Miloš Kojić (Short Biography)

Personal Data. Born on 24. Dec. 1941 in Zakuta (near Kraljevo), Serbia**.** He finished primary school in Zakuta and Vitkovac, and high school at Gimnazija Kragujevac in 1960. He graduated (BS in Mechanical Engineering) at Mechanical Engineering Faculty of University of Belgrade (Department in Kragujevac) on October 10, 1964 with the first diploma ever issued in Kragujevac for higher education. He finished his Master studies at the Faculty of Natural Sciences and Mathematics (Group Mechanics), University of Belgrade with an MS thesis in the field of aerodynamics (MS thesis: Application of Galuert's Theory of Thin Aeroprofiles to Thick Aeroprofiles). He completed his Ph.D. studies at Rice University, Houston, Texas, Department of Mechanical Engineering, in only 1.5 years, with Ph. D. thesis: Influence of Fluid Pressure Gradient on Plasticity of Porous Media.

Awards. For his outstanding results in education, research and overall societal contribution, Professor Kojic got various awards, among which are a Scholarship from the Fulbright Foundation and Assistantship from Rice University; Grant for Research of Institute for International Educational Exchange; Special Award for Contribution in Research, Automobile Industry, Kragujevac; Award for Contribution in Teaching and Research, Faculty of Mechanical Engineering; Award of Chamber of Industry of Kragujevac Region for contribution in industrial development of the Region; Diploma of the City of Kragujevac for contribution in development of the City and the University of Kragujevac; Gold Medal of the Serbian Engineering Society.

Professional Career. Professor Kojic began his professional career in 1964 as an *Assistant* for Mechanics at the Mechanical Engineering Faculty of University of Belgrade, Department in Kragujevac (later Mechanical Engineering Faculty of the University of Kragujevac), followed by his election as *Docent* (1972), *Associate Professor* (1976), *Full Professor* (1979). He was engaged as a *Research Scientist* (later, Senior Research Scientist) at the Institute of the automobile factory "Zastava" in the period 1972-2000; *Visiting Scholar* at MIT, 1983; *Research Scientist*, ADINA R&D in Boston, 1985-1992 (4 years full-time employee); *Research Professor*, The University of Texas Health Science Center at Houston, Department of Bioengineering, 2009-2010; *Senior Research Scientist*, Harvard School of Public Health, Boston, 2001-2010. Currently he is: *Senior Member* at the Methodist Hospital Research Institute, Houston; and *Adjunct Professor*, Department of Computer Science, University of

Houston. In 2009 he was elected as a *Corresponding Member* of the Serbian Academy of Sciences and Arts. Also, he is a *Member* of Engineering Academy of Serbia, and South-East Academy of Nonlinear Sciences.

Organizational Activities. Professor Kojic was *Head* of Department of Mechanics, and *Head* of Faculty of Mechanical Engineering; *Vice-Rector* and *Rector* of University of Kragujevac; *Vice-Director* of the Center for Scientific Research of the Serbian Academy of Sciences and Arts and University of Kragujevac. He is currently: *Director*, R&D Center for Bioengineering, Kragujevac; *President* of the Serbian Society for Computational Mechanics, member of ECCOMAS; *Editor* of the Journal of the Serbian Society for Computational Mechanics (JSSCM), published under auspices of ECCOMAS. He initiated (together with Professor Papadrakakis) South-East European Conferences on Computational Mechanics; the first conference was held in Kragujevac in 2006.

Educational Activities. Professor Kojic initiated research and education in the field of computational mechanics and software development for engineering applications. Since 1972 he has been leading groups of researchers, usually of 10-15 members in size. More than 30 Ph. D. and MS theses were mentored by Professor Kojic, mainly oriented to development or application of computational methods and software in engineering and bioengineering. The various research topics include: Finite Element Method, Discrete Particle Methods, Methods for Numerical Inelastic Analysis, Software Development based on FE and DP Methods, Elasticity and Plasticity, Rigid Body Mechanics, Biomechanics, Coupled Problems. He initiated a number of undergraduate and graduate courses, as well as Ph.D. programs in Bioengineering (University of Kragujevac) and Bioinformatics (Belgrade Metropolitan University).

Research Programs. In the period 1972-2012 the research programs initiated and lead by Professor Kojic were realized through numerous scientific and industrial national and international projects. The projects have been supported by national ministry of science (Yugoslavian, Serbian), national companies ("Zastava", "Electro-Enterprise Serbia", "Jugobanka", and others), national institutions (Institute for Water Resources "Cerni"), City of Kragujevac; National Institutes of Health, USA (Harvard University), EU grants, and Methodist Hospital Research Institute, among others. This multi-decade work lead to the development of the general-purpose finite element code PAK, today consisting of a number of moduli specialized for solid mechanics, fluid mechanics, heat or mass transfer, coupled problems, and biomechanics. The PAK program is well-established and has been used at universities and industry nationally and internationally. As a result of this endeavour, the "Serbian school of computational mechanics" is well recognized nationally and internationally, with distinguished professors and researchers in the field. Around 40 researchers are currently engaged within various projects at R&D Center for Bioengineering and at the University of Kragujevac.

Scientific Results. Professor Kojic is author and co-author of more than 250 publications, which include scientific papers published in leading world journals, national journals, international and national conferences, and books (14 textbooks) in Serbian and English. He has contributed in various fields of computational methods, and particularly in the methods of materially nonlinear analysis. His work in this field is summarized in the book Kojic and Bathe (2005). Lately, his research has been focused on bioengineering problems, mainly summarized in the book Kojic et al. (2008). Here are two illustrations as the most representative original scientific contributions, one from earlier work in plasticity of engineering materials (Fig. 1), and one in the current research on diffusive transport of molecules within composite media (Fig. 2).

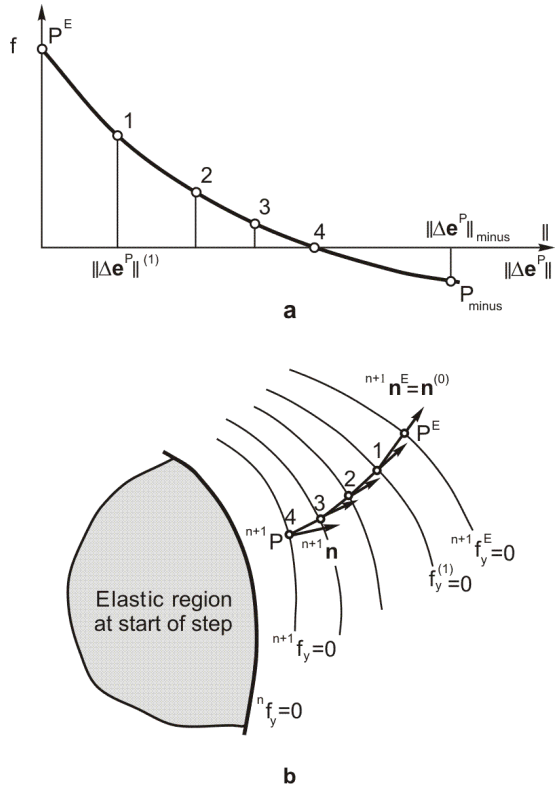

Fig. 1. Stress integration for elastic-plastic deformation. Professor Kojic introduced the "governing parameter method" (initially the "effective-stress-function"), first published in 1987 and generalized in 1996. According to this method, solution for the stresses and plastic strains at the end of the incremental step can be obtained by solving a nonlinear equation (a) with respect to a governing parameter, which geometrically represents a return mapping form the elastic state surface to the final yield surface (b). Application of this methodology to metal plasticity and creep, general 3D solids, shells and pipes, and to geological materials, with small and large strains, is summarized in the book M. Kojic and K. J. Bathe (2005).

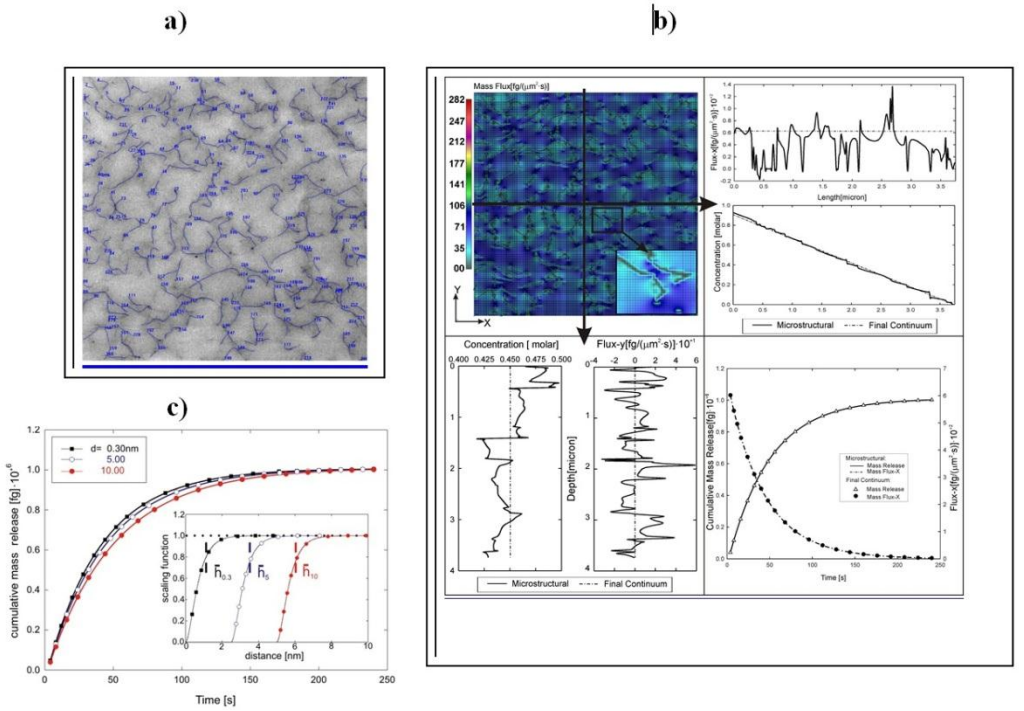

Fig. 2. Multiscale modeling of diffusion based on numerical homogenization. The multiscale method couples molecular dynamics (MD) and FE method. The microstructural model accounts for real internal pore geometry (here agarose polymeric gel, fig. (a), with discretization of fibers shown in the figure) and uses scaling functions (iset in fig. (c)) for correction of the diffusion coefficient due to chemical interaction between diffusing molecules and solid surfaces of pores. The novel concept of numerical homogenization, based on mass release curves (figs. (b) lower right pannel, and (c)), is introduced to evaluate equivalent continuum model parameters (diffusion coefficient tensor, and equivalent distances from solid surface). Continuum and microstructural models give the same mass release curves within a reference volume (figs. (b) and (c)), while distributions of concentration and fluxes are different (fig. (b), right upper and lower left pannels); flux distribution at start of diffusion is shown in fig. (b), upper left and right lower pannels.

References

Milos Kojic and K. J. Bathe, Inelastic Analysis of Solids and Structures, Springer Verlag, 2005.

M. Kojic, N. Filipovic, B. Stojanovic, N. Kojic, Computer Modelling in Bioengineering – Theory, Examples and Software, J. Wiley and Sons, 2008.

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A review of 40 (1972-2012) year work of Kragujevac Research Group

Milos Kojic

Belgrade Metropolitan University - Bioengineering Research and Development Center BioIRC Kragujevac, Prvoslava Stojanovica 6, 3400 Kragujevac, Serbia
The Methodist Hospital Research Institute, The Department of Nanomedicine, 6670 Bertner Ave., R7-116, Houston, TX 77030

Abstract

In this review are briefly summarized activities of research group in computational methods and software development, in the period from the start in 1972 to 2012. The research group initiated by Milos Kojic, consisting usually of 10-15 members, was mainly oriented to development of numerical methods and engineering software – synthesized into the finite element general purpose program PAK (abbreviation of „**P**rogram for **S**tructural **A**nalysis“ in Serbian). The results of this development are published in hundreds of publications, including articles in the leading international and national journals and conferences, as well as through the national and internatinal books and monographs. A large number (several tens) of national and international grants has been realized in various fields of engineering and bioengineering, with the aim of the fundamental development of numerical methods and their applications. More than 40 MS and Ph. D. theses have been completed through the Research Group research. The Group initiated a number of educational university undergraduate and graduate programs and courses in computational methods and their applications (Mechanical Engineering Faculty of University of Kragujevac, University of Kragujevac, Belgrade Metropolitan University).

Based on the overall results within the period of 40 years, it can be said that a „Kragujevac School“, or „Serbian School“ of computational methods and software development has been established.

Keywords: PAK program, Kragujevac Research Group, numerical methods, finite element method, discrete methods

1 History of the developments

The work in computational methods started in 1972 (initiated by Milos Kojic) within the Institute of Automobile Factory „Zastava“. The first computer programs for engineering aplications, written in Fortran IV, were run in Computater Center of „Zastava“ under suppervizion of Milutin Marinkovic. The programs were developed using punched cards. In the first several years the basic knowledge about organization of the FE software was gained using the open source code SAP IV, and the first diploma works of the most talented studetnts started to appear (Radovan Slavkovic, Djuro Pavic).

Establishment of the foundation of the original software package PAK was achieved in the period 1975-1983. The first publications of the growing group of young talented researchers, related to the FE method, started to appear in national and international journals and conferences. Topics on which the group was working included linear and nonlinear noninear analysis in solid mechanics, heat transfer and acoustics. Special emphasis was to applications in the automobile industry. The first MS theses were completed in that period (Dragoljub Grujovic, Gradimir Zivkovic, Radovan Slavkovic, Vera Nikolic, Aleksandra Jankovic).

In the period 1983-1996 the program PAK has advanced with significant achievements in various fields of linear and nonlinear solid mechanics, fluid mechanics, and flow though porous media. The initial PAK software was completely reorganized, with a number of advanced features, including various iterative schemes, as the Newton-Rapson and BFGS, and substructures (M. Kojic, R. Slavkovic, Miroslav Zivkovic, Nenad Grujovic, Nenad Filipovic). A number of MS and Ph. D. teheses were completed (R. Slavkovic, M. Zivkovic, N. Grujovic, Vladimir Manojlovic, among others) and built within the PAK program, with new results published in the leading world journals. Significant advances have been achieved in everal fields, as: materially nonlinear analysis of metals and geological materials, summarized in the book Kojic and Bathe: Inelastic Analysis of Solids and Structures, Springer (2005), (also in Ph. D. thesis of R. Slavkovic, and MS thesis of Dusan Begovic); specific and unique finite elements (e.g. beam superelement, M. Zivkovic), solution porcedures (N. Grujovic), fluid mechanics and mass transport (N. Filipovic), acoustics (late Zivomir Petronijevic, V. Manojlovic), coupling to element free Galerkin method (Ph. D. thesis of Ivo Vlastelica), multipoint constraints (MS thesis of Zoran Bogdanovic), XFEM method (Ph. D. thesis of Gordana Jovicic), contact modeling (Ph. D. theses of N. Grujovic and Snezana Vulovic).

In 1996 started research in bioengineering, parallel with the work in previous fields of engineering. This new area of research was suggested by Srboljub Mijailovic at Harvard University, with the intial developments in tissue mechanics of S. Mijailovic and M. Kojic. Reserach in the new field of bioengineering was enthusiastically supported by Ministry of Science of Serbia (minister late Dusan Kanazir) and it atracted young researchers. A number of scientific publications appeared from this field, accompanied by Ph. D. theses (N. Filipovic, Nebojsa Zdravkovic). As a result of intensive work in bioengineering, a research program, called Scientific Program Bioengineering, was introduced at the Center for Scientific Research of the Serbian Academy of Sciences and Arts and University of Kragujevac. The Program was suported by City of Kragujevac. With five young full-time employed talents, significant advances were achieved through grants from Ministry of Science of Serbia and other international grants (Harvard University, Polytechnical Univesrity of Hong Kong, Institute „Jaroslav Cerni“), followd by Ph. D. theses (Boban Stojanovic, Vladimir Rankovic, Milos Ivanovic – from the research center). Finally, the Research and Development Center for Bioengineering „BIOIRC“ was establihed in 2009, as a research institution, registered according to Serbian law; it is also registerd by EU. The founders of BioIRC are the Serbian Society for Computational Mechanics, City of Kragujevac and State University of Novi Pazar. BIOIRC is a constitutional member of Belgrade Metropolitan University. Currently, BioIRC has 19 full-time employed researchers. A summary of results in bioengineering is given in the book:

M. Kojic, N. Filipovic, B. Stojanovic, N. Kojic: Computer Modeling in Bioengineering, J. Wiley and Sons (2008). A significant number of publications in the world journals has appeared from the work of the BioIRC researchers, and also Ph. D. theses have been formulated (three of those are completed, by Dejan Veljkovic, Velibor Isailovic and Miljan Milosevic).

Research in solid mechanics and application in engineering has continued within Laboratory for Engineering Software (lead by M. Slavkovic and M. Zivkovic) at Faculty of

Engineering Sciences (former Faculty of Mechanical Engineering). Over 15 young researchers have continuoasly been participating in research within this laboratory in last 15 years, with notable research results (Ph. D. theses of Gordana Jovicic and Snezana Vulovic) and applications to various complex engineering problems.

The basic research relies on the finite element method, but also other computational methods have been investigated (discrete methods: Dissipative Particle Dynamics-DPD , Smoothed Particle Method- SPH, Lattice-Boltzman method; meshless methods: Element free Galerkin - EFG) by the Research Group. Particular attention has been devoted to coupling of different methods, multiscale and multiphysics modeling.

2 Education

The scientifc work of the Research Group has been translated into university programs. Initial courses, such as Numerical Analysis of Structures, followed by Nonlinear Srtuctural Analysis, Computational Methods in Bioengineering and other courses more specialized in computational methods, were introduced at undergraduate and graduate levels at Faculty of Mechanical Engineering of University of Kragujevac. A large number of dipolma work (sveral tens) has been completed, togther with more than 40 MS and Ph. D. theses.

Graduate program in the field of Bioengineering, as a multidisciplinary educational program, was introduced at University of Kragujevac in the period 2000-2009. Also, the Ph. D. graduate program Bioinformatics has been introduced at Belgrade Metropolitan University (as a result of collaboration between BioIRC and Belgrade Metropolitan University; BioIRC is a member of this university) . The basis of these educational programs consists of numerical methods and software development and application to various problems in biomedicine.

Some of the most typical theses have been cited above. The results of these theses have been published in national and international journals and conferences. It can be said that the theses and diploma works reflect the research of the Kragujevac School of computational methods and software development. Also, approximately four generations of researchers belong to the Research Group.

The program PAK has been the basic tool in achieving the goals specified by mentors who navigate the research in the Research Group.

In the reference list are given books related to the work of the Research Group which basically summarize the results in research and education, given in chronological order.

3 Research grants

Numerous grants have been initiated and successfuly realized by the Research Group within the period of 40 years. Here are notified several the most typical and dominant projects for the overall development. The pricipal investigators (PIs) are from the Resarch Group or from abroad, but the grant was realized with the Group participation.

- Development of methods for noninear finite element analysis (1983-1985), (PIs Milos Kojic and Klaus-Jurgen Bathe), Yugoslavian- American project supported by American Institute for Educational Exchange, contract M.I.T. – Faculty of Mechanical Engineering, Univ. Kragujevac.

- Development of computational methods and software for structural analysis, (PI Milos Kojic), continuously supported through various specific projects by Ministry of Science of Yugoslavia and Serbia, in the period 1976-1997.
- Development of methods and software in bioengineering, various grants supported by Ministry of Science of Serbia in the period 1997-2012, PI Milos Kojic. Current grant is: Methods of multiscale modeling with applications to biomedicine, OI 174028, 2011-2014.
- Applied biomedical engineering in preclinical and clinical practice, III41007, (PI Nenad Filipovic), 2011-2014.
- Development of methods and software for turbine support structure analysis,(PI Milos Kojic), Electro Distribution of Serbia – Faculty of Mechanical Engineering, 2003-2006.
- Particles in Developing Lung: Bioengineering Approach, NIH – National Institute of Health, (2003-2008), PI Akira Tsuda, Boston (Milos Kojic PI for part in Serbia), subcontract between Harvard Univesity and University of Kragujevac.
- Development of methods and software for modeling undergroud water flow, (PIs Milos Kojic and Nenad Filipovic) Institute „Jaroslav Cerni“, 1998-present.
- Mechanistic Damage Modelling of Skeletal Muscles Using Hybrid Segment Superelement Technique , G-T645 ,Polytechnic University of Hong Kong – University of Kragujevac, (PIs CY Tang and Milos Kojic), 2002-2004.
- PolyU 5271/03E, Mechanistic Damage Modelling of Skeletal Muscles Using Hybrid Segment-Superelement Technique, Polytechnic University of Hong Kong – University of Kragujevac, (PIs CY Tang and Milos Kojic), 2003-2006.
- ARTreat: Multi-level patient-specific artery and atherogenesis model for outcome prediction, decision support treatment, and virtual hand-on training, EU FP7 program, Serbian partner Unversity of Kragujevac, (PI Nenad Filipovic), 2009-2014.
- Modeling of Blood Microcirculation, Margination and Endocytosis of Particles, The Methodist Hospital Research Institute, Houston – BioIRC, (PI Milos Kojic at TMHRI and Nenad Filipovic at BioIRC), 2010-2013.
- Multifunctional Materials for Future Vehicles, MUST, EU FP7, (PI Aleksandar Jovanovic, Stuttgart; BioIRC PI Nenad Filipovic) 2008-2012.
- Reinforcement of Research Capacity in Software Development and Innovative Collaborative Design and Engineering in Serbia and Montenegro, FP6, (PI Radovan Slavkovic), 2006-2009.
- Solving of multiphysics problems using software PAK, 2012-2013 DAAD, (PIs Radovan Slavkovic and Hermann G Matthies, Braunshweig).
- Development of Methods and Software for Analysis, Simulation and optimization of processes of large strains in machine industry, TR0258, (PI Miroslav Zivkovic), Ministry of Science, Technology and Development Republic of Serbia, 2002-2004.
- Development of software for calculation of strength and durability estimation of structure, TR6204, (PI Miroslav Zivkovic), Ministry of Science and Environmental Protection Republic of Serbia, 2005-2007.

- Development of software for explicit nonlinear dynamic analysis, TR12005, (PI Miroslav Zivkovic), Ministry of Science and Environmental Protection Republic of Serbia, 2008-2010.
- Development of software for coupled multi-physics problems, TR32036, (PI Miroslav Zivkovic), Ministry of Education, Science and Technological Development Republic of Serbia, 2011-2014.
- NIH R01 DC 011528, Multiscale mechanisms of lingual mechanical function, (PI Srboljub Mijailovic, Boston), Subcontract of BioIRC to Steward/St. Elizabeth Hospital, Boston, (Boban Stojanovic is subcontract PI), 2011-2016.
- FP7 Project-NMP-2007-LARGE-1, Multifunctional materials for future vehicles, MUST, (PI T. Hack, Stuttgart; participation of members of the Research Group), 2008-2013.
- FP7 Project- 211338, SEE-GRID-SCI – SEE-GRID, Infrastructure for regional science, (PI Vasilis, Ioannina, Grece; participation of members of the Research Group) 2007-2011
- Software and hardware development and application in the clinical practice, TR12007, Ministy of Science and Technology of Serbia, (PI Nenad Filipovic), 2008-2010.
- Bioengineering analysis of muscle mechanics and Metabolism , NIH R01 AR48776-01A1,(PI Srboljub Mijailovich; participation of members of the Research Group), 2003-2008.
- FP6 Project, International Europian project for software development of clinical information system for orthopedic clinic in Bologna, (PI M. Viceconti; participation of members of the Research Group), 2003-2005.
- COST Action , MP1005 NAMABIO Action Full Title: Action - From nano to macro biomaterials (design, processing, characterization, modeling) and applications to stem cells regenerative orthopaedic and dental medicine, Sponsoring organization: European Cooperation in Science and Technology, (PI Prof. Fraco Rustichelli, participation of members of the Research Group), 2011-2015.
- FP7-ICT-2011-9, SIFEM project, Semantic Infostructure interlinking an open source Finite Element tool and libraries with a model repository for the multi-scale Modelling of the inner-ear, (PI R. Fox; BioIRC is a partner, PI Nenad Filipovic) 2013-2016.

Besides financial support through grants, the research has been supported in different forms by other institutions, as „Jugobanka“ Kragujevac, and City of Kragujevac.

References – books published by the Research Group

Here are listed books where the research of the Group is summarized.

1. Milos Kojic, A General Concept of Implicit Integration of Constitutive Relations for Inelastic Material Deformation, (in Serbian) Center for Scientific Research of Serbian Academy of Sciences and Art and University of Kragujevac, Kragujevac, 1993.
2. Milos Kojic, Computational Procedures in Inelastic Analysis of Solids and Structures, (in English) Center for Scientific Research of Serbian Academy of Sciences and Art and University of Kragujevac, Kragujevac, 1997.

3. Milos Kojic, Radovan Slavkovic, Miroslav Zivkovic and Nenad Grujovic, Finite Element Method I - Linear Analysis, (in Serbian) Faculty of Mechanical Engineering, Kragujevac, 1998.
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7. G. Jovicic, M. Zivkovic, S. Vulovic, Computational Crack and Fatique Analysis, (in Serbian) Faculty of Mechanical Engineering, Kragujevac, 2011.
8. N. Filipovic, Basic Bioengineering, (in Serbian) Faculty of Mechanical Engineering, Kragujevac, 2012.