Topics of dissertations for the admission procedure
to the doctoral program
at the CTU in Prague Faculty of Transportation Sciences

Commencement of Study: 1. March 2024

Department of Mechanics and Materials (K618)

***Study programme*: Transportation Systems and Technology**

Supervisor: **prof. Ing. Ondřej Jiroušek, Ph.D., e-mail contact: jirousek@fd.cvut.cz**	
Topic: **Constitutive modelling of 3D printed materials under complex loading in a broad range of strain rates**	
Research topic is chosen from offered topics	***Language*:** **English**
Abstract: **The goal of the dissertation is to develop a constitutive model for numerical simulation of behaviour of 3D printed structures during complex loading modes at intermediate and high strain rates. Nowadays, additively manufactured materials are being used in demanding industrial application including dynamic and impact loading. Detailed description of deformation behaviour and a reliable constitutive model for the intended application spectrum is an essential tool for relevant numerical simulations, optimization tasks and design studies. Content of the dissertation will be an identification of mechanical properties of a 3D printed material with emphasis on printing parameters, anisotropy, time-dependent processes using methods for quasi-static and particularly dynamic measurements. The material will be tested in complex loading modes using specialized devices for, e.g., dynamic penetration or dynamic bending (SHPB/OHPB, linear motors). For the identification of deformation behaviour and an internal damage, the advanced analysis methods using high speed cameras and high speed X-ray imaging will be employed. The experimental results will be used for formulation of a constitutive model for simulations of the material during dynamic loading including dynamic damage or failure.** **The work will be solved using modern laboratory equipment of the Department of Mechanics and Materials and utilizing wide international cooperation of the Department in this field.**	
***References*:** **H.Z. Xing et al., International Journal of Impact Engineering 113 (2018) 61–72** **H. L. Yue et al., Applied Mechanics and Materials, Vols. 405-408, pp. 2515-2519, 2013**	
Number of doctoral students: 1	
Form of study: full-time	

Supervisor:
prof. Ing. Ondřej Jiroušek, Ph.D., e-mail contact: jirousek@fd.cvut.cz

Topic:
High speed X-ray radiography in low to medium velocity impact dynamics

Research topic is ***chosen from offered topics***	***Language*:** **English**

Abstract:
The topic of the dissertation is an application of high speed X-ray radiography in impact dynamics with low and medium impact velocities. The goal is to conduct the instrumented impact experiments with strain rate in range from 0.1 to 1000 1/s (approximately corresponding to the impact velocities of 0.1 - 20 m/s) together with high speed X-ray imaging of the specimen during the impact. For the experiments, the direct impact stage equipped with linear motors or a variety of split Hopkinson bars will be used. The high speed X-ray imaging will be performed using a stationary high power X-ray source in combination with a scintillation panel and high-speed camera or state-of-the-art direct deposition X-ray imaging detector. The subject of the dissertation will be to investigate capabilities of high speed X-ray imaging during the impact experiments for detection of deformation mechanisms in porous solids or for identification and tracking of defects in the specimen, including analysis of crack development and propagation. During the dissertation, it is expected that the candidate will research also the techniques for volumetric analysis, i.e. methods of computed tomography, digital image/volume correlation based on X-ray projections, or methods combining X-ray data with the information from the surface of the specimen. The outcome of the dissertation will be an application of novel experimental approach for characterization of complex materials under dynamic loading.
The work will be solved using modern laboratory equipment of the Department of Mechanics and Materials and utilizing wide international cooperation of the Department in this field.

***References*:**
H.Z. Xing et al., International Journal of Impact Engineering 113 (2018) 61–72
H. L. Yue et al., Applied Mechanics and Materials, Vols. 405-408, pp. 2515-2519, 2013

Number of doctoral students: 1

Form of study: full-time

Supervisor:
doc. Ing. Daniel Kytýř, Ph.D., e-mail contact: kytyrd1@fd.cvut.cz
(supervisor specialist Ing. Tomáš Fíla, Ph.D.)

Topic:
Laboratory based X-ray imaging techniques with very high temporal and spatial resolution

Research topic is ***chosen from offered topics***	**Language:** **english**

Abstract:
Actual challenges in the state-of-the-art in-situ X-ray imaging can be divided into the following key goals: to increase spatial resolution, to increase temporal resolution, to reduce scanning time, to get high quality visualizations of problematic materials, e.g., low attenuation materials like biological tissues, or materials with very different phases like polymers with metal reinforcements, and to keep costs of the measurement in a reasonable range. While the technical challenges can be overcome in particle accelerators like synchrotrons with very high costs, it is extremely demanding task in versatile laboratory based X-ray systems but with application potential. The topic of the dissertation is a development of a laboratory based X-ray computed tomography system for in-situ material testing with unprecedently high temporal and spatial resolution. To achieve this goal, a state-of-the-art liquid anode X-ray source will be integrated together with a variety of radiation imaging systems, detectors, and in-situ devices, while all the elements will be synchronized in real-time. The system will be combined with advanced data

processing and post-processing methods allowing for automated analysis of large datasets, e.g., identification and tracking of damage in the material microstructure. The capabilities of the system will be demonstrated on representative applications studying time-dependent processes in biomechanics and material engineering.
The dissertation will be performed in close co-operation and sharing of research infrastructure between Department of Mechanics and Materials FTS CTU and Department of Biomechanics ITAM CAS

***References*:**

E.A. Zwanenburg et al.: Review of high-speed imaging with lab-based x-ray computed tomography, Measurement Science and Technology, 2022, 33(1), DOI:10.1088/1361-6501/ac354a
S.C. Garcea et al.: X-ray computed tomography of polymer composites, Composites Science and Technology, 2018, 156, DOI:10.1016/j.compscitech.2017.10.023

L. Xuekun et al.: Anisotropic Crack Propagation and Deformation in Dentin Observed by Four-Dimensional X-ray Nano-Computed Tomography, Acta Biomaterialia, 2019, 96(3), DOI: 10.1016/j.actbio.2019.06.042

Number of doctoral students: 1

Form of study: full-time

Supervisor:
doc. Ing. Petr Zlámal, Ph.D., e-mail contact: zlamal@fd.cvut.cz
(supervisor specialist Ing. Tomáš Fíla, Ph.D.)

Topic:
Mechanical and wave propagation properties of multi-material structures produced *by additive manufacturing*.

Research topic is	***chosen from offered topics***	**Language:**
		english

Abstract:
Currently, the production of structures and components using additive manufacturing techniques is growing rapidly. The majority of structures are produced from single material (metal, plastic). In the field of development of additive manufacturing technology, first attempts are currently being made to enable simultaneous 'printing' with several types of materials. This trend is most striking in the area of metal materials, where the multi-material printing has to overcome many problems, especially with regard to the sufficient quality of the interface. For this reason, it is necessary to analyse individual multi-material structures with regard to the inner structure and resulting mechanical properties. In addition to behaviour from the point of view of mechanical properties, where these new structures can bring significant improvement in many application (e.g. deformation behaviour, energy absorption, directional control of mechanical properties, etc.) a large area of research work aims at the description of the rate of influence of stress wave propagation through multi-material interfaces. In addition, research in this area can enable the possibility to effective control the rate of attenuation using the shape and material properties of the interface.
The topic of the dissertation is development of laboratory experimental tests, analytical and numerical tools and procedures for testing, analysing, and predicting the behaviour (mechanical, wave, etc.) of structures prepared using multi-material additive manufacturing techniques. To achieve this goal, material (e.g. SEM), static and dynamic tests (e.g. SHPB, OHPB) will be used, and the possibility of their connection with fast X-ray imaging will be tested. The results of the

dissertation will lead to a deepening of knowledge about these promising structures in the field of basic research and, above all, in the design stage of structure properties for a specific application.

***References*:**

A. Nazir, et. al.,Multi-material additive manufacturing: A systematic review of design, properties, applications, challenges, and 3D printing of materials and cellular metamaterials, Materials & Design, Volume 226, 2023, doi:10.1016/j.matdes.2023.111661.

B. Nurel, et. al., Split Hopkinson pressure bar tests for investigating dynamic properties of additively manufactured AlSi10Mg alloy by selective laser melting, Additive Manufacturing, Volume 22, 2018, pp 823-833, doi:10.1016/j.addma.2018.06.001.

Number of doctoral students: 1

Form of study: full-time

Topics of dissertations for the admission procedure to the doctoral program at the CTU in Prague Faculty of Transportation Sciences

Commencement of Study: 1.March 2024

Department of Applied Mathematics (K611)

Study programme: Smart Cities

***Supervisor*:**
prof. Ing. Ondřej Přibyl, Ph.D., e-mail contact: pribylo@fd.cvut.cz

Topic:
Integration of cooperative and automated vehicles into traffic management

Research topic is agreed with supervisor	***Language*:** English

Abstract:

Cooperative and automated cooperative vehicles (CAVs) are facing an enormous growth in both research and commercial projects. However, there is still limited knowledge of how to manage properly CAVs and how to integrate them into traffic and urban management. As part of this work, the student designs and implements algorithms for traffic control and optimization in the network with regard to autonomous vehicles.

The topic is thus focusing on distributed traffic control methods using multi-agent systems. The algorithms will include topics such as load balancing in the network (using routing), recommendations for changing the speed with regard to the green wave and traffic harmonisation, and others. As part of this work, the possibilities will be analyzed and new algorithms will be designed and further verified using simulation tools to determine their impact on transport and the environment.

References:

Vreeswijk, J., Přibyl, O., Blokpoel, R., Schindler, J., Rondinonee, M. (2017). Managing automated vehicle at signalized intersections. In Proceedings: International Conference on Intelligent Transport Systems in Theory and Practice, mobil.TUM, Munich.

Blokpoel, R., Lu, M. (2018). Cooperative systems for future automated road transport and traffic management in urban areas. In Proceedings: The 7th Transport Research Arena (TRA), 16-19 April 2018, Vienna.

Czechowski, A., Zhang, X., Blokpoel, R. (2018). Cooperative queue data for adaptive traffic control. In Proceedings: The 25th ITS World Congress, Copenhagen, Denmark, 17-21 September 2018. Paper ID EU TP1130

Lu, M. (Ed.) (2019). Cooperative Intelligent Transport Systems: Towards High-Level Automated Driving. IET (Institution of Engineering and Technology), London.

Počet doktorandů / Number of doctoral students: 1

Forma studia: prezenční
Form of study: full-time

Supervisor:
prof. Ing. Ondřej Přibyl, Ph.D., e-mail contact: pribylo@fd.cvut.cz

Topic:
Modeling of activity behavior with respect to mobility in smart cities

Research topic is agreed with supervisor	***Language*:** English

Abstract:
The aim of this thesis is to learn about the factors affecting travel behavior in smart cities, especially with respect to new travel modes and concepts (for example mobility as a service). This includes mathematical modelling and microscopic simulation of daily activity plans and the decission making process. Part of the work will include modification of simulation tools, with regard to measuring the impact of policies focusing on mobility as a service. It will be necessary to study the existing possibilities of microsimulation tools MatSim or SUMO, propose a solution to this topic and verify the approach in simulations.

***References*:**
Matowicki, M.; Pecherková, P.; Přibyl, O. Project SMART Understanding Mode Choice Decisions of the Czech Population: Models and Results Praha: CESKE VYSOKE UCENI TECHNICKE V PRAZE, 2023. ISBN 978-80-01-07090-1.
Maia Pereira, A.; Dingil, A.; Přibyl, O.; Myška, V.; Vorel, J.; Kříž, M. An Advanced Travel Demand Synthesis Process for Creating a MATSim Activity Model: The Case of Ústí nad Labem Applied Sciences. 2022, 12(19), ISSN 2076-3417.

Number of doctoral students: 2

Form of study: full-time