUT RESULTS AND IMPORTANCE OF WAREHOUSE RACKING INSPECTIONS 530
- 63 **Josip Radić, Antonija Ereš, Držislav Vidaković, Marijana Hadzima-Nyarko**  
 ASSESSMENT OF BUILDING VULNERABILITY THROUGH RAPID VISUAL SCREENING METHOD: CASE STUDY OF SELECTED STREET BLOCKS IN OSIJEK 536

## QUALITY, MANAGEMENT AND ORGANIZATION

|    |  |     |
|----|--|-----|
| 64 | <b>Monika Lutovska, Zoran Trifunov, Izet Zeqiri, Stevan Kjosevski</b><br>OCCUPATIONAL SAFETY AWARENESS MEASURING TOOL<br>AMONG AGRICULTURAL WORKERS IN NORTH MACEDONIA                   | 544 |
| 65 | <b>Danijela Tadić, Nikola Komatina, Marija Savković</b><br>FORECASTING DEMAND TRENDS IN AUTOMOTIVE INDUSTRY:<br>COMPARATIVE ANALYSIS OF EXPONENTIAL SMOOTHING AND<br>REGRESSION ANALYSIS | 550 |
| 66 | <b>Snežana Nestić, Danijela Tadić, Tijana Petrović</b><br>DETERMINING THE WEIGHTS OF COMMERCIAL CRITERIA FOR<br>INVESTMENT PROJECT EVALUATION BASED ON THE IDOCRIV<br>METHOD             | 558 |
| 67 | <b>Aleksandar Aleksić, Ivana Spasenić, Danijela Tadić</b><br>ASSESSMENT AND SELECTION OF CLOUD SERVICE PROVIDERS<br>FOR HOSTING WEB APPLICATIONS BY APPLYING MADM<br>APPROACH            | 566 |
| 68 | <b>Jovana Dragutinovic, Angela Fajsi, Slobodan Morača, Slaviša<br/>Moljević, Ranka Sudžum</b><br>KEY SUCCESS FACTORS OF AGILE TRANSFORMATION IN<br>MANUFACTURING COMPANIES               | 575 |
| 69 | <b>Slavenko Stojadinovic, Milos Pjevic, Nikola Slavkovic, Radovan<br/>Puzovic</b><br>3D SCANNING AND INSPECTION GEOMETRICAL PARAMETERS OF<br>SPROCKET TOOTH PROFILE                      | 581 |
| 70 | <b>Vlado Medaković, Bogdan Marić</b><br>OVERALL EFFICIENCY AND EFFECTIVE PERFORMANCE OF<br>PRODUCTION EQUIPMENT – CASE STUDY   | 587 |
| 71 | <b>Ivan Mačuzić, Marija Savković, Nastasija Nikolić, Đorđe Milojević</b><br>APPLICATION OF ROBOTICS SYSTEMS FOR QUALITY<br>INSPECTION IN INDUSTRY  | 595 |
| 72 | <b>Radoslav Vučurević, Zdravko Krivokapić, Brankica Čomić</b><br>THE INFLUENCE RANKING OF DRILLING PROCESS INPUT<br>PARAMETERS ON SURFACE ROUGHNESS                                      | 604 |
| 73 | <b>Dragan Vujović, Pavle Popović, Oto Iker</b><br>INTELLECTUAL CAPITAL MANAGEMENT IN CONDITIONS OF<br>UNCERTAINTY  | 613 |
| 74 | <b>Vasko Milatović, Nikola Šibalić, Aleksandar Vujović</b><br>MEASUREMENT OF NOISE LEVELS IN THE WORKPLACE   | 621 |
| 75 | <b>Belma Fakić, Adisa Burić, Edib Horoz</b><br>ENSURING THE VALIDITY OF TEST RESULTS TO ENSURE<br>RELIABILITY  | 629 |
| 76 | <b>Tamara Koroman, Sanja Kanostrevac-Vidaković</b><br>ACCREDITATION PROCESS OF THE STANDARD METHOD BAS<br>EN ISO 12156-1 IN THE "SISTEM QUALITA,S" LTD. PALE TESTING<br>LABORATORY       | 635 |
| 77 | <b>Ranka Sudžum, Angela Fejsi, Luka Jevtović</b><br>EVALUATION OF INNOVATION PROJECTS USING INTUITIONISTIC<br>FUZZY TOPSIS METHOD  | 642 |

## SPONSORS CONFERENCE COMETA 2024



---

## USER INTERFACE DEVELOPMENT FOR IDENTIFYING CDP CONSTITUTIVE MODEL PARAMETERS

**Dragan Rakić<sup>1</sup>, Vukašin Slavković<sup>2</sup>, Aleksandar Bodić<sup>3</sup>, Milan Bojović<sup>4</sup>, Miroslav Živković<sup>5</sup>**

*Abstract: This paper presents the development of a user interface for the automatic identification of concrete damage plasticity (CDP) constitutive model parameters, based on the results of experimental results. The application uses the results of uniaxial compressive and tensile tests. CDP constitutive model is often used in the simulation of the mechanical behaviour of concrete, and with appropriate modifications it can also be used to simulate the behaviour of the rock mass. The theoretical basis of the concrete damage plasticity constitutive model is given in the paper and the theoretical meaning of certain parameters is explained. In order to unambiguously identify the material parameters, it is necessary to obtain the experimental stress-strain dependence, as well as the stress-degradation dependence. In order to determine these dependencies, it is necessary to carry out load-unload tests, until the complete failure of the specimen. Verification of the material parameters obtained by the identification process using the developed user interface was carried out through numerical simulations of uniaxial compression and tension tests using PAK software.*

*Key words: concrete damage plasticity, finite element method, material parameters identification, PAK, user interface*

### 1 INTRODUCTION

Concrete is a highly heterogeneous material that exhibits complex, nonlinear mechanical behavior. Therefore, precise description of concrete behavior within numerical simulations of concrete structures is very difficult. In addition, accurate definition and assessment of damage within concrete structures represents a great

---

<sup>1</sup> PhD, Dragan Rakić, Faculty of Engineering University of Kragujevac, Kragujevac, Serbia, [drakic@kg.ac.rs](mailto:drakic@kg.ac.rs) (CA)

<sup>2</sup> PhD Vukašin Slavković, Faculty of Engineering University of Kragujevac, Kragujevac, Serbia, [vukasin@fink.rs](mailto:vukasin@fink.rs)

<sup>3</sup> Aleksandar Bodić, Faculty of Engineering University of Kragujevac, Kragujevac, Serbia, [abodic@uni.kg.ac.rs](mailto:abodic@uni.kg.ac.rs)

<sup>4</sup> Milan Bojović, Faculty of Engineering University of Kragujevac, Kragujevac, Serbia, [mbojovic@outlook.com](mailto:mbojovic@outlook.com)

<sup>5</sup> PhD Miroslav Živković, Faculty of Engineering University of Kragujevac, Kragujevac, Serbia, [zile@kg.ac.rs](mailto:zile@kg.ac.rs)

challenge for engineers and researchers. To address these complexities in finite element analysis (FEA) of concrete structures, material models are employed [1]. One widely utilized example is the Concrete Damaged Plasticity (CDP) model which integrates the principles of plasticity and damage mechanics, enabling a more comprehensive and effective analysis of concrete behaviour under various loading conditions [2, 3]. Nowadays, there are many papers where CDP is used for the numerical analysis of structures such as: reinforced concrete structures with glass fiber-reinforced polymers [4] or carbon-fiber reinforced polymers [5], corners of reinforced concrete frames [6], reinforced concrete shear walls [7], reinforced concrete buildings subjected to blast loading [8], missile impact on reinforced concrete structures [9, 10], etc. Therefore, it can be concluded that the application of this material model is very widespread and significant in the numerical analysis of concrete structures.

A great challenge in using this material model is the correct determination of its parameters. Accordingly, procedures developed for the identification of the parameters of this material model can be found in literature [11, 12, 13]. This paper is a continuation of the previous research [14] in which a methodology was developed for determining CDP parameters. In this paper, an application developed for the automatic determination of parameters based on experimental data from uniaxial compression and tension tests is presented. Verification is performed by comparing results of numerical analysis with experimental data from literature [15, 16].

## 2 THEORETICAL BASICS

### 2.1 Concrete damaged plasticity material model

The yield function of CDP material model [3] is defined by equation:

$$F(\bar{\boldsymbol{\sigma}}, \boldsymbol{\kappa}) = \frac{1}{1-\alpha} \left( \alpha \bar{I}_1 + \sqrt{\frac{3}{2}} \|\bar{\mathbf{S}}\| + \beta(\boldsymbol{\kappa}) \langle \bar{\sigma}_{\max} \rangle \right) - c_c(\boldsymbol{\kappa}) \leq 0 \quad (1)$$

where  $c_c(\boldsymbol{\kappa})$  is material cohesion,  $\bar{I}_1$  is first stress invariant,  $\bar{\mathbf{S}}$  is deviator of effective stress,  $\bar{\sigma}_m$  is mean effective stress,  $\bar{\sigma}_{\max}$  is algebraic maximum of eigenvalues of effective stress tensor.

The effective stress – total strain dependence for tension and compression is shown in Figure 1, where the terms in the figure are:  $f_c'$  is compressive strength,  $f_t'$  is tensile strength,  $f_{c0}$  is compression yield stress,  $E_0$  is initial value of Elasticity modulus,  $d_c$  is damage parameter for compression,  $d_t$  is damage parameter for tension,  $e^E$  is elastic strain,  $e^P$  is plastic strain.

### 2.2 Identification of CDP material parameters

Identification of concrete damaged plasticity material model parameters can be performed by using experimental results of the cyclic loading-unloading uniaxial compression and tension tests. The following is an overview and identification procedure of material model parameters [14].

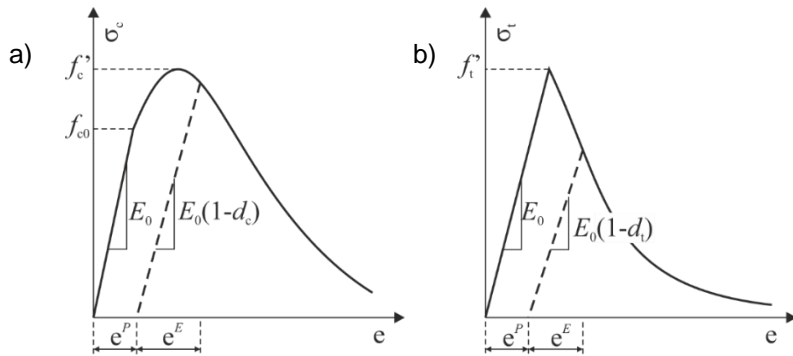


Figure 1. Dependence of stress on total strain for: a) compression and b) tension

Based on the stress-strain dependence, using basic relations from the theory of plasticity and damage theory, stress-plastic strain and stress-degradation dependences can be determined. Young's modulus represents the dependence between stress and strain in the elastic behavior region of a material and it can be determined as the initial slope of the curve on the stress-total strain chart. Value of degradation can be determined at each unloading cycle based on the current and initial elasticity modulus of material using equation:

$$E = (1-d)E_0 \tag{2}$$

Based on that it is possible to create stress-plastic strain and stress-degradation chart for uniaxial compression and tension, which are essential for determining other parameters. Compressive and tensile strength represent maximum stress values on stress-total strain chart and can be read directly from those charts. Compression curve parameter  $a_c$  can be determined from relation between compressive strength and yield stress which is given by equation:

$$f'_c = f_{cm} = f_{c0} \frac{(1+a_c)^2}{4a_c} \tag{3}$$

Parameter  $D_c$  represents the degradation which corresponds to the compressive strength. Parameter  $D_t$  represents degradation which corresponds to the stress value  $f'_t / 2$ . Both parameter can be determined from the stress-degradation charts (Figure 2) for compression and tension tests, respectively.

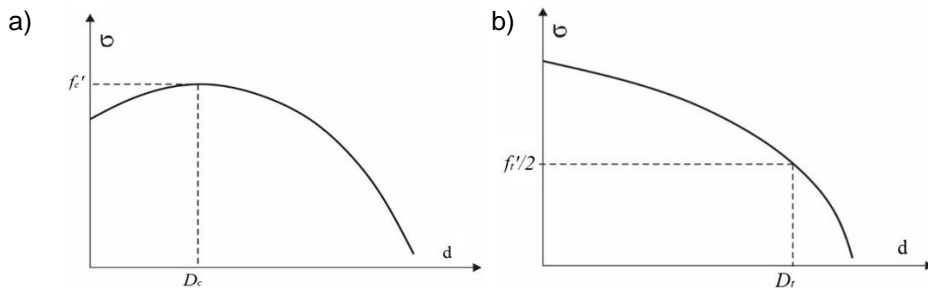


Figure 2. Determination of a)  $D_c$  and b)  $D_t$  parameter

The compressive fracture energy  $G_c$  and the tensile fracture energy  $G_t$  represent the areas below the stress-plastic strain curve for uniaxial compression and tension tests, respectively.

Parameter  $D_{cr}$  represents the maximum value of degradation that can be reached during uniaxial compression and tension tests. The parameter  $\alpha$  defines the ration of the uniaxial and biaxial initial yield stresses and can be calculated using:

$$\alpha = \frac{\frac{f_{b0}}{f_{c0}} - 1}{2 \frac{f_{b0}}{f_{c0}} - 1} \quad (4)$$

where  $f_{c0}$  and  $f_{b0}$  represent initial yield stresses for uniaxial and biaxial compression.

The parameter  $\gamma$  defines the ratio of the second invariant of deviatoric stress in the tension and compression meridians, which correspond to the same value of the first stress invariant. The dilatation parameter  $\alpha_p$  represents the tangent of the dilatation angle  $\psi$ .

### 3 USER INTERFACE FOR AUTOMATIC IDENTIFICATION OF CDP PARAMETERS

In this part, we present the basic functionalities of the GeoGraphy toolbox, a tool intended for the automatic determination of CDP model parameters. This tool enables FEM engineers working with geomaterials to automatically determine the material parameters related to concrete material using the values of experimental results. GeoGraphy toolbox is written in Python language using libraries: PyQt5, matplotlib, numpy and scipy. shows the layout of the window with the available options: palette of basic options, space for plotting experimental results, options for manipulation of experimental results and determination of individual parameters.

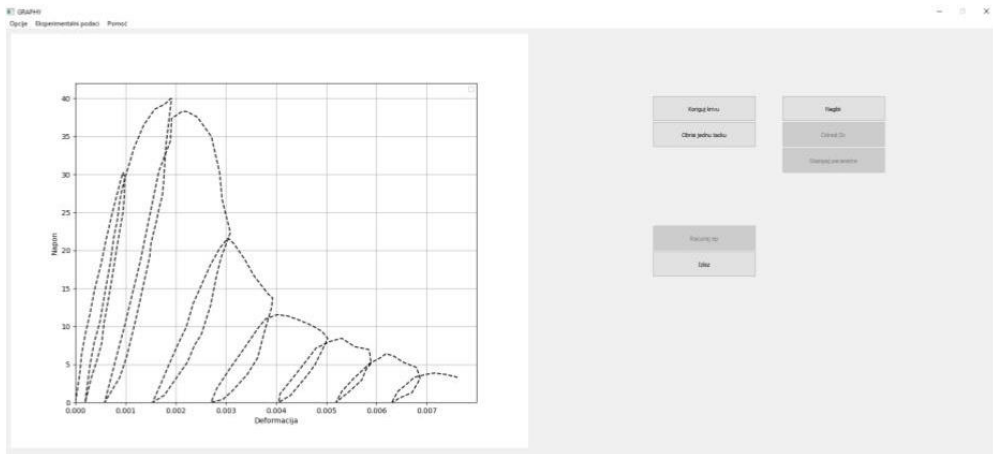


Figure 3. Toolbox after loading the compression experimental results

Experimental results obtained for concrete model often contain certain imperfections, inaccuracies or there is a lack of a certain part of the data. The developed GeoGraphy toolbox enables engineers to directly interact with experimental data,

manipulate and correct obtained experimental curves and add missing parts of data. The stress-strain curves recreated and modified in this way can be used as a basis for determining certain parameters of the model graphically. Figure 3 shows the toolbox window after loading the compression experiment stress-strain curve (dashed black line). After loading the experimental results, it is possible to directly graphically correct the displayed curve and determine new slope values during relaxation. In order to make the work of engineers easier during manipulation, it is possible to recreate the entire curve, parts of the curve or delete individual points. After recreating the stress-strain curve, it is possible to export the parameter values to a file. Figure 4 shows the recreated stress-strain curve (blue solid line) and slopes (dashed green line).

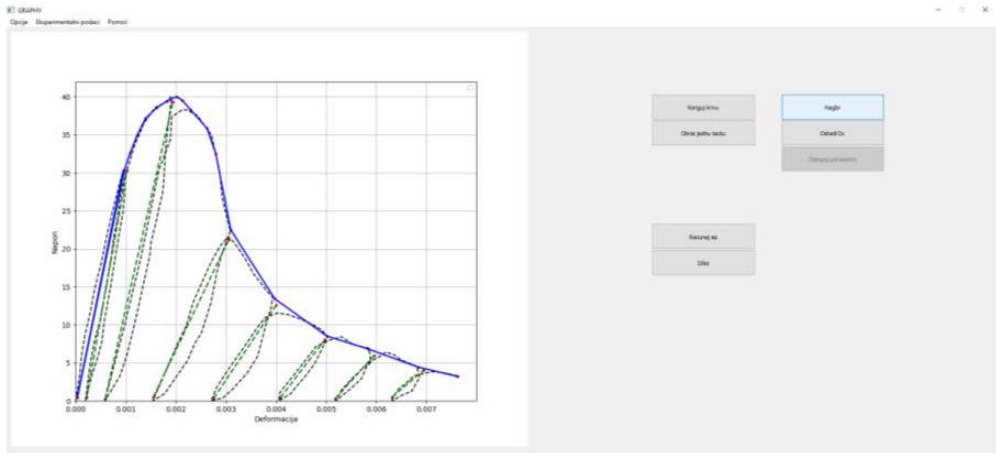


Figure 4. Toolbox window after defining the stress-strain curve and slopes by the user

#### 4 VERIFICATION

Numerical simulations of load-unload uniaxial compression and tension tests are performed using PAK software package [17]. For the purpose of numerical simulations, CDP model is used, and parameter values determined using developed application are used. The numerical simulations results are compared with the experimental data from the literature.

A schematic representation of the specimen model used in uniaxial tests simulations with defined boundary conditions and load is given in Figure 5. The FE model consists of one 3D hexahedral 8-noded finite element.

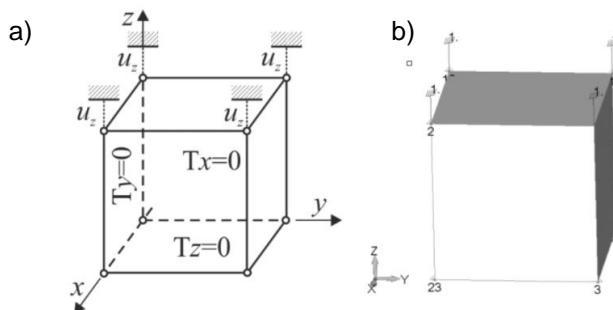


Figure 5. Specimen model for uniaxial tests a) schematic representation, b) FE model

Parameters of CDP material model determined using developed application are shown in Table 1.

Table 1. Parameters of CDP model determined using application

| Parameter                  | Value              |
|----------------------------|--------------------|
| $E$ (kPa)                  | $41/32 \cdot 10^6$ |
| $\nu$                      | 0.2                |
| $f_c$ (kPa)                | $40 \cdot 10^3$    |
| $f_t$ (kPa)                | $3.68 \cdot 10^3$  |
| $a_c$                      | 4.136              |
| $D_c$                      | 0.29               |
| $a_t$                      | 0.225              |
| $D_t$                      | 0.31               |
| $G_c$ (kN/m <sup>3</sup> ) | 122                |
| $G_t$ (kN/m <sup>3</sup> ) | 0.67               |
| $D_{cr}$                   | 0.95               |

Boundary conditions are set to correspond to the specimen experimental uniaxial test conditions. Symmetry boundary conditions are set on nodes located in symmetry planes. The load is applied using prescribed displacement in the direction of the z-axis at the nodes on the upper face of the model. In both, uniaxial compression and tension tests, the prescribed displacement is multiplied by the load function that corresponds to the experiment.

#### 4.1 Results of numerical simulations

The results of uniaxial tests numerical simulations are compared with experimental data. Figure 6 shows the comparison of stress-total strain dependence.

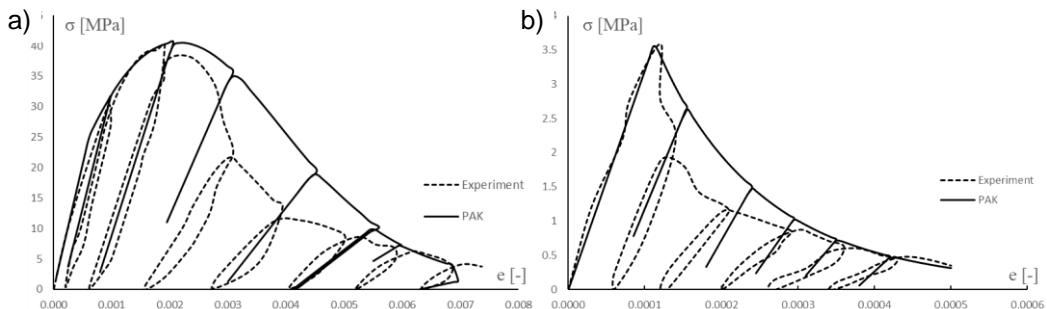


Figure 6. Stress – total strain charts for a) compression, b) tension

Figure 7 shows stress – degradation chart for uniaxial compression and tension. By comparing the previous charts, it can be concluded that the numerical simulation results by correspond to the experimental data. Therefore, it can be concluded that developed application can be used identification of material parameters for CDP effectively.



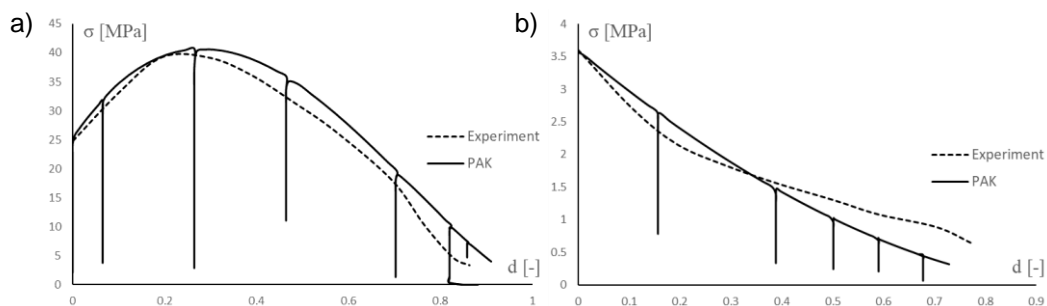


Figure 7. Stress – degradation charts for a) compression, b) tension

## 5 CONCLUSION

The application for automatic identification of CDP material model parameters is presented in this paper. This research is a continuation of the previous work in which a methodology was developed for determining CDP parameters is established. The previously developed procedure for the identification of CDP parameters is given in the paper.

Parameter identification is performed based on experimental data from the literature. The parameters of this material model can be determined based on experimental tests of uniaxial compression and tension with unloading. Using the developed application, the process of determining the parameters for this material model was automated. The verification was carried out by numerical simulations of uniaxial compression and tension tests and by comparing the results with the literature.

Based on the obtained results, it can be concluded that by using this user application, the process of identifying the parameters of the CDP material model can be effectively automated. Automating this process can significantly save engineering time and reduce human error.

## ACKNOWLEDGMENT

This research is partly supported by the Science Fund of the Republic of Serbia, #GRANT No 7475, Prediction of damage evolution in engineering structures – PROMINENT.

## REFERENCES

- [1] M. Kojić , R. Slavković, M. Živković and N. Grujović, *Metod konačnih elemenata I*, Kragujevac: Mašinski fakultet Univerziteta u Kragujevcu , 1998.
- [2] J. Lubliner, J. Oliver and E. Onate, “A plastic-damage model for concrete,” *International Journal of Solids and Structures*, vol. Volume 25, no. 3, pp. 299-326, 1989.
- [3] J. Lee, *Theory and implementation of plastic-damage model for concrete structures under cyclic and dynamic loading*, Berkeley, California: University of California, 1996.

- [4] A. Raza, Q. uz Zaman Khan and A. Ahmad, "Numerical Investigation of Load-Carrying Capacity of GFRP-Reinforced Rectangular Concrete Members Using CDP Model in ABAQUS," *Advances in Civil Engineering*, vol. 2019, pp. 1-21, 2019.
- [5] M. de Santana Santos and T. Denyse Pereira de Araujo, "NUMERICAL ANALYSIS OF THE BEHAVIOR OF CONCRETE COLUMNS CONFINED WITH CFRP USING THE CONSTITUTIVE MODEL CONCRETE DAMAGED PLASTICITY," in *Proceedings of the XLI Ibero-Latin-American Congress on Computational Methods in Engineering*, Foz do Iguac,u/PR, Brazil, 2020.
- [6] M. Szczecina and A. Winnicki, "NUMERICAL SIMULATIONS OF CORNERS IN RC FRAMES USING STRUT-AND-TIE METHOD AND CDP MODEL," in *XIII International Conference on Computational Plasticity. Fundamentals and Applications*, Barcelona, Spain, 2015.
- [7] Q. Wang, K. Hou, J. Lu, Q. Dong, D. Yao and Z. Lu, "Study on concrete damaged plasticity model for simulating the hysteretic behavior of RC shear wall," in *International Conference CIBv2019 Civil Engineering and Building Services*, Brasov, Romania, 2020.
- [8] M. Talaat, E. Yehia, S. Mazek, M. Genidi and A. Sherif, "Finite element analysis of RC buildings subjected to blast loading," *Ain Shams Engineering Journal*, vol. 13, no. 4, 2022.
- [9] X.-X. Li, "Parametric Study on Numerical Simulation of Missile Punching Test Using Concrete Damaged Plasticity (CDP) Model," *International Journal of Impact Engineering*, vol. 144, 2020.
- [10] A. Fedoroff and K. Calonijs, "Using the Abaqus CDP model in impact simulations," *Journal of Structural Mechanics*, vol. 53, no. 3, pp. 180-207, 2020.
- [11] M. Labibzadeh, M. Zakeri and A. Adel Shoaib, "A New Method for CDP Input Parameter Optimization of the ABAQUS Software Guaranteeing the Uniqueness and Precision," *International Journal of Structural Integrity*, vol. 8, no. 2, pp. 264-284, 2017.
- [12] Y. Sümer and M. Aktaş, "Defining parameters for concrete damage plasticity model," *CHALLENGE JOURNAL OF STRUCTURAL MECHANICS*, vol. 1, no. 3, pp. 149-155, 2018.
- [13] D. Rakić, A. Bodić, N. Milivojević, V. Dunić and M. Živković, "Material parameters identification of concrete damage plasticity material model," in *8th International Congress of Serbian Society of Mechanics*, Kragujevac, 2021.
- [14] D. Rakić, A. Bodić, N. Milivojević, V. Dunić and M. Živković, "CONCRETE DAMAGE PLASTICITY MATERIAL MODEL PARAMETERS IDENTIFICATION," *Journal of the Serbian Society for Computational Mechanics*, vol. 15, no. 2, pp. 111-122, 2021.
- [15] D. Karsan and J. Jirsa, "Behavior of Concrete Under Compressive Loadings,," *Journal of the Structural Division*, vol. 95, 1969.
- [16] R. Taylor, FEAP: a finite element analysis program for engineering workstation. Rep. No. UCB/SEMM-92 (Draft version), University of California: Berkeley: Department of Civil Engineering, 1992.
- [17] M. Kojić, R. Slavković, M. Živković and N. Grujović, PAK-S: Program for FE Structural Analysis, Kragujevac: University of Kragujevac, Faculty of Engineering, 2011.