

# MY FIRST CONFERENCE 2026



MFC 2026

**September 17, 2026**

Hosted by the University of Rijeka,  
Faculty of Engineering  
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RITEH



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## **My First Conference 2026**

**Faculty of Engineering, Rijeka, Croatia, September 17, 2026**

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## Preface to the 10th edition

Dear Reader,

It is our great pleasure to present the Book of Abstracts for the 10th Annual PhD Conference on Engineering and Technology “My First Conference 2026.” The Faculty of Engineering, the Faculty of Civil Engineering, and the Faculty of Maritime Studies of the University of Rijeka jointly organise the conference, with hosting responsibilities rotating annually among them. This year’s edition was held on 17 September 2026 at the Faculty of Engineering in Rijeka.

My First Conference brings together talented PhD and graduate researchers from various engineering and technological disciplines to share their ongoing work, exchange ideas and forge new collaborations. We believe early exposure to scientific presentation and discussion is invaluable, and we hope all participants find the experience rewarding.

This volume contains 28 abstracts, including two keynote lectures, covering topics such as theory, experimentation, modelling, innovation in materials and structures, environmental engineering, and more. Each contribution reflects not only the depth of technical work but also the vigour and creativity of emerging scholars.

We wish to thank all authors for their contributions and participation in the 10th edition of My First Conference, including our Keynote Speakers, Karlo Jakac, Luka Lanča, and Hrvoje Marušić. We also thank the organising institutions and the members of the Scientific and Organising Committees for their support in making this year’s event possible.

May this conference continue to grow and serve as a platform for young researchers to exchange ideas, build collaborations, and advance their research. We wish you an engaging and inspiring experience as you explore the research presented in this Book of Abstracts.

MFC 2026 Organisers

## **KEYNOTE LECTURES**

# Autonomous UAV System for Oceanic Search and Rescue

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## Abstract

This paper provides an overview of the completed AOSeR project, funded by the Croatian Science Foundation (HRZZ), which focused on developing an innovative autonomous drone system to accelerate search and rescue (SAR) operations in challenging environments.

The lecture will introduce the concept and development of the autonomous system, with particular emphasis on how it reduces the need for manual piloting and overcomes the limitations of predefined search patterns. At the core of the system is the Heat Equation Driven Area Coverage (HEDAC) algorithm, which enables multiple drones to autonomously coordinate their search and dynamically prioritise areas with a higher probability of locating a missing person/object. The system will focus on maritime search and rescue, incorporating data from custom-developed floating buoys to estimate sea-surface currents. This information allows the autonomous search strategy to continuously adapt to the evolving drift of a person or object at sea. The presentation will cover system development, experimental results, and lessons learned from extensive field testing (both on land and at sea).

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# Connecting Classrooms, Labs, and Companies: RITEH's Holistic Approach to University-Industry Cooperation for the Employability of Students and the Competitiveness of Local Industry

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## Abstract

The Faculty of Engineering of the University of Rijeka (RITEH) considers cooperation with companies as an integral part of how we teach, do research and support students' careers, aiming to enhance the employability of students and contribute to the competitiveness of local industry.

The lecture will demonstrate how classrooms, laboratories and companies are systematically connected at and by RITEH to help students develop relevant skills and build a clear path towards employment. The new "AI in Engineering" study programme will be used as a real-life example of the industry's involvement in designing new study programmes, shaping learning outcomes and suggesting topics for projects, fast-tracking students to employment and high productivity after employment.

The lecture will look beyond study programmes, highlighting opportunities for students to develop links to industry during their studies by participating in joint research and development projects, working with modern equipment and research infrastructure, and getting involved in EU-funded initiatives alongside academic staff and company partners.

Additionally, insight will be provided into the role of the RITEH Economic Advisory Board as a bridge between the Faculty of Engineering and the economic sector, supporting joint R&D investments and projects, internships, lifelong learning programmes, and lasting cooperation with alumni.

The lecture aims to motivate current and prospective students to actively use these opportunities, create their own networks in industry during their studies and increase their employability after graduation.

**Keywords:** academia-industry cooperation, employability, competitiveness, R&I

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## **CONTRIBUTING LECTURES**

# Mechanical and Durability Performance of High-Strength Concrete Reinforced with Recycled Polymer Fibres

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## Abstract

The aim of this study was to present the mix design and laboratory preparation of high-strength concrete reinforced with recycled polymer fibres as an example of polymer-waste reuse within the Concrete Theory and Technology course. Four mixtures were prepared: reference concrete without fibres (REF), concrete with industrially manufactured polyolefin fibres (M1), concrete with recycled polypropylene fibres from waste strapping tapes (M2), and concrete with hybrid recycled fibres from strapping tapes and cleaning brushes (M3). All fibre-reinforced mixtures contained 0,2 vol.% fibres and had a water-to-binder ratio of 0,32. The mixes contained cement, silica fume, metakaolin, crushed limestone aggregate, and chemical admixtures. The recycled materials were collected, cleaned, and manually cut into 50 mm tape fibres and 20 mm brush fibres, used in equal volume fractions in M3. Fibres were gradually added during mixing to ensure uniform distribution. The fresh concrete was then placed into moulds, compacted on a vibrating table, demoulded after 24 h, and cured in water until 28 days of age. Tests covered workability, density, compressive and flexural strength, fracture energy, gas permeability, water penetration under pressure, and abrasion resistance. Eleven students participated, from mix design and fibre preparation to specimen testing and result analysis. Clear task allocation, coordination, and joint decision-making supported consistent laboratory work. The main challenges were manual waste processing, uniform fibre dimensions and distribution, and achieving slump class S4. The study confirmed that mix design and preparation require careful planning, accurate dosing, controlled procedures, and systematic evaluation of fresh and hardened concrete properties. All mixtures achieved satisfactory mechanical performance. M3 showed the most favourable post-cracking behaviour and improved selected durability indicators. It had lower gas permeability but a greater water penetration depth than REF, indicating different gas- and water-transport mechanisms within the concrete matrix [1]. Future research should examine other polymer-waste sources and evaluate their performance and economic feasibility as substitutes for industrially manufactured fibres.

**Keywords:** high-strength concrete, recycled polymer fibres, concrete mix design, polymer-waste reuse, durability

## References

- [1] Antolović, S., Dragčević, P., Mrakovčić, S., Torić Malić, N., 2026. Mechanical and Durability Performance of High-Strength Concrete Reinforced with Recycled Polymer Fibers. In: *Proceedings of the 29th International Conference on Building Materials, Products & Technologies (ICBMPT 2026)*. Faculty of Civil Engineering, Brno University of Technology (BUT). Brno, Czech Republic. Unpublished. Available online: <https://www.icbmpt.com/schedule>, accessed 15 July 2026

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# Machine Learning-Based Estimation of Oil Burial Depth as a Tool for Coastal Beach Pollution Assessment

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## Abstract

Following an oil spill, the prompt removal of fuel from coastal areas is critical, as unremoved oil can become buried at depths of several meters, where it may persist and pose a long-term source of environmental contamination.

Recent literature [2,3] has proposed a theoretical approach for estimating the penetration depth of oil within the coastal zone between high and low tide.

The aim of this study is to develop and validate an equivalent machine-learning model, and to enable sensitivity analysis and the identification of key parameters governing the penetration process, based on the analytical calculations.

Identifying the most influential parameters allows for the optimisation of field measurements, i.e., it indicates which quantities need to be measured with greater precision.

The prediction is carried out using several regression approaches based on machine-learning methods [1]: Linear Regression (LR), Random Forest (RF), Support Vector Regression (SVR), and Neural Network (NN).

A comparison between the machine-learning models and the analytical results was performed, where the NN algorithm yielded the highest correlation coefficient, along with high  $R^2$  values and the lowest RMSE values, indicating the best performance among the models.

The analysis showed that the machine-learning model faithfully reproduces the physical relationship and can serve as a rapid approximation of the analytical model.

The sensitivity analysis of input parameters, which involves varying one parameter while keeping the others fixed and monitoring the resulting change in penetration depth, was conducted.

The key influential parameters for predicting the burial depth of oil are grain diameter, oil viscosity, and beach slope.

**Keywords:** oil penetration depth, machine learning regression, sensitivity analysis, coastal grain properties, environmental contamination

## References

- [1] Alpaydin, E., 2021. *STROJNO UČENJE: NOVA UMJETNA INTELIGENCIJA*. Mate d.o.o. Zagreb, Croatia. ISBN: 9789532464603. Available online: <https://www.mate.hr/proizvod/strojno-ucenje>, accessed 10 July 2026
- [2] Bernabeu, A.M., Fernández-Fernández, S., Rey, D., 2016. A theoretical model to estimate the oil burial depth on sandy beaches: A new oil spill management tool. *Mar Pollut Bull* 109(1): pp. 361–372. doi: [10.1016/j.marpolbul.2016.05.052](https://doi.org/10.1016/j.marpolbul.2016.05.052)

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- [3] Soulsby, R., 1997. *Dynamics of Marine Sands: A manual for practical applications*. Thomas Telford. London, UK. ISBN: 9780727725844. Available online: [https://books.google.hr/books/about/Dynamics\\_of\\_Marine\\_Sands.html?id=4N1M5IWlyAoC](https://books.google.hr/books/about/Dynamics_of_Marine_Sands.html?id=4N1M5IWlyAoC), accessed 10 July 2026

# Effect of Surface Colour and Wood Ash in Asphalt Mixtures on Asphalt Pavement Thermal Behaviour

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## Abstract

Surface temperature of asphalt pavements depends mainly on solar reflectance, emissivity and thermal conductivity [1,4], influencing rutting and the urban heat island effect [5]. In coastal Rijeka, asphalt surfaces have reached up to 61°C, with lighter or light-coated surfaces averaging up to 3.4°C lower [2]. This ongoing research, conducted in Osijek (continental climate), examines how surface colour and mixture composition affect asphalt heating and cooling, with qualitative comparison to previously published coastal data [2]. Five samples are studied: four from an identical mixture, three pigmented (yellow, red, white) and one unpigmented; the fifth uses the same base mixture with wood ash from a regional Slavonian biomass cogeneration plant (CaO 33-47 mass%, density 2.65 Mg/m<sup>3</sup>) [3,6]. The thermal behaviour of the investigated asphalt mixtures is evaluated by monitoring maximum temperature, heating and cooling rates, and the time required to reach ambient temperature. Measurements are performed using data loggers, an infrared thermometer, and a thermal camera during heating-cooling cycles. The results are expected to identify the surface treatment and mixture providing the most favourable thermal performance under continental climate conditions.

**Keywords:** asphalt pavement, surface colour, wood ash, surface temperature, cooling rate

## References

- [1] Chen, Y., Li, Z., Ding, S., Yang, X., Guo, T., 2021. Research on heat reflective coating technology of asphalt pavement. *Int J Pavement Eng* 23(13): pp. 4455–4464. doi: [10.1080/10298436.2021.1952410](https://doi.org/10.1080/10298436.2021.1952410)
- [2] Deluka-Tibljša, A., Šurdonja, S., Babić, S., Cuculić, M., 2015. Analyses of urban pavement surface temperatures. *Balt J Road Bridge Eng* 10(3): pp. 239–246. doi: [10.3846/bjrbe.2015.30](https://doi.org/10.3846/bjrbe.2015.30)
- [3] Dimter, S., Kuburić, G., Ević, E., Vrhovac, G., 2025. Road building using wood ash. *Gradev* 76(12): pp. 1077–1086. doi: [10.14256/jce.4157.2024](https://doi.org/10.14256/jce.4157.2024)
- [4] Md. Tukiran, J., Ariffin, J., Abdul Ghani, A.N., 2016. COMPARISON ON COLORED COATING FOR ASPHALT AND CONCRETE PAVEMENT BASED ON THERMAL PERFORMANCE AND COOLING EFFECT. *J Teknol* 78(5): pp. 63–70. doi: [10.11113/jt.v78.8239](https://doi.org/10.11113/jt.v78.8239)
- [5] Wong, T.L.X., Lim, E.L., Mohd Hasan, M.R., Sougui, O.O., Milad, A., Qu, X., 2024. Effectiveness of heat-reflective asphalt pavements in mitigating urban heat islands: A systematic literature review. *J Road Eng* 4(4): pp. 399–420. doi: [10.1016/j.jreng.2024.04.008](https://doi.org/10.1016/j.jreng.2024.04.008)
- [6] Yinfei, D., Ling, X., Haibin, D., Deyi, D., Hao, W., Weidong, L., 2020. Evaluation of thermal behavior and high-temperature performances of asphalt mixture containing fly ash cenosphere. *Constr Build Mater* 245: 118429. doi: [10.1016/j.conbuildmat.2020.118429](https://doi.org/10.1016/j.conbuildmat.2020.118429)

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# Parametric Finite Element Analysis of Keyway Length and Shoulder Fillet Radius in a Windlass Main Shaft under DNV Static Pull

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## Abstract

Keyways and shoulder transitions are established stress raisers [3,4]. This study therefore evaluates their combined effect on a windlass main shaft subjected to the DNV static pull condition with the band brake activated. A simplified windlass model was prepared in Autodesk Inventor, and the extracted main shaft was analysed in ANSYS. A 53000 N remote force was applied at the cable lifter seat, corresponding to 45% of the 116000 N minimum breaking load of a Ø14 mm K2 stud link chain [2]. The calculated von Mises stresses were assessed against the assumed yield strength of 725 MPa for 42CrMo4 Q+T steel. The Ø50 mm shaft seat incorporated a rounded end keyway dimensioned according to DIN 6885-1 for a 14×9 mm Form A parallel key, with  $t_1=5.5\text{mm}$  [1]. Following mesh convergence, a 4 mm global element size and 1 mm local refinement were used in the keyway and shoulder fillet regions. The parametric study comprised nine configurations combining keyway lengths of 180, 160, and 140 mm with shoulder fillet radii of 2.5, 4, and 6 mm. As the keyway was shortened symmetrically, the distance between its end and the shoulder increased from 12.5 to 32.5 mm. For the baseline configuration, the linear elastic model predicted a maximum von Mises stress of 1073.5 MPa, exceeding the assumed yield strength and indicating a critical stress concentration. The best initial configuration reduced the stress to 764.2 MPa, representing a 28.8% reduction, although it remained above yield. Within the investigated parameter ranges, ANOVA indicated that the shoulder fillet radius accounted for approximately 98.8% of the variation in maximum von Mises stress, while the fitted stress response model yielded  $R^2=0.9991$ . Additional checks with an 8 mm fillet radius reduced the peak stress to 699.08 MPa in the best case, below the assumed yield strength. Among the investigated variables, increasing the shoulder fillet radius produced the largest reduction in peak stress.

**Keywords:** windlass main shaft, DIN 6885-1 keyway, cable lifter, finite element analysis

## References

- [1] DIN, 1968. Drive Type Fastenings without Taper Action; Parallel Keys, Keyways, Deep Pattern. Beuth Verlag GmbH. Berlin, Germany. pp. 1–5. doi: [10.31030/1123771](https://doi.org/10.31030/1123771)
- [2] DNV, 2023. DNV-RU-SHIPS PART 3 CHAPTER 11 Part 3 Hull - Chapter 11 Hull equipment, supporting structure and appendages. Available online: <https://standards.globalspec.com/std/14612709/dnv-ru-ships-part-3-chapter-11>, accessed 29 June 2026
- [3] Domazet, Ž., Lukša, F., Bugarin, M., 2014. Failure of two overhead crane shafts. *Eng Failure Anal* 44: pp. 125–135. doi: [10.1016/j.engfailanal.2014.05.001](https://doi.org/10.1016/j.engfailanal.2014.05.001)
- [4] Pedersen, N.L., 2010. Stress concentrations in keyways and optimization of keyway design. *J Strain Anal Eng Des* 45(8): pp. 593–604. doi: [10.1243/03093247jsa632](https://doi.org/10.1243/03093247jsa632)

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# Resilience-Oriented Planning of Territorial Virtual Power Plants for Critical Infrastructure Supply

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## Abstract

Power system planning is traditionally focused on identifying economically efficient investments and operating strategies. However, increasing uncertainty, changing energy consumption patterns, and the growing share of renewable energy sources require planning approaches that also account for the system's ability to withstand and recover from various disturbances. This research proposes a resilience-oriented power system planning framework based on the open-source modelling environment [1-5].

The main objective is to extend conventional cost-optimal planning to incorporate additional aspects of system security, flexibility, and risk. The proposed approach considers different categories of electricity demand, regional islanding conditions and uncertain operating scenarios. In this way, the model can evaluate system performance under both normal operating conditions and more severe disturbances. Stochastic optimisation and Conditional Value-at-Risk are used to assess low-probability, high-impact events and to reduce the influence of extreme outcomes on the overall system.

A territorial virtual power plant is introduced as a coordinated portfolio of distributed energy resources, such as renewable generation, energy storage and flexible backup units. Its role is to improve the use of local resources and support regional operation when connections to the wider power system are limited or unavailable.

The expected result is a transparent and reproducible framework for comparing conventional and resilience-oriented planning strategies. The methodology will support the evaluation of trade-offs between economic efficiency, system flexibility and resilience, while providing guidance for future investment and operational decisions in regional power systems.

**Keywords:** power system resilience, virtual power plant, stochastic optimisation, islanding, open source

## References

- [1] Baringo, A., Baringo, L., Arroyo, J.M., 2019. Day-Ahead Self-Scheduling of a Virtual Power Plant in Energy and Reserve Electricity Markets Under Uncertainty. *IEEE Trans Power Syst* 34(3): pp. 1881–1894. doi: [10.1109/tpwrs.2018.2883753](https://doi.org/10.1109/tpwrs.2018.2883753)
- [2] Brown, T., Hörsch, J., Schlachtberger, D., 2018. PyPSA: Python for Power System Analysis. *J Open Res Softw* 6(1): 4. doi: [10.5334/jors.188](https://doi.org/10.5334/jors.188)
- [3] Hörsch, J., Hofmann, F., Schlachtberger, D., Brown, T., 2018. PyPSA-Eur: An open optimisation model of the European transmission system. *Energy Strateg Rev* 22: pp. 207–215. doi: [10.1016/j.esr.2018.08.012](https://doi.org/10.1016/j.esr.2018.08.012)
- [4] Pampado, A., Fioriti, D., Poli, D., 2025. Exploring Uncertainties in Future Power Systems: Methodology and Analysis for Italy 2040. In: *Proceedings of The 2025 IEEE International Conference on Environment and Electrical Engineering and 2025 IEEE Industrial and Commercial Power Systems Europe (EEEIC / I&CPS Europe)*. IEEE. Chania, Crete, Greece. pp. 1–6. doi: [10.1109/eeeic/icpseurope64998.2025.11169239](https://doi.org/10.1109/eeeic/icpseurope64998.2025.11169239)
- [5] Ranjbar, H., Hosseini, S.H., Zareipour, H., 2021. Resiliency-Oriented Planning of Transmission Systems and Distributed Energy Resources. *IEEE Trans Power Syst* 36(5): pp. 4114–4125. doi: [10.1109/tpwrs.2021.3065395](https://doi.org/10.1109/tpwrs.2021.3065395)

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# Multi-Scale Marine Diesel Engine Modelling for a Real-Time Engine Room Simulator

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## Abstract

Modelling marine engines for dedicated training simulators faces a twofold constraint: the simulation must remain real-time and computationally lightweight yet detailed enough to satisfy the requirements of classification societies and the market [4,5]. The goal of this work is to provide a tool for the relatively fast and simple tuning of an engine mathematical model to the specific unit installed on board, while preserving real-time execution and an acceptable modelling accuracy. The proposed approach relies on operator splitting along the characteristic time scales [1], separating the fast in-cylinder thermodynamic and chemical processes from the comparatively slow crankshaft dynamics and the auxiliary systems (cooling, lubrication) by means of a Strang scheme. The fast in-cylinder block is integrated by an explicit numerical scheme over crank angle and includes Wiebe heat release, Woschni heat transfer, Hardenberg ignition delay, and emission formation (Hiroyasu soot, two-zone Zeldovich/Heywood NO<sub>x</sub>) [3]. The model is implemented in the Modelica language [2], which required addressing architectural and numerical issues in the cylinder description (choice of explicit integrators and their order, multi-cycle interval synchronisation, etc.). The assembled model is exported to the FMU format (FMI standard), enabling its direct integration into an engine room simulator (ERS) and real-time execution; both single-cylinder and multi-cylinder configurations have been realised. Preliminary results confirm a physically consistent behaviour of the in-cylinder cycle and an acceptable computational cost. Further work is directed towards configurability: reconfiguring a single ERS engine model to a specific engine by varying the number and layout of cylinders, the valve timing, the geometry, and the fuel grade (including LNG, methanol, and ammonia), with subsequent validation against experimental data.

**Keywords:** engine room simulator, operator splitting, Modelica, marine diesel engine

## References

- [1] Blanes, S., Casas, F., Murua, A., 2024. Splitting Methods for differential equations. *arXiv preprint* 2024: 2401.01722. doi: [10.48550/arxiv.2401.01722](https://doi.org/10.48550/arxiv.2401.01722)
- [2] Fritzson, P., 2014. *Principles of Object Oriented Modeling and Simulation with Modelica 3.3: A Cyber-Physical Approach, 2nd Edition*. Wiley-IEEE Press. Hoboken, NJ, USA. ISBN: 9781118989166. doi: [10.1002/9781118989166](https://doi.org/10.1002/9781118989166)
- [3] Heywood, J.B., 2018. *Internal Combustion Engine Fundamentals, 2nd Edition*. McGraw Hill Education. Columbus, OH, USA. ISBN: 9781260116106. Available online: <https://www.mheducation.com/highered/mhp/product/internal-combustion-engine-fundamentals-2e.html>, accessed 30 June 2026
- [4] International Maritime Organization, 2017. *Engine-Room Simulator: Model Course 2.07, 2017 Edition*. International Maritime Organization Publishing. London, UK. ISBN: 9789280116762. doi: [10.62454/etb207e](https://doi.org/10.62454/etb207e)
- [5] Kim, T.E. et al., 2021. The continuum of simulator-based maritime training and education. *WMU J Marit Aff* 20(2): pp. 135–150. doi: [10.1007/s13437-021-00242-2](https://doi.org/10.1007/s13437-021-00242-2)

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# Technical Analysis of a Micro-Hydro Power System Integrated with a Water Distribution System in the Istria Region

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## Abstract

This paper presents a study on the feasibility and operational benefits of a micro-hydropower plant located in the Istria region of Croatia with the purpose of improving the resilience and sustainability of local water and energy infrastructure. The proposed system exploits the hydraulic resources available in the region for renewable electricity production, without compromising the water distribution functions. The strategic applications are focused on ensuring the continuous provision of potable water during grid blackouts and supplying electrical energy during periods of peak tourist demand when electricity consumption significantly increases.

**Keywords:** Micro-Hydro Power Plant (MHPP), sustainable energy, energy modelling, blackout resilience

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# Supramolecular Biomaterials: From Composition to Morphology and Function

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## Abstract

Low-molecular-weight gelators based on Fmoc-amino acids are versatile building blocks for functional supramolecular materials due to their structural simplicity, tunability and biocompatibility<sup>1</sup>. In this work, we investigate the self-assembly of Fmoc-histidine (Fmoc-His), Fmoc-cysteine (Fmoc-Cys) and their 1:1 co-assembly by combining molecular dynamics (MD) simulations with experimental characterisation. MD simulations revealed differences in aggregation behaviour and intermolecular interactions, demonstrating that co-assembly modifies the organisation and local environment of the individual building blocks. Experimental characterisation confirmed differences in morphology, with the co-assembled material forming a fibrous hydrogel. These structural differences were also reflected in the catalytic activity toward p-nitrophenyl acetate hydrolysis. Overall, these results demonstrate that co-assembly can be used to modulate the morphology, material properties and functional behaviour of minimal Fmoc-amino-acid assemblies. The combination of computational and experimental approaches [1] provides insight into the molecular interactions governing their assembly and offers a simple strategy for designing functional supramolecular hydrogels.

**Keywords:** biomaterials, supramolecular organisation, self-assembly, co-assembly

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## References

- [1] Dražić, E., Jelušić, D., Janković Bevandić, P., Mauša, G., Kalafatović, D., 2025. Using Machine Learning to Fast-Track Peptide Nanomaterial Discovery. *ACS Nano* 19(22): pp. 20295–20320. doi: [10.1021/acsnano.5c00670](https://doi.org/10.1021/acsnano.5c00670)

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# Numerical FE Model for Creep Buckling of an Al-SiC Composite Beam

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## Abstract

This paper presents a finite element formulation for the creep buckling analysis of Al-SiC functionally graded beam and frame structures. The material consists of an aluminium matrix reinforced with silicon carbide particles, with the reinforcement volume fraction varying through the cross-section according to a power-law distribution. The creep behaviour is described by the Norton creep law, while the creep parameters are determined locally from experimentally based relations available in the literature [1-3]. The proposed formulation accounts for the spatial variation of material properties by evaluating them at monitoring areas distributed over the cross-section. The formulation is first verified through elastic buckling analyses by comparison with MSC Nastran solutions, showing very good agreement for both homogeneous and functionally graded structures. It is then applied to creep buckling analyses under sustained compressive loading. The results show that the creep buckling time is strongly influenced by the applied load, the SiC content and the material gradation. Increasing the amount of SiC improves both the elastic buckling resistance and the long-term creep stability, while the distribution of reinforcement through the cross-section also has a significant effect on the structural response.

**Keywords:** buckling, Al-SiC composite, creep, numerical model, finite element formulation

## References

- [1] Golmakaniyoon, S., Akhlaghi, F., 2016. Time-dependent creep behavior of Al-SiC functionally graded beams under in-plane thermal loading. *Comput Mater Sci* 121: pp. 182–190. doi: [10.1016/j.commatsci.2016.04.038](https://doi.org/10.1016/j.commatsci.2016.04.038)
- [2] Lanc, D., Turkalj, G., Brnić, J., 2007. Finite-element model for creep buckling analysis of beam-type structures. *Commun Numer Methods Eng* 24(11): pp. 989–1008. doi: [10.1002/cnm.1004](https://doi.org/10.1002/cnm.1004)
- [3] Lanc, D., Vo, T.P., Turkalj, G., Lee, J., 2015. Buckling analysis of thin-walled functionally graded sandwich box beams. *Thin-Walled Struct* 86: pp. 148–156. doi: [10.1016/j.tws.2014.10.006](https://doi.org/10.1016/j.tws.2014.10.006)

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# Multi-Horizon Forecasting of Household Electricity Consumption Using Ensemble Learning

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## Abstract

Accurate forecasting of household electricity consumption is important for energy management, smart metering, demand-side flexibility, and reliable smart grid operation [2,3]. This work presents a machine learning framework for multi-horizon household electricity forecasting using high-resolution residential power consumption data. Minute-level measurements containing more than 2 million records were aggregated to an hourly resolution and enriched with temporal, lag-based, rolling-window, exponential moving average, and physically derived features [1]. The forecasting task was defined for 1 h, 6 h, and 24 h ahead and included multiple target variables, such as global active power, global intensity, and unmetered household consumption. Several ensemble-based regression models were evaluated together with seasonal baseline predictors based on daily and weekly consumption patterns. A chronological train-validation-test split was used to preserve the temporal structure of the data and reduce the risk of data leakage. Preliminary results indicate that the proposed ensemble approach improves forecasting accuracy compared with the seasonal baseline model. In the current setup, the average RMSE reduction was approximately 30%, with improvements above 40% for the 1 h forecasting horizon. These findings are consistent with previous studies on machine learning and deep learning methods for short-term and residential load forecasting [4,5]. The main contribution of this work is a reproducible and interpretable forecasting framework for residential energy management, smart grid analytics, and data-driven decision support in energy systems.

**Keywords:** energy forecasting, smart meters, ensemble learning, household consumption, multi-horizon forecasting

## References

- [1] Ahmad, T., Chen, H., Guo, Y., Wang, J., 2018. A comprehensive overview on the data driven and large scale based approaches for forecasting of building energy demand: A review. *Energy Build* 165: pp. 301–320. doi: [10.1016/j.enbuild.2018.01.017](https://doi.org/10.1016/j.enbuild.2018.01.017)
- [2] Hippert, H.S., Pedreira, C.E., Souza, R.C., 2001. Neural networks for short-term load forecasting: a review and evaluation. *IEEE Trans Power Syst* 16(1): pp. 44–55. doi: [10.1109/59.910780](https://doi.org/10.1109/59.910780)
- [3] Hong, T., Fan, S., 2016. Probabilistic electric load forecasting: A tutorial review. *Int J Forecast* 32(3): pp. 914–938. doi: [10.1016/j.ijforecast.2015.11.011](https://doi.org/10.1016/j.ijforecast.2015.11.011)
- [4] Kong, W., Dong, Z.Y., Jia, Y., Hill, D.J., Xu, Y., Zhang, Y., 2019. Short-Term Residential Load Forecasting Based on LSTM Recurrent Neural Network. *IEEE Trans Smart Grid* 10(1): pp. 841–851. doi: [10.1109/tsg.2017.2753802](https://doi.org/10.1109/tsg.2017.2753802)
- [5] Mocanu, E., Nguyen, P.H., Gibescu, M., Kling, W.L., 2016. Deep learning for estimating building energy consumption. *Sustain Energy Grids Netw* 6: pp. 91–99. doi: [10.1016/j.segan.2016.02.005](https://doi.org/10.1016/j.segan.2016.02.005)

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# Military Vehicle Mobility Assessment

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## Abstract

The paper investigates the theoretical influence of field conditions, road geometry, and vehicle dynamic characteristics on the cross-country mobility of military vehicles. The vehicle-dynamic and geometric characteristics of military vehicles play a key role in determining their mobility, stability, and operational applicability under different field conditions. When military equipment is redeployed, such vehicles frequently rely on civilian road infrastructure; therefore, route suitability and the potential impact on civilian traffic must be assessed in accordance with NATO standard AMovP-1(A) [1], which considers route width, route type, military load classification, vertical clearance, and possible traffic obstacles. According to this standard, the minimum driving lane width for wheeled military vehicles is 3.5 m. At the same time, Croatian regulations [2] prescribe lane widths of 2.25-3.25 m on state and regional roads with a design speed between 40 and 80 km/h, which make up the largest part of the road network in the Republic of Croatia. Therefore, it is advisable to test the suitability of these roads for heavy military vehicles.

A passability assessment was conducted on the Zagreb-Bjelovar route at four characteristic locations: the roundabout in Mičevac, the left turn from Zagrebačka Street to Domovinska Street, the roundabout in Farkaševac, and the left turn in the settlement of Bolč. The analysis was performed using AutoCAD Vehicle Tracking software, with a Mercedes 6x4 tractor and 7-axle semitrailer as the design vehicle, characterised by an overall length of 19.485 m, a width of 3.45 m, and a turning radius of 9.8 m. The simulation results showed that the passage of the selected design vehicle is unobstructed at all four analysed locations; however, its manoeuvring envelope interfered with traffic from the opposite direction. The results indicate that heavy military vehicles can use the investigated route, but not under regular traffic conditions. Their movement is feasible only as authorised heavy haulage, accompanied by the prescribed traffic control and safety measures.

**Keywords:** cross-country passability, operational applicability

## References

- [1] NATO Standardization Office, 2004. *NATO - AMOVP-1(A) ROAD MOVEMENTS AND MOVEMENT CONTROL*. NATO Allied Movement Publication. Brussels, Belgium. Available online: <https://standards.globalspec.com/std/1025330/amovp-1-a>, accessed 19 June 2026
- [2] Republic of Croatia, Ministry of the Sea, Transport and Infrastructure, 2021. Regulation on the Basic Conditions That Public Roads Outside Settlements and Their Elements Must Fulfil from the Aspect of Traffic Safety (in Croatian). Zagreb, Croatia. Available online: [https://narodne-novine.nn.hr/clanci/sluzbeni/2001\\_12\\_110\\_1829.html](https://narodne-novine.nn.hr/clanci/sluzbeni/2001_12_110_1829.html), accessed 19 June 2026

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# Numerical Analysis of Fluid Flow and Heat Transfer Characteristics in a Plate Heat Exchanger with Chevron-Type Corrugation

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## Abstract

The present numerical study represents a numerical analysis of fluid flow and heat transfer characteristics in a plate heat exchanger with sinusoidal chevron-type corrugation. For this numerical analysis, a steady-state three-dimensional mathematical model was formulated, comprising governing equations for fluid flow and heat transfer, along with appropriate boundary conditions. To represent the heat transfer in a plate heat exchanger more realistically, a representative computational domain was defined comprising two complete adjacent water flow channels (hot and cold). Numerical simulations were performed using the finite volume method and the ANSYS Fluent solver. The mathematical model and numerical procedure were validated using a comparison of numerical results with experimental data and established correlations from the literature [1-4]. A good agreement between the results was observed, confirming the validity of the proposed mathematical model. Several numerical simulations were performed for plate geometries with corrugation angles ranging from 15° to 80° and Reynolds numbers ranging from 70 to 363. Fluid flow and heat transfer characteristics were analysed considering the Colburn  $j$ -factor, Fanning friction factor  $f$ , as well as  $j/f$  and  $j/f^{1/3}$  goodness factors. Additionally, temperature and velocity distributions are shown for selected planes to further illustrate the flow and heat transfer behaviour.

**Keywords:** plate heat exchanger, chevron-type corrugation, numerical analysis, Colburn  $j$ -factor, Fanning friction factor  $f$

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## References

- [1] Dović, D., Švaić, S., 2007. Influence of Chevron Plates Geometry on Performances of Plate Heat Exchangers. *Teh Vjesn* 14(1,2): pp. 37–45. Available online: <https://hrcak.srce.hr/13511>, accessed 3 June 2026
- [2] Martin, H., 1996. A theoretical approach to predict the performance of chevron-type plate heat exchangers. *Chem Eng Process* 35(4): pp. 301–310. doi: [10.1016/0255-2701\(95\)04129-x](https://doi.org/10.1016/0255-2701(95)04129-x)
- [3] Mohebbi, S., Veysi, F., 2019. An experimental investigation on the heat transfer and friction coefficients of a small plate heat exchanger with chevron angle. *Heat Mass Transfer* 56(3): pp. 849–858. doi: [10.1007/s00231-019-02749-0](https://doi.org/10.1007/s00231-019-02749-0)
- [4] Mohebbi, S., Veysi, F., 2021. Numerical investigation of small plate heat exchangers performance having different surface profiles. *Appl Therm Eng* 188: 116616. doi: [10.1016/j.applthermaleng.2021.116616](https://doi.org/10.1016/j.applthermaleng.2021.116616)

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# Offshore Wind Farm Layout Optimisation

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## Abstract

As global demand for installed renewable energy capacity grows, offshore wind farm (OWF) locations with higher energy potential are recognised, offering stronger and steadier wind resources that lead to greater energy production [5]. To maximise OWF energy production while minimising costs and losses, the optimal positions of wind turbines (WTs) within a predefined area need to be determined. To address this challenge, heuristic methods, such as Particle Swarm Optimisation and Genetic Algorithm, are commonly employed [4]. This study presents an optimisation framework, using the Indago library [2], that employs an array-based parametrisation approach, representing the layout with only a few parameters and thereby reducing the dimensionality of the search space. As the objective function, the minimisation of the Levelized Cost of Energy (LCOE) was used, where total costs include expenditures for the foundation system and cabling, both of which are strongly dependent on sea depth. The wake effect causes a reduction in wind speed behind each WT when WTs are near one another, resulting in losses in the Annual Energy Production (AEP) of up to 20%. Therefore, these losses are accounted for in the objective function. The dataset on wind characteristics was obtained from the Global Wind Atlas [1], while EMODnet [3] was used as a source for the bathymetry dataset. The framework is designed to be flexible and applicable to different offshore sites, turbine types, and optimisation objectives. The obtained results demonstrate the effectiveness of the proposed approach in reducing wake losses and improving overall wind farm performance. The array-based parametrisation approach proves particularly advantageous in achieving competitive solutions with a significantly reduced number of decision variables, highlighting its potential for practical application in large-scale OWF design. Future work will improve optimisation accuracy through more detailed calculations and cost evaluation and extend the framework to multi-purpose offshore energy hubs that integrate hydrogen production and seawater desalination.

**Keywords:** wake effect, bathymetry, array parametrisation, levelized cost of energy

## References

- [1] Badger, J. et al., 2025. Global Wind Atlas 4.0. Available online: <https://globalwindatlas.info/en>, accessed 30 June 2026
- [2] Družeta, S., Ivić, S., 2021. Indago 0.2.0. Available online: <https://pypi.org/project/Indago/0.2.0>, accessed 30 June 2026
- [3] EMODnet, 2025. EMODnet Map Viewer. Available online: <https://emodnet.ec.europa.eu/geoviewer>, accessed 30 June 2026
- [4] Pillai, A.C., Chick, J., Johanning, L., Khorasanchi, M., 2018. Offshore wind farm layout optimization using particle swarm optimization. *J Ocean Eng Mar Energy* 4(1): pp. 73–88. doi: [10.1007/s40722-018-0108-z](https://doi.org/10.1007/s40722-018-0108-z)
- [5] Silva, I.F.D., Lazzarin, T.B., Schmitz, L., Panisson, A.R., 2025. Genetic Algorithm-Based Optimization Framework for Offshore Wind Farm Layout Design. *IEEE Access* 13: pp. 170081–170094. doi: [10.1109/access.2025.3614516](https://doi.org/10.1109/access.2025.3614516)

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# Numerical and Experimental Investigation of Progressive Failure in Adhesively Bonded Masonry Under Dynamic Loading

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## Abstract

The use of adhesive binders in masonry construction and strengthening offers new opportunities for improving structural performance, particularly under seismic loading, where joint fracture and debonding play a crucial role. This work presents a two-dimensional nonlinear interface-element model for simulating damage initiation and propagation in adhesive masonry joints based on mixed-mode cohesive zone modelling. The proposed formulation extends a previously developed linear-elastic interface model [1,3] by incorporating bilinear [2] and parabolic traction-separation laws coupled through a quadratic mixed-mode criterion. The dynamic response is obtained by solving the equations of motion using the Newmark method in conjunction with a Newton-Raphson iterative scheme. In contrast to contact-based approaches, the proposed formulation represents the entire adhesive layer by a single interface element, providing an efficient computational framework while accurately capturing progressive damage and complete debonding. The model is validated against dynamic experiments on clay brick blocks bonded to a moving base using adhesive foam, where the interface properties are identified from dedicated tensile, compressive and shear fracture tests. The proposed methodology provides an efficient tool for analysing the dynamic behaviour of both existing and novel adhesive-bonded masonry systems and establishes a framework for future extensions incorporating post-debonding contact and friction.

**Keywords:** masonry, adhesive, damage, cohesive-zone models, dynamic analysis, experimental validation

## References

- [1] Janković, A., 2024. Numerical and Experimental Analysis of the Dynamic Response of a Block Portal With Elastic Contacts (in Croatian), Bachelor's thesis. University of Rijeka, Faculty of Civil Engineering. Rijeka, Croatia. Available online: <https://urn.nsk.hr/urn:nbn:hr:157:229105>, accessed 10 July 2026
- [2] Ranjbar, M., Škec, L., Jelenić, G., Ribarić, D., 2022. Mixed-mode delamination of layered structures modeled as Timoshenko beams with linked interpolation. *Int J Numer Methods Eng* 124(8): pp. 1773–1797. doi: [10.1002/nme.7187](https://doi.org/10.1002/nme.7187)
- [3] Sindičić, I., 2024. Numerical and Experimental Analysis of Seismic Response of Masonry Structures With Elastic Binder (in Croatian), Master's thesis. University of Rijeka, Faculty of Civil Engineering. Rijeka, Croatia. Available online: <https://urn.nsk.hr/urn:nbn:hr:157:304641>, accessed 10 July 2026

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# Hyperspectral vs RGB Imaging for Deep Learning-Based Segmentation of In Vitro Fungal Colonies

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## Abstract

Fungal infections, including those caused by drug-resistant *Candida* species, pose a notable challenge in medical diagnosis, as conventional culture-based identification is slow and often difficult, partly because of the visual similarity between species [1,2]. Optical imaging methods capable of resolving both spatial and spectral details offer a route toward quicker, automated, non-destructive identification of pathogens directly from culture plates [3]. In this study, Petri-dish cultures of multiple clinically relevant fungal species, primarily *Candida* and *Aspergillus*, were imaged with a hyperspectral camera covering the visible to near-infrared range (VIS-NIR, 400–1000 nm). While the hyperspectral images provide more data, they do so with a substantially higher acquisition and processing cost. Thus, in order to evaluate whether the extra data is worth the increase in complexity, RGB images were derived from the hyperspectral cubes, emulating imaging by conventional cameras, and several dimensionality reduction techniques were applied to the hyperspectral cubes to reduce the number of spectral bands while retaining the relevant spectral data [4]. Deep learning-based pixel-level segmentation models were trained independently on each modality, and their performance on discriminating fungal colonies at the species level was compared. Preliminary comparisons do not present a clear winner, with the performance of each modality varying across different species. These findings are an early step toward clarifying whether hyperspectral imaging is worth its higher cost and complexity for automated identification of fungal species in microbiology workflows.

**Keywords:** hyperspectral imaging, semantic segmentation, deep learning, dimensionality reduction, fungi

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## References

- [1] Bhargava, A., Klammer, K., Sharma, M., Ortiz, D., Saravolatz, L., 2025. *Candida auris*: A Continuing Threat. *Microorganisms* 13(3): 652. doi: [10.3390/microorganisms13030652](https://doi.org/10.3390/microorganisms13030652)
- [2] Bongomin, F., Gago, S., Oladele, R., Denning, D., 2017. Global and Multi-National Prevalence of Fungal Diseases—Estimate Precision. *J Fungi* 3(4): 57. doi: [10.3390/jof3040057](https://doi.org/10.3390/jof3040057)
- [3] Femenias, A., Gatiús, F., Ramos, A.J., Teixido-Orries, I., Marín, S., 2022. Hyperspectral imaging for the classification of individual cereal kernels according to fungal and mycotoxins contamination: A review. *Food Res Int* 155: 111102. doi: [10.1016/j.foodres.2022.111102](https://doi.org/10.1016/j.foodres.2022.111102)
- [4] Mantripragada, K., Dao, P.D., He, Y., Qureshi, F.Z., 2022. The effects of spectral dimensionality reduction on hyperspectral pixel classification: A case study. *PLoS One* 17(7): e0269174. doi: [10.1371/journal.pone.0269174](https://doi.org/10.1371/journal.pone.0269174)

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## Digital Twin Technology in Marine Engineering

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### Abstract

Digital twin (DT) technology is recognised as a promising tool in marine engineering, particularly for improving the operation, monitoring, and maintenance of marine diesel engines under variable loads and demanding service conditions [3]. This paper reviews recent research and industrial developments related to DT applications in marine engines [1]. The analysis is based on literature published between 2017 and 2025 and focuses on the main elements required for a functional marine engine DT, including the physical asset, data acquisition, digital modelling, data processing and analytics, and the user interface. On this basis, a general framework for marine engine DT implementation is discussed, together with the main applications of the concept in fault detection, predictive maintenance, and performance optimisation [4]. A SWOT analysis is used to identify the principal strengths, weaknesses, opportunities, and threats associated with DT deployment in marine engineering. The paper also considers the potential of the concept in the context of the ongoing digitalisation of shipping and stricter environmental requirements [2]. The results show that DT technology has strong potential in marine engineering, but further work is still needed to improve model robustness, data quality, and practical integration into shipboard systems.

**Keywords:** marine engineering, digital twin, monitoring, maintenance, optimisation, digitalisation

### References

- [1] Madusanka, N.S., Fan, Y., Yang, S., Xiang, X., 2023. Digital Twin in the Maritime Domain: A Review and Emerging Trends. *J Mar Sci Eng* 11(5): 1021. doi: [10.3390/jmse11051021](https://doi.org/10.3390/jmse11051021)
- [2] Stoumpos, S., Theotokatos, G., Mavrelos, C., Boulougouris, E., 2020. Towards Marine Dual Fuel Engines Digital Twins—Integrated Modelling of Thermodynamic Processes and Control System Functions. *J Mar Sci Eng* 8(3): 200. doi: [10.3390/jmse8030200](https://doi.org/10.3390/jmse8030200)
- [3] Tsitsilonis, K.M., Theotokatos, G., Patil, C., Coraddu, A., 2023. Health assessment framework of marine engines enabled by digital twins. *Int J Engine Res* 24(7): pp. 3264–3281. doi: [10.1177/14680874221146835](https://doi.org/10.1177/14680874221146835)
- [5] van Dinter, R., Tekinerdogan, B., Catal, C., 2022. Predictive maintenance using digital twins: A systematic literature review. *Inf Softw Technol* 151: 107008. doi: [10.1016/j.infsof.2022.107008](https://doi.org/10.1016/j.infsof.2022.107008)

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# Web-Based AI-Assisted Annotation Framework for Croatian Radiology Reports

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## Abstract

Downstream evaluation of domain-specific language models for medical applications relies on high-quality annotated datasets [2]. In previous research, a Croatian radiology language model was developed by further pretraining the BERTiC model [5] using the Masked Language Modelling objective on approximately two billion texts extracted from the RadiologyNET collection of narrative radiology reports [3]. To evaluate the model, a series of annotated benchmark datasets is being created [1]. Each dataset contains approximately 1,000 radiology reports from a single anatomical region and imaging modality, annotated for multiclass document classification and named entity recognition (NER). The NER schema is based on the RadLex ontology [4], while classification labels are defined separately for each dataset. A web-based annotation framework was developed to support expert annotation. The framework integrates AI-generated pre-annotations from the Qwen2-7B-Instruct large language model [6], adapted through lightweight instruction fine-tuning. The proposed framework enables the systematic creation of benchmark datasets across multiple radiological domains, providing a scalable foundation for evaluating Croatian domain-specific language models and supporting future medical natural language processing research.

**Keywords:** medical natural language processing, annotation framework, domain-specific language models, named entity recognition, document classification

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## References

- [1] Bosma, J.S. et al., 2025. The DRAGON benchmark for clinical NLP. *npj Digit Med* 8(1): 289. doi: [10.1038/s41746-025-01626-x](https://doi.org/10.1038/s41746-025-01626-x)
- [2] He, Z. et al., 2023. MedEval: A Multi-Level, Multi-Task, and Multi-Domain Medical Benchmark for Language Model Evaluation. *arXiv preprint* 2023: 2310.14088. doi: [10.48550/arxiv.2310.14088](https://doi.org/10.48550/arxiv.2310.14088)
- [3] Krajčí, M., Napravnik, M., Štajduhar, I., 2024. Processing Medical Diagnostic Reports using Machine Learning. In: *Proceedings of The 2024 47th MIPRO ICT and Electronics Convention (MIPRO)*. IEEE. Opatija, Croatia. pp. 114–119. doi: [10.1109/mipro60963.2024.10569875](https://doi.org/10.1109/mipro60963.2024.10569875)
- [4] Langlotz, C.P., 2006. RadLex: A New Method for Indexing Online Educational Materials. *Radiographics* 26(6): pp. 1595–1597. doi: [10.1148/rg.266065168](https://doi.org/10.1148/rg.266065168)
- [5] Ljubešić, N., Lauc, D., 2021. BERTiC - A transformer language model for Bosnian, Croatian, Montenegrin and Serbian. In: *Proceedings of the 8th Workshop on Balto-Slavic Natural Language Processing*. Association for Computational Linguistics. Kiyv, Ukraine. pp. 37–42. Available online: <https://www.aclweb.org/anthology/2021.bsnlp-1.5>, accessed 30 June 2026
- [6] Yang, A. et al., 2024. Qwen2 Technical Report. *arXiv preprint* 2024: 2407.10671. doi: [10.48550/arxiv.2407.10671](https://doi.org/10.48550/arxiv.2407.10671)

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# Networking Urban Voids: Public Infrastructure Model for Fragmented Port Cities

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## Abstract

Infrastructural, industrial and port-related spaces in Western contexts are often interpreted as residual and approached through a before/after logic. In contrast, Eastern spatial logic understands such spaces as dynamic components of the urban system, shaped by continuous interaction and use [4]. This research focuses on port cities, which are particularly vulnerable to the formation of urban voids due to functional zoning and the expansion of port-related infrastructure. Also, it emphasises the need to find ways to live with and around barriers, rather than overcome them. Paradoxically, cities that historically served as points of connection have become synonymous with fragmentation, raising the question of whether their original purpose of connection can be reactivated as a mechanism for their own regeneration. Although urban voids [5] have been widely discussed in Western literature, recent research still identifies important gaps, particularly regarding unclear definitions and attributes, the need for planning and design approaches that consider perception and emotion, and the differences between Western and Eastern cultural interpretations of voids [2]. In the context of port cities, existing studies still tend to organise the topic around single-site regeneration [1], waterfront redevelopment [6] or the port-city interface [3], rather than around the explicit networking of urban voids. This research aims to address these gaps by identifying, classifying, and connecting urban voids in fragmented port cities through a combined Eastern and Western lens. The proposed approach works with existing urban stocks rather than relying on demolition, replacement or tabula rasa development. Its outcome is envisioned as a network model of urban voids, supported by design criteria, demonstrating how connected spatial fragments can increase urban porosity, improve access to the sea and support more inclusive and resilient forms of urban development. Methodologically, the research combines literature review, example case analysis, GIS mapping and, potentially, expert interviews.

**Keywords:** urban void, connectivity, public infrastructure, port cities, resilience

## References

- [1] Andrade, M.J., Jiménez-Morales, E., Rodríguez-Ramos, R., Martínez-Ramírez, P., 2024. Reuse of port industrial heritage in tourist cities: Shipyards as case studies. *Front Archit Res* 13(1): pp. 164–183. doi: [10.1016/j.foar.2023.09.005](https://doi.org/10.1016/j.foar.2023.09.005)
- [2] Grabar, M., Dupre, K., 2022. Questioning the phenomenon of void in the built environment through a multidisciplinary perspective. *Archnet-IJAR* 17(4): pp. 759–773. doi: [10.1108/arch-01-2022-0025](https://doi.org/10.1108/arch-01-2022-0025)
- [3] Hein, C. (Ed.), 2021. Planning for Porosity: Exploring Port City Development through the Lens of Boundaries and Flows. *Urban Plan* 6(3): pp. 1–222. doi: [10.17645/up.i222](https://doi.org/10.17645/up.i222)
- [4] Jonas, M., Rahmann, H., 2014. *Tokyo Void - Possibilities in Absence*. Jovis. Berlin, Germany. ISBN: 9783868592726. Available online: <https://www.degruyterbrill.com/document/isbn/9783868592726/html>, accessed 25 June 2026
- [5] Lopez-Pineiro, S., 2020. *A Glossary of Urban Voids*. Jovis. Berlin, Germany. ISBN: 9783868596045. Available online: <https://www.degruyterbrill.com/document/isbn/9783868596045/html>, accessed 25 June 2026
- [6] Tommarchi, E., 2025. Waterfront Redevelopment Five Decades Later: An Updated Typology and Research Agenda. *Ocean Soc* 2: 9265. doi: [10.17645/oas.9265](https://doi.org/10.17645/oas.9265)

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# Comparing Virtual Reality and Computer-Based Visualisation in Simulation and Modelling Learning

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## Abstract

Immersive virtual reality (VR) is increasingly recognised as an educational technology capable of strengthening student engagement, motivation, and experiential learning by enabling repeated practice, immediate feedback, and safe interaction with simulated processes. This paper investigates whether the visualisation of a simulation model in an immersive VR environment increases students' perceived immersion and learning engagement compared with conventional computer-based visualisation. The study was conducted within the Simulation and Modelling course using a previously developed FlexSim-based model [8] translated into a VR environment. The exercise was performed with a Meta Quest 3 headset and controllers. A total of 49 graduate students participated, primarily from Logistics and Management in Maritime Industry and Transport and Nautical Studies and Maritime Transport Technology programs. After completing the exercise, students filled in a structured questionnaire which collected general information, prior experience with VR, self-assessed ability to work in FlexSim, and comparative perceptions of computer-based and VR-based model visualisation. The results indicate a general preference for VR-based visualisation across all eight comparative questions. Students perceived the VR environment as more interesting, motivating, intuitive, and useful for relating the model to real-world processes. This preference was more consistent among students with previous VR experience, although students without prior VR experience also tended to favour the immersive environment. The findings support previous research showing that VR can enhance engagement, immersion, and active learning in education [1-16]. They also suggest that immersive VR environments may be particularly valuable for simulation and modelling education, where understanding dynamic processes and spatial relationships is essential. Although the study is limited by sample size, single-headset implementation, and reliance on self-reported perceptions, it provides initial evidence that VR can enrich conventional teaching methods in maritime logistics and transport-related curricula. Future work should include larger samples, multiple VR devices, longitudinal assessment, and direct measurement of learning outcomes to further evaluate the pedagogical value of immersive simulation environments.

**Keywords:** immersive learning, maritime education, simulation modelling, student engagement, virtual reality

## References

- [1] Ai, D., Xiao, J., Xing, L., Li, T., Yang, G., Fang, G., 2025. Virtual Reality Technology in Education: Dynamic Analysis of Student Engagement and Cognitive Load. In: *Proceedings of The 2025 International Conference on Distance Education and Learning (ICDEL)*. IEEE. Kunming, China. pp. 298–302. doi: [10.1109/icdel65868.2025.11193491](https://doi.org/10.1109/icdel65868.2025.11193491)
- [2] Avila, J.C., Nieto-Jalil, J.M., Betton, L.G.F., 2025. Exploring the Integration of Virtual Reality in Multivariable Calculus: A Study on Technology Acceptance and Student Engagement. In: *Proceedings of The 2025 Mexican International Conference on Computer Science (ENC)*. IEEE. Orizaba, Veracruz, Mexico. pp. 1–6. doi: [10.1109/enc68268.2025.11311933](https://doi.org/10.1109/enc68268.2025.11311933)

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\* Corresponding/presenting author

- [3] Bhatia, D., Hesse, H., 2023. Enhancing Student Engagement in Engineering and Education Through Virtual Reality: A Survey-Based Analysis. In: *Proceedings of The TENCON 2023 - 2023 IEEE Region 10 Conference (TENCON)*. IEEE. Chiang Mai, Thailand. pp. 170–175. doi: [10.1109/tencon58879.2023.10322377](https://doi.org/10.1109/tencon58879.2023.10322377)
- [4] Cai, Z., 2023. Construction of Immersive Learning Environment for College English Speaking Based on Virtual Reality Technology. In: *Proceedings of The 2023 International Conference on Intelligent Computing, Communication & Convergence (ICI3C)*. IEEE. Bhubaneswar, India. pp. 359–364. doi: [10.1109/ici3c60830.2023.00075](https://doi.org/10.1109/ici3c60830.2023.00075)
- [5] Calvert, J., Abadia, R., Tauseef, S.M., 2019. Design and Testing of a Virtual Reality Enabled Experience that Enhances Engagement and Simulates Empathy for Historical Events and Characters. In: *Proceedings of The 2019 IEEE Conference on Virtual Reality and 3D User Interfaces (VR)*. IEEE. Osaka, Japan. pp. 868–869. doi: [10.1109/vr.2019.8797864](https://doi.org/10.1109/vr.2019.8797864)
- [6] Chang, C.W., Heo, J., Yeh, S.C., Han, H.Y., Li, M., 2018. The Effects of Immersion and Interactivity on College Students' Acceptance of a Novel VR-Supported Educational Technology for Mental Rotation. *IEEE Access* 6: pp. 66590–66599. doi: [10.1109/access.2018.2878270](https://doi.org/10.1109/access.2018.2878270)
- [7] Erdogmus, E., Ryherd, E., Diefes-Dux, H.A., Armwood-Gordon, C., 2021. Use of Virtual Reality to Improve Engagement and Self-Efficacy in Architectural Engineering Disciplines. In: *Proceedings of The 2021 IEEE Frontiers in Education Conference (FIE)*. IEEE. Lincoln, NE, USA. pp. 1–7. doi: [10.1109/fie49875.2021.9637182](https://doi.org/10.1109/fie49875.2021.9637182)
- [8] Liker, L., Bačnar, D., Barić, D., Jardas, M., 2025. Translating FlexSim Models into Virtual Reality Environments. In: *Proceedings of The 2025 MIPRO 48th ICT and Electronics Convention*. IEEE. Opatija, Croatia. pp. 1582–1586. doi: [10.1109/mipro65660.2025.11131880](https://doi.org/10.1109/mipro65660.2025.11131880)
- [9] Lin, S.C., Lee, T.J., Wang, H.W., Chan, H.C., 2018. Developing the Immersion Virtual Reality Platform Based on Experiential Learning Cycle - Using Fire Disaster Prevention Education as an Example. In: *Proceedings of The 2018 7th International Congress on Advanced Applied Informatics (IIAI-AAI)*. IEEE. Yonago, Japan. pp. 948–949. doi: [10.1109/iiat-aa.2018.00195](https://doi.org/10.1109/iiat-aa.2018.00195)
- [10] Oubibi, M., Fute, A., Oubibi, A., Jing, H., Saleem, A., Zhou, Y., 2022. Integration of Virtual Reality Technology in the Primary School: Students' Creativity and Learning Engagement. In: *Proceedings of The 2022 Eleventh International Conference of Educational Innovation through Technology (EITT)*. IEEE. New York, NY, USA. pp. 120–125. doi: [10.1109/eitt57407.2022.00027](https://doi.org/10.1109/eitt57407.2022.00027)
- [11] Pagano, K., Haddad, A., Crosby, T., 2017. Virtual Reality-Making Good On the Promise of Immersive Learning: The effectiveness of in-person training, with the logistical and cost-effective benefits of computer-based systems. *IEEE Consum Electron Mag* 6(1): pp. 45–47. doi: [10.1109/mce.2016.2614413](https://doi.org/10.1109/mce.2016.2614413)
- [12] Ruiz-Cantisani, M.I., Lima-Sagui, F.D.C., Aceves-Campos, N., Ipiná-Sifuentes, R., Flores, E.G.R., 2020. Virtual Reality as a tool for active learning and student engagement: industrial engineering experience. In: *Proceedings of The 2020 IEEE Global Engineering Education Conference (EDUCON)*. IEEE. Porto, Portugal. pp. 1031–1037. doi: [10.1109/educon45650.2020.9125225](https://doi.org/10.1109/educon45650.2020.9125225)
- [13] Samarasinghe, D.A.S., Latif, S.A., Baghaei, N., 2019. Virtual Reality Models for Promoting Learners Engagement in Construction Studies. In: *Proceedings of The 2019 IEEE Global Engineering Education Conference (EDUCON)*. IEEE. Dubai, United Arab Emirates. pp. 1331–1335. doi: [10.1109/educon.2019.8725120](https://doi.org/10.1109/educon.2019.8725120)
- [14] Sims, R., Rutherford, N., Sukumaran, P., Yotov, N., Smith, T., Karnik, A., 2021. Logibot: Investigating Engagement and Development of Computational Thinking Through Virtual Reality. In: *Proceedings of The 2021 7th International Conference of the Immersive Learning Research Network (iLRN)*. IEEE. Eureka, CA, USA. pp. 1–5. doi: [10.23919/ilrn52045.2021.9459352](https://doi.org/10.23919/ilrn52045.2021.9459352)
- [15] Sun, C., Yao, Y., Wang, R., Ye, X., 2020. A Study on the Influence of Scene Reality of VR Environment on English Learners' Learning Engagement and Learning Effectiveness. In: *Proceedings of The 2020 IEEE 2nd International Conference on Computer Science and Educational Informatization (CSEI)*. IEEE. Xinxiang, China. pp. 181–185. doi: [10.1109/csei50228.2020.9142520](https://doi.org/10.1109/csei50228.2020.9142520)
- [16] Zakraoui, J., Al-Maadeed, S., Salah, M., Alja'Am, J., 2021. A Study of Children Engagement and Focus During Handwriting in VR with a Haptic Device. In: *Proceedings of The 2021 31st International Conference on Computer Theory and Applications (ICCTA)*. IEEE. Alexandria, Egypt. pp. 66–70. doi: [10.1109/iccta54562.2021.9916629](https://doi.org/10.1109/iccta54562.2021.9916629)

# Confidence Correction Based on Real-World Target Size for UAV Object Detection

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## Abstract

Object detection using unmanned aerial vehicles (UAVs) and deep learning algorithms has become an important tool in search operations, environmental monitoring, and surveillance. The influence of UAV flight speed and image ground sampling distance (GSD) on object detection performance was previously investigated, and optimal flight regimes that maximise effective search coverage were identified [1]. Although modern object detection algorithms provide confidence scores for detected objects, these scores are based solely on image features and do not consider the estimated real-world surface area of the detected target.

In this study, a confidence correction method based on the estimated real-world target area was developed. The surface area of each detected target was calculated from the image bounding box using the UAV position, the coordinates of the flight home point, the relative flight altitude, and a Digital Elevation Model (DEM) describing the terrain. The estimated target area was then compared with the expected target area of the searched object, and the original detection confidence was adjusted accordingly. Detections with implausible target areas were assigned lower confidence values, while detections whose estimated area matched the expected target size retained or received higher confidence values.

The proposed methodology was evaluated by comparing the original and corrected detection results using Precision, Recall, F1-score, and Precision–Recall curves. The obtained results enabled an assessment of the influence of real-world target area-based confidence correction on the overall detection performance, including Precision, Recall, F1-score, and the Precision–Recall relationship. The study demonstrated the applicability of integrating geometric information derived from UAV navigation data and terrain elevation models into the post-processing stage of UAV-based object detection.

**Keywords:** UAV, object detection, confidence correction, DEM, target area, YOLO

## References

- [1] Lanča, L., Mališa, M., Jakac, K., Ivić, S., 2025. Optimal Flight Speed and Height Parameters for Computer Vision Detection in UAV Search. *Drones* 9(9): 595. doi: [10.3390/drones9090595](https://doi.org/10.3390/drones9090595)

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# Circular Use of ASA Filaments: Influence of Marine Exposure on Mechanical Properties and Recycling Potential

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## Abstract

Additive manufacturing is increasingly being adopted for producing functional polymer components for demanding marine engineering applications. Despite the excellent weatherability and ultraviolet (UV) resistance of acrylonitrile styrene acrylate (ASA), limited information is available regarding the long-term behaviour of FDM-printed ASA components exposed to natural marine environments, particularly following mechanical recycling [1-5].

This research investigates the degradation of FDM-printed ASA specimens exposed to natural seawater for periods of 4, 8, and 12 months. Standardised tensile specimens were manufactured using identical printing parameters and periodically removed for mechanical testing to evaluate changes in tensile strength, Young's modulus, and elongation at break. The obtained results will be correlated with the duration of marine exposure in order to assess the influence of environmental ageing on the structural integrity of the material. Following the completion of the first exposure cycle, all tested specimens will be mechanically recycled, re-extruded into new filament, and used to manufacture a second generation of test specimens. These recycled specimens will then be subjected to a new marine exposure programme with planned evaluation after 2, 4, and 6 months. The second phase of the research aims to determine whether recycled ASA retains sufficient mechanical performance for repeated engineering applications in marine environments.

The study contributes to a better understanding of polymer ageing in seawater while simultaneously addressing the growing need for sustainable material management in additive manufacturing. The obtained results are expected to provide practical guidelines for the reuse of engineering thermoplastics exposed to marine conditions and support the implementation of circular economy principles in polymer-based manufacturing.

**Keywords:** ASA filament, additive manufacturing, marine degradation, recycling, tensile testing

## References

- [1] Kopic, M., Mihaljec, B., 2025. Environmental Ageing of Structural Materials in Shipbuilding and Marine Engineering - A Review. *Pomorstvo* 39(2): pp. 235–253. doi: [10.31217/p.39.2.5](https://doi.org/10.31217/p.39.2.5)
- [2] Silva, D., Garrido, J., Lekube, B., Arrillaga, A., 2023. On-board and port 3D printing to promote a maritime plastic circular economy. *J Cleaner Prod* 407: 137151. doi: [10.1016/j.jclepro.2023.137151](https://doi.org/10.1016/j.jclepro.2023.137151)
- [3] Tomastik, J., Siskova, K., Vaclavek, L., Ctvrtlik, R. et al., 2026. Photooxidative ageing of 3D printed polymers PLA, ABS, PET, HIPS and PC induced by long-term UV radiation. *arXiv preprint* 2026: 2606.00068. doi: [10.48550/arxiv.2606.00068](https://doi.org/10.48550/arxiv.2606.00068)
- [4] Vukelic, G., Vizentin, G., Brnic, J., Brcic, M., Sedmak, F., 2021. Long-Term Marine Environment Exposure Effect on Butt-Welded Shipbuilding Steel. *J Mar Sci Eng* 9(5): 491. doi: [10.3390/jmse9050491](https://doi.org/10.3390/jmse9050491)
- [5] Wang, X., Travis, C., Sorna, M., Arola, D., 2024. Durability of Ultem 9085 in Marine Environments: A Consideration in Fused Filament Fabrication of Structural Components. *Polymers* 16(3): 350. doi: [10.3390/polym16030350](https://doi.org/10.3390/polym16030350)

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# Human-in-the-Loop Semantic Segmentation of Bacterial Colonies Across Acquisition Conditions

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## Abstract

Automated identification of microbial colonies is an important step towards objective analysis in clinical microbiology laboratories, where colonies are usually read manually in a way that is subjective, slow, and varies between technicians. This work uses semantic segmentation of Petri dish images to separate bacterial colonies from the agar and other background, and to tell different bacterial strains apart. Several deep learning models were trained on a first batch of images acquired under one set of acquisition conditions [2], using image patches and data augmentation. On the test set, they clearly outlined the colonies and reached a macro-averaged Dice score above 0.80, with DeepLabV3+ performing best [1]. A second batch, acquired under different conditions, was used to check how well the models generalise. Here they still separated the colonies (foreground) from the agar, Petri dish, and background, but became noticeably worse at telling individual strains apart, with most mistakes coming from assigning the wrong strain rather than missing colonies. To adapt the models, a human-in-the-loop approach was used: the predicted masks on the second batch were checked and the strain labels corrected by hand, then used to retrain the models, which improved strain separation with much less manual work than labelling from scratch. Finally, the retrained models were applied to a third, unlabelled batch acquired under conditions like the second and closer to real mixed-culture plates, with several strains growing together in one dish. Colony outlining stayed reliable, while telling apart strains growing side by side remained the main open problem. Overall, pairing automated segmentation with targeted human correction is a practical way to adapt models across acquisition conditions, and a step towards a scalable pipeline for automated bacterial colony analysis.

**Keywords:** semantic segmentation, bacterial colonies, human-in-the-loop, domain shift, computer vision, laboratory automation

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## References

- [1] Chen, L.C., Zhu, Y., Papandreou, G., Schroff, F., Adam, H. et al., 2018. Encoder-Decoder with Atrous Separable Convolution for Semantic Image Segmentation. *arXiv preprint* 2018: 1802.02611. doi: [10.48550/arxiv.1802.02611](https://doi.org/10.48550/arxiv.1802.02611)
- [2] Mikulić, M., Robek, A., Stergar, J., Modic, M., Milanić, M., Štajduhar, I., 2026. Semantic Segmentation for Automated Identification of Bacterial Colonies. In: *Proceedings of The 2026 49th MIPRO ICT and Electronics Convention (MIPRO)*. IEEE. Opatija, Croatia. pp. 1270–1275. doi: [10.1109/mipro70003.2026.11591795](https://doi.org/10.1109/mipro70003.2026.11591795)

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# CFD Investigation of Cavitation in a Francis Turbine: Identifying Cavitation in a Commissioned Hydroelectric Power Plant

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## Abstract

Cavitation is a well-known challenge in water turbine systems and is almost always undesirable [2]. Due to cavitation, hydroelectric power plants require more frequent maintenance, and in extreme cases, some main components may be damaged to the extent that they need to be replaced [3]. In addition, cavitation causes a reduction in overall system efficiency, which together leads to increased operating costs [1]. Identifying the cause of cavitation once the power plant has been commissioned, with the goal of avoiding it or reducing its occurrence in future operations, can be challenging. For this purpose, numerical simulations may be employed. Using numerical simulations, multiple operating conditions can be examined, enabling faster identification of potential problems. Moreover, at the same time, improved design solutions can be proposed. In the present study, computational fluid dynamics simulations of a real hydroelectric power plant were performed following the observation of cavitation-induced issues during turbine operation. Since the unit is currently in service, simulations were employed as a non-intrusive tool to investigate the potential causes. Operating conditions were analysed by varying the guide vane angles from 5° to 25°, in increments of 2.5°. The results indicate that cavitation develops near the leading edge of the runner blades, where pressure values are expected to be the highest. To validate the numerical findings, the plant's snail diagram and the cavitation-damaged areas observed on the old runner were used for comparison.

**Keywords:** cavitation, computational fluid dynamics, water brines, Francis water turbine

## References

- [1] Kumar, K., Saini, R.P., 2022. Economic analysis of operation and maintenance costs of hydropower plants. *Sustain Energy Technol Assess* 53: 102704. doi: [10.1016/j.seta.2022.102704](https://doi.org/10.1016/j.seta.2022.102704)
- [2] Kumar, P., Saini, R.P., 2010. Study of cavitation in hydro turbines—A review. *Renewable Sustainable Energy Rev* 14(1): pp. 374–383. doi: [10.1016/j.rser.2009.07.024](https://doi.org/10.1016/j.rser.2009.07.024)
- [3] Singh, R., Tiwari, S.K., Mishra, S.K., 2011. Cavitation Erosion in Hydraulic Turbine Components and Mitigation by Coatings: Current Status and Future Needs. *J Mater Eng Perform* 21(7): pp. 1539–1551. doi: [10.1007/s11665-011-0051-9](https://doi.org/10.1007/s11665-011-0051-9)

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# The Quality 5.0 Paradigm: Redefining Quality Management for Industry 5.0 Manufacturing

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## Abstract

Industry 5.0 represents a new paradigm for manufacturing systems that extends beyond the technology-driven focus of Industry 4.0 by emphasising the collaboration between advanced digital technologies and human capabilities. Accordingly, Quality 5.0 expands the principles of Quality 4.0 by integrating digitalisation with human-centricity, sustainability, organisational resilience and ethical governance [6]. Recent studies indicate that the transition towards Quality 5.0 requires a broader understanding of quality that encompasses not only operational performance but also social, environmental and human-related outcomes [1,5]. Despite the growing interest in the topic, Quality 5.0 research remains largely conceptual, while empirically validated measurement frameworks are still scarce. Reliable instruments for measuring human-centricity and the multidimensional performance of Quality 5.0 systems are only beginning to emerge [3]. Furthermore, existing research highlights that successful implementation of Quality 5.0 depends on the effective integration of advanced digital technologies with organisational and human factors, particularly within human-centric manufacturing environments [2]. Overall, the current body of knowledge suggests that Quality 5.0 represents an evolutionary step towards a socio-technical quality management paradigm; however, additional empirical studies are needed to validate theoretical concepts and support their practical implementation in Industry 5.0 [4].

**Keywords:** Quality 5.0, Industry 5.0, sustainability, socio-technical systems, manufacturing

## References

- [1] Bucci, I., Fani, V., Rossi, M., Bandinelli, R., Tucci, M., 2026. Quality 5.0: a systematic literature review and a gap-driven research agenda. *TQM J* 2026: pp. 1–23. doi: [10.1108/tqm-12-2025-0747](https://doi.org/10.1108/tqm-12-2025-0747)
- [2] Fani, V., Bucci, I., Bandinelli, R., Rossi, M., 2025. Advancing human-centric zero defect manufacturing: a theoretical framework and practical insights. *Int J Prod Res* 2025: pp. 1–18. doi: [10.1080/00207543.2025.2579770](https://doi.org/10.1080/00207543.2025.2579770)
- [3] Ibrahim, Y.M., Abdulameer, S.S., 2026. Measuring Quality 5.0 in manufacturing: scale development and validation in an emerging economy. *TQM J* 2026: pp. 1–20. doi: [10.1108/tqm-12-2025-0753](https://doi.org/10.1108/tqm-12-2025-0753)
- [4] Kumar, V., Singh, A., Sharma, N., Verma, P., 2026. Integrating quality 5.0 approaches for the future of quality management. *TQM J* 2026: pp. 1–35. doi: [10.1108/tqm-04-2025-0210](https://doi.org/10.1108/tqm-04-2025-0210)
- [5] Montera, R., Nevi, G., Cucari, N., 2026. Framing Quality 5.0 through purpose governance: a conceptual model for humanizing organizations. *TQM J* 2026: pp. 1–23. doi: [10.1108/tqm-08-2025-0476](https://doi.org/10.1108/tqm-08-2025-0476)
- [6] Paixão, D., Sá, J.C., Ulewicz, R., Ingaldi, M., Fonseca, L., Pereira, A., 2025. Industry 5.0 and Quality 5.0: A Framework for the Next Generation of Operational Excellence. In: *Advances in Lean Manufacturing, Volume 2*. Springer Nature Switzerland. Cham, Switzerland. pp. 379–401. ISBN: 9783032101112. doi: [10.1007/978-3-032-10111-2\\_31](https://doi.org/10.1007/978-3-032-10111-2_31)

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# Development of Hardness Prediction Models for Quenched and Tempered Steels

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## Abstract

Quenching and tempering are widely used heat treatment processes for achieving the required mechanical properties of engineering steels. Since hardness is closely related to microstructure and other mechanical properties, its accurate prediction is important for the design and optimisation of heat-treated components. This work presents a unified approach to hardness prediction in quenched and tempered steels, based on previously developed mathematical models [1-3]. The prediction of as-quenched hardness is based on the characteristic cooling time from 800 °C to 500 °C and its relation to the Jominy hardenability curve. Tempered hardness is then predicted from the as-quenched hardness using mathematical relations based on DIN 17021 and the model proposed by E. Just [3]. Improved models additionally include material parameters such as the specific Jominy distance and the carbon equivalent, which describe the influence of steel hardenability and chemical composition on tempering behaviour [1,2]. The presented approach enables computer simulation of hardness distribution in steel components after quenching and tempering. Such models can reduce experimental work and support the optimisation of heat treatment parameters in engineering practice.

**Keywords:** mathematical modelling, quenching, tempering, hardness prediction, hardenability

## References

- [1] Iljkić, D., Smokvina Hanza, S., Smoljan, B., Kvrđić, D., 2023. MATHEMATICAL MODELLING OF TEMPERED HARDNESS OF QUENCHED STEEL. In: *Proceedings of the MTECH International Conference 2023*. Croatian Society for Heat Treatment and Surface Engineering. Cavtat, Croatia. pp. 114–121. Available online: [https://hdmt.hr/wp-content/uploads/2025/12/MTECH2023\\_Zbornik.pdf](https://hdmt.hr/wp-content/uploads/2025/12/MTECH2023_Zbornik.pdf), accessed 6 July 2026
- [2] Iljkić, D., Smokvina Hanza, S., Smoljan, B., Kvrđić, D., 2023. Prediction of quenched and tempered Steel Hardness Using carbon equivalent (CE). In: *Proceedings of The METAL 2023*. TANGER Ltd.. Brno, Czech Republic. pp. 333–339. doi: [10.37904/metal.2023.4702](https://doi.org/10.37904/metal.2023.4702)
- [3] Smoljan, B., Iljkić, D., Totten, G.E., 2015. Mathematical Modeling and Simulation of Hardness of Quenched and Tempered Steel. *Metall Mater Trans B* 46(6): pp. 2666–2673. doi: [10.1007/s11663-015-0451-6](https://doi.org/10.1007/s11663-015-0451-6)

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# Calculation of Natural Frequencies and Mode Shapes of Euler-Bernoulli Beams Using the PINN Method

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## Abstract

The calculation of natural frequencies and mode shapes is the first step in the analysis of the dynamic behaviour of structures [2,4]. In this paper, these quantities are calculated for a thin beam with classical boundary conditions using the Euler-Bernoulli beam theory [1,4]. The calculation was also performed by applying the Physics-Informed Neural Networks (PINN) method, which incorporates the Rayleigh quotient and directly embeds the physical formulation of the eigenvalue problem into the optimisation process [3,5]. By applying the Rayleigh quotient, the natural frequency can be explicitly estimated from the approximated mode shape, reducing the need for additional constraints and improving the stability of the learning process [4,5]. The calculated natural frequencies and mode shapes are compared with analytical solutions to assess the advantages and limitations of the applied method [1,4].

**Keywords:** natural frequencies, mode shapes, Euler-Bernoulli beam, physics-informed neural networks, Rayleigh quotient, eigenvalue problem, structural dynamics

## References

- [1] Karnovsky, I.A., Lebed, O.I., 2001. *Formulas for Structural Dynamics: Tables, Graphs, and Solutions, 1st Edition*. McGraw Hill Education. Columbus, OH, USA. ISBN: 9780071394659. Available online: <https://www.mheducation.com/highered/mhp/product/formulas-structural-dynamics-tables-graphs-solutions.html>, accessed 9 July 2026
- [2] Meirovitch, L., 2001. *Fundamentals of Vibrations*. McGraw Hill Education. Columbus, OH, USA. ISBN: 9780070413450. Available online: [https://books.google.hr/books/about/Fundamentals\\_of\\_Vibrations.html?id=u358QgAACAAJ](https://books.google.hr/books/about/Fundamentals_of_Vibrations.html?id=u358QgAACAAJ), accessed 9 July 2026
- [3] Raissi, M., Perdikaris, P., Karniadakis, G.E., 2019. Physics-informed neural networks: A deep learning framework for solving forward and inverse problems involving nonlinear partial differential equations. *J Comput Phys* 378: pp. 686–707. doi: [10.1016/j.jcp.2018.10.045](https://doi.org/10.1016/j.jcp.2018.10.045)
- [4] Rao, S.S., 2019. *Vibration of Continuous Systems, 2nd Edition*. Wiley-IEEE Press. Hoboken, NJ, USA. ISBN: 9781119424284. doi: [10.1002/9781119424284](https://doi.org/10.1002/9781119424284)
- [5] Rayleigh, J.W.S., 1894. *The Theory of Sound, 2nd Edition*. Macmillan. London, UK. Available online: [https://books.google.hr/books/about/The\\_Theory\\_of\\_Sound.html?id=hd8EAAAAYAAJ](https://books.google.hr/books/about/The_Theory_of_Sound.html?id=hd8EAAAAYAAJ), accessed 9 July 2026

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# Modelling the Efficiency of Differential GPS Corrections as a Function of Range

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## Abstract

Differential Global Positioning System (DGPS) enhances positioning accuracy in maritime navigation, geodetic surveying, and hydrographic applications by applying corrections from a reference station to rover receivers [2,5]. DGPS performance is constrained by the distance between base and rover stations, as increased separation reduces the spatial correlation of error sources such as ionospheric and tropospheric delays [3,9]. While this degradation is well documented, the relationship between baseline distance and positioning error remains complex and nonlinear. A previous preliminary study demonstrated the existence of distance-dependent degradation in DGPS positioning accuracy using the same EUREF station network, while highlighting the need for more advanced statistical modelling of this relationship [10]. The present study models DGPS accuracy degradation to identify statistical methods that effectively capture this relationship and support predictive applications.

The analysis utilises GNSS data from the EUREF Permanent GNSS Network [1], with one base station in Rome (M0SE00ITA) and eight rover stations distributed across Europe. Station separations range from 11 km to 1802 km. Building upon the dataset and processing methodology presented in the previous study [10], data were processed using RTKLIB 2.4.3 [7,8]. RINEX observation and navigation files provided positioning solutions at 60-second intervals over a 24-hour period under quiet geomagnetic conditions [4,6]. Positional errors in latitude, longitude, and height were assessed against known coordinates and standardised to a common metric scale. To characterise error patterns and variability, statistical measures, including the mean, standard deviation, range, and interquartile range, were calculated in RStudio.

Multiple regression models were employed and compared to characterise DGPS error as a function of distance. Linear models served as a baseline, while higher-degree polynomial and spline regressions were applied to capture nonlinear trends. Whereas the previous study focused primarily on evaluating the effectiveness of DGPS corrections as a function of baseline distance [10], the present study extends the analysis by statistically modelling the relationship between baseline distance and positioning error using multiple regression techniques. Model performance was evaluated using adjusted  $R^2$ , F-statistics, p-values, and residual analysis, with predefined criteria to ensure statistical reliability.

The results show that DGPS positioning errors increase steadily as the distance between stations grows, affecting all spatial components. Horizontal errors in latitude and longitude rise gradually, while vertical errors vary more and are more affected by local factors like multipath and satellite geometry. The modelling shows that the link between distance and error is strongly nonlinear. Linear models do not capture the observed trends well, especially for longitude and height, where the errors do not follow a simple pattern and can change locally. In contrast, higher-degree polynomial and spline models fit the data better, capturing both overall trends and local changes. For example, spline models can show the ups and downs in vertical errors and the peaks in longitude errors at certain distances, which simpler models miss.

The findings demonstrate that DGPS errors are component-dependent and do not conform to a simple pattern, necessitating advanced modelling approaches for accurate characterisation. Spline and higher-degree polynomial regressions outperform traditional linear models in explaining and predicting errors, making them valuable for real-time reliability assessments and decision support. These findings expand upon the conclusions of the previous preliminary investigation [10] by demonstrating that the degradation of DGPS performance with increasing baseline distance is fundamentally nonlinear and can be represented

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more accurately using flexible regression techniques. These results underscore the advantages of flexible modelling and provide a foundation for enhancing accuracy and optimising DGPS in high-precision applications. Future research should incorporate larger datasets and additional environmental variables to increase the generalizability and practical relevance of the results.

**Keywords:** DGPS, regression models, positioning accuracy, nonlinear modelling, RINEX data processing

## References

- [1] EPN CB, 2026. EUREF Permanent GNSS Network. Available online: <https://epncb.oma.be>, accessed 8 July 2026
- [2] Kaplan, E.D., Hegarty, C.J. (Eds.), 2005. *Understanding GPS Principles and Applications, 2nd Edition*. Artech House. Norwood, MA, USA. ISBN: 9781580538954. Available online: <https://ieeexplore.ieee.org/document/9106073>, accessed 8 July 2026
- [3] Madad, A., Shah, M.A., Shaikh, N.A., Ali, G., 2009. The Impact of Performance Parameters over a DGPS Satellite Navigation System 1. Available online: [https://www.researchgate.net/publication/294645944\\_The\\_Impact\\_of\\_Performance\\_Parameters\\_over\\_a\\_DGPS\\_Satellite\\_Navigation\\_System\\_1](https://www.researchgate.net/publication/294645944_The_Impact_of_Performance_Parameters_over_a_DGPS_Satellite_Navigation_System_1), accessed 8 July 2026
- [4] Sanz Subirana, J., Juan Zornoza, J.M., Hernández-Pajares, M., 2011. GNSS Basic Observables - Navipedia. Available online: [https://gssc.esa.int/navipedia/index.php/GNSS\\_Basic\\_Observables](https://gssc.esa.int/navipedia/index.php/GNSS_Basic_Observables), accessed 8 July 2026
- [5] Specht, C., 2022. Maritime DGPS System Positioning Accuracy as a Function of the HDOP in the Context of Hydrographic Survey Performance. *Remote Sens* 15(1): 10. doi: [10.3390/rs15010010](https://doi.org/10.3390/rs15010010)
- [6] Stack Overflow Contributors, 2015. Understanding GPS GNSS RINEX FILES and relevant parameters - Stack Overflow. Available online: <https://stackoverflow.com/questions/29227799/understanding-gps-gnss-rinex-files-and-relevant-parameters>, accessed 8 July 2026
- [7] Takasu, T., 2013. RTKLIB ver. 2.4.2 Manual. Available online: [https://www.rtklib.com/prog/manual\\_2.4.2.pdf](https://www.rtklib.com/prog/manual_2.4.2.pdf), accessed 8 July 2026
- [8] Takasu, T., Yasuda, A., 2009. Development of the low-cost RTK-GPS receiver with an open source program package RTKLIB. Available online: [https://gpspp.sakura.ne.jp/paper2005/isgps\\_2009\\_rtklib\\_revA.pdf](https://gpspp.sakura.ne.jp/paper2005/isgps_2009_rtklib_revA.pdf), accessed 8 July 2026
- [9] Teunissen, P.J.G., Montenbruck, O. (Eds.), 2017. *Springer Handbook of Global Navigation Satellite Systems*. Springer International Publishing. Cham, Switzerland. ISBN: 9783319429281. doi: [10.1007/978-3-319-42928-1](https://doi.org/10.1007/978-3-319-42928-1)
- [10] Vušković, B., Veverec, S., Brčić, D., Kos, S., 2023. The Study on the Efficiency of Differential GPS Corrections in the Function of Range. In: *Proceedings of the 7th My First Conference*. University of Rijeka. Rijeka, Croatia. pp. 32–33. Available online: <https://mfc.uniri.hr/wp-content/uploads/2023/09/MFC-2023-BOOK-OF-ABSTRACTS-1.pdf>, accessed 8 July 2026

# Integrating Field Monitoring and Soil Characterisation for Slope Stability Modelling

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## Abstract

Understanding the hydraulic behaviour of unsaturated soils remains a major challenge in modelling rainfall-induced slope instability. Although direct determination of soil-water retention properties provides the most reliable input for hydro-mechanical analyses, such testing is often impractical due to the time, cost, and specialised equipment involved. This study presents ongoing research at the Havišće coastal test site in Croatia, where an integrated monitoring system has been established to investigate transient hydraulic processes within shallow colluvial deposits. Continuous measurements of soil moisture, pore-water pressure, matric suction, and meteorological variables enable detailed observation of infiltration dynamics and their influence on the slope's hydraulic state under natural environmental conditions. Alongside field monitoring, laboratory testing was conducted to determine basic geotechnical properties of the soil, including grain-size distribution, plasticity characteristics, and density-related parameters. This data was used to estimate the soil-water characteristic curve (SWCC) through the predictive models of Aubertin et al. [1] and Perera et al. [2]. Comparison between SWCC predictions and field-derived hydraulic responses provides insight into the applicability and limitations of simplified estimation methods. The presented framework highlights the value of combining field observations with laboratory characterisation to improve the reliability of hydro-mechanical analyses and ultimately enhance predictions of slope instability in similar data-scarce environments.

**Keywords:** field monitoring, slope stability, soil-water characteristic curve, unsaturated soil, coastal landslides

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## References

- [1] Aubertin, M., Mbonimpa, M., Bussière, B., Chapuis, R.P., 2003. A model to predict the water retention curve from basic geotechnical properties. *Can Geotech J* 40(6): pp. 1104–1122. doi: [10.1139/t03-054](https://doi.org/10.1139/t03-054)
- [2] Perera, Y.Y., Zapata, C.E., Houston, W.N., Houston, S.L., 2005. Prediction of the Soil-Water Characteristic Curve Based on Grain-Size-Distribution and Index Properties. In: *Proceedings of The Geo-Frontiers Congress 2005*. American Society of Civil Engineers. Austin, Texas, United States. pp. 1–12. doi: [10.1061/40776\(155\)4](https://doi.org/10.1061/40776(155)4)

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## Statistics

The first edition of My First Conference took place at the University of Rijeka, Faculty of Engineering, in September 2017. At the first conference, two keynote lectures and 29 contributed lectures were presented.

The second edition of My First Conference was held at the University of Rijeka, Faculty of Maritime Studies, in September 2018. During the conference, 34 papers were presented along with two plenary lectures.

The third edition of My First Conference took place at the University of Rijeka, Faculty of Civil Engineering, in September 2019. During the conference, 27 papers were presented along with one plenary lecture.

The fourth edition of My First Conference was held at the University of Rijeka, Faculty of Engineering, in September 2020. At the fourth edition, 33 abstracts were presented, along with one keynote lecture.

The fifth edition of My First Conference was held at the University of Rijeka, Faculty of Maritime Studies, on September 23, 2021. The conference received 30 abstracts, three plenary presentations, and one keynote lecture.

The sixth edition of My First Conference was held at the University of Rijeka, Faculty of Civil Engineering, on September 22, 2022. During the conference, 29 papers were presented, along with one plenary and one keynote lecture.

The seventh edition of My First Conference was held at the University of Rijeka, Faculty of Engineering, on September 14, 2023. It included 19 abstracts, one keynote lecture and one plenary lecture.

The eighth edition of My First Conference was held at the University of Rijeka, Faculty of Maritime Studies, on September 19, 2024. It included 24 abstracts, two keynote lectures, along with two interactive workshops.

The ninth edition of My First Conference was held at the University of Rijeka, Faculty of Civil Engineering, on September 22, 2025. It included 21 abstracts, one keynote lecture, and an interactive workshop.

This year, the conference takes place at the University of Rijeka, Faculty of Engineering, on September 17, 2026. The programme includes 28 abstracts and two keynote lectures.