FACULTY OF MECHANICAL
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UNIVERSITY OF KRAGUJEVAC

XI TRIENNIAL INTERNATIONAL CONFERENCE
HEAVY MACHINERY - HM 2023

21 – 24 June 2023 Vrnjačka Banja, Serbia

Book of Abstracts

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PREFACE

Ladies and gentlemen, dear colleagues,

Welcome to Vrnjačka Banja, to the International Scientific Conference Heavy Machinery. The first conference was held in 1993, so this is the thirtieth anniversary of the Heavy Machinery conference.

This year the Eleventh International Conference Heavy Machinery is held by the Faculty of Mechanical and Civil Engineering in Kraljevo, University of Kragujevac, from 21 to 24 June 2023.

The conference has gained a unique recognizable form of exchange of information, ideas and new scientific research. It is held in the year when the Faculty of Mechanical and Civil Engineering in Kraljevo celebrates 63 years of university teaching.

During several decades of its existence, the Faculty has acquired a specific and recognizable form in domestic and foreign scientific circles thanks to its scientific and research results.

The goal of the Conference is to make the research in the fields covered at the Faculty of Mechanical and Civil Engineering in Kraljevo available and applicable within both domestic and foreign frames. Also, our scientists will have the opportunity to learn about the results of research done by their colleagues from abroad in the fields of transport design in industry, energy control, production technologies, and civil engineering through the following thematic sessions:

- Earth-moving and transportation machinery,
- Railway engineering,
- Production technologies,
- Automatic control and fluid technique,
- Applied mechanics,
- Thermal technique and environment protection,
- Civil engineering.

The high scientific reputation of domestic and foreign participants as well as the number of papers provide guarantees that the Conference will be very

successful. The papers reflect the state-of-the-art and deal with a wide spectrum of important topics of current interest in heavy machinery.

I would especially like to thank the Ministry of Science, Technological Development and Innovation of the Republic of Serbia for its support to the organization of the Conference and our efforts to promote science and technology in the areas of mechanical and civil engineering in Serbia. Also, I would like to express our gratitude to other sponsors of the Conference: Serbian Chamber of Engineers, TeamCAD d.o.o. Zemun-Belgrade, Banim reklame d.o.o. Kraljevo and Radijator Inženjering d.o.o. Kraljevo.

My sincere thanks also go to all members of the scientific, organizing and technical committees, the reviewers, and all the participants including the invited speakers for their participation in the Conference and presentation of their papers.

Thank you and see you at the next conference in three years.

Kraljevo, Vrnjačka Banja, June 2023 Conference Chairman

Prof. Dr Mile Savković

CONTENTS

PLENARY SESSION

WAREHOUSING 4.0

Boris Jerman, Jurij Hladnik

Faculty of Mechanical Engineering, University of Ljubljana, Ljubljana, Slovenia

Abstract: The article presents research on robotic warehouse order-picking systems that can also be used as feeding systems in the production processes. In the first part, the machine vision system is discussed, the developed object recognition software is presented, and the built and tested robotic order-picking system is described. The results show a very good performance of the system when picking larger parts and a much worse performance when picking smaller parts. For this reason, the basic vision system was replaced with the system with a much better resolution, and a significant improvement in gripping capabilities for smaller parts was observed. In the second part, the robot grippers of different types (vacuum grippers, servo-electric two-finger grippers, pneumatic two-finger grippers, gecko grippers, etc.) are investigated for the quality of their gripping as a function of the characteristics of the parts in question. For this investigation, a suitable test method was selected among the known methods and a suitable set of objects was chosen, comparable to those used in other similar investigations. The object set used, consists of various tools, cloths, chains, fruits, cardboard boxes, balls, etc. In the third part, the design and testing of our own two-finger pneumatic robotic gripper is presented. Its fingers were 3D printed from Flexible 80A resin. The developed gripper was tested for its functionality and its gripping force was measured for different applied pneumatic pressures and different gripping distances. In the last part of the article, the modelling of the gripping with the two-finger robotic gripper in Adams software is presented. Using this model, the gripping quality is numerically tested for different objects and their different orientations, for different gripping points and different approach angles of the gripper. Some interesting results of the simulations are also introduced.

The presented article is the result of the joint work and efforts of members of the Laboratory of Cognitive Systems in Logistics at the University of Maribor, Faculty of Logistics, and the Laboratory of Support Structures and Transport Machinery at the University of Ljubljana, Faculty of Mechanical Engineering. The research was supported by the Slovenian Research Agency (ARRS) within the applied research project entitled "Warehousing 4.0-Integration model of robotics and warehouse order-picking systems"; grant number: L5-2626.

Keywords: Machine Vision, Order-picking Systems, Robot Grippers, Gripping Quality

DEVELOPMENT OF A DOMESTIC 4-AXIS SCARA ROBOT

Zoran Miljković[1], Nikola Slavković[1], Bogdan Momčilović[1], Đorđe Milićević[2]

[1]Faculty of Mechanical Engineering, Department for Production Engineering, University of Belgrade, Belgrade, Serbia
[2]Smurfit Kappa Paper Factory Belgrade LLC, Belgrade, Serbia

Abstract: The global manufacturing industry has been demanding a steady increase in active industrial robots worldwide for years. The fields and technological tasks in which industrial robots are applied are rapidly expanding with a constant demand for improvement of their functions, technical characteristics as well as control and programming systems. One of the goals of the current research in the Laboratory for Robotics & AI is development of a domestic industrial robot with the possibility of automated programming based on information obtained from the camera. The paper presents the first part of the research developing a 4-axis SCARA industrial robot with the control system integrated camera. Professor Hiroshi Makino from Yamanashi University designed SCARA (Selective Compliance Assembly Robot Arm), and this robot is the most famous robot configuration originated at the universities. This part of the research includes the design of the mechanical structure, preliminary CAD/CAM testing, development of control and programming systems, virtual robot simulation, and robot production that were parts of two Master theses done in 2022. The realization of the robot control system starts from a well-known SCARA robot kinematic model. The open architecture control system realized in the LinuxCNC software allows the possibility of further development and full camera integration. The control system includes the integrated virtual robot model configured using several predefined Python classes and OpenGL as a digital shadow of the developed SCARA robot. Several successfully done examples of technological tasks of laser engraving have shown the verification of the complete robotic system.

Keywords: Industrial robot, Control and programming, Virtual robot.

30 YEARS OF THE INTERNATIONAL SCIENTIFIC CONFERENCE "HEAVY MACHINERY"

Mile Savković, Goran Marković, Milan Bižić, Nataša Pavlović

Faculty of Mechanical and Civil Engineering in Kraljevo, University of Kragujevac, Kraljevo, Serbia

Abstract: The first conference “Heavy Machinery” was held in Kruševac and Vrnjačka Banja (Serbia) from 8 to 10 October 1993. The conference is triennial so that the eleventh one is in 2023. At the beginning, the main thematic fields were: design and calculations, production technologies, testing and control. New scientific knowledge, fast technological development, lifting sanctions on our country and the globalisation of the world market caused significant changes in science and research. Accordingly, the thematic fields of the conferences have been adjusted. Their number has increased so that the papers from the last conference were classified into seven scientific fields: Earth-moving and Mining machines and Transportation systems, Railway vehicles, Production technologies, Automatic control, robotics and fluid technique, Applied mechanics, Thermal technique and environment protection and Civil engineering and materials. This year’s conference covers similar fields. Thirty years of tradition are also an opportunity to sum up the results from the previous conferences as well as to establish the directions of further research, the place and the role of the conference “Heavy Machinery”, regarding both the development of the faculty and the influence on a wider scientific community.

Keywords: Heavy machinery, Mechanical engineering, Civil engineering, History.

SESSION A: EARTH-MOVING AND TRANSPORTATION MACHINERY

DEVELOPMENT AND STATE-OF-THE ART IN GREEN ELEVATORS TECHNOLOGIES: A SURVEY

Nenad Zrnić[1], Andro Dragović[1], Nenad Kosanić[1], Vladan Milovanović[2]

[1]University of Belgrade, Faculty of Mechanical Engineering, Belgrade, Serbia
[2]Kleemann Lifts, Belgrade, Serbia

Abstract: Green elevators represent a new standard in all elevator facilities. This paper analyzes all new technologies that need to be applied, and this refers to the energy efficiency of the drive, the use of a different configuration, and the changed components on the elevator. This paper also deals with models that change the classic motion of the elevator and emit low energy consumption. It is of the key importance to show which countries strive to replace all their plants with new configurations and regulations, where the most important fact is to perform an impact assessment on an annual basis. The main goal of this paper is to show that all components designed at the experimental level should be introduced into standard plants and reduce their production cost. From a comprehensive analysis of the previous research, it is concluded that the most significant advantages are achieved by using new electrical schemes, components, and energy sources that are not connected directly to the power distribution grid. At the end, from the corresponding literature, it is concluded that many major manufacturers in the elevator industry have to apply the modern technology from their development centers to existing standard elevators, in order to meet all new ecological and emission standards.

Keywords: Elevators, Energy efficiency, Power management, Regenerative energy.

RESEARCH OF THE DYNAMICS OF THE PROCESS OF EXCAVATING THE SOIL WITH THE ADDITIONAL SLOPE BOARD OF THE BULLDOZER ON THE CATERPILLAR TRACK

A.I. Dotsenko[1], T.K. Babaev[2]

[1]Road Building Machines Department, Moscow Automobile and Road Construction State Technical University (MADI), Moscow, Russia
[2]Mechanization and Automation of Construction Department, Moscow State University of Civil Engineering (National Research University), Moscow, Russia

Abstract: The purpose of the research is to determine the conditions for maintaining the course stability of the bulldozer on the caterpillar track (hereinafter referred to as the term "caterpillar") in the process of excavating the soil with the slope board. The paper presents mathematical model of the process of operation of the caterpillar bulldozer with the slope board, taking into account its main parameters: 1) parameters of the slope board and its installation angles; 2) parameters of the base machine; 3) dynamic parameters of the bulldozer with the slope board; 4) parameters of the soil. Based on the developed model, using the computer modelling method in Mathcad Prime 3.0 program, a hodograph of the maximum force applied on the slope board of the caterpillar bulldozer was built, which made it possible to determine the maximum allowable force applied on the slope board, taking into account the retention of the course stability.

Keywords: Caterpillar bulldozer, Slope board, Course stability.

STRENGTH OF FILLET-WELDED JOINT CONNECTIONS: COMMENTS ON CORRELATION BETWEEN CLASSICAL AND PARTICULAR FINITE ELEMENT APPROACH

Vlada Gašić, Aleksandra Arsić, Nenad Zrnić

Faculty of Mechanical Engineering, University of Belgrade, Belgrade, Serbia

Abstract: The paper deals with strength of load-carrying fillet welds with application of two different approaches. First one is calculation by classical/scholar approach while second one is devoted to finite element analysis. The classical approach is concerned with national and European engineering practice. The finite element approach includes the application of particular tool which preserves main recommendations from modern postulations in design of joints. The object of interest is welded beam-to-column joint with different structural elements and the stresses are obtained for two models. It is investigated correlation of results of weld stresses from both the approaches. Direct matching of results was neither expected nor found but basic correlation is revealed within the joint behaviour under loadings. Considering finite element approach as prevailing, its advantage is clearly shown throughout inclusion of local effects of plates. However, classical approach is essential for proper understanding of joint behaviour and should be always the first step in structural analysis. The usage of at least two different approaches is one way of improving safety checks in engineering and stands for purpose of validation or verification of design.

Keywords: Joint, Fillet weld, Stress, Classical approach, FEA.

CONTINUOUSLY VARIABLE TRANSMISSION FOR CONSTRUCTION MACHINES TO INCREASE EFFICIENCY AND PRODUCTIVITY

Jasna Glišović[1], Vanja Šušteršič[1], Jovanka Lukić[1], Saša Vasiljević[2]

[1]Faculty of Engineering/Department for Motor Vehicles and Motors, University of Kragujevac, Kragujevac, Serbia
[2]High Technical School of Professional Studies, Kragujevac, Serbia

Abstract: According to estimates, by 2050 two-thirds of the world's population will live in large cities. This trend also comes with disadvantages: fuel emissions, fine dust and noise impact the environment and residents. Ideally, the construction site of the future should not only be environmental neutral, but it should also operate safely and efficiently. Mobile machines used in construction, mining, forestry and agriculture are engineered to withstand extreme working environments while allowing operators to control equipment safely, comfortably and efficiently. Power transmissions make it possible to move extremely heavy loads by applying a multiple increase in torque. However, transmissions must also allow vehicles to move with loads at speeds appropriate to the situation. Careful selection of transmissions can provide an optimal solution: towing or pushing loads at low speeds and operating at higher speeds when needed. Very few mobile construction machines made today are equipped with purely manual transmissions; instead, they are more likely to be equipped with variable-speed transmissions or other automated transmission types. Continuous variable transmission is characterized by: an infinite number of ratios improving vehicle performance and engine optimization, and increasing work efficiency; automatic shifting with smooth forward/reverse shuttling, increasing productivity and drive comfort; maximize fuel savings versus current technologies, allowing cost savings. An objective comparative analysis of various design solutions of continuously variable transmission for modern construction machines and assessment of the most likely trend of the future development of this class of heavy machines was carried out in the paper.

Keywords: CVT, Construction Machines, Performance, Productivity, Design ring.

ARTIFICIAL INTELLIGENCE (AI) AND THE FUTURE OF THE MACHINE ELEMENTS DESIGN

Marko Popović[1], Nedeljko Dučić[1], Vojislav Vujičić[1], Milan Marjanović[1], Goran Marković[2]

[1]Faculty of Technical Science Čačak, University of Kragujevac, Čačak, Serbia
[2]Faculty of Mechanical and Civil Engineering in Kraljevo, University of Kragujevac, Kraljevo, Serbia

Abstract: Artificial intelligence (AI), is becoming an important tool in the fields of mechanical engineering. AI have potential power, to give fast predict of the dimensions and shapes of the machine elements, trough optimization process in initial and the final design stage. This paper give the review of the potential use of the AI in the field of the machine element design.

Keywords: Machine Design, Machine Elements, Artificial Intelligence (AI).

A STUDY OF EMERGING TECHNOLOGIES SCHEDULING AT CONTAINER TERMINALS USING CONCEPTUAL MAPPING

Branislav Dragović[1], Nenad Zrnić[2], Andro Dragović[2]

[1]Maritime Faculty of the University of Montenegro, Kotor, Montenegro
[2]University of Belgrade, Faculty of Mechanical Engineering, Belgrade, Serbia

Abstract: The main long-term objectives in container terminal (CT) development are Automation, Electrification and Digitalization (AED). The paper studied the integrated scheduling trends of the CTs emerging technologies. The recent achievements of these trends are reviewed and relevant research topics in the CTs. Thus, a study how these trends would facilitate the CTs to achieve their strategic objectives is conducted. Multiple Correspondence Analysis-based Conceptual Mapping of the CTs towards AED is employed. The paper aims to fill the gap in the literature resulting from the need to enumerate and evaluate these relevant elements that must be taken into account on AED change at the CTs. The results indicate that despite the common interest in long-term plans, there are still gaps between theory approach and real practice at the CTs. Some research directions are highlighted for AED objectives in the coming years.

Keywords: Emerging Technologies Scheduling, CT, Conceptual Mapping, Multiple Correspondence Analysis.

FEM RECOMMENDATION FOR SHUTTLE RACKING TOLERANCES AND CLEARANCES

Rodoljub Vujanac[1], Nenad Miloradovic[1], Snezana Vulovic[2]

[1]Faculty of Engineering / Mechanical Construction and Mechanization, University of Kragujevac, Kragujevac, Serbia
[2]Institute of Information Technologies, University of Kragujevac, Kragujevac, Serbia

Abstract: Compared to conventional drive-in and drive-through accumulation racking systems, more efficient for the great amounts of the same storage units are shuttle racking systems. These systems operated by shuttles, conventional fork lift trucks, storage and retrieval machines or aisle carriers provide further increase in productivity, reduced damages, improved safety and ergonomics. This paper provides basic information on the requirements, design and use of shuttle pallet racking system in accordance with state-of-the-art regulations and standards with special emphasis on minimal required clearances and tolerances for safety operation.

Keywords: Pallet racking, Shuttle, Tolerance, Clearance.

LARGE SPAN GANTRY CRANE STRUCTURAL ANALYSIS USING FINITE ELEMENT METHOD

Marko Todorović[1], Goran Marković[1], Nebojša Zdravković[1], Mile Savković[1], Goran Pavlović[2]

[1]Faculty of Mechanical and Civil Engineering in Kraljevo, University of Kragujevac, Kraljevo, Serbia
[2]Faculty of Electronic Engineering, University of Niš, Serbia

Abstract: As a part of internal logistic systems many industries heavily rely on gantry cranes for their robustness and reliability which depend largely on the structure of the crane. Wire model of a truss structure of a gantry crane with a 60 m span used in timber industry was created and subjected to the loads characteristic to such devices in order to perform structural analysis using the finite element method. The loads that were taken into the account were longitudinal and traverse load in horizontal plane caused by acceleration and deceleration of the crane, vertical loads, as well as the effect of skewing. The results of the conducted structural analysis were displayed in this paper.

Keywords: Large span gantry crane, Finite element method, Truss structure, Structural analysis.

THE OPTIMIZATION OF THE LOADING RAMP MECHANISM OF A HEAVY-WEIGHT TRAILER

Predrag Mladenović[1], Radovan Bulatović[1], Nebojša Zdravković[1], Mile Savković[1], Goran Marković[1], Goran Pavlović[2]

[1]Faculty of Mechanical and Civil Engineering in Kraljevo, University of Kragujevac, Kraljevo, Serbia
[2]Faculty of Electronic Engineering, University of Niš, Serbia

Abstract: This research optimized the loading ramp mechanism of the trailer for transporting heavy construction machinery to minimize the force in the hydro-cylinder. Firstly, a mathematical model for the mechanism transition between the loading and unloading position was established. Then, it was used to optimize the lengths of the mechanism members using the metaheuristic method to achieve the operational function of the ramp. Besides the lengths of the members, the positions of the lever, which transfers the action of the hydro-cylinder to the ramp and the hydro-cylinder, were also considered during the optimization process. Finally, the optimized positions were determined by their coordinates in the vertical plane.

Keywords: Optimization, Trailer, Loading ramp, Mechanism, Hydro-cylinder, Special vehicle.

MULTI AISLE AUTOMATED RACK WAREHOUSE SIMULATION FOR AVERAGE TRAVEL TIME

Goran Bošković[1], Marko Todorović[1], Goran Marković[1], Zoran Čepić[2], Predrag Mladenović[1]

[1]Faculty of Mechanical and Civil Engineering in Kraljevo, University of Kragujevac, Kraljevo, Serbia
[2]Faculty of Technical Sciences, University of Novi Sad, Novi Sad, Serbia

Abstract: Increased consumption of various goods in modern society requires efficient logistic systems. In order to accomplish high efficiency automated systems for internal transport of goods within a storage unit have been widely employed. Widespread use of these systems induces the need for adequate simulation models that imitate realistic warehouse workflow and can adapt to dynamic changes in operation. Travel time is one of the parameters with great impact on operational costs of the warehouse. Accurate estimation of average travel time can be used to evaluate efficiency of the logistic chain. The new three-dimensional warehouse simulation model which was proposed in this paper takes into consideration the dynamic changes in operation for obtaining average travel time estimation closer to the realistic warehouse operation.

Keywords: Internal transport, Average travel time, Three-dimensional warehouse model, Warehouse simulation.

FRAMEWORK AND REASONABLENESS OF APPLICATING THE CONCEPT OF CRANE STRUCTURAL HEALTH MONITORING IN INLAND WATER HARBOURS

Atila Zelić[1], Dragan Živanić[1], Mirko Katona[1], Nikola Ilanković[1]

[1]*Faculty of Technical Sciences, University of Novi Sad, Novi Sad, Serbia*

Abstract: During last two decades an intensive development of various Structural Health Monitoring Systems (SHMS) has been noticed, and such systems are already in extensive use for bridges, towers, airplanes, wind generators, mining and transporting machines. Cranes belong to the last mentioned machine group, since they are exposed to various dynamic loadings due to transporting load effects, as well as environment influences in course of their operation. Integration of SHMS into the crane structure and its facilities is of special importance for cranes operating in heavy industries, nuclear plants, dangerous material plants, etc. Activities in the field of inland water traffic revitalization in the region of South-East Europe recognize the importance of the Danube harbours in the scope of European logistic chains. Enlarged quantity of goods in inland water traffic demands the reliable harbour mechanization, able to perform cargo ships loading and unloading as fast as possible. In such circumstances, even a minor failure on an aged crane (average age of cranes in inland water harbours is over 40 years!) can cause hours-long (and often even days-long) interruptions in ship attending, resulting in very high time and money losses. In aim to eliminate these undesired consequences of crane failure in the course of its intensive operation, implementation of SHMS can be very useful. The aim of the paper is to point out the importance of further development of simple, but effective SHMS, applicable to cranes in inland water harbours with intensive traffic. In case that economic and technical analyses confirm the reasonableness of crane condition monitoring, valuable data collections can be established, as a basis for estimating crane relevant components and structure condition and remaining life-time.

Keywords: cranes, structural health monitoring, vibration analysis, stress-strain states.

MEASURING THE KINEMATIC CHARACTERISTICS ON A REDUCED-SIZE ZIPLINE MODEL

Tanasije Jojić, Jovan Vladić, Radomir Đokić

Faculty of Technical Sciences, University of Novi Sad, Serbia

Abstract: This paper gives an overview of the procedure for creating a computational zipline model, as a basis for making an experimental model with adjusted geometric characteristics in relation to the real system. Since it is not possible to satisfy the geometric similarity between all sizes of the real zipline and the experimental zipline model, the model can be formed so that it has the same inclination angle and the same deflection ratio in the loaded and unloaded state compared to the real one. The kinematic characteristics are later measured by appropriate small-sized sensors, for example, such as those which are foreseen for Arduino. Additionally, the measured characteristics can be compared with the calculated values.

Keywords: Zipline, Kinematic Characteristics, Similitude, Measurement.

TESTING OF CONVEYOR BELTS AND FORMATION OF VERIFICATION MODEL USING FEM

Dragan Živanić[1], Nikola Ilanković[1], Nebojša Zdravković[2]

[1]Faculty of Technical Sciences, University of Novi Sad, Novi Sad, Serbia
[2]Faculty of Mechanical and Civil Engineering in Kraljevo, University of Kragujevac, Kraljevo, Serbia

Abstract: Conveyor belts, textile composites by their structure, are inhomogeneous and anisotropic. As such, they are the subject of experiments and study in order to better understand their behavior under loading, especially dynamic loading. Due to the large number of influential factors on the load bearing capacity and durability of the conveyor belt, such as the number and material of the carcass, the way of weaving of the carcass material, working conditions, etc., it is not easy to describe them with analytical and mechanical models. Therefore, a great role in understanding the exploitation characteristics of conveyor belts is played by experimental tests on conveyor belt testing devices, as well as the use of numerical methods such as FEM. At the beginning of the paper, the theoretical foundations in the field of textile composites and material fatigue are given. Then, the conveyor belt testing device UZITT MKM 5000 was presented, as well as the results of the experimental test. After, the creation of verification models using FEM using the Autodesk Inventor Nastran software package is shown. At the end, the obtained results of the experimental test and the results obtained by the MKE method were compared.

Keywords: Conveyor belt, Durability, Fatigue, FEM.

ANALYSIS HYBRID DRIVES OF MOBILE MACHINES

Vesna Jovanović, Dragoslav Janošević, Jovan Pavlović

Faculty of Mechanical Engineering, University of Niš, Serbia

Abstract: In this paper, three variants of hybrid mechanic-hydrostatic transmission for moving drive of mobile machines are analyzed. Kinematic and dynamic transmission ratio defined. Based on results of listed numerical example, comparative analysis transmissions conducted based on certain traction characteristic.

Keywords: Mobile machine, Hybrid transmissions.

DETERMINATION OF RESISTANCE FORCES IN THE WHEEL LOADER USING DISCRETE ELEMENT METHOD

Jovan Pavlović, Dragoslav Janošević, Vesna Jovanović, Nikola Petrović

Faculty of Mechanical Engineering/Department for Material Handling Equipment and Logistics, University of Niš, Niš, Serbia

Abstract: Determining the resistance force is an important task in the synthesis of drive mechanisms of mobile machines that interact with soil or granular material. The paper presents the three most commonly used material loading techniques used by operators in wheel loaders. Reaction forces that occur during the interaction of bucket-granular material are determined using the software based on the discrete element method which considers each particle of granular material as separate (discrete) element. Granular material in simulation is generated with different size of particles. The research shows that the resistance forces depends on the type of material and on the loading techniques. As an example, resistance forces for a loader with a mass of 15.000 kg and a bucket volume of 2.3 m3 are given.

Keywords: Wheel loader, Resistance forces, Discrete element method.

MOBILE CRANE MODELLING FOR ROBOTIC FUNCTIONAL INTEGRATION

Cătălin Frâncu, Cristina Sescu-Gal, Oana Tonciu

Technical University of Civil Engineering Bucharest, Bucharest, Romania

Abstract: In this paper is presented a method for direct and inverse kinematic modelling of a telescopic jib mobile crane. The method used is from industrial robots field, which is also the reason for robotic assimilation of the lifting and positioning mechanisms of the end-effector. The end-effector is represented by the lifting hook, or by some other device used accordingly in emergency situations.

Such machines are gaining new functionalities necessary for the existing equipment, having the possibility of operating the same machine in 2 distinct modes (manual and robotic), but also their integration into centralized control systems within the frame of complex works.

The use of robotic telescopic mobile cranes is indicated in environments that pose imminent risks and/or e interventions in emergency situations (earthquakes, floods, dangerous climate events, contamination accidents, etc) following natural disasters to save human property and life.

The integration of robotic machines into BIM software systems in the construction field is the necessary step in order to exploit the benefits of the fields` digitalization. Robotization and automation in the construction field is successfully applied for construction of roads, bridges and earth-moving, being facilitated by the technological processes that are based on the system of construction machinery and equipment.

Keywords: Telescopic mobile cranes, Robotics.

ANALYSIS AND CALCULATION OF OVERHEAD CHAIN CONVEYOR FOR METAL HOUSINGS TRANSPORTATION

Spasoje Trifkovic, Miroslav Milutinovic, Srdjan Samardzic

University of East Sarajevo, Faculty of Mechanical Engineering East Sarajevo, Bosnia and Herzegovina

Abstract: Overhead chain conveyors are used to increase productivity in manufacturing processes and warehouse centers. These are continuous transport devices that operate above or over the head of both workers and other equipment. Their advantage is that they can transfer the load in any direction in space. Steel ropes and chains are used as pulling elements. The pulling element is connected to the trolley where the carriers are attached. The loads from the cargo are transferred via the wheels to the carrier conveyor track. The carrier track is most often connected to the construction of the hall. In this paper, the analysis and calculation of the overhead chain conveyor for the transportation of metal housings was performed.

Keywords: Transport devices, Continuous transport, Overhead chain conveyor.

STRESS STATE ANALYSIS OF HINGED SHACKLE USING ANALYTIC AND FINITE ELEMENT METHOD

Srdjan Samardzic, Spasoje Trifkovic, Miroslav Milutinovic

University of East Sarajevo, Faculty of Mechanical Engineering East Sarajevo, Bosnia and Herzegovina

Abstract: Shackles are elements used for lifting loads in heavy cranes with a large capacity. They can be closed type - forged or hinged. Weight of the shackle is a load that crane should always lift, which reduces weight of the load and increases the requisite power of the motors. In order to reduce the required power for hoisting and increase the capacity, it is necessary that the dimensions of the shackle have the minimum required value at the prescribed safety factor. This paper analysis stress state of the hinged shackle by an analytical method and using finite element method (FEM).At the end, a comparison of the obtained results is given.

Keywords: Shackle, Stress, Finite element method.

A HYBRID MCDM MODEL FOR WASTE OIL TRANSFER STATION LOCATION SELECTION

Jelena Mihajlović[1], Goran Petrović[1], Danijel Marković[1], Dragan Marinković[2], Žarko Ćojbašić[1], Dušan Ćirić[1]

[1]*Faculty of Mechanical Engineering in Niš, University of Niš, Niš, Serbia*
[2]*Department of Structural Analysis, University TU Berlin, Berlin, Germany*

Abstract: The facility location selection became a major interest for the organizations to establish their planned businesses for a long period of time. The choice of the best location among a set of available locations is a complex process. Although the multiple criteria decision-making (MCDM) methods are applicable for location selection problems, different solutions can be obtained using different MCDM methods. In this paper, the application of hybrid MCDM approaches, for the selection of the best location of the waste oil transfer station in the regional canter of southern and eastern Serbia - the city of Niš, is considered. Specifically, the criteria weights have been determined by the fuzzy PIPRECIA (Pivot Pairwise Relative Criteria Importance Assessment) method in combination with Geometric Mean (GM). Chosen methods, the fuzzy TOPSIS (Technique for the Order Preference by Similarity to Ideal Solution), the fuzzy WASPAS (Weighted Aggregated Sum Product Assessment), and the fuzzy ARAS (Additive Ratio Assessment) have been used for ranking alternative locations.

Keywords: Hybrid MCDM model, Fuzzy, Waste oil, Transfer station, Location selection.

SESSION B: RAILWAY ENGINEERING

PROOF TESTS OF GEOMETRIC-KINEMATIC CALCULATIONS OF RAILWAY VEHICLES

Dragan Milković, Goran Simić, Vojkan Lučanin, Saša Radulović, Aleksandra Kostić Miličić

Faculty of Mechanical Engineering / Rail Vehicles Department, University of Belgrade, Belgrade, Serbia

Abstract: Geometric-kinematic calculations and experimental proof tests of the mutual position of assemblies and sub-assemblies of wagons that are in relative displacement are significant in developing new types of railway vehicles and especially in the application of non-standard solutions. In the case of standard types of wagons and standard solutions, compliance with the recommended geometric dimensions and parameters of the vehicle should guarantee that even in extreme positions there will be no irregular contact between moving parts of the rail vehicle. This is especially important if it is necessary to place some elements or parts of the wagon's equipment in the zone of wheelsets and in the zone of the connection between the bogies and the car body. This check can be carried out using graphic-analytical methods, according to the methodology given in the relevant EN standards, ORE reports, and AVV publications, and the limit values of the angular and translational coordinates of the moving parts. Verification of these calculations and verification of the derived state can be done by simulating these movements on the vehicle prototype itself or using a mock-up. This paper presents limit values and proof tests, for checking the mutual position of the running gear and the vehicle car body of a tank wagon car type Zacns. The test was performed using a transfer table for simulating the rotation of bogies relative to the car body in the horizontal plane and by using pads placed under wheels for simulating rotation in the vertical plane. The check was performed by visual inspection and by distance measurements.

Keywords: Geometric-kinematic calculations, Proof tests, Mutual position of the running gear and the railway vehicle car body.

NETWORK MODEL AND VIBRATION SIMULATION OF A RAILWAY TRACK

Mustafa Berkant Selek[1], Erol Uyar[2], Mücahid Candan[3]

[1,3]Higher Vocational School of Ege, Ege University, Izmir, Turkey
[2]Electric-Electronics Engineering Department, Ege University, Izmir, Turkey

Abstract: The stresses caused by the components used in railway systems (such as rails, rail joint laying and supports, broken rails) cause vibrations in rail vehicles and thus significantly affect the safety and comfort of trains. The design of the suspension system, which minimizes the effects of these vibration loads transmitted to the wagon through the rail-wheel (bogie) and bogie-wagon relationship, is an important point in terms of ensuring safe and optimal running conditions, especially in high-speed trains. The vibration behavior in the medium and high frequency range (40–1500 Hz) of the train, which is influenced by the rail structure, can be used as an indicator of the sound propagation, the vibration sensitivity and the coupling of the rail work to the rail system. In this study, mathematical modelling and simulation of a railway vehicle is performed to study different vibrations. The natural frequencies of a metro wagon are examined under different self-excited conditions. The dynamic behavior of a specially designed suspension system like double-jointed bogie construction, consisting of mass dampers and springs, is selected and calculated as a model with two degrees of freedom. In particular the resonance conditions are studied for vertical movements as a function of various parameters. The double-jointed bogie construction, consisting of mass dampers and springs, is selected and calculated as a model with two degrees of freedom. The results of Vibration Simulations of the track model are then demonstrated with graphics.

Keywords: Rail corrugation, Wear friction, Self-excited vibration, Vibration mode, Resonance, Natural frequency.

VIBRATION MEASUREMENT WITH WIRELESS HETEROGENEOUS INTEGRATED DISPLACEMENT SENSOR AND DETERMINATION OF DYNAMIC DEFLECTION OF SLEEPERS AND STIFFNESS OF RAILWAY TRACKS

Branislav Gavrilović[1], Vladimir Aleksandrovich Baboshin[2], Zoran Pavlović[3]

[1,3]Academy of Technical and Art Applied Studies Belgrade, Department: Railway College, Belgrade, Serbia
[2]Military institute (Railway troops and military communications), Department of Reconstruction of Automation, Telemechanics and Communication Devices on Railways, Sankt. Peterburg, Russia

Abstract: The paper proposes a system for wireless measurement of vibrations with a heterogeneous integrated displacement sensor, which was perfected at the Technical Faculty in Novi Sad within the current project no. TR-32016 at the Ministry of Education, Science and Technological Development of the Republic of Serbia. The application of these sensors can completely simplify and eliminate the measurement imperfections that can be found with the use of wireless accelerometers due to the need for single and double integration in time in order to determine the displacement, ie dynamic deflection of railway sleepers and the stiffness of railway tracks.

Keywords: Wireless sensor networks, Railway, Vibrations of sleepers.

METHOD FOR DETERMINING THE FORCES ACTING ON A AXLE BOX DESIGNED FOR THE INSTALLATION OF AN ADAPTER BEARING

Dobrinka Atmadzhova, Vanio Ralev

Todor Kableshkov University of transport (VTU), Sofia, Bulgaria

Abstract: The installation of adapter bearings (cassette type) provides new opportunities to achieve longer maintenance intervals and to improve performance and safety. In the developed methodologies for calculating the forces acting on a axle box unit in European and state standards, dependencies are defined for axle boxes with short cylindrical rollers and conical or cassette type bearings where the transmission of the vertical load between the axle box and the bearings is on a cylindrical surface. In the contact area of a segment, in addition to the standard static, dynamic, centrifugal and inertial forces of the axle box, additional forces also act. Overloading occurs when the axle box has become detached from the bearing by lifting off of it. Under these conditions, the transmission of forces between the axle box and the bearing takes place not through the normal tight contact along a segment of 120º, but through the edge of the axle box shell. In this publication, a method is proposed for determining the forces in an axle box designed for the installation of an adapter bearing.

Keywords: Railway vehicles, Bogie, Axle box, Adapter bearing, Force.

STUDY OF THE CONTACT BETWEEN DESIGN PROFILES OF RAILS AND RIMS USED IN THE TRAM TRACK OF THE CITY OF SOFIA

Vladimir Zhekov

National Railway Infrastructure Company, Sofia, Bulgaria

Abstract: The report examines the interaction between the design profiles of rail 49E1, grooved rails 60 R1, 60 R2, block rail B60 and rim profiles T81 and RPSf 2018, which are used in the tram track of the city of Sofia. The report aims to compare the contact interaction of T81 and RPSf 2018 rim profiles with rail profiles, showing the profile contact point graphs, the rolling radii difference and calculating the design equivalent conicity values.
Based on the analysis, conclusions were drawn about the interaction between the currently used RPSf 2018 profile and the previously used T81 profile.

Keywords: Railway track, Contact point, Rail, Rim, Tram.

INVESTIGATION OF THE BEHAVIOUR OF A FREIGHT WAGON BRAKING SYSTEM ON A BRAKE SYSTEMS BENCH

Vasko Nikolov, Georgi Nikolov

Department of Transport Equipment, Todor Kableshkov Transport University, Sofia, Bulgaria

Abstract: The article examines the behavior of a braking system for class S freight wagons mounted on a brake bench. A review of the regulations that determine the technical characteristics of the braking systems of railway vehicles was made. A comparison between the theoretically set technical parameters and those obtained during the bench tests was made. The behavior of the pneumatic and mechanical parts of the stand was analyzed. Conclusions from the observations and analyses are drawn.

Keywords: Brake system, Safety, Freight wagon, Brake system bench, Rolling stock.

TECHNICAL CONDITION OF RAILWAY VEHICLES AS A SAFETY FACTOR IN TRAFFIC

Marija Vukšić Popović[1], Jovan Tanasković[2], Ivan Krišan[3]

[1]Department School of Railroad Transport, Academy of Technical and Art Applied Studies Belgrade, Belgrade, Serbia
[2]Department of Rail Vehicles, Faculty of Mechanical Engineering, University of Belgrade, Belgrade, Serbia
[3]Joint Stock Company for Freight Railway Transport "Serbia Cargo" Belgrade, Belgrade, Serbia

Abstract: The railway vehicles in operation must have all subsystems functional and effective, especially brake, running gear, buffing and draw gear, suspension, etc. Any irregularities in the railway system (vehicles, tracks, signals, management, etc.) can affect transport safety. In this paper, only the influence of the vehicle's condition on railway transport safety was considered. Irregularities of railway vehicles can be observed at function failure, noticed in operation, or viewed in inspection performed by railway staff. In cases of accident or incident, the failure of the vehicle is stated in the investigation report. In operation or inspections, the failure of vehicles is stated by railway staff on labels and in workshops on measuring lists. Analysis of accidents and incidents caused by the technical condition of railway vehicles was done according to data from railway undertaker "Serbia Cargo". Analysis of irregularities was done according to data from inspections of freight railway vehicles. Analysis shows that irregularities in railway vehicles affect only some types of accidents and incidents.

Keywords: Railway vehicles, Traffic safety, Technical condition.

REQUIREMENTS OF UIC STANDARDS FOR BRAKE TRIANGLES OF RAILWAY VEHICLES

Milan Bižić, Dragan Petrović

Faculty of Mechanical and Civil Engineering in Kraljevo, University of Kragujevac, Kraljevo, Serbia

Abstract: The brake triangles are among the most important parts in the braking system of railway vehicles. Given that their quality and reliability directly affect the safety of rail traffic, the requirements for their suppliers are very rigorous. In this sense, the production of brake triangles can only be entrusted to those suppliers who are able to provide appropriate proofs of the quality. The aim of this paper is to analyze the requirements of the International Union of Railways (UIC) for the brake triangles of railway vehicles. Special attention is paid to the requirements for inspection of brake triangles, which includes specific static and dynamic tests. The results of conducted research are basis for analyzing the possibility of conquest of production of brake triangles for international market.

Keywords: Railway vehicles, Braking, Brake triangle, Testing, UIC 833.

APPLICATION OF METAL-RUBBER ELEMENTS IN THE SPRING SUSPENSION OF ROLLING STOCK

Emil Kostadinov, Nencho Nenov

Todor Kableshkov University of Transport, Sofia, Bulgaria

Abstract: The present work is dedicated to the study of the spring suspension of rolling stock, performed with metal-rubber elements (MRE). In order to reduce the amplitude of oscillation of the moving railway vehicle and to avoid the risk of resonance, special vibration damping devices are applied in the spring suspension of vehicles. The spring suspension reduces the dynamic load, which reduces the stress in the axles, axle boxes, bogies, car body, track, etc. As is well known, MREs applied in the spring suspension of railway bogies absorb part of the kinetic energy and improve the quality of the dynamic behavior and safety of railway vehicles, i.e. in addition to having elastic features, they exercise a resistance (damping) force. Since rubber, as a structural component of MRE, changes negatively its features in the process of operating the elements, they change their operational characteristics. On the other hand, the magnitude of the resistance force differs significantly depending on which branch of the characteristics the MRE operates on (loading branch or unloading branch). The study presents both an overview of the different types of MRE and their field of application, as well as box spring suspension structures of railway vehicles with MRE. The above substantiates the relevance of research in the field of:

- Determining the deformation of the MRE;
- Design of a axle box assembly with MRE for bogie type Y25;
- Strength calculations of metal-rubber elements from spring suspension;
- Determination and analysis of model parameters and values of selected materials.

Keywords: Rolling stock, Spring suspension, Metal-rubber elements.

AN ANALYSIS REGARDING TRAIN DERAILMENTS CAUSED BY CRACKED WHEELSETS

Eugen Ghita

Politehnica University of Timisoara, Timisoara, Romania

Abstract: The wheelset is a critical component of a bogie's rolling equipment, and safety requirements necessitate both static and fatigue analysis of wheelset axles.

This paper proposes a comparative analysis of derailments and accidents caused by cracked wheelsets, a topic that is extensively debated among wheelset manufacturers and railway administrations. The central issue under discussion is whether the cause of wheelset axle cracking is attributed to failure in complying with wagon or locomotive loading requirements, leading to increased static stress, or to material fatigue. The answer to this debate may be found through technical expertise that involves analyzing the cross-section of the cracking, stress levels, and the impact of dynamic conditions.

Keywords: Wheelset, Crack, Stress, Fatigue.

DEVELOPMENT OF LABORATORY FOR TESTING OF RAILWAY VEHICLES AND STRUCTURES

Dragan Petrović, Milan Bižić

Faculty of Mechanical and Civil Engineering in Kraljevo, University of Kragujevac, Kraljevo, Serbia

Abstract: The aim of this paper is to elucidate the need for the establishment and continuous development of a laboratory for testing of railway vehicles and mechanical structures at the Faculty of Mechanical and Civil Engineering in Kraljevo. The development strategy of the Centre for Railway Vehicles and Structures Testing at the Faculty of Mechanical Engineering and Civil Engineering in Kraljevo is oriented in three directions. The first direction of development refers to high-quality and efficient teaching and education of students in the field of railway engineering and structures testing, at all levels of study. The second direction of development refers to the creation of conditions for the scientific and professional advancement of the members of the Centre and Laboratory, as well as their continuous improvement in accordance with the leading world trends. The third direction refers to the scientific work of the Centre and Laboratory, which includes the verification of theoretical solutions, designed and manufactured elements, sub-assemblies and assemblies of various types of constructions. In this way, it is possible to produce high-quality graduation, masters and doctoral theses, participation in domestic and international scientific research projects and cooperation with universities, institutes and the economy. The procurement and development of modern measuring equipment and software, as well as the equipping of a suitable space for work, were necessary as a prerequisite for the highest quality performance of the aforementioned tasks.

Keywords: Railway vehicles, Wagon, Laboratory, Kraljevo, Testing, Structures.

CHALLENGES FOR TECHNICAL SPECIFICATIONS FOR INTEROPERABILITY (TSI) IN THE EUROPEAN UNION (EU)

Miltcho Lepoev

Faculty of Transportation Engineering, Railway Construction, University of Architecture, Civil Engineering and Geodesy, Sofia, Bulgaria

Abstract: All countries in the EU when designing in different phases - conceptual, technical and working design, as well as during the construction and control of the linear projects of the railway infrastructure of the Republic of Bulgaria, need to comply with the recommended nature of the TSI for the various subsystems. The publication analyses the problems related to the application of TSI with a view to convergence with the national experience of the Republic of Bulgaria, and the author offers options for solving open questions and specific discussion questions related to TSI, as well as issues related to the constituent elements of interoperability and communication technologies.

Keywords: TSI, Interoperability, National experience, Convergence.

DETERMINING THE PARAMETERS FOR PERFORMING PUBLIC PASSENGER RAIL TRANSPORT OF THE CARRIERS

Mirena Todorova, Kostadin Trifonov

Todor Kableshkov University of Transport, Sofia, Bulgaria

Abstract: Recently there has been a lack of rolling stock in railway transport – locomotives, wagons and railcars, which directly affects the quality and the comfort of passenger service. The delay of trains due to damage of rolling stock leads to a decrease in the number of passengers using railway transport. One of the ways to improve the condition of passenger railway transportation is liberalization of the market through implementation of a procedure under the Public Procurement Act for selection of a carrier. The subject of this study is the conditions for inclusion of new licensed transport companies for public transport. A model has been developed for determining packages of sections on which to carry out transport activity by a certain transport company based on the assessment of transport efficiency on the sections of railway network. The model is applied to the suburban transport of the capital city Sofia and the serviced sections. The obtained results can be used in developing the conditions for the forthcoming tenders for assigning assigning) a contract for provision of public transport services in the field of railway transport in the Republic of Bulgaria.

Keywords: Passenger rail transport, Liberalization, Passenger service.

POSSIBILITY OF REPLACING LOW-CARBON STRUCTURAL STEEL WITH HIGH-STRENGTH STEELS, FOR PRODUCING WELDED STRUCTURES IN INDUSTRY OF HEAVY MACHINES

Đorđe Ivković[1], Dušan Arsić[1], Radun Vulović[2], Vukić Lazić[1], Aleksandar Sedmak[3], Srbislav Aleksandrović[1], Milan Đorđević[4]

[1]Faculty of Engineering, University of Kragujevac, Kragujevac, Serbia
[2]Institute for Information Technologies Kragujevac, Kragujevac, Serbia
[3]Faculty of Mechanical Engineering, University of Belgrade, Belgrade, Serbia
[4]Faculty of Technical Sciences, Kosovska Mitrovica, Serbia

Abstract: Modern trends of research and development of new products are focused on saving materials through mass reduction of various parts, so the high-strength steels (HSS) are used more often than conventional low-carbon structural steels. It is well known that high strength of HSS is providing a possibility for parts to be produced with smaller dimensions and cross-sections. This often results in decreasing in weight of parts and whole structures. In this paper possibility for replacing commonly used, low-carbon, structural steels which have good weldability, with HSS, in industry of heavy machines is analyzed. Main goal of this replacement is weight reduction as well as to keep adequate load capacity and reliability of parts and structures. Properties of three structural steels were analyzed: Č0562 (S355J0), ČRO460 (P460NL1) and STRENX 700 (S690QL). Furthermore, both advantages and disadvantages of HSS application, complexity of choosing the correct welding method, correct filler materials and favorable welding technology are indicated. After the trial welding on samples, experimental investigation of important mechanical and microstructural properties such as strength, plasticity, impact toughness, hardness and microstructure evaluation were conducted. Based on the obtained experimental results the specific conclusions were given.

Keywords: Welding, Structural steel, High Strength Steel, Mechanical Properties, Microstructure.

INVESTIGATION OF THE OCCURRENCE OF FAILURES IN THE AXLE BOX AND PRIMARY SPRING SUSPENSION OF PASSENGER BOGIES

Vanio Ralev

Todor Kableshkov University of Transport (VTU), Sofia, Bulgaria

Abstract: The assessment of the strength and durability of the structural elements is one of the main tasks that arise when developing new machines and mechanisms. The main factor determining the durability of most machine parts is both the mechanical load and the intensity of occurrence of failures. The axle boxes are designed to take the load from the bogie frame and transmit it to the axle necks, to ensure the rotation of the wheelsets with minimal resistance, to limit the longitudinal and transverse displacement of the wheelsets. The primary spring suspension is elastic and damping system, providing transmission between the load of the bogie frame and the axle box, ensuring the necessary smoothness of the movement and damping of the vibrations that occur. The reliability of the axle box and the primary spring suspension of railway bogies, as technical systems, mainly depend on the design calculation, operating load, monitoring system, as well as their maintenance and repair. The presented article analyzes the causes of the damage to the axle box and the primary spring suspension of railway bogies in operation of the Bulgarian State Railways.

Keywords: Railway vehicles, Passenger bogies, Axle box, Primary spring suspension, Failures.

APPLICATION OF AGILE PROJECT MANAGEMENT METHODOLOGY IN RAILWAY TRANSPORT

Irena Petrova, Dimitar Dimitrov

Faculty of Transport Management/Department of Technology, Organization and Management of Transport, Todor Kableshkov University of Transport, Sofia, Bulgaria

Abstract: High fuel prices and global trends towards the use of greener transport have made rail transport as such of the future through the development of high-speed railways and intermodal transport. The growing importance of rail transport worldwide requires an infrastructure that meets the demand in terms of safety, speed and capacity. Years of neglected problems in rail transport now require urgent solutions. Modernizing the railway sector to meet the demands of competitive and sustainable transport is of great social and political importance. A flexible project management approach is a modern way to solve transportation needs.
The article presents a generalized flexible model for planning and managing railway projects, ensuring the construction and maintenance of the transport infrastructure.

Keywords: Rail transport, Agile project management, Project management, Strategic planning and development, Transport infrastructure, Agile method.

COMPARATIVE ANALYSIS OF THE EFFECT OF LATERAL SWINGING OF THE TRAM BODY ON DIFFERENT TYPES OF ELECTRICAL CURRENT COLLECTORS

Emil M. Mihaylov[1], Emil Iontchev[2], Rosen Miletiev[3], Metodi Atanasov[4], Rashko Vladimirov[2]

[1]Department of Lifting-transport and construction machines and systems, University of Transport, Sofia, Bulgaria
[2]Department of Telecommunications and Safety Equipment and Systems, University of Transport, Sofia, Bulgaria
[3]Faculty of Telecommunication, Technical University of Sofia, Bulgaria
[4]National Railway Infrastructure Company, Sofia, Bulgaria

Abstract: The article assesses the impact of side swinging of trams, with different types of suspension of the undercarriage, on their electrical current collectors. A comparative analysis has been made between the different designs of electrical current collectors based on the estimates obtained from the number of failures and emergency breaks. The rail track on which the research took place is made of grooved rails on top of panels which have frequent asymmetrical collapses of the two rails with different frequency and depth. To determine the lateral deflection angle of the body, the linear accelerations, angular velocities, and magnetic field values along the three axes of each of the trams were measured. The sensors have been mounted on the roof of the carriage just under the electrical current collector. It has been established that the lateral swinging of the body of the tram with different bogie design in combination with their respective design of the electrical current collectors influences the damage and failures to a different extent.

Keywords: Electrical current collector, Railroad, Accelerometer, Gyroscope, Magnetometer, Kalman filter.

A SENSOR NETWORK-BASED MODEL FOR INCREASING SAFETY ON HIGH-SPEED RAILWAYS

Zoran G. Pavlović, Veljko Radičević, Branislav Gavrilović, Marko Bursać, Miloš Milanović

Belgrade Academy of Technical and Art Applied Studies, College of Railway Engineering, Belgrade, Serbia

Abstract: Today, railway traffic, by increasing the speed, facilitates the transportation of users and personal luggage. User mobility is currently current on the Belgrade - Novi Sad line. The user covers the distance on the specified route in 35 minutes. The terrain on which the railway is located is flat and it can be said that the possible influence of external factors (collapse of hills and mountains) related to safety is excluded. Traffic operation is regulated by the European train control system ETCS (European Train Control System). In the near future, the modernization of the railway infrastructure on the route Belgrade - Niš will begin. Considering that the central part of Serbia is hilly, the configuration of the terrain represents the emergence of critical places, there is a possibility of disrupting and endangering the safe functioning of railway traffic as well as the safety of users. For this reason, this paper proposes a model for improving the safety of the entire railway traffic system, which is based on sensors. Sensors react to changes, register and forward to take security procedures.

Keywords: Security, Sensors, Sensor network, Railway traffic.

METHODOLOGY FOR CALCULATING THE PROCESS OF EMERGENCY COLLISION IN RAILWAY VEHICLES

Venelin Pavlov

Todor Kableshkov University of Transport (VTU), Sofia, Bulgaria

Abstract: Ensuring passive safety in the event of an emergency collision of railway rolling stock with obstacles requires, as does the design, manufacture and certification of a system of energy-absorbing elements (EAE). The companies producing EAE carry out bench tests of the developed structures. However, before performing bench tests, the developed structures of EAE must be subjected to a number of theoretical studies and analysis of the processes in an emergency collision. The article proposes a methodology in accordance with the requirements of Russian regulations (GOST 32410-2013, etc.) and supplemented in accordance with the requirements of the European standard EN15227-2020 for theoretical calculation of processes as a result of emergency collisions of rolling stock with obstacles. Dependencies for determining the absorbed energy in an emergency collision depending on the impact speed and various obstacles are given.

Keywords: Railway vehicles, Passenger trains, Emergency collision.

SESSION C: PRODUCTION TECHNOLOGIES

MANUFACTURING TECHNOLOGIES FOR GFRP'S WITH THERMOSETTING POLYMERIC BINDERS

Cristina Sescu-Gal[1], Cătălin Frâncu[1], Cornelia Dobrescu[2], Petre Bălan[3]

[1]Faculty of Mechanical Engineering and Robotics in Construction, Technical University of Civil Engineering, Bucharest, Romania
[2]Faculty of Engineering and Agronomy from Brăila, Department of Engineering and Management Sciences, "Dunărea de Jos" University, Galati, Romania
[3]Chief eng. Dypety S.R.L., Moinești, Romania

Abstract: The manufacture of GFRP's (Glass-Fibres Reinforced Polymers) with thermosetting polymer binders has seen a remarkable development, with the aim of identifying replacement materials for steel products. The development of composite materials led to the identification of GFRP products, which can be used as substitutes for traditional materials for reinforcing concrete elements. The concern of researchers in the field is directed towards obtaining some mechanical and geometrical characteristics that ensure concrete structures the characteristic resistance properties. Having very good results regarding mechanical tensile strength, the products can be used for reinforcement in concrete elements for structures such as: platforms placed on the ground, piles for indirect foundations, moulded walls, concrete tubes for sewage networks, etc. Through these processes, bars, nets, wires or tubular elements with constant or variable section can be made.

Keywords: Glass fiber reinforced polymers, Reinforced concrete, Bars, Model.

ADDITIVE MANUFACTURING – A VIEW THROUGH THE PRISM OF STANDARDIZATION

Pavle Ljubojević[1], Tatjana Lazović[1], Snežana Ćirić-Kostić[2]

[1]Faculty of Mechanical Engineering, University of Belgrade, Belgrade, Serbia
[2]Faculty of Mechanical and Civil Engineering in Kraljevo, University of Kragujevac, Kraljevo, Serbia

Abstract: This paper explores the significance of standardization in the field of additive manufacturing (AM). The rapid growth of AM in modern industries has highlighted the need for standardization to ensure compatibility, quality control, and market opportunities for AM products. The paper emphasizes the flexibility of AM technologies in meeting industrial and ecological requirements, revolutionizing business models, and satisfying customer needs. It provides an overview of the International Organization for Standardization (ISO) and ASTM International (American Society for Testing and Materials), two major organizations involved in developing and publishing international standards for AM. The paper discusses the technical committees, working groups, and collaborations established by ISO and ASTM to address various aspects of AM standardization. Additionally, it highlights the ongoing efforts in Serbian national standardization and proposes future research on analyzing the scopes and contents of AM standards for improved usability. Overall, the paper emphasizes the crucial role of standardization in supporting the continued advancement of additive manufacturing.

Keywords: Additive manufacturing, Additive technologies, Standardization, Standards, ISO, ASTM International.

ANALYSIS OF SPECIFIC CUTTING ENERGY IN LONGITUDINAL TURNING OF UNALLOYED STEELS

Milan Trifunović, Miloš Madić

Faculty of Mechanical Engineering in Niš, University of Niš, Serbia

Abstract: More than 90% of machining processes environmental impact is due to electrical energy consumption. Reduction in electrical energy consumption of machining processes can be achieved by optimizing existing machining processes. Specific cutting energy, unlike the cutting power, incorporates the material removed, and hence is an appropriate variable for expressing the environmental impact of a machining process. It depends upon cutting conditions, and therefore, can be easily controlled by the machine tool end user through careful selection of cutting parameters and cutting tool geometry. This article proposes an approach for identification of the most important main and interaction effects of cutting parameters and cutting tool geometry parameters regarding the specific cutting energy in dry longitudinal single-pass turning of unalloyed steels. Five parameters (depth of cut, feed rate, cutting speed, rake angle and cutting edge angle) were varied at two levels by applying fractional factorial design 25-1. Specific cutting energy was estimated for sixteen cutting regimes based on the cutting tool manufacturer's machining calculator and well-known analytical relationships. The analysis of obtained results involved the identification of main and interaction effects, determination of statistically significant effects and development of specific cutting energy prediction model.

Keywords: Turning, Fractional factorial design, Specific cutting energy, Unalloyed steels.

STATE OF THE ART IN THE FIELD OF COLD FORGING TOOLS

Ilija Varničić, Miloš Pjević, Mihajlo Popović

Department of Production Engineering, Faculty of Mechanical Engineering, University of Belgrade, Serbia

Abstract: This paper chronologically presents the development of the geometry of cold forging tools, as well as the factors that influence the tool lifespan. Tools for plastic deformation processing are of strategic importance for large-scale and mass production. Their lifespan and properties have a great impact on process productivity and product quality. Cold forging represents an efficient metal processing technique through plastic deformation with significant material savings. One of the main challenges of this processing technique is managing high contact normal stresses in the tool, which can lead to serious tool damage. In order to better understand tribological phenomena in the cold forging process, which involve tool wear, fatigue, and failure, this paper will present a practical example of how to improve tool lifespan from the perspective of tool design and construction. The example taken is a forging tool for manufacturing a screw in four operations. The distribution of contact pressure in the contact zone between the working tool and the workpiece was examined using the finite element method for each of the geometries tested. This allowed for a comparison of the service life of the matrix for each of the tested matrix geometries.

Keywords: Cold forging, Tool geometry, Wear, Finite element method.

APPLICATION OF THE POKA-YOKE METHOD IN SMALL WOOD PROCESSING COMPANIES

Jovana Perić[1], Milovan Lazarević[2], Mitar Jocanović[2], Vladan Grković[1]

[1]The Faculty of Mechanical and Civil Engineering in Kraljevo, University in Kragujevac, Kraljevo, Serbia
[2]Faculty of Technical Sciences, University of Novi Sad, Novi Sad, Serbia

Abstract: In the modern business environment, achieving a high level of product quality is a key factor for the success of every manufacturing company. However, producing error-free products is always a challenge, especially in low-volume production where mistakes can have a significant impact. Therefore, the focus of this research is on a case study that addresses the issue of non-conformity between delivered products and documentation within the low-volume production system of interior doors. Specifically, this study aims to analyze the factors that contribute to errors in the packaging process of interior doors and propose solutions to prevent errors by implementing the Poka-Yoke method.

Keywords: Lean, Poka-Yoka, Errors, Small enterprise.

DEVELOPMENT A SYSTEM FOR DESIGNING OPTIMAL TECHNOLOGICAL PROCESSING PARAMETERS AT MACHINING CENTERS

Zvonko Petrović[1], Milan Kolarević[2], Radovan Nikolić[1], Milica Tufegdžić[1], Violeta Đorđević[1]

[1]Academy of Professional Studies Šumadija, Department Trstenik, Trstenik, Serbia
[2]Faculty of Mechanical and Civil Engineering in Kraljevo, University of Kragujevac, Kraljevo, Serbia

Abstract: Changes in the circulation of goods and services at the world level motivate manufacturers to fulfill the requirements of each individual customer in order to achieve a good position in the market. This phenomenon imposes increasingly strict requirements that the technological system must fulfill, so today flexible technological systems tend to become intelligent technological systems. The paper presents the development of a system for designing optimal technological processing parameters at machining centers based on biologically inspired Particle Swarm Optimization (PSO) algorithms.

Keywords: Flexible technological systems, Processing parameters, PSO algorithm.

APPLICATION OF THE ANFIS METHOD TO SUPPORT DECISION-MAKING IN THE PREDICTION OF THE FACTORS THAT MOST INFLUENCE THE PRODUCT PRICE

Marija Mojsilović[1], Radoje Cvejić[2], Goran Miodragović[1], Snežana Gavrilović[1], Selver Pepić[1]

[1]Academy of Professional Studies Šumadija, Department Trstenik, Trstenik, Serbia
[2]Faculty of Information Technologies and Engineering, Nikola Tesla University, Belgrade, Serbia

Abstract: This paper presents the application of the Anfis method in predicting the most influential factors on the formation of the optimal selling price of a product. From a large set of factors that can influence the formation of the sales price, the following costs are singled out: raw materials, labor, tools and machines, as well as the manufacturing technology, i.e. the time of manufacturing the product. The idea is to carry out an individual assessment of the impact of each of the mentioned factors on the price of the product, that is, the combined impact of two or three factors. The obtained results can serve as an input parameter in decision support systems, which would allow managers to accurately predict all factors and have a better insight into how these factors influence the formation of the sales price.

Keywords: DSS, Neural Networks, Anfis, Prediction.

SOME CONSIDERATIONS REGARDING THE INVESTIGATION AND REDUCTION OF THE NOISE GENERATED BY THE RUNNING OF ROAD VEHICLES

Vasile Bacria, Nicolae Herisanu

University Politehnica Timisoara, Timisoara, Romania

Abstract: Road vehicles generate a high level of noise while moving on the traffic arteries. A fairly significant percentage of this is due to their turnover. In the paper, an investigation of this noise is carried out regarding the causes of production, propagation model, effects, admissible limits and existing levels determined by measurements. In order to reduce it, some methods of reduction, the way of implementation and the resulting effects are analyzed.

Keywords: Noise, Road vehicles, Methods of reduction.

SUPPLEMENTARY ELEMENTS OF TRAFFIC NOISE BARRIERS

Vladan Grković[1], Violeta Đorđević[2], Milan Kolarević[1], Branko Radičević[1]

[1]The Faculty of Mechanical and Civil Engineering in Kraljevo, University in Kragujevac, Kraljevo, Serbia
[2]Academy of Applied Study Šumadija, Department Trstenik, Trstenik, Serbia

Abstract: Depending on the acoustic, aesthetic, and other needs, additional objects are often incorporated into traffic noise barriers, such as caps to cover the top of the barrier, emergency openings, drainage openings, wall-mounted attachments, barrier protection from traffic, vertical supports for climbing plants, sound absorbers, protective caps for posts, and similar. The most common are the caps that are installed to improve the acoustic performance of the barrier, such as:

- noise resonators,
- tubular absorbers,
- diffraction edge,
- devices for passive phase interference,
- devices for active noise control, etc.

Keywords: Sound resonators, Tubular absorbers, Diffraction caps.

IDENTIFICATION OF NOISE SOURCE BASED ON SOUND INTENSITY IN VERTICAL CNC MILLING MACHINE

Tanja Miodragović[1], Branko Radičević[1], Stefan Pajović[1], Nenad Kolarević[2]

[1]Faculty of Mechanical and Civil Engineering in Kraljevo, University of Kragujevac, Kraljevo, Serbia
[2]Faculty of Mechanical Engineering, University of Belgrade, Belgrade, Serbia

Abstract: The paper presents a procedure for identifying the sound sources of a vertical CNC milling machine based on sound intensity measurements using the "two-microphone" method. Dominant noise sources for different operating modes in the machining process are determined based on contour maps of sound intensity levels measured on five sides of an imaginary parallelepiped that encompasses the machine. The research results can be used for designing noise protection systems for the dominant sound sources of the machine. The obtained results provide valuable guidance for designing machines that generate lower noise levels, which is crucial in machine certification processes.

Keywords: Identification of noise sources, Sound intensity, CNC milling machine.

SURFACE TREATMENTS FOR TRAFFIC NOISE BARRIERS

Violeta Đorđević[1], Jovana Perić[2], Tanja Miodragović[2], Stefan Pajović[2]

[1]Academy of Applied Study Šumadija, Department Trstenik, Trstenik, Serbia
[2]The Faculty of Mechanical and Civil Engineering in Kraljevo, University in Kragujevac, Kraljevo, Serbia

Abstract: A large number of various materials are used to make traffic noise barriers. The choice of a particular texture for the surface treatment of the barrier depends on many factors, such as the aesthetic appearance of both sides of the barrier, structural characteristics, maintenance requirements, type of material used to construct the barrier, etc. Therefore, surface treatments for barriers must also be considered. Surface treatments include textures, colors, graffiti, and coatings. The paper provides a classification of surface treatments for traffic noise barriers and guidelines for their use.

Keywords: Traffic sound barriers, Texture, Colours, Coatings, Graffiti.

COMPARISON OF MECHANICAL BEHAVIOUR OF TIG AND MIG WELDED JOINT DISSIMILAR ALUMINUM ALLOYS 2024 T351 AND 6082 T6

Dragan Milčić[1], Miodrag Milčić[1], Tomaž Vuherer[2], Aleksija Đurić[3], Nataša Zdravković[1], Andreja Radovanović[4]

[1]Faculty of Mechanical Engineering, University of Niš, Serbia
[2]University of Maribor, Faculty of Mechanical Engineering, Slovenia
[3]University of East Sarajevo, Faculty of Mechanical Engineering, Bosnia and Herzegovina
[4]IMW Institute, Serbia

Abstract: Different aluminum alloys are used for the production of light constructions of transport vehicles (rail vehicles, ships, airplanes) due to the low density of the material, good mechanical properties, good corrosion resistance, etc. The aim of this work is to study the mechanical properties of dissimilar assemblies of 2024 T351 and 6082 T6 aluminum alloy welded by the TIG and MIG process. Aluminum alloy 6082 T6 is well weldable by classical fusion welding processes (MIG and TIG), while aluminum alloy 2024-T351 is almost non-weldable with MIG and TIG process. Optimum technology for MIG and TIG welding process is very important for the mechanical properties of welded joints of dissimilar aluminum alloys 2024 T351 and 6082 T6. For experimental investigations of mechanical properties of welded joints of aluminum alloys 2024 T351 and 6082 T6 were sheets with a thickness of 8 mm. AlSi5 aluminum alloy wire was used as a filler wire in both TIG and MIG welding processes. TIG welding of aluminum alloys 2024 and 6082 was in argon as shielding gas, and the MIG process in a mixture of argon and helium as shielding gas. The assessment of the mechanical properties of the welded joint of dissimilar Al alloys was performed by Vickers hardness testing, tensile and bending tests of the welded samples.

Keywords: AA2024 T351, AA6082 T6, TIG welding, MIG welding, Mechanical properties.

TAGUCHI-BASED DETERMINATION OF DOUBLE-ELLIPSOIDAL HEAT SOURCE PARAMETERS FOR NUMERICAL SIMULATIONS OF GMAW PROCESS

Mišo Bjelić, Mladen Rasinac, Aleksandra Petrović, Marina Ivanović

Faculty of Mechanical and Civil Engineering in Kraljevo, University of Kragujevac, Kraljevo, Serbia

Abstract: The results of the application of welding simulation models are highly dependent on the input parameters, particularly on the parameters of the heat source model. In this study, a method for determining the heat source parameters for a three-dimensional quasi-stationary heat transfer model for gas metal arc welding is presented. The commonly used double-ellipsoidal heat source has five input parameters, the values of which are mainly chosen based on the researcher's experience. This approach is a common source of error; to estimate these values, we applied a calibration procedure using the Taguchi method with two objective functions based on weld geometry. The simulation results show that the Taguchi method can be successfully used to determine the heat source parameters.

Keywords: Numerical simulation, Taguchi method, Heat source, GMAW.

OPTIMIZATION OF GMA WELDING PARAMETERS USING THE GRASSHOPPER OPTIMIZATION ALGORITHM

Mladen Rasinac, Mišo Bjelić, Aleksandra Petrović, Marina Ivanović

Faculty of Mechanical and Civil Engineering, University of Kragujevac, Kraljevo, Serbia

Abstract: This paper presents the method for choosing optimal parameters for GMA welding of P355GH low-carbon steel plates. The welding parameters such as seam overhang coefficient, degree of mixing, number of passes and welding current were obtained using the grasshopper optimization algorithm (GOA). Optimal parameters were obtained to yield minimum welding costs while considering technological constraints such as maximum permissible cooling rate and maximum permissible hardness of the heat affected zone (HAZ).

Keywords: Optimization, GMA welding, Grasshopper optimization algorithm.

SESSION D: AUTOMATIC CONTROL AND FLUID TECHNIQUE

EVENT-TRIGGERED ADAPTIVE DYNAMIC PROGRAMMING BASED OPTIMAL CONTROL FOR HYDRAULIC SERVO ACTUATOR

Vladimir Djordjevic[1], Vladimir Stojanovic[1], Hongfeng Tao[2], Xiaona Song[3], Shuping He[4], Weinan Gao[5]

[1]Faculty of Mechanical and Civil Engineering in Kraljevo, University of Kragujevac, Kraljevo, Serbia
[2]Key Laboratory of Advanced Process Control for Light Industry of Ministry of Education, Jiangnan University, Wuxi, China
[3]School of Information Engineering, Henan University of Science and Technology, Luoyang, China
[4]Key Laboratory of Intelligent Computing and Signal Processing, School of Electrical Engineering and Automation, Anhui University, Hefei, China
[5]State Key Laboratory of Synthetical Automation for Process Industries, Northeastern University, Shenyang, China

Abstract: This paper considers optimal tracking control for hydraulic servo actuator with unknown dynamics as a highly complex nonlinear system. The aim is to achieve asymptotic tracking and disturbance rejection by minimizing some predefined performance index. Through the combination of adaptive dynamic programming (ADP) and event-triggered control (ETC), which is introduced to save the communication resources and reduce the number of control updates. An approximate optimal controller is iteratively learned online using measurable input/output data instead of unmeasurable states and unknown system parameters. The discrete-time algebraic Riccati equation is iteratively solved by ADP approach. Simulation results demonstrate the feasibility and effectiveness of the proposed approach.

Keywords: Adaptive dynamic programming, Event-triggered control, Optimal control, Hydraulic servo actuator, Unknown dynamics.

$H\infty$ CONTROL OF AEROPENDULUM

Dušan Božić, Luka Filipović, Milan Ristanović

University of Belgrade, Faculty of Mechanical Engineering, Belgrade, Serbia

Abstract: This paper introduces a robust control design for an aeropendulum system, utilizing the $H\infty$ control technique. The aeropendulum setup and equipment are described, followed by the derivation of a mathematical model and system identification to accurately represent the system dynamics. The $H\infty$ control method is then applied to create a controller, considering system uncertainties and disturbances. The efficacy of the controller is verified through experimental results, showing robust performance despite model uncertainties and time delay.

Keywords: $H\infty$, Robust Control, Aeropendulum.

DESIGN AND IMPLEMENTATION OF AN AEROPENDULUM CONTROLLER VIA LOOP SHAPING

Luka Filipović, Milan Ristanović, Dušan Božić

University of Belgrade, Faculty of Mechanical Engineering, Belgrade, Serbia

Abstract: This paper presents a robust control design for an aeropendulum system using the loop shaping method. We describe the system setup, derive its mathematical model, and conduct system identification to capture its dynamics accurately. The loop shaping technique is then used to design a controller, considering system uncertainties and noise. The effectiveness of the controller is validated through experiments, demonstrating robust performance in the face of time delay and model uncertainties.

Keywords: Loop Shaping, Robust Control, Aeropendulum.

ANALYSIS OF THE CURRENT SITUATION IN SERBIA RELATED TO THE EDUCATION IN THE FIELD OF APPLIED ARTIFICIAL INTELLIGENCE

Anđela Đorđević[1], Marko Milojković[1], Miodrag Spasić[1], Dejan Rančić[2], Saša S. Nikolić[1], Miroslav Milovanović[1]

[1]Faculty of Electronic Engineering/Department of Control Systems, University of Niš, Serbia
[2]Faculty of Electronic Engineering/Department of Computer Science, University of Niš, Serbia

Abstract: The fastest growing and most exciting scientific field today is Artificial Intelligence (AI) with its real world applications. The current transformation of society and business needs for AI specialists with specific competencies and skills dictate the transformation of the Serbian educational system and its adjustment toward modern demands. This paper presents some results and analysis of conducted surveys in the scope of the Erasmus+ project "Future is in Applied Artificial Intelligence" related to the current state of AI education in Serbia, existing university AI courses, knowledge and attitude of students and teachers toward AI contents, needs of the employers and the preferred future directions of the transformation of education system toward a competency-based digital society through formulating adequate AI learning requirements.

Keywords: Applied artificial intelligence, Engineering education, Competency-based education.

EXPLORING THE BENEFITS OF NEURAL NETWORKS IN FUNCTION APPROXIMATION COMPARED TO CLASSICAL INTERPOLATION METHODS

Filip Stanić

Faculty of Mechanical Engineering of the University of Belgrade, Belgrade, Serbia

Abstract: Lagrange Interpolating Polynomial (LIP) and Newton Interpolation are classical methods for function approximation. However, these methods may suffer from instability and inaccuracies, especially when the data is noisy or contains outliers. This study investigates the potential of using neural networks to enhance the accuracy of the function approximation by learning the underlying patterns in the data. The neural network is trained using input-output pairs generated from LIP and Newton Interpolation, and optimized with a back propagation algorithm. Results show that the neural network significantly improves the accuracy of the function approximation, especially for complex and noisy datasets. This research provides insights into the use of neural networks as a complementary method to traditional function approximation techniques, and highlights their potential to overcome limitations associated with noisy or outlier data.

Keywords: Lagrange Interpolating Polynomial, Newton Interpolation, Neural networks, Function approximation.

CONCEPTUAL MODELING OF HYSTERESIS IN PIEZO CRYSTALS USING NEURAL NETWORKS

Lazar Kelić, Dragan Pršić

Faculty of Mechanical and Civil Engineering in Kraljevo, University of Kragujevac, Serbia

Abstract: Piezoelectric materials are a subset of a larger class of materials known as ferroelectric materials. Ferroelectricity is the characteristic of certain materials that have a spontaneous electrical polarization that can be reversed by the application of an electric field. Like the magnetic equivalent (ferromagnetic materials), ferroelectric materials exhibit hysteresis loops based on the applied electric field and the history of that applied electric field. Hysteresis compensation is necessary wherever high precision positioning or piezo control of the mechanism is required. For forecasting purposes, of hysteresis, the Bouc-Ven model was most often used, and more recently, hysteresis modeling using neural networks has begun. The paper will show a way of conceptual predicting, and then for hysteresis, using a neural network.

Keywords: Ferroelectric materials, Hysteresis, Neural network.

DESIGN OF PD CONTROLLERS FOR THE SYSTEM OF A VALVE CONTROLLED HYDRO-MOTOR

Ljubiša Dubonjić[1], Saša Prodanović[2]

[1]Faculty of Mechanical and Civil Engineering in Kraljevo, University of Kragujevac, Kraljevo, Serbia
[2]University of East Sarajevo, Faculty of Mechanical Engineering, East Sarajevo, Bosnia and Herzegovina

Abstract: This paper presents design of a PD controller for the system of a valve-controlled motor. By using possibilities offered by computers and software the graphical method is used in the design of PD controllers. The D–decomposition method including system performances, damping and settling time was applied. The system performances are included in a new manner without the need for calculation of Chebyshev functions for every change of the damping coefficient thanks to strong software support.

Keywords: PD controller, D-decomposition, Relative stability, Settling time, Robustness.

ADVANCED ELECTRO-HYDRAULIC SYSTEMS FOR DRIVING THE MOVEMENT OF RADIAL GATES

Dragan Nauparac

PPT-Engineering, Belgrade, Serbia

Abstract: Radial gates are standardly used on spillway fields on dams for the evacuation of large periodic waters or for regulating the flow of water. The design of electrohydraulic systems for driving gate movement is considered. All elements of the design of such systems are analyzed in order to obtain the most advanced solution. This is especially important because the projected service life for such systems is 35 years until major overhaul. Special attention has been paid to transfer the dynamic behavior of the radial gate movement to an adequate load on the piston rod end of the hydraulic cylinder.

Keywords: Radial gate, Electrohydraulic system, Radial gate movement.

MODELING AND SIMULATION HYDRAULIC EXCAVATOR'S ARM

Almir Osmanović, Elvedin Trakić, Salko Ćosić, Mirza Bećirović

Faculty of Mechanical Engineering/Mechatronic, University of Tuzla, Tuzla, Bosnia and Herzegovina

Abstract: With the development and implementation of new techniques in hydraulics, hydraulic systems are increasingly applied as systems by which the transfer is made and power management for the systems with which the operation is performed with working organs that perform technological operations of mobile machinery and equipment. In this paper is present application of hydraulic components and systems as part of mechatronic subsystems on mobile machines. There are advanced modern hydraulic components that enable fast change of direction of the executive organs working machines with continuously changing pressure and flow rate. Also in the work is present the application of software tools that allow the simulation of hydraulic system, from which then allows flexibility in terms of finding the best solutions in the design of the above systems. It is significant to note also that the developed model with some corrections can be used for simulation, analysis and control of the hydraulic system on similar mobile machines similar with similar or same configuration, with respect to a number of different types of mobile machines that are in use.

Keywords: Hydraulics, Hydrostatic power transmission, Mechatronic systems, Control, Modeling, Simulation, Mobile machine and equipment.

DIAGNOSTICS OF THE VEHICLE CONTROL SYSTEM BREAKDOWN – CASE STUDY: AUDI

Ljiljana Pecić, Milija Džekulić, Marko Milivojčević

Academy of Technical and Art Applied Studies, Serbia

Abstract: Safety of technical systems, such as vehicles, is very important, considering the consequences that breakdown of some components of the system can cause: material damage and loses, but also human injury and death. Diagnostics of technical systems is part of regular maintenance process, but it is also the first step that had to be done when some breakdown occurs. In this paper the case study of carried out diagnostics and detection of breakdown on Audi A3 control system is presented. Paper will include a full description of steering by wire system and the implementation of device BOSCH KTS 540 for breakdown detection on a vehicle with difficulties in turning the steering wheel

Keywords: Vehicle, Breakdown, Control system, Diagnostics.

EMERGING TECHNOLOGY OF AMBIENT LOOP HEAT PUMPS ENERGY SYSTEMS

Olivier Boennec

Introba, United Kingdom

Abstract: Safety of technical systems, such as vehicles, is very important, considering the consequences that breakdown of some components of the system can cause: material damage and loses, but also human injury and death. Diagnostics of technical systems is part of regular maintenance process, but it is also the first step that had to be done when some breakdown occurs. In this paper the case study of carried out diagnostics and detection of breakdown on Audi A3 control system is presented. Paper will include a full description of steering by wire system and the implementation of device BOSCH KTS 540 for breakdown detection on a vehicle with difficulties in turning the steering wheel.

Keywords: Ambient loop heat pumps, District heating and cooling networks, Heat pumps.

SESSION E: APPLIED MECHANICS

INFLUENCE ON THE SUPPORT RESISTANCE OF A MOBILE PLATFORM DUE TO THE EFFECT OF HIGH-INTENSITY IMPULSIVE FORCE

Aleksandra B. Živković[1], Slobodan R. Savić[1], Nebojša P. Hristov[2], Damir D. Jerković[2], Andjela G. Mitrović[1], Marija V. Milovanović[3], Lazar M. Arsić[3]

[1]Faculty of Engineering, University of Kragujevac, Kragujevac, Serbia
[2]Military Academy, University of Defense, Belgrade, Serbia
[3]Military Technical Institute, Belgrade, Serbia

Abstract: In this study, a Finite Element Method (FEM) analysis was performed to evaluate the support resistance of a vehicle's chassis under the effect of a high-intensity, impulsive force of very short duration. The FEM model of the chassis was created, and material properties were defined to simulate the actual scenario. The model was subjected to the impulsive force, and the results were analyzed to determine the support resistance of the vehicle's base. The findings of the analysis can help enhance the structural integrity of the vehicle's chassis under impulsive loading conditions, thus improving the safety and reliability of the vehicle. In conclusion, the study provides valuable insights into the support resistance of a vehicle's chassis under impulsive loading conditions. The results of the analysis can help improve the design and performance of the vehicle's base, ensuring the safety and reliability of the vehicle under different loading conditions.

Keywords: Simulation, FEM, Support Resistance.

METHODS FOR MODELING BOLTED CONNECTIONS USING FEM

Vladimir Milovanović[1], Miloš Pešić[2], Rodoljub Vujanac[1], Marko Topalović[2], Milan Stojiljković[1]

[1]Faculty of Engineering, University of Kragujevac, Kragujevac, Serbia
[2]Institute for Information Technologies, University of Kragujevac, Kragujevac, Serbia

Abstract: In constructions with complex geometry, bolted connections are most often used to connect parts. Modeling a complete bolted connection which consists of bolt, nut and washers using 3D finite elements is either not always possible or requires a lot of engineering time. For this reason, it is necessary to approximate the bolted connection using other types of finite elements. This paper presents methods for modeling bolted connections using different types of finite elements. A complete bolted connection loaded in shear and bending was modeled using 3D finite elements. The bolted connection analysis results obtained using 3D finite elements were used as a reference. After that, the bolted connection was modeled using 1D beam finite element in combination with 3D, RBE2 and RBE3 finite elements. By comparing the results of the numerical analyses, an approximation of the bolt connection which best corresponds to the reference model was obtained. It can be concluded that the shown approximation of bolted connections gives satisfactory results and significantly saves engineering time.

Keywords: Finite element method, Bolted Connection, Beam finite element, RBE2, RBE3.

ANALYSIS OF PARASITIC DISPLACEMENTS OF LUMPED COMPLIANT PARALLEL-GUIDING MECHANISMS

Slaviša Šalinić

Faculty of Mechanical and Civil Engineering in Kraljevo, University of Kragujevac, Kraljevo, Serbia

Abstract: Parasitic displacements of a guiding plate of a lumped compliant parallel-guiding mechanism are analysed using the pseudo-rigid-body (PRB) approach. Small deformations of flexure hinges are assumed. Each flexure hinge of the compliant mechanism is modelled by the PRB model with 3-DOF (degrees of freedom). This model allows that axial deformation of the flexure hinge to be considered. The corresponding expressions for both translational and rotational parasitic displacements of the compliant mechanism are derived. The obtained expressions enable the analysis of the influence of various structural parameters as well as various types of flexure hinges on the parasitic displacements of the considered type of compliant parallel-guiding mechanisms.

Keywords: Pseudo-rigid-body model, Compliant mechanisms, Parasitic displacements, Quasi-static, Flexure hinge.

OPTIMAL DYNAMIC BALANCING OF PLANAR MECHANISMS: AN OVERVIEW

Marina Bošković

Faculty of Mechanical and Civil Engineering Kraljevo, University of Kragujevac, Kraljevo, Serbia

Abstract: The problem of dynamic balancing of planar mechanisms using the optimization technique is discussed in the paper. The application of different optimization algorithms in the process of dynamic balancing of three types of planar mechanisms: planar serial manipulator, four-bar linkage, and multi-bar mechanisms was analyzed. The aim of the paper is to provide an overview of recent research in optimal dynamic balancing of planar mechanisms. The author hopes that this study can be used as an informative reference for future research in balancing of mechanisms.

Keywords: Multi-objective optimization, Dynamic balancing, Planar mechanisms, Review.

MODIFIED 2D ARC-STAR STRUCTURE WITH NEGATIVE POISSON'S RATIO

Vladimir Sinđelić, Aleksandar Nikolić, Nebojša Bogojević, Snežana Ćirić-Kostić

Faculty of Mechanical and Civil Engineering Kraljevo, University of Kragujevac, Kraljevo, Serbia

Abstract: In the last decade, metamaterials with negative Poisson's ratio play an important role in engineering practice. With the application of new technologies, such as 3D printing, the development of these metamaterials has become much easier. These structures are widely used in mechanical engineering, aviation industry, automotive industry, space industry and biomedicine. Based on the new 2D arc-star-shaped structure with negative Poisson's ratio, in this paper we presented a modified version of the 2D arc-star-shaped structure. The influence of Poisson's coefficient and the influence of Yung's modulus of elasticity of the 2D arc-star-shaped structure and the modified 2D arc-star-shaped structure were analyzed by the Finite Element Method. Numerical simulation was carried out for several different geometrical parameters. We presented the obtained results graphically, based on which the structures were compared.

Keywords: Metamaterial, Negative Poisson's ratio, Arc-star-shaped structure, 3D configurations.

SESSION F: THERMAL TECHNIQUE AND ENVIRONMENT PROTECTION

CARBON DIOXIDE EMISSIONS CALCULATION OF THE TRANSPORT PROCESS IN ROAD FREIGHT TRANSPORT

Nikola Petrović[1], Vesna Jovanović[1], Dragan Marinković[1,2], Jovan Pavlović[1]

[1]Faculty of Mechanical Engineering/Department of Transport Engineering and Logistics, University of Niš, Niš, Serbia
[2]Faculty of Mechanical Engineering and Transport Systems, Department of Structural Analysis, Berlin Institute of Technology, Berlin, Germany

Abstract: Transport plays an important role in the social and economic development of the country, but it negatively affects all elements of the environment (air, water, soil, fauna, and flora). The total production of greenhouse gases (GHG) in transport has increased by a quarter in the past decades in the 32 member countries of the European Environmental Protection Agency. Carbon dioxide (CO2) is the main component of transport emissions of greenhouse gases, and road transport has the largest share of these emissions. In recent years, in addition to determining the shortest movement paths or the shortest travel time of freight vehicles, special attention has been paid to determining the amount of CO2 emitted. In the paper, the ecological optimization procedure of the freight vehicle utilization for the calculation of the CO2 emitted amount for the transport of a certain amount of goods is presented through a numerical task.

Keywords: Road freight transport, Carbon dioxide emissions, CEN-EN 16258 standard.

POLLUTANTS IN THE AIR

Svetlana K. Belošević[1], Maja B. Djukić[2]

[1]Faculty of Technical Sciences, University of Priština in Kosovska Mitrovica, Kosovska Mitrovica, Serbia
[2]University of Kragujevac, Faculty of Science, Kragujevac, Serbia

Abstract: Air pollution is a major problem all over the world in both developed and developing countries. Environmental protection has been the main topic of politicians, economists, ecologists, and the broader scientific community for more than a decade. Accelerated industrialization and the development of technology have led to great changes that man has willingly accepted without thinking about how all this affects nature and the environment. The modern and very fast way of life of recent years has left a great negative impact on the natural environment. Without caring about the consequences of achieving a simpler and seemingly more beautiful way of life, man has endangered his environment. The result of this kind of human behavior is a polluted environment that has been talked about for ten years and must be talked about in order to preserve it. Environmental protection covers a wide range of activities, from the protection of soil, water, natural resources, and beyond, to the protection of air, without which not a single person on our planet could breathe. The composition of air is known to everyone, but what is in the air that affects its pollution? In this paper, we will show what pollutants are in the air, focusing on the region of Raska, the city of Kraljevo, how they affect, and how to reduce them with the goal of a healthier environment.

Keywords: Air, Pollutants, Environmental protect.

DETERMINATIONS OF EQUATION IN 1D CONDUCTION: EXPERIMENTAL INVESTIGATION FOR WALL HEATING

Aleksandar Vičovac

Thermal Earth Ltd, Ammanford, Carmarthenshire, Wales, United Kingdom

Abstract: The paper presents the results of research to determine the optimal feed water inlet temperature. In the standard calculations of the designers, the value of the feed water is determined according to the external design temperature. In this case, the new design water temperature value that supplies the wall panels will depend on the outside temperature and the return temperature from the system.

Keywords: Wall heating panels, Boundary conditions, Transient and One Dimensional.

THE PROPOSAL OF THE RECUPERATOR DESIGN FOR THE ROTARY KILNS WITH A DRIVING MECHANISM IN THE CALCINATION ZONE

Nenad Stojić[1], Nebojša Bogojević[1], Miljan Marašević[1], Dragan Cvetković[2], Aleksandar Nešović[3]

[1]Faculty of Mechanical and Civil Engineering in Kraljevo, University of Kragujevac, Kraljevo, Serbia
[2]Institute for Information Technologies, University of Kragujevac, Kragujevac, Serbia
[3]Faculty of Engineering, University of Kragujevac, Kragujevac, Serbia

Abstract: The rotary kilns have been used in the industry in various applications, mostly in the cement industry and for calcination of dolomite ores. The rotary kilns characterize the high-temperature processes and therefore the heat losses are very high. In the order to increase the efficiency of the kiln and reduce fuel consumption, several different designs of recuperators are developed. One of the problems in the design of the recuperator is the position of the driving mechanism or tyre of the rotary kiln. This paper has presented a solution of the two separated recuperators in order to resolve the previous mentioned problems and increase the overall efficiency of the rotary kiln. The analytical model has been used for the determination of the geometry and heat losses of the recuperator while the CAD model has been used for the calculation of the heat losses and analysis of the airflow in the recuperator. The results obtained from both models have shown a good correlation and show that with the presented two-part recuperator design is possible to increase the efficiency of the rotary kiln when the driving mechanism or tyre is placed on the kiln shell in the calcination zone.

Keywords: Recuperator, Design, Model, Flow simulation, Rotary kiln, Energy efficiency, Heat transfer, Heat exchanger.

THE USAGE OF NATURAL GAS HHV FROM SMALL COGENERATION SYSTEMS IMPLEMENTED IN A 3RD GENERATION DH PLANT

Milan Marjanović[1], Miloš Nikolić[2], Rade Karamarković[2], Anđela Lazarević[3], Đorđe Novčić[2]

[1]Faculty of Technical Sciences/Department for Mechanical Engineering, University of Kragujevac, Čačak, Serbia
[2]Faculty of Mechanical and Civil Engineering/Department for Energy and Environment Protection, University of Kragujevac, Kraljevo, Serbia
[3]Faculty of Mechanical Engineering/Department for Management in Mechanical Engineering, University of Niš, Niš, Serbia

Abstract: Compared with households, Serbian district heating (DH) companies pay higher natural gas and electricity prices. These facts together with the lack of incentives for DH connection and relatively mild winters encourage customers to disconnect and use split systems. To reduce the heating cost and retain customers, DH companies try to reduce operating costs. A promising way is to implement small cogeneration systems that meet their electricity demand. For a case study DH system, the paper analyzes the usage of heat from passive condensation and oil cooling in natural gas-fired cogeneration systems with capacities in the range of 100 kWe to 2 MWe. The available heat from cogeneration systems is modeled based on the manufacturers' data. The case study is a boiler room with a total installed capacity of 37.73 MW and a nominal temperature regime 130/75 ^{o}C. As the plant operates with approximately constant water flow and variable supply and return water temperatures, the average temperature regime is 69.4/49.5^{o}C for the average outdoor temperature of 5.4^{o}C. The average regime and mild weather enable the usage of oil cooling and flue gas condensation from the cogeneration plant. The heat recuperation for variable minimum temperature differences from parallel and in-series connections of an oil cooler (OC) and a flue gas condenser (FGC) based on meteorological data are simulated. Paradoxically, the system is the least efficient during the coldest weather, when the heat from oil cooling is wasted, and FGC operates as a dry flue gas cooler.

Keywords: District heating, Modelling, Cogeneration, Higher heating value, Heat exchanger.

CFD ANALYSIS OF WIRE COIL TURBULATORS WITH CONICAL INLETS

Đorđe Novčić[1], Miloš Nikolić[1], Rade Karamarković[1], Milan Marjanović[2]

[1]Faculty of Mechanical and Civil Engineering/Department for Energy and Environment Protection, University of Kragujevac, Kraljevo, Serbia
[2] Faculty of Technical Sciences/Department for Mechanical Engineering, University of Kragujevac, Čačak, Serbia

Abstract: To improve overall thermal performance, heat exchangers use passive enhancement techniques. This implies inserting into flow channels, usually, metal inserts, known as turbulators, as they turn a laminar boundary layer into a turbulent one at lower Reynolds numbers. The overall enhancement ratio is used to evaluate different designs, like wire coils, twisted tape, conical rings, etc., which performance depends on Reynolds number, flow channels, and applied fluid. The number of possible designs significantly decreases when there is a need for their employment in biomass boilers. A proven design is a wire coil turbulator, which is used not only to increase heat transfer but also to remove deposits from the pipe surface through which flue gas flows. The goal of the paper is to analyze the impact of a conical top on the performance of wire coil turbulators. The angles of the conical top are varied from 60^o to 120^o, whereas the geometry of the wire coils is defined with the dimensionless pitch (p/d) in the range between 0.36÷0.61, dimensionless wire diameter (e/d) = 0.04÷0.1, and pitch to wire diameter ratios (p/e) = 3.75÷14.3. Proper surface cleaning defines these ratios. The CFD analysis is carried out for the pipe with the nominal diameter DN80. The addition of a conical top at the free end of wire coils increases the effect of the rotation of the core flow on the heat transfer enhancement. The shorter the pipe with wire coils, the more significant the effect of the conical top.

Keywords: CFD modelling, Wire Coils, Conical Top, Reynolds number, Flue gas.

SESSION G: CIVIL ENGINEERING

MASONRY DEVELOPMENT OF BUILDING CONSTRUCTION ON THE TERRITORY OF SERBIA

Bojan Miloševič[1,2], Vladimir Mandić[1], Dušan Turina[2], Aleksandar Kostić[2], Katarina Krstić[2]

[1]Faculty of Mechanical and Civil Engineering in Kraljevo, University of Kragujevac, Kraljevo, Serbia
[2]Academy of Technical and Art Applied Studies, Belgrade, School of Civil Engineering and Geodesy, Belgrade, Serbia

Abstract: Human evolution has led to the development of Civil Engineering and Building Construction and it has not diminished the importance of traditional masonry. The need for quality building material leads to its industrial output. There are a lot of regulations that appear in this process, by which the process of designing, building and maintenance of masonry is defined. The aim of this project is to present the development of masonry system in building construction, masonry units needed for their output, as well as legal standards which define carrying capacity of structural units of these buildings. This project also presents the survey results conducted among constructors and their knowledge of masonry regulations.

Keywords: Masonry units, Masonry, Masonry design regulations.

KRIGING INTERPOLATION OF PRECIPITATION FOR LAKE ĆELIJE CATCHMENT

Vladimir Mandić[1], Slobodan Kolaković[2], Milan Stojković[3], Bojan Milošević[1,4], Iva Despotović[1,4]

[1]Faculty of Mechanical and Civil Engineering in Kraljevo, University of Kragujevac, Kraljevo, Serbia
[2]Faculty of Technical Sciences, University of Novi Sad, Novi Sad, Serbia
[3]Institute for Artificial Intelligence Research and Development of Serbia, Novi Sad, Serbia
[4] Academy of Technical and Art Applied Studies, Belgrade, School of Civil Engineering and Geodesy, Belgrade, Serbia

Abstract: The research analyzed the necessary conditions for the successful application of the Kriging method of spatial interpolation for the purposes of average annual precipitation interpolation on a certain area. The Kriging method is widely used in the field of interpolation of spatially distributed data, which also includes rainfall data. The paper analyzes the influence of the number of rainfall gauging stations, as well as model parameter adoption, on the results of spatial interpolation of precipitation. Precipitation interpolation was performed for the experimental catchment of Lake Ćelije, which is located on the Rasina River in the Republic of Serbia. The conducted research presents conclusions on the influence of the number of rainfall gauging stations on the interpolation results, as well as the suggestions for the practical application of the mentioned method for the needs of spatial interpolation of average annual precipitation on a catchment.

Keywords: Kriging, Average annual precipitation, Hydrology, Spatial interpolation.

POSSIBILITIES OF RECYCLED CONCRETE AGGREGATE IMPROVEMENT

Iva Despotović[1,2], Adrijana Savić[3], Stefan Mihajlović[1], Jovana Bojković[1], Marijana Janićijević[1]

[1]Faculty of Mechanical and Civil Engineering in Kraljevo, University of Kragujevac, Kraljevo, Serbia
[2] Academy of Technical and Art Applied Studies, Belgrade, School of Civil Engineering and Geodesy, Belgrade, Serbia
[3]HNTB Company, Chicago, Ilinois, United States

Abstract: Recycled aggregate consists of the original aggregate and cement mortar layer remaining of the old concrete. Physical and mechanical properties of recycled aggregate dependent on the properties, as well as on the quantity of remaining mortar. Removing and strengthening the adhered mortar are the two main methods for improvement the properties of recycled concrete aggregate, as well as improvement treatments with different acids and carbon dioxide (accelerated carbonation). This paper reviews the published improvement methods for recycled concrete aggregate and points out their advantages and disadvantages, also showing an example of own experimental investigation with hydrochloric acid. The overall results show that if RCA is obtained by crushing of compact, high-quality concrete, the procedures of aggregate quality improvement are not necessary.

Keywords: Recycled concrete aggregate, Improvement, Acid, Accelerated carbonation.

METHODS FOR DETERMINING THE CHARACTERISTICS OF BIOCOMPOSITES

Jovana Bojković[1], Vesna Bulatović[2], Branko Radičević[1], Nenad Stojić[1], Miljan Marašević[1]

[1]Faculty of Mechanical and Civil Engineering in Kraljevo, University of Kragujevac, Kraljevo, Serbia
[2]Faculty of Technical Sciences, University of Novi Sad, Novi Sad, Serbia

Abstract: The use of biocomposite materials in the world is rapidly developing. The production of new biomaterials has made a big shift towards sustainable production, which also has a positive effect on ecology. Biocomposites are defined as a combination of two or more different materials, each of which has its characteristic properties. To define the use of a new biocomposite, it is necessary to examine its characteristics as a whole. The characteristics of that biocomposite are defined by the application of methods for extracting physical and mechanical properties, more precisely, porosity, bulk density, water absorption, airflow resistance, and heat flux, from which the coefficient of thermal conductivity is calculated. In this way, it is possible to determine the exact application of the material and compare it with long-used materials in the defined area of application. Therefore, new biocomposite materials can be used as an alternative to conventional materials.

Keywords: biocomposite, porosity, bulk density, thermal conductivity, airflow resistance

STATIC ANALYSIS OF THE RC MULTI-STOREY BUILDING DEPENDING ON MODEL AND SOIL PARAMETERS

Stefan Mihajlović[1], Miloš Šešlija[2], Iva Despotović[1,3], Vladimir Mandić[1], Marijana Janićijević[1]

[1]Faculty of Mechanical and Civil Engineering in Kraljevo, University of Kragujevac, Kraljevo, Serbia
[2]Faculty of Technical Sciences, University of Novi Sad, Novi Sad, Serbia
[3] Academy of Technical and Art Applied Studies, Belgrade, School of Civil Engineering and Geodesy, Belgrade, Serbia

Abstract: The following paper contains a static analysis reinforced concrete multistorey building with flooring P+5 residential and business purposes. The building is designed as a reinforced concrete frame structure consisting of beams and columns of the same cross-section on all floors. The ground floor, which will be used for business purposes, is designed with reinforced concrete walls on the brim of the structure. The base of the building has rectangular cross-section dimensions of 15x25m, with a basic span construction of 5 m. Analysis of all relevant loads which are acting on the structure was considered according to Eurocode standards. In the paper, the bending moments of the fundamental slab are analyzed with special emphasis on the on interaction analysis of the fundamental slab and soil which is modeled as a half-space. For such a model are given the dependence of the bending moments on the dimensions of the half-space by which the soil is represented and the characteristics of the soil itself, which are given by different deformation modules. For structure analysis software Tower 8 was used.

Keywords: Static analysis of structure, Half-space, Foundation, Fundamental slab, Concrete structures, Multi-storey building, Geomechanics.

NONLINEAR STATIC ,,PUSHOVER" ANALYSIS OF MULTI-STOREY REINFORCED CONCRETE BUILDING

Marijana Janićijević[1], Bojan Milošević[1,3], Stefan Mihajlović[1], Jovana Bojković[1], Saša Marinković[2]

[1]Faculty of Mechanical and Civil Engineering, University of Kragujevac, Kraljevo, Serbia
[2]Marko Barlov PR izgradnja stambenih i nestambenih objekata LMT Inženjering Kraljevo, Serbia
[3] Academy of Technical and Art Applied Studies, Belgrade, School of Civil Engineering and Geodesy, Belgrade, Serbia

Abstract: Contemporary structural design implies the nonlinear behaviour of ductile structural elements for the design of seismic actions, which implies the application of nonlinear analysis. Pushover analysis evaluates the seismic performance of the structure and combines the behavior of bearing and non-bearing elements thus forming a description of the overall degree of damage to the construction for different levels of seismic action. This paper presents the results of the nonlinear static "pushover" analysis of a multi-storey reinforced concrete building designed according to EN 1992-1-1 and EN 1998-1. The structure was exposed to a monotonically increasing lateral load. The analysis was performed using four different material nonlinearity models (infrmFB, infrmDB, infrmFBPH, infrmDBPH) for two orthogonal directions in the SeismoStruct program. The assessment of seismic performance of the structure was performed based on the results of the "pushover" analysis for each of the applied nonlinear material models.

Keywords: Pushover analysis, Material nonlinearity, Target displacement, Seismic action.

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The Faculty of Mechanical
and Civil Engineering in Kraljevo
The University of Kragujevac
Serbia, 36000 Kraljevo, Dositejeva 19
Phone/fax +381 36 383 269, 383 377

E-mail: office@mfkv.kg.ac.rs
www.mfkv.kg.ac.rs