



# **EWG-ORSDCE**

# NEWSLETTER OF EWG ORSDCE DECEMBER 2023

ORSDCE - The OR in Sustainable Development and Civil Engineering Working Group of EURO https://www.euro-online.org/websites/orsdce/

# Content of the issue

# Words of chairman

Dear Members of EWG-ORSDCE, dear Friends,

This issue of newsletter presents this year news, achievements and forthcoming events.

The active members of EWG-ORSDCE published several successful Special Issues in different Clarivate Analytics Web of Science journals and currently, some more issues open for submissions in journals related to the research field of our Working Group presented in this newsletter.

Please visit EWG-ORSDCE website <u>https://www.euro-online.org/websites/orsdce/</u> register or update your personal information on members' portal.

As usual, we invite you to submit the papers to the journals published by the active members of EWG-ORSDCE: Technological and Economic Development of Economy, Journal of Civil Engineering and Management, Journal of Business Economics and Management, International Journal of Strategic Property Management, and Engineering Structures and Technologies. Congratulations on all your achievements and best wishes for future activities.

With my best wishes, yours sincerely, Edmundas Kazimieras Zavadskas, Chair of EWG-ORSDCE

# Forthcoming events



# 19th Colloquium & 9th meeting of EWG ORSDCE, 28–29 May 2024, Poznan, Poland

# Dear Colleagues,

We are pleased to invite you to the joint meeting of researchers and practitioners active in the field of construction management: The 18th Colloquium "Innovative Solutions in Sustainable Construction Management" and the 9th meeting of the EURO working group Operational Research in Sustainable Development and Civil Engineering.

Venue: Poznan University of Technology, 5 Piotrowo Str., 60-138, Poznan, POLAND

Date: May, 28–29, 2024

# General aims of the conference and workshop:

- the inspiration of young researchers to work
- discussion and development of new ideas and solutions with partners from industry
- presentation of innovative projects
- knowledge bridge creation between academia-industry PhD students
- verification of the concepts in practice case studies in progress

# Topics

sustainable development in the built environment; operational research; decision making; civil engineering; construction technology and management; flexible management; lean management; building information modeling (BIM); agile management; buildings life cycle; qualification of human resources; real estate management; project management; quality management.

# **Contact persons:**

# Chairman of the scientific committee:

Prof. dr. Jerzy Pasławski; tel. +48616652113; e-mail: jerzy.paslawski@put.poznan.pl

# Chairman of organizing committee:

Dr. Marcin Gajzler; tel. +48616652190; e-mail: marcin.gajzler@put.poznan.pl

Conference e-mail: <u>fscm@put.poznan.pl</u>



Welcome Organising Committee Venue Contact









33rd European Conference on Operational Research 30th June – 3rd July 2024 Technical University of Denmark (DTU), Copenhagen, Denmark

https://euro2024cph.dk/

# Venue

The Technical University of Denmark - often simply referred to as DTU - was founded in 1829 at the initiative of Hans Christian Ørsted (the father of electromagnetism) to develop and create value using the natural sciences and the technical sciences to benefit society.

Today, DTU is ranked among Europe's leading engineering institutions and recognized internationally as a leading university in the areas of the technical and natural sciences, renowned for its business-oriented approach, high level of international research, its sought-after graduates, and its focus on sustainability.

The conference venue is in DTU Lyngby campus in the northern part of Copenhagen, close to the sea and the forest of Dyrehaven. The campus is connected to the city of Lyngby and Copenhagen via bus and suburban train lines. We have a modern campus with upgraded learning facilities.

# Keydates & deadlines:

- Abstract submission opens: Sunday, October 1, 2023
- Registration opens: Sunday, November 5, 2023
- Abstract Submission Deadline: Sunday, March 3, 2024 at hrs. 23:59 CET
- Early registration closes: Sunday, March 24, 2024 at hrs. 23:59 CET
- Author registration deadline: Sunday, April 21, 2024 at hrs. 23:59 CET

Plenary & Keynote Speakers: <u>https://euro2024cph.dk/programme/plenary-keynote-speakers</u>

# Call for Abstracts

Researchers, academics, practitioners, and students interested in any branch of Operational Research, mathematical modelling or economic analysis are invited to submit abstracts or organize sessions.

Invited and contributed papers will be organized in parallel sessions.

The abstract submission process is done through the EURO Online. Click <u>HERE</u> to get access. The deadline for abstract submission is Sunday March 3, 2024 at hrs. 23:59 CET.

Please click <u>HERE</u> for more information.

Abstracts: max. 1500 characters; submission deadline: March 3, 2024.

No participant can present more than one paper at the Conference.

Researchers who wish to organize a stream should contact the EURO 2024 Conference Secretariat: <u>euro2024cph@discongress.com</u>

**Streams:** <u>https://www.euro-online.org/conf/euro33/streams</u>

# Contact

EURO 2024 Conference Secretariat: DIS Congress Service Lautruphøj 1-3 2750 Ballerup Denmark

e: <u>euro2024cph@discongress.com</u> p: +45 4492 4492

Please contact the conference secretariat regarding any queries you may have in relation to the congress registration or general information.



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# The website for EWG ORSDCE

The website of EURO Working Group on Sustainable Development and Civil Engineering can be accessed using this link:

https://www.euro-online.org/websites/orsdce/

If you are a member of the working group, but your name is not yet on the list of members, please register here: <u>https://www.euro-online.org/websites/orsdce/register/</u>

# Register

Create your account on Euro Online MultiSite				
Username:				
(Must be at least 4 characters, letters and numbers only.)				
Email Address:				
We send your registration email to this address. (Double-check your email address before continuing.)				
First Name:				
(Must be input.)				
Last Name:				
(Must be input.)				
Institution:				
Country:				
<b>T</b>				
Interests:				
Personal website:				
The following information are for internal use and will not be shared.				
Circ.				
Address				
Zipcode				
Confirm you are human:				
I'm not a robot				
Signup				
orgrup				

To become a member of EURO Working group on Sustainable Development and Civil Engineering, please register and send the filled form to Coordinator. The form you can upload from the website.

# Journal Special Issues aimed at optimization of processes in engineering and management

# Edmundas Kazimieras Zavadskas, Jurgita Antuchevičienė, Tatjana Vilutienė, Audrius Banaitis

We are proud to announce that active members of EWG-ORSDCE published many successful Special Issues in different Clarivate Analytics Web of Science journals and currently some more issues are open for submissions in journals related to the research field of our Working Group.

# Special Issues published in 2023:



# mathematics

• Special Issue "*Multi-Criteria Decision Making and Data Mining II*" in Journal *"Mathematics"* (closed on 31 December 2023)

*Guest Editors: James Liou, Artūras Kaklauskas* <u>https://www.mdpi.com/journal/mathematics/special\_issues/22V910Y0HL</u>



# mathematics

• Special Issue "*Multiple Criteria Decision Making, 2nd Edition*" in Journal *"Mathematics"* (closed on 31 December 2023)

*Guest Editors: Violeta Keršulienė, Zenonas Turskis* <u>https://www.mdpi.com/journal/mathematics/special issues/Multiple Criteria Decision Makin</u> <u>g 2022</u>



• Special Issue "*Sensitivity Analysis and Decision Making*" in Journal *"Mathematics"* (closed on 31 December 2023)

Guest Editors: Zdeněk Kala, Jurgita Antucheviciene https://www.mdpi.com/journal/mathematics/special\_issues/PJJU4RY647



International Journal of Environmental Research and Public Health

• Special Issue "*Occupational Safety and Risks in Construction*" in Journal "*International Journal of Environmental Research and Public Health*" (closed on 30 November 2023)

*Guest Editors: Jolanta Tamošaitienė, Jerzy Pasławski* <u>https://www.mdpi.com/journal/ijerph/special issues/occupational safety risks</u>



• Special Issue "*Architectural, Civil, and Infrastructure Engineering in View of Sustainability*" in Journal *"Sustainability"* (closed on 30 January 2023)

Guest Editors: Oleg Kapliński, Lili Dong, Agata Bonenberg, Wojciech Bonenberg https://www.mdpi.com/journal/sustainability/special issues/View of Sustainability



• Special Issue "*Project Management, Supply Chain Management and Optimization in Civil & Industrial Engineering*" in Journal *"Sustainability"* (closed on 10 December 2023)

*Guest Editors: Mohammad Khalilzadeh, Jurgita Antucheviciene* <u>https://www.mdpi.com/journal/sustainability/special\_issues/Project\_Supply\_Chain\_Civil\_Indus</u> <u>trial\_Engineering</u>



• Special Issue "*Sustainable Decision Making in Civil and Construction Engineering*" in Journal *"Sustainability"* (closed on 26 March 2023)

# Guest Editor: Jolanta Tamošaitienė https://www.mdpi.com/journal/sustainability/special issues/Sustainable Decision Making



• Special Issue "*Intelligent Multi-Criteria Decision-Making Methodologies in Building and Construction Management*" in Journal "*Buildings*" (closed on 31 December 2023)

*Guest Editors: S.A. Edalatpanah, Jurgita Antucheviciene* <u>https://www.mdpi.com/journal/buildings/special issues/decision construction management</u>



• Special Issue "*Computational Approach Applications in Housing and Real Estate* " in Journal "*Buildings*" (closed on 31 August 2023)

# Guest Editor: Natalija Lepkova

https://www.mdpi.com/journal/buildings/special issues/Computational Applications Housing <u>Real\_Estate</u>



• Special Issue "*Fuzzy Logic and Fuzzy Hybrid Techniques for Construction Engineering*" in Journal "*Applied Sciences*" (closed on 10 February 2023)

# Guest Editor: Edyta Plebankiewicz

https://www.mdpi.com/journal/applsci/special issues/fuzzy logic fuzzy hybrid techniques co nstruction engineering



• Special Issue "*Application of BIM in Intelligent Construction Technology* " in Journal "*Applied Sciences*" (closed on 20 July 2023)

# Guest Editor: Darius Migilinskas

https://www.mdpi.com/journal/applsci/special issues/BIM in Intelligent Construction



• Special Issue "*Entropy for Data-Driven Decision-Making Problems*" in Journal "*Entropy*" (closed on 31 May 2023)

Guest Editors: Abbas Mardani, Edmundas Kazimieras Zavadskas, Dragan Pamucar, Fausto Cavallaro

https://www.mdpi.com/journal/entropy/special issues/9C14870ZUD



• Special Issue "*Algorithms for Multi-Criteria Decision-Making under Uncertainty*" in Journal "Symmetry" (closed on 31 March 2023)

Guest Editors: Dragan Pamucar, Željko Stević, Abbas Mardani, Edmundas Kazimieras Zavadskas https://www.mdpi.com/journal/symmetry/special\_issues/Algorithms\_Multi\_Criteria\_Decision\_ Making



Computer Modeling in Engineering & Sciences

• Special Issue "*Linguistic Approaches for Multiple Criteria Decision Making and Applications*" in Journal "*CMES-Computer Modeling in Engineering & Sciences*" (closed on 30 June 2023)

Guest Editors: Huchang Liao, Xingli Wu, Abbas Mardani, Zeshui Xu, Edmundas Kazimieras Zavadskas

https://www.techscience.com/CMES/special detail/linguistic approaches



Computer Modeling in Engineering & Sciences

• Special Issue "Advanced Computational Models for Decision-Making of Complex Systems in Engineering" in Journal "CMES-Computer Modeling in Engineering & Sciences" (closed on 31 July 2023)

*Guest Editors: Željko Stević, E.K. Zavadskas, Vladimir Simić* <u>https://www.techscience.com/CMES/special detail/engineering</u>



• Special Issue "*Moving towards Digitalization in Building Energy Modeling*" in Journal "*Energies*" (closed on 31 March 2023)

Guest Editors: Serdar Durdyev, Saeed Reza Mohandes, David John Edwards, Edmundas Kazimieras Zavadskas

https://www.mdpi.com/journal/energies/special issues/Digitalization in Building Energy Mo deling



• Special Issue "*Symmetric and Asymmetric Data in Solution Models, Part II*" in Journal "Symmetry" (closed on 31 January 2023)

Guest Editors: Edmundas Kazimieras Zavadskas, Jurgita Antuchevičienė, Zenonas Turskis https://www.mdpi.com/journal/symmetry/special\_issues/Symmetric\_Asymmetric\_Data\_Soluti on Models part II



• Special Issue "*Shaping the future of digital economy using business analytics models*" in Journal "Economic Research-Ekonomska Istraživanja" (closed on 30 June 2023)

Guest Editors: Abbas Mardani, Edmundas Kazimieras Zavadskas, Reza Farzipoor Saen, Fausto Cavallaro

https://www.tandfonline.com/journals/rero20/collections/RERO\_SFDE



• Special Issue " *Uncertain multiple criteria decision making methodologies and their applications in healthcare management*" in Journal "Computers & Industrial Engineering" (Last update 29 September 2022)

*Guest Editors: Huchang Liao, Abbas Mardani, Edmundas Zavadskas, Francisco Herrera* <u>https://www.sciencedirect.com/journal/computers-and-industrial-engineering/special-issue/10GQ3F6659M</u>

# **Open Special Issues:**



• Special Issue "*Analysis on Real-Estate Marketing and Sustainable Civil Engineering*" in Journal *"Sustainability"* (Deadline for manuscript submissions: **20 April 2024**)

*Guest Editors: Natalija Lepkova, Laura Tupėnaitė* <u>https://www.mdpi.com/journal/sustainability/special issues/estate marketing</u>

# buildings

• Special Issue "*Construction Management – Future Innovations, Methods, Techniques and Technologies*" in Journal "*Buildings*" (ongoing Topical Collection)

Guest Editors: Agnieszka Leśniak, Krzysztof Zima

https://www.mdpi.com/journal/buildings/special issues/Construction Management Innovation <u>n Methods Technologies</u>

applied sciences

• Special Issue "*Application of Fuzzy Sets in Civil Engineering* " in Journal "*Applied Sciences*" (Deadline for manuscript submissions: **20 July 2024**)

# Guest Editor: Edyta Plebankiewicz

https://www.mdpi.com/journal/applsci/special issues/fuzzy logic fuzzy hybrid techniques construction engineering



• Special Issue "*Developments in Sustainable Buildings*" in Journal "*Buildings*" (Deadline for manuscript submissions: **30 June 2024**)

*Guest Editors: Laura Tupėnaitė, Loreta Kanapeckienė* https://www.mdpi.com/journal/buildings/special\_issues/516K30V1SV



• Special Issue "Application of Emerging Techniques and Sustainable Quality Management in the Architectural, Engineering, Construction (AEC) and Facilities Management Industries" in Journal "Sustainability" (Deadline for manuscript submissions: 30 November 2024)

*Guest Editor: Natalija Lepkova* <u>https://www.mdpi.com/journal/sustainability/special issues/628NVK900Y</u>



International Journal of Environmental Research and Public Health





architecture

• Special Issue "*Interior Design towards the Sustainable Environment: People, Environment, Design, Technology*" in above journals (Deadline for manuscript submissions: **30 November 2024**)

*Guest Editors: Oleg Kapliński, Agata Bonenberg, Jan Słyk, Wojciech Bonenberg* <u>https://www.mdpi.com/topics/OU59ZRX6C0</u>

# *Review on developments and applications of EDAS (Evaluation based on Distance from Average Solution)*

# Edmundas Kazimieras Zavadskas, Mehdi Keshavarz Ghorabaee, Muhammet Deveci, Jurgita Antuchevičienė

A lot of multiple criteria decision-making (MCDM) methods have been developed by members of EWG ORSDCE. New developments and extensions of methods are usually mentioned in our yearly Newsletters.

The methods are widely applied by other researchers for different engineering and management problems. Several review papers about MCDM methods developed by members of EWG ORSDCE have been written by other researchers. The main of them are the following [1-6].

The most recent review paper about Evaluation based on Distance from Average Solution (EDAS) was published this year by Ali Ebadi Torkayesh, Muhammet Deveci, Selman Karagoz and Jurgita Antuchevičienė in Expert Systems with Applications, 2023 [7].

Keshavarz Ghorabaee, Zavadskas, Oflat and Turskis in 2015 [8] developed EDAS method, as a ranking method to tackle complicated decision-making problems where number of alternatives should be prioritized with respect to multiple criteria. Compared to other methods, one of the major differences of EDAS is reflected in its normalization process. Unlike traditional methods such as TOPSIS and VIKOR which are designed to determine best alternative according to ideal and anti-ideal solutions, in real-life decision-making problems lower distance to ideal solution and higher distance to anti ideal solution would not guarantee to get the most suitable solution. Therefore, EDAS aims to determine the best alternative according to average solution-based normalization technique. To determine the score of each alternative and determine their relative ranking order, EDAS utilizes two measures, named PDA (positive distance from average value), and NDA (negative distance from average value).

The steps for using the EDAS method are as follows [9]:

**Step 1.** Calculation of the elements of average solution  $(g_i)$ :

$$g_j = \frac{\sum_{i=1}^n x_{ij}}{n} \tag{2}$$

*Step 2.* Determination of the positive  $(\mathcal{P}_{ij}^d)$  and negative  $(\mathcal{N}_{ij}^d)$  distances:

$$\mathcal{P}_{ij}^{d} = \begin{cases} \frac{max(0, x_{ij} - \mathcal{G}_j)}{\mathcal{G}_j} & \text{if } j \in B\\ \frac{max(0, \mathcal{G}_j - x_{ij})}{\mathcal{G}_j} & \text{if } j \in C \end{cases}$$

$$(3)$$

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# $\mathcal{N}_{ij}^{d} = \begin{cases} \frac{\max(0, \mathcal{G}_{ij} - x_{ij})}{\mathcal{G}_{j}} & \text{if } j \in B\\ \frac{\max(0, x_{ij} - \mathcal{G}_{j})}{\mathcal{G}_{ij}} & \text{if } j \in C \end{cases}$

where *B* and *C* are the sets of benefit and cost criteria, respectively.

*Step 3.* Computation of the weighted summation of the distances:

$$\mathcal{P}_{i}^{w} = \sum_{j=1}^{m} w_{j} \mathcal{P}_{ij}^{d} \tag{5}$$

$$\mathcal{N}_i^w = \sum_{j=1}^m w_j \mathcal{N}_{ij}^d \tag{6}$$

*Step 4.* Normalization of the values of the weighted summations:

$$\mathcal{P}_i^n = \frac{\mathcal{P}_i^w}{\max_k \mathcal{P}_k^w} \tag{7}$$

$$\mathcal{N}_i^n = 1 - \frac{\mathcal{N}_i^w}{\max_k \mathcal{N}_k^w} \tag{8}$$

*Step 5.* Calculation of the appraisal score of each alternative:

$$S_i = \frac{1}{2} \left( \mathcal{P}_i^n + \mathcal{N}_i^n \right) \tag{9}$$

*Step 6.* Rank the alternatives according to decreasing values of  $S_i$ .

The effectiveness of crisp EDAS method with respect to the defined rank reversal phenomenon measures was shown in [9]. Later, after development of the original crisp EDAS, many studies attempted to enhance the reliability and capability of this method by implementing different uncertainty sets to efficiently tackle real-life complex problems (Table 1). The comprehensive description of the developments including respective references can be found in [7].

# **Table 1.** Uncertainty sets used for EDAS [7]

Uncertainty	# of studies	Uncertainty	# of studies
Crisp	56	2-tuple linguistic neutrosophic	1
Type-1 fuzzy set	27	Linguistic neutrosophic environment	1
Intuitionistic fuzzy set	6	Single-valued complex neutrosophic environment	1
Grey theory	4	Four-branch fuzzy set	2
Picture fuzzy set	3	Single-valued neutrosophic soft set	1
Probabilistic linguistic set	4	Interval numbers	2
Hesitant fuzzy set	3	Interval-valued complex fuzzy soft set	1
Interval type-2 fuzzy set	4	Interval-valued fuzzy set	1
Interval-valued neutrosophic set	2	Interval-valued Pythagorean fuzzy set	1
Single-valued neutrosophic set	2	Picture 2-tuple linguistic set	1
q-rung orthopair fuzzy set	3	Pythagorean 2-tuple linguistic set	1
Rough theory	2	Refined single-valued neutrosophic soft Set	1
2-dimension uncertain linguistic variables	1	Stochastic environment	1
Double hierarchy fuzzy set	1	Epistemic uncertainty	1
Fermatean fuzzy set	1	Interval rough	1
Intuitionistic fuzzy rough set	3	Pythagorean probabilistic hesitant fuzzy set	1
Trapezoidal bipolar fuzzy set	1	Trapezoidal neutrosophic set	1

Based on the detailed review of published EDAS studies, nine applications groups are found out which cover all the studies. Fig. 1 presents yearly distribution of studies conducted in nine application areas. According to this figure, EDAS method is mostly applied in business management, construction management, supply chain management, and energy and natural resources.



Fig. 1. Application based yearly distribution of papers [7]

Fig. 2 discloses statistics of various MCDM methods in the literature combined with the EDAS approach. According to the figure, most of the researchers preferred to combine EDAS with the AHP method. As AHP considers hierarchical structure in the decision-making process, is simple to apply real-world cases with a small or moderate number of criteria and is consistent in quality assurance, it is the most preferred technique by the researchers. After AHP, TOPSIS, SWARA and WASPAS are the most popular hybrid methods used with EDAS.

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Fig. 2. Distribution of hybrid methods [7]

As the review paper about EDAS was prepared and submitted to the journal in 2022, papers published between 2015 and 2021 were included in the study. Therefore, the number of studies published up to 2021 and the citations up to then are shown in Fig. 3.



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However, the method does not lose its popularity, and the number of publications as well as citations is increasing. The newest data from Web of Science data base is presented in Figs. 4 -6.



**Fig. 4.** Number of publications using EDAS method (<u>https://www.webofscience.com/wos/woscc)\*</u>

\*Please note, that slight inconsistencies may exist in the Fig. 4, because the search was made according to author keyword "EDAS" in WoS, but the results were not screened manually.

As of July/August 2023, this highly cited paper of Keshavarz Ghorabaee, Zavadskas, Oflat and Turskis (2015) [8] received enough citations to place it in the top 1% of the academic field of Computer Science based on a highly cited threshold for the field and publication year. It is cited 582 times in total in Web of Science referred publications (searched on 2023-12-04 in Clarivate Analytic WoS data base).





29 JOURNAL OF INTELLIGENT FUZZY SYSTEMS	16 MATHEMATICS	12 COMPUTERS INDUSTRIAL ENGINEERING	11 INFORMATION SCIENCES	10 ION APPLIED S COMPUTIN		ITERNATIONAL URNAL OF ZZY STEMS
	14 JOURNAL OF CLEANER PRODUCTION	12 INFORMATICA				
26 SUSTAINABILITY			9 ENGINEERING APPLICATIONS OF ARTIFICIAL INTELLIGENCE		8 7 MATHEMAT INTERNA PROBLEMS JOURNAL	
	14 SOFT COMPUTING	12 SYMMETRY BASEL	9 INTERNATIONAL JOURNAL OF INFORMATION		ENGINEERIN HYDRO ENERG	
17	13 IEEE ACCESS	11	TECHNOLOGY DECISION MAKING			
TECHNOLOGICAL AND ECONOMIC DEVELOPMENT OF ECONOMY		EXPERT SYSTEMS WITH APPLICATIONS	8 ARTIFICIAL INTELLIGENCE REVIEW		6 AXIOMS	

Fig. 6. Journals citing Keshavarz Ghorabaee et al. [8] paper (https://www.webofscience.com/wos/woscc)

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# Conference proceedings "Modern Building Materials, Structures and Techniques" MBMST 2023



# Editors: Joaquim A. O. Barros, <u>Gintaris Kaklauskas</u>, <u>Edmundas K.</u> <u>Zavadskas</u>

- Explores new horizons and research frontiers of building materials and structures
- Features the state of the art in smart construction technologies
- Written by leading experts in the field

# Part of the book series: Lecture Notes in Civil Engineering (LNCE, volume 392)

**Conference series link(s):** <u>MBMST: International Conference Modern Building Materials</u>, <u>Structures and Techniques</u>

# About this book

This book gathers the latest advances, innovations and applications in the field of sustainable construction materials and structures, as presented by leading international researchers and engineers at the 14th International scientific conference "Modern Building Materials, Structures and Techniques" (MBMST 2023), held in Vilnius, Lithuania, on 5–6 October 2023. It covers topics such as modern building materials and their production technologies; investigation and design of reinforced concrete, steel, glass, timber and composite structures; innovative calculation techniques for bridges; geotechnics; new building technologies and management; and building information modelling. The contributions, which were selected through a rigorous international peer-reviewed process, share exciting ideas that will spur novel research directions and foster new multidisciplinary collaborations.

# Section: Operational Research (Chairmans: A. Al-Refaie and N. Lepkova)

# Selection of Technology for the Reconstruction of Masonry Walls of Heritage Buildings

Edvinas Markauskas, Jonas Šaparauskas Pages 493-501

# <u>Evaluation of the Use of Unmanned Aerial System (Drone) on Risk/Accidents Involved in</u> <u>Construction Project Monitoring, Enugu State, Nigeria</u>

H. Chidiebere Ajaelu, O. Patrick Okaka Pages 502-507

# Pricing and Construction Contract Type Selection Model

Arvydas Vilkonis, Jurgita Antuchevičienė, Vladislavas Kutut Pages 508-516

# *Effects of Overall Satisfaction with PV Systems and Subsidy Policy on Energy Security for Rooftop Buildings Using System Dynamics*

Abbas Al-Refaie, Natalija Lepkova **Pages 517-525** 

# <u>Evaluation of Financial Efficiency of Real Estate Investment Projects: The Significance of</u> <u>Sustainability Indicators in the Long-Term Perspective</u>

Ieva Poderytė, Audrius Šešplaukis **Pages 526-536** 

# *Evaluation of Suspended Veneer Façade Criteria at the Construction Stage* Darius Migilinskas, Viačeslav Zigmund, Jurgita Antuchevičienė Pages 537-544

# <u>Usefulness of Crisp AHP/ANP Rating Scales to Risk Assessment Differentiation</u>

Grzegorz Ginda, Chellappa Vigneshkumar Pages 545-555

# <u>Development of Timber Construction in European Countries: Drivers, Barriers, and</u> <u>Education</u>

Laura Tupenaite, Loreta Kanapeckiene, Jurga Naimaviciene Pages 556-565

# Decision Support Systems in Construction: A Bibliometric Analysis

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# International recognition

Congratulations to the member of EWG-ORSDCE Dr. Abbas Mardani recognized being among the world's most influential researchers of the past decade, demonstrated by the production of multiple highly-cited papers that rank in the top 1% by citations for field and year in Web of Science. Experts from the Institute for Scientific Information provide exclusive insight into the list of Highly Cited Researchers 2023, including the methodology, country, and institutional breakdowns, and much more.

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# *Vilnius Gediminas Technical University (VILNIUS TECH) scientists are among the 2 percent best in the world*

October 2023 data-update for "Updated science-wide author databases of standardized citation indicators"

Published: 4 October 2023 | Version 6 | DOI: <u>https://doi.org/10.17632/btchxktzyw.6</u> Contributor: John P.A. Ioannidis

Stanford University, together with the publishing house Elsevier and SciTech Strategies, has created a ranking of 2% of the best scientists in the world. The dataset in version 6 is based on the October 1, 2023 snapshot from Scopus, updated to end of citation year 2022. Work uses Scopus data provided by Elsevier through ICSR Lab (https://www.elsevier.com/icsr/icsrlab). 38 scientists from Lithuania were listed in the ranking, including 7 VilniusTech employees: Zavadskas E., Turskis Z., Kaklauskas A., Antuchevičiene J., Kaklauskas G., Dynel M. Sivilevičius H.

# "AD Scientific Index" (Alper-Doger Scientific Index)

The AD Scientific Index (Alper-Doger Scientific Index), unlike other systems that provide evaluations of journals and universities, is a ranking and analysis system based on the scientific performance and the added value of the scientific productivity of individual scientists. Furthermore, it provides rankings of institutions based on the scientific characteristics of affiliated scientists. This index has been developed by Prof. Dr. Murat ALPER (MD) and Associate Prof. Dr. Cihan DÖĞER (MD) by using the total and last 5 years' values of the i10 index, h-index, and citation scores in Google Scholar. In addition, the ratio of the last 5 years' value to the total value of the abovementioned indexes is used. Using a total of nine parameters, the "AD Scientific Index" shows the ranking of an individual scientist by 11 subject (https://www.adscientificindex.com/about-us/).

Three Lithuanian scientists Zavadskas E. K. (position in region 1,087) and Turskis Z. (position in region 6,178) both from VilniusTech, and Ramanavičius A. (position in region 8,216) from VU were listed in the European Top 10,000 scientists.

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# VILNIUS TECH Prof. Edmundas Kazimieras Zavadskas among the world's top scientists

For the second time, the science magazine Research has ranked the world's top scientists and universities. The innovators of Vilnius Gediminas University of Technology (VILNIUS TECH) were ranked in different scientific categories.

The ranking is based on the researcher's D index (discipline H index), which takes into account only the publication and citation data of the discipline in question. The ranking is also based on information obtained from various data sources, including OpenAlex and CrossRef. The bibliometric data for the evaluation of the citation-based indices were collected on 21 December 2022.

The highest ranking in the Business and Management World Ranking was achieved by Prof. Edmundas Kazimieras Zavadskas, PhD, ranked 14th.

Three representatives of VILNIUS TECH - Prof. habil. dr. Edmundas Kazimieras Zavadskas (37th place), Prof. dr. Zenonas Turskis (70th place) and Prof. dr. Jurgita Antuchevičienė (5308th place) - were ranked in the engineering and technology category.

World Online Ranking of Best Business and Management Scientists – 2023 Report (<u>https://research.com/careers/best-business-management-scientists-2023-report</u>)

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# Systems and Uncertainty Analysis

Professor Edmundas Kazimieras Zavadskas

was elected as a



of the International Association of Grey Systems and Uncertainty Analysis. The term of appointment is from October 2023 to October 2028

Date: 10/10/2023

Signature

President: Sifeng Line Executive President: Jugie Jong

# *Newly developed or extended methods*

Alrasheedi, A., Mishra, A., Rani, P., Zavadskas, E., & Cavallaro, F. (2023). Multicriteria group decision making approach based on an improved distance measure, the SWARA method and the WASPAS method. *GRANULAR COMPUTING*, *8*(6), 1867–1885. <u>https://doi.org/10.1007/s41066-023-00413-x</u>

# Abstract

The concept of intuitionistic fuzzy set (IFS) has extensively used to handle the uncertainty of reallife decision making problems. The aim of this study is to propose an integrated multicriteria group decision making (MCGDM) approach with intuitionistic fuzzy information and apply to select the most suitable renewable energy source with respect to multiple aspects of sustainability criteria. For this purpose, we firstly propose an improved distance measure to quantify the degree of difference between IFSs. Some numerical examples are presented to show the effectiveness of the proposed measure over the existing distance measures under the context of IFS. Further, we develop a weighting approach to find the criteria weights, which combines the objective weighting model using improved distance measure and the subjective weighting model using stepwise weighted assessment ratio analysis (SWARA) with intuitionistic fuzzy information. Based on the proposed criteria weighting model, we develop an integrated weighted aggregated sum product assessment (IF-WASPAS) approach for solving MCGDM problems under intuitionistic fuzzy environment. To prove the applicability and efficacy of the developed approach, we implement it on a case study of renewable energy source selection problem with multiple aspects of sustainability including technical, socio-political, environmental, and economic perspectives. Moreover, the sensitivity and comparative analyses are discussed to examine the feasibility and steadiness of introduced approach in order to assess the RES options. In this paper, we present an improved decision making approach, which makes a significant contribution to the renewable energy sources evaluation process with uncertainty.

Amiri, M., Hashemi-Tabatabaei, M., Keshavarz-Ghorabaee, M., Kaklauskas, A., Zavadskas, E., & Antucheviciene, J. (2023). A Fuzzy Extension of Simplified Best-Worst Method (F-SBWM) and Its Applications to Decision-Making Problems. *SYMMETRY-BASEL*, *15*(1). https://doi.org/10.3390/sym15010081

# Abstract

Today, most of the issues and challenges faced by managers and decision makers are complex and multifaceted. More clearly, due to the developments of technologies, emerging trends in various industries, competitive markets, and rapid and transformative changes in the business environment, managers and decision makers have faced an uncertain environments and issues that cannot be resolved definitively. The use of multi-criteria decision-making (MCDM) methods as a practical and decision-supporting tool allows managers to examine decision-making issues in various organizations and industries based on various criteria, alternatives, and objectives and make decisions with greater reliability. The use of fuzzy techniques and concepts in MCDM methods and their mathematical relationships makes it possible to consider complexities and uncertainties in decisions related to various issues and it can lead to better and more realistic decisions. In this paper, the simplified best-worst method (SBWM), which is one of the methods

based on pairwise comparisons, has been developed using triangular fuzzy numbers (TFNs) to propose a fuzzy extension of SBWM (F-SBWM). Triangular fuzzy numbers in different symmetric and asymmetric forms have widely been used in MCDM approaches and pairwise comparisons. It is noteworthy that symmetric numbers are used when we are using equal division of the domain due to an increased ambiguity and lack of information. The proposed approach as a simplified fuzzy MCDM method helps managers and decision makers in various industries to solve decisionmaking problems under uncertainty without the need for complex calculations, specialized skills, and software packages. To check the feasibility and applicability of the proposed approach, two numerical examples and a computational experiment with real data are presented, and the results are analyzed and discussed. Furthermore, to check the robustness of the results obtained from the proposed approach, sensitivity analysis and comparison of methods have been performed.

Deb, P., Bhattacharya, D., Chatterjee, I., Chatterjee, P., & Zavadskas, E. (2023). An Intuitionistic Fuzzy Consensus WASPAS Method for Assessment of Open-Source Software Learning Management Systems. *INFORMATICA*, *34*(3), 529–556. <u>https://doi.org/10.15388/23-INFOR523</u>

# Abstract

Ineffective evaluation of open-source software learning management system (OSS-LMS) packages can negatively impact organizational effectiveness. Clients may struggle to select the best OSS-LMS package from a wide range of options, leading to a complex multi-criteria group decision-making (MCGDM) problem. This evaluates OSS-LMS packages based on several criteria like usability, functionality, e-learning standards, reliability, activity tracking, course development, assessment, backup and recovery, error reporting, efficiency, operating system compatibility, computermanaged instruction, authentication, authorization, troubleshooting, maintenance, upgrading, and scalability. Handling uncertain data is a vital aspect of OSS-LMS package evaluation. To tackle MCGDM issues, this study presents a consensus weighted sum product (c-WASPAS) method which is applied to an educational OSS-LMS package selection problem to evaluate four OSS-LMS packages, namely ATutor, eFront, Moodle, and Sakai. The findings indicate that the priority order of alternatives is Moodle > Sakai > eFront > ATutor and, therefore, MOODLE is the best OSS-LMS package for the case study. A sensitivity analysis of criteria weights is also conducted, as well as a comparative study, to demonstrate the effectiveness of the proposed method. It is essential to note that proper OSS-LMS package evaluation is crucial to avoid negative impacts on organizational performance. By addressing MCGDM issues and dealing with uncertain information, the c-WASPAS method presented in this study can assist clients in selecting the most appropriate OSS-LMS package from multiple alternatives. The findings of this study can benefit educational institutions and other organizations that rely on OSS-LMS packages to run their operations.

Ghasemi, M., Mousavi, S., Aramesh, S., Shahabi-Shahmiri, R., Zavadskas, E., & Antucheviciene, J. (2023). A new approach for production project scheduling with time-cost-quality trade-off considering multi-mode resource-constraints under interval uncertainty. *INTERNATIONAL JOURNAL OF PRODUCTION RESEARCH*, 61(9), 2962–2984. https://doi.org/10.1080/00207543.2022.2074322

# Abstract

Due to today's competitive environment and information boom, companies are concerned about production planning in uncertain conditions. This paper integrates decision-making method with production scheduling model by considering limited resources. In this paper, a new mathematical

model is extended for production project scheduling with multiple execution modes. The main aim of the formulation is to plan and schedule real production projects in uncertain environments. A new mixed-integer linear formulation is presented by considering trade-off of cost, time, as well as quality. Cost-time-quality trade-off is extended with the interval information. In the presented model, activity quality could be enhanced by reworking. The interval forms of some parameters, including duration, quality of activities, cost, and total available resources, are obtained by determining weights of experts and aggregating them. The presented group decision-making method is based on a bi-directional projection measure to deal with interval information. Since the mathematical model is multi-objective and some data are interval, a new modified solution method is developed for solving the model. The presented method for both decision-making and mathematical models is investigated by a real-world production project and two datasets to ascertain the accuracy of the model. Finally, an appropriate sensitivity analysis is proposed.

Jovanovic, S., Zavadskas, E., Stevic, Z., Marinkovic, M., Alrasheedi, A., & Badi, I. (2023). An Intelligent Fuzzy MCDM Model Based on D and Z Numbers for Paver Selection: IMF D-SWARA-Fuzzy ARAS-Z Model. *AXIOMS*, *12*(6). <u>https://doi.org/10.3390/axioms12060573</u>

# Abstract

One of the most important challenges when building road infrastructure is the selection of appropriate mechanization, on which the efficiency of construction and the life of exploitation depends largely. As construction machinery, pavers occupy a significant place in civil engineering projects, so their selection, depending on a road category, is a very important activity. The objective of this paper is to develop an intelligent Fuzzy MCDM (Multi-Criteria Decision-Making) model, which consists of the integration of D and Z numbers for the selection of construction machinery. The IMF D-SWARA (Improved Fuzzy D Step-Wise Weight Assessment Ratio Analysis) method was used to determine weighting coefficients. A novel Fuzzy ARAS-Z (Additive Ratio Assessment) method has been developed to determine an adequate paver for a lower category of roads (asphalt width up to 5 m), which represents an important contribution and novelty of the paper. A total of 10 alternatives were evaluated based on 16 criteria which were classified into 4 main groups. The results have shown that the alternative A8—SUPER 1300-3 represents a paver with the best characteristics for the considered set of parameters. After that, verification tests were calculated, and they include a comparative analysis with four other MCDM methods based on Z numbers, a change in the normalization procedure, and the impact of changing the size of an initial fuzzy matrix. The tests showed the stability of the developed model with negligible deviations.

## Abstract

Hydrogen is the new age alternative energy source to combat energy demand and climate change. Storage of hydrogen is vital for a nation's growth. Works of literature provide different methods for storing the produced hydrogen, and the rational selection of a viable method is crucial for promoting sustainability and green practices. Typically, hydrogen storage is associated with diverse sustainable and circular economy (SCE) criteria. As a result, the authors consider the

Krishankumar, R., Sundararajan, D., Ravichandran, K., & Zavadskas, E. (2023). An Evidence-Based CoCoSo Framework with Double Hierarchy Linguistic Data for Viable Selection of Hydrogen Storage Methods. *CMES-COMPUTER MODELING IN ENGINEERING & SCIENCES*. https://doi.org/10.32604/cmes.2023.029438

situation a multi-criteria decision-making (MCDM) problem. Studies infer that previous models for hydrogen storage method (HSM) selection (i) do not consider preferences in the natural language form; (ii) weights of experts are not methodically determined; (iii) hesitation of experts during criteria weight assessment is not effectively explored; and (iv) three-stage solution of a suitable selection of HSM is unexplored. Driven by these gaps, in this paper, authors put forward a new integrated framework, which considers double hierarchy linguistic information for rating, criteria importance through inter-criteria correlation (CRITIC) for expert weight calculation, evidence-based Bayesian method for criteria weight estimation, and combined compromise solution (CoCoSo) for ranking HSMs. The applicability of the developed framework is testified by using a case example of HSM selection in India. Sensitivity and comparative analysis reveal the merits and limitations of the developed framework.

Lai, H., Wu, Z., Zhang, X., Liao, H., & Zavadskas, E. (2023). A method for product appearance design evaluation based on heterogeneous data. *ADVANCED ENGINEERING INFORMATICS*, *57*. https://doi.org/10.1016/j.aei.2023.102089

## Abstract

The eye-tracking and electroencephalogram data, as physiological information, have been viewed as effective supplements to subjective reporting for guiding the product appearance design. In this context, how to combine heterogeneous information is a challenging question. This study proposes different methods to determine subjective and objective weights of criteria regarding the self-reporting, eye-tracking, and electroencephalogram data for the evaluation of product appearance design. We introduce the probabilistic linguistic term set with interval uncertainty (IUPLTS) to represent complex self-reporting data, and develop a method to aggregate IUPLTSs. An algorithm is proposed to fuse physiological data on the data layer and feature layer. To combine the obtained heterogeneous information, we define an objective weighting method that examines the differences in indicator data and the correlation between indicators, and then use a level difference maximization model to fuse subjective and objective weights. To ensure the stability of decision-making results for the problem involving a large number of indicators, we use the Measurement of Alternatives and Ranking according to the Compromise Solution (MARCOS) to rank alternatives. An example regarding the evaluation of automobile appearance design schemes is presented to show the validity and practicality of the proposed method. The prototype support system of the proposed method has been developed and is freely available at https://github.com/BitSecret/DAQQSO.

Petrovas, A., Bausys, R., & Zavadskas, E. (2023). Gestalt Principles Governed Fitness Function for<br/>Genetic Pythagorean Neutrosophic WASPAS Game Scene Generation. INTERNATIONAL JOURNAL<br/>OF<br/>COMPUTERS<br/>COMMUNICATIONS<br/>CONTROL, 18(4).<br/>https://doi.org/10.15837/ijccc.2023.4.5475

# Abstract

The maintenance of visual appeal and coherence in the procedural game scene generation is still a difficult problem. Traditional procedural game scene generation algorithms produce samples that show a noticeable resemblance to each other. The proposed algorithm allows us to add diverse game object compositions and increase creativity value in that way. Result diversity is formed by the proposed genetic algorithm modification and MCDM method based on the fitness function. Video game immersion is reached by aesthetic game element pattern composition, and one of the solutions for this issue is to apply automated aesthetic modelling of the generated game levels. In this research, the construction of fitness function was extended by the modelling of aesthetic principles, which were reverse-engineered from Gestalt principles. All rules were implemented by construction of a focal function with a square zone for each matrix cell of the single game scene. Five types of Gestalt rules were modelled and combined into a Pythagorean neutrosophic WASPAS method and the final score calculation algorithm was proposed. The proposed approach to generating game scenes strikes a balance between functionality and aesthetics to provide players with an engaging and immersive gaming experience.

# *New scientific papers*

# The list presents papers co-authored by the members of EWG-ORSDCE and published in 2023 only in journals with IF.

- Alrasheedi, A., Mishra, A., Rani, P., Zavadskas, E., & Cavallaro, F. (2023). Multicriteria group decision making approach based on an improved distance measure, the SWARA method and the WASPAS method. *GRANULAR COMPUTING*, 8(6), 1867–1885. <u>https://doi.org/10.1007/s41066-023-00413-x</u>
- Al-Refaie, A., & Lepkova, N. (2023). A Proposed DEA Window Analysis for Assessing Efficiency from Asymmetry Dynamic Data. *SYMMETRY-BASEL*, 15(9). https://doi.org/10.3390/sym15091650
- Al-Refaie, A., Abu Hamdieh, B., & Lepkova, N. (2023). Prediction of Maintenance Activities Using Generalized Sequential Pattern and Association Rules in Data Mining. *BUILDINGS*, 13(4). <u>https://doi.org/10.3390/buildings13040946</u>
- Al-refaie, A., Al-hawadi, A., Lepkova, N., & Abbasi, G. (2023). BLOCKCHAIN OF OPTIMAL MULTIPLE CONSTRUCTION PROJECTS PLANNING UNDER PROBABILISTIC ARRIVAL AND STOCHASTIC DURATIONS. JOURNAL OF CIVIL ENGINEERING AND MANAGEMENT, 29(1), 15–34. https://doi.org/10.3846/jcem.2023.17927
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- Amiri, M., Hashemi-Tabatabaei, M., Keshavarz-Ghorabaee, M., Kaklauskas, A., Zavadskas, E., & Antucheviciene, J. (2023). A Fuzzy Extension of Simplified Best-Worst Method (F-SBWM) and Its Applications to Decision-Making Problems. *SYMMETRY-BASEL*, 15(1). https://doi.org/10.3390/sym15010081
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- Ashrafzadeh, M., Taheri, H., Gharehgozlou, M., & Zolfani, S. (2023). Clustering-based return prediction model for stock pre-selection in portfolio optimization using PSO-CNN plus MVF. *JOURNAL OF KING SAUD UNIVERSITY-COMPUTER AND INFORMATION SCIENCES*, 35(9). <u>https://doi.org/10.1016/j.jksuci.2023.101737</u>
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# Recently finished and ongoing research projects

# The competences employees will need to meet the EU 2030 sustainable development goals



# Violeta Motuzienė, Genrika Rynkun, Artur Rogoža, Edita Šarkienė, Tatjana Vilutienė

We have reached the point when the world needs to respond to the climate and biodiversity crises, and we are the last generation that can still do something. This decade is a critical juncture where our commitments under the Paris Agreement for the health, well-being and prosperity can be achieved. Setting an example, the EU has set ambitious targets to reduce net emissions by at least 55% below 1990 levels by 2030 and to become the first climate-neutral continent by 2050. These targets are no longer aspirations or ambitions, but obligations set out in Europe's first climate law, opening up new opportunities for innovation, investment and job creation<sup>1</sup>.

The buildings and construction sector accounts for around 36% of final energy consumption and 39% of energy and process-related carbon dioxide (CO<sub>2</sub>) emissions, including 11% from the production of building materials and products such as steel, cement and glass<sup>2</sup>. The buildings sector still has significant untapped potential for energy savings and emissions reductions, but achieving the EU's ambitious targets will require more than legislation or policy documents - it will require the people who work in the sector. Driving change and decarbonising the buildings sector requires both skilled workers and high-level professionals, who already need new skills.

Since 2011, the European Commission has been running the BUILD UP Skills strategic initiative under the Intelligent Energy - Europe programme. The initial aim of this initiative was to increase the number of trained and skilled construction professionals across Europe to carry out highly energy efficient building renovations and construct new near zero energy buildings. As the European Union's policy ambitions for 2030 have evolved, technological advances, economic transformation and societal change have led to a broadening of the main objective of Build Up Skills.

LIFE-CET-2021-BUILDSKILLS initiative includes projects taking place in Austria (<u>ReBUSk</u>), Bulgaria (<u>BUILDUPSkillsBG</u>), Croatia (<u>CRO skills RELOAD</u>), Czech Republic + Slovakia

<sup>&</sup>lt;sup>1</sup> <u>https://eur-lex.europa.eu/legal-content/LT/TXT/HTML/?uri=CELEX:52021DC0550&from=EN</u>

<sup>&</sup>lt;sup>2</sup> https://www.iea.org/reports/global-status-report-for-buildings-and-construction-2019

(DoubleDecker), France (BUS2 FRANCE), Greece (REGROUP), Hungary (ConstructSkills4LIFE), Ireland (BUSI2030), Lithuania (REBOOT-SKILLS-LT), The Netherlands (BUS-NL), Poland (BUPS Poland), Romania (BUS4RoBOOST), Spain (Construye 2030). In Lithuania, the BuildUpSkillsLT2030 project is currently being implemented under the leadership of the Lithuanian Builders' Association (LBA) with the participation of Vilnius Gediminas Technical University (VILNIUS TECH) together with Kaunas University of Technology (KTU), the Construction Sector Development Agency (SSVA) and the Regional Innovation Management Centre (RIMC).

The <u>REBOOT-SKILLS-LT</u> project aims to renew the platform connecting the construction sector stakeholders' competence development organisations in Lithuania (employers' and employees' organisations, education and training centres, public authorities) and, following an analysis of the current situation, to develop a national action plan (Roadmap) to prepare the participants in the building construction sector for the above-mentioned market shifts. The new trends in the building sector go beyond energy efficiency and renewable energy sources. There is an emerging need for competences in the construction sector related to the sustainability of buildings in a broader context, both in terms of buildings and in terms of competences related to the whole life cycle of a building and its environmental impact.

# **Relevant competences for the buildings sector in 2030**

The project's analysis identified 12 competency areas for sustainable building that will be needed to achieve the 2030 goals:

- Digitalisation of the construction process and Building Information Modelling (BIM);
- *Applying energy conservation/efficiency measures in buildings;*
- Integration of renewable energy technologies in buildings;
- Sustainable renovation of building structures and their technical systems;
- Construction of zero energy and zero emission buildings;
- *Making buildings (new and existing) smarter (automation);*
- Green procurement;
- *Renovation of heritage buildings;*
- Building Management Systems (BMS) and their data analysis;
- Life cycle analysis of buildings and their components;
- *Recycling and reuse of materials (circular construction);*
- Application of modular (prefabricated) building structures.

# Market research

In order to identify the needs of workers and professionals in the construction sector, a survey was carried out among participants in the construction sector (broadly defined), including companies involved in the whole life-cycle of a building, such as its design, construction, installation, engineering, maintenance, supply of materials, energy performance assessment, etc. (123 representatives of companies in managerial positions participated).

Looking ahead over the next five years, employers have assessed the need for their workforce to be competent in the following areas of sustainable construction (Figure 1). On a scale of 1 to 5 (in order of importance), competences related to the following areas had the highest relevance: digitisation of the construction process and building information modelling (e.g. BIM), application of energy conservation/efficiency measures in buildings, integration of renewable energy technologies (RES) in buildings, sustainable renovation of building structures and technical systems (for energy and environmental benefits), construction of zero energy buildings (NZEB) and zero emission buildings (ZEB). In general, there is no significant difference in importance between the different areas and the need is evident in all of them.

When assessing the shortage of occupations needed for sustainable construction in the market over the next 5 years, at least 30% of employers indicated that they would need automation and electronic systems installers, building construction workers (using innovative materials), building insulation/thermal insulation installers, solar cell system installers, heat pump system installers, HVAC system installers.





Figure 1. The need for workforce skills in sustainable construction

When employers were asked (Figure 2) what measures would be most likely to encourage their employees to acquire the missing competences related to sustainable construction (up to a choice of three measures), more than 30% of employers identified four main measures: Support for training of professionals/availability of additional funding for training, Support for training of blue-collar professions/availability of additional funding for training, Increased opportunities for distance learning, and the emergence of competitive, market-ready training.

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Support for training of blue-collar professions/availability of additional funding for training

- Increased opportunities for distance learning
- The emergence of competitive, market-ready training
- Increased dissemination of information
- Compulsory certification of employers
- Increasing the market uptake of the Builder's Card as a tool for comparability of competences (www.statreg.lt)
- No suitable answer options
- Other (please specify)

# **Figure 2.** Measures that would most encourage employees to acquire the missing competences related to sustainable construction (distribution of responses)

In response to the question (Figure 3) on what measures would encourage women to enter the construction sector, the four main answers chosen by employers were: equal pay for men and women, promotion of a higher work culture in the team, education of young people about the opportunities for women to work in the sector, and more favourable working conditions for mothers with children.





Recently, fewer and fewer graduates are choosing to study engineering, and this is a global trend. The survey sought to find out what would make young people more interested in sustainable construction. The 3 main answers chosen by employers were (Figure 4): including engineering studies in the list of national priority specialisations with additional financial support for students; encouraging traineeships, internships in construction companies; showcasing modern construction tools (drones, digital twins, BIM models, etc.) at exhibitions and other youth events and distributing free invitations. And only 2% of employers indicated that there are no such measures.

The market needs survey was followed by interviews with selected representatives of the participating enterprises. The purpose of the interviews was to clarify the relevance of the topic in more detail and to clarify the answers given in the questionnaire. In addition, the questionnaire was designed to summarise attitudes towards training needs, identify problems, collect suggestions and recommendations, and identify opportunities and obstacles. The interviews focused on the knowledge and skills of existing and new recruits from training institutions in the areas analysed in the project (BIM, energy efficiency, green procurement, etc.), the choice of training method, and how company managers assess the knowledge and skills of existing workers and professionals. It also asked about the impact of changes in the market on the development of competences in sustainable construction.



# **Figure 4.** Measures that would be most likely to increase the involvement of young people in the sustainable construction sector (distribution of responses)

The interviews revealed a lack of knowledge of engineering and legal regulations in the construction sector, of new materials and systems, of general engineering skills (e.g. blueprint

reading), of skills in working with specific equipment and of the ability to apply the knowledge acquired in practice. Interviewees stressed that the abolition of the certification of design firms has not been beneficial as the quality of design has deteriorated significantly. It was mentioned that there is a shortage of specialists with interdisciplinary knowledge, there is a need for specialists who are able to combine construction engineering knowledge with IT knowledge, there is a need for specialists who have knowledge of civil engineering and building engineering systems (+AEI), there is a need for procurement managers who know how to use the BIM model, there is a shortage of programmers who know HVAC systems, there is a shortage of sustainability of the solutions, and there is a lack of procurement specialists and construction managers. Master craftsmen lack digital skills, knowledge of reading BIM models.

There is currently a shortage of professionals in construction and other sectors in Lithuania. The shortage of engineering professionals has also been confirmed by a forecast by LINPRA, the Lithuanian Association of Engineering and Technology Companies, which predicts that more than 12,000 new jobs will be created in the engineering industry by 2025. The demand for engineering professionals is expected to grow 2-3 times annually, with an even stronger acceleration in the future.

The Roadmap is being developed in the light of the analysis of the current situation and the needs and observations of market players. To this end, consultation events with stakeholders are taking place, and five meetings have already been held so far with representatives of enterprises, research and studies, vocational training centres and public authorities. Each meeting has been attended by more than 50 representatives of various companies and institutions, working in groups to assess trends in the development of the sector, to develop future scenarios and to identify the needs for new professions and competences throughout the life cycle of buildings.

In Q1 2024, as a result of the project, a roadmap will be developed and published, which will provide concrete measures to reduce the skills gap in the field of sustainable building and to meet the needs of the market and the changing environment.

No.	Programme	Project	Short	Date	Responsible
			name	from -	person (project
				to	manager
1	HORIZON2020	BIM based tools for fast & efficient	BIM4REN	2018-	Prof. Habil. Dr.
		renovation		2022	Artūras
		https://bim4ren.eu/			Kaklauskas
2	Erasmus+	Integrating education with consumer	BECK	2018-	Prof. Habil. Dr.
		behaviour relevant to energy efficiency		2022	Artūras
		and climate change at the Universities of			Kaklauskas
		Russia, Sri Lanka and Bangladesh			
		http://beck-erasmus.com/			
3	Erasmus+	Minimizing the influence of coronavirus	MICROBE	2020-	Prof. Habil. Dr.
		in a built environment		2023	Artūras
		http://microbe-erasmus.vilniustech.lt/			Kaklauskas
4	HORIZON2020	Regeneration and Optimisation of	ROCK	2017-	Prof. Habil. Dr.
		Cultural heritage in creative and		2021	Artūras
		Knowledge cities			Kaklauskas
		https://rockproject.eu/			
5	HORIZON2020	Students Achieving Valuable Energy	SAVES2	2017-	Prof. Dr. Audrius
		Savings		2021	Banaitis
		https://saves.unioncloud.org/articles/w			
		elcome-to-saves2			

# PhD Dissertations defended during 2023

Robertas KONTRIMOVIČIUS PHOTOGRAMMETRY-BASED MODEL FOR THE OPTIMISATION OF CONSTRUCTION-SITE PLANNING



### Supervisor

Prof. Dr Habil. Leonas USTINOVIČIUS

### **Object of the dissertation**

The object of the study is a construction site in a BIM environment, assessing the need for construction mechanisms, temporary infrastructure (access roads, storage areas, temporary engineering systems, fencing, etc.) and spatial planning, using photogrammetry technology.

### Aim of the dissertation

The dissertation aims to improve the planning of construction sites by creating an optimised planning methodology for construction sites using photogrammetry. Using it, the automated determination of the need for construction mechanisms, devices, and temporary objects is performed, and the analysis of alternatives for the organisation of optimised construction site plans is accelerated.

### Formulation of tasks of the dissertation

The following tasks are solved to achieve the aim:

- 1. To perform an analysis of mathematical models in the scientific literature, which examines the installation of the construction site, to calculate the need for construction mechanisms and temporary infrastructure.
- 2. To perform an analysis of software, the specifics of which are construction planning. Determine whether the software is capable of not only a visual representation of construction mechanisms and temporary infrastructure but also whether- the software has an integrated mathematical algorithm for determining the need.
- 3. To create an algorithm for the mathematical model of construction mechanisms and the need for temporary infrastructure.
- 4. To conduct a case study of photogrammetry technology, i.e., to create a photogrammetric model of the building and determine the accuracy of the photogrammetric model.
- 5. To perform a graphic representation of the desired result of the created mathematical model an optimised construction site plan, using photogrammetry.

## Research methodology

When preparing the dissertation and scientific articles, the analysis of scientific sources from foreign countries and Lithuania is applied. Research methods such as data comparison, grouping, detailing, multicriteria and optimisation methods, and real application of software are applied in order to achieve the goal of the work. When determining the capabilities of the developed software, the functionality was used, communicating with the software representatives in order to understand the already developed tools as much as possible. The construction site planning methodology defined in the dissertation covers only the field of construction engineering sciences, construction planning and organisation, therefore, the development of a system prototype and performance demonstration typical of the field of informatics engineering sciences is not performed. The dissertation applies photogrammetry technology, which is used to determine the current condition of the construction site.

# The scientific novelty of the dissertation

During the preparation of the dissertation, the following new results were obtained for the field of construction engineering.

- 1. The proposed application of the photogrammetric model, analysing the current situation on the construction site before starting construction work and planning the construction site.
- 2. The algorithm and selection methodology of the mathematical model of construction mechanisms and temporary infrastructure needs was developed, using multicriteria and optimisation methods.
- 3. A mathematical model of construction site planning is proposed, which includes all construction mechanisms and temporary infrastructure necessary for construction planning.
- 4. Proposed and adapted the use of the photogrammetric model, BIM model, and consistency of use in evaluating construction mechanisms, and temporary infrastructure.

## The practical value of the research findings

After creating a mathematical model of an optimised construction site plan using photogrammetry, information technology specialists can create working software. Using the developed software will allow the participants of the construction project to implement the practical activities listed below, which are already relevant today.

- 1. To implement the BIM application cases presented in the initial proposals of the Lithuanian Ministry of Environment regarding the project provisions of the BIM normative documents (Ministry of Environment of Lithuania, 2022), which are specifically related to the planning of construction.
- 2. Implement the requirements of sustainability assessment systems, which are closely related to construction planning.
- 3. Using a mathematically based method to determine the effective need for the necessary construction mechanisms, and temporary infrastructure, using the created BIM model.
- 4. Using a mathematically based method, choose a rational version of the construction site plan, evaluating the current condition of the plot and the project solutions in an automated way.

### **Defended statements**

- 1. The algorithm developed in the mathematical model of the need for construction mechanisms and temporary infrastructure allows us to calculate the need for construction mechanisms and temporary infrastructure.
- 2. The photogrammetric model created for the building and the accuracy determined for the photogrammetric model allows one to analyse the current condition of the construction site using photogrammetry.
- 3. The created mathematical model of the optimised construction site plan allows for complex construction planning, evaluates the current situation of the site, the information of the projected BIM model, and determines the need for all construction mechanisms and temporary infrastructure and their rational arrangement on the construction site.

# Approval of the research findings

Six articles on the dissertation subject were published in scientific journals.

# Danylo SHKUNDALOV INTEGRATION OF BIM, GIS AND WEB ENVIRONMENTS FOR SOLVING MULTIFACETED CONSTRUCTION PROJECT PROBLEMS



### **Supervisor**

Assoc. Prof. Dr Tatjana VILUTIENĖ

### **Research object**

The research object is the integration of BIM, GIS, and Web environments for decision-making in a construction project.

### Aim of the dissertation

The dissertation aims to develop a conceptual model based on the integration of BIM, GIS, Web environments and multi-criteria decision-making methods to allow complex analyses for more efficient solutions in a construction project.

### **Objectives of the dissertation**

To achieve the aim of the dissertation, the following objectives must be reached:

- 1. To conduct the state-of-the-art analysis related to the integration of BIM, GIS, and Web environments.
- 2. To develop a principal solution for relationships between in-model objects in a BIM model representation in the Web environment.
- 3. To develop a method (QUVIAS) for visibility analysis that uses BIM, GIS, and Web environments to mathematically calculate visibility and represent it by quantitative parameters.
- 4. To develop methodological and technological solutions to automate the data collection process in multi-criteria decision-making analysis addressing property attractiveness and building location problems.
- 5. To develop a method for solving the problems of selecting and operating a crane based on the integration of BIM, GIS and Web environments.
- 6. To demonstrate the practical application of the proposed model and methods in case studies. Development of a Web-based spatial decision support system for construction projects

### **Research methodology**

A bibliometric analysis of the state-of-the-art was conducted on the dissertation's topic, including analytical, regression, numerical, scientific theoretical and comparative methods.

Scientific theoretical, comparative and statistical methods were used in the development of the QUVIAS method for the geospatial analysis. Mathematical statistics and comparative methods were used to determine the set of criteria for a building location problem. The criteria significance was determined using the Delphi method. The agreement between the expert judgments was determined using a concordance approach. Fuzzy TOPSIS, fuzzy COPRAS, and fuzzy EDAS methods were applied to select the rational building location. The crane selection- and operation process, as well as the automation of data collection for building location problems, were done based on BIM data and using geospatial analysis and GIS databases, including the QUVIAS method, buffer analysis, and GIS tools. All of the proposed developments were validated and analysed using the case study method. The BIM models were created using Autodesk Revit.

### The scientific novelty of the dissertation

The aspects of scientific novelty in theoretical and experimental investigation of the integration of BIM, GIS, and Web environments are as follows:

- 1. The original conceptual model was proposed for the complex analysis of rational solutions in a construction project with the integration of BIM, GIS, Web environments and multi-criteria analysis.
- 2. A novel method was developed to define relationships between BIM model objects inside the Web environment.
- 3. The new unique method (QUVIAS) was created and validated by a case study. This method determines view quality in terms of quantitative parameters using mathematical calculations based on spherical coordinates and data from BIM and GIS environments within the Web environment.
- 4. A novel approach was proposed based on the QUVIAS method for solving the property attractiveness problem.
- 5. A new method was presented for automating multi-criteria decisionmaking analysis and validated in a case study on building location problems. The method uses data provided by BIM and GIS environments and performs geospatial analysis within the Web environment. A new method for crane selection and operation based on visibility analysis and buffer method was presented and validated in a case study.

### Practical value of the research findings

The presented research proves the usefulness of the BIM, GIS, and Web environment integration by solving problems in the construction project and increasing the accuracy of the decision-making process. The developed methodology for BIM model processing enables the inclusion of BIM models into a geospatial analysis inside the Web environment. The proposed QUVIAS method introduces a mathematical computation of the view. This approach improves the decision-making process by including the view as quantitative criteria in the multi-criteria analysis. The quantitative representation of the view, combined with the BIM model processing, allows for solving the property attractiveness problem and crane selection and operation problems within BIM, GIS, and Web environments. The proposed automated multi-criteria decision-making analysis significantly decreases time consumption and increases the accuracy of the decision-making process. The practical value of the research findings was confirmed by the practical implementation of all the results into a Web-based spatial decision-support system developed in this dissertation. The case-study results confirm the benefits of integrating BIM, GIS, and Web environments and identify the need for further investigation.

The results of this study are related to digitalisation in construction and the introduction of innovations in the construction industry, which can, directly and indirectly, affect the economic sector. The developed spatial decision-support system with methods proposed in this dissertation can support the decisions of municipalities, real estate and project developers for efficient design of the built environment, thus leading to sustainable construction.

### **Defended statements**

- 1. The proposed conceptual model enables the complex analysis of rational solutions in a construction project by integrating BIM, GIS, Web environments and multi-criteria decision-making methods.
- 2. Objects presented in the BIM model within the Web environment can be manipulated and analysed based on the in-model relations.

- 3. The QUVIAS method, proposed by the author, makes it possible to mathematically calculate a view from a window and present it by a quantitative parameter through the integration of BIM, GIS, and Web environments.
- 4. The visibility analysis performed inside the Web environment, based on the data provided by BIM and GIS environments, can improve the crane selection and operation process.
- 5. The integration of BIM, GIS, and Web environments allows for solving the property attractiveness problem.
- 6. The solution for automating multi-criteria analysis using data provided by BIM and GIS inside the Web environment allows fast and accurate estimation of appropriate and rational building location.

## Approval of the research findings

Eight scientific articles were published on the topic of the dissertation.

# Anastasiia VELYKORUSOVA DEVELOPMENT OF A METHOD AND INTELLIGENT DECISION SUPPORT SYSTEM FOR SUSTAINABLE RENOVATION OF THE BUILT ENVIRONMENT



### Supervisor

Prof. Dr Habil. Artūras KAKLAUSKAS

# **Research object**

The object of the dissertation research is the process of creating an analytical recommended method with a knowledge-based decision support system integrated with a multi-layer artificial neural network, proposing an approach that provides obtained data for making decisions and analyzing all life cycles of it.

# Aim of the dissertation

To develop the intelligent decision support system for the sustainable renovation of a built environment by applying a framework, set of steps and methods for the collection, measurement and analysis of data on physiological and emotional state, economic and social criteria in a human-centred built environment.

## **Objectives of the dissertation**

To achieve the goal of the work, the following tasks are solved at work:

- 1. To conduct an analytical survey of the most recent scientific research related to the dissertation.
- 2. To form rational solutions for the stability of the building at the stage of renovation, create a multicriteria analysis of building reconstruction based on the COPRAS method and use FaceReader software and practical use in a real project (case of study, Kyiv, Ukraine).
- 3. To perform a map of the physiological and emotional state of people based on the proposed neurodecision matrix.
- 4. To integrate the affective attitudes of customers and their emotional and physiological state with the help of a decision-making neuromatrix (case of study, Vilnius, Lithuania).
- 5. To apply multi-criteria analysis of video advertising and neuromarketing to different consumer segments in the construction industry using neurodecision tables. And investigate the levels of psychological comfort of end-users.
- 6. To reveal the benefits of integrating decision support systems, fuzzy systems and artificial neural networks in modeling rational solutions for sustainable buildings.

### **Research methodology**

Multi-criteria decision-making (MCDM) means that the crowd makes completely rational decisions (Oses et al., 2018). In MCDM, decisions are usually made without the influence of the emotional state. Subjective research of human emotions in urban contexts has been conducted using qualitative methods i.e., selfreports, and interviews to record people's subjective experiences and explore their emotions.

Objective research of human emotions involved the use of biometric systems and methods such as heart rate variability, body temperature etc. (e.g., Kalantari, 2019; Ergan et al., 2019). More than 200 million data on physiological and emotional states and air and noise pollution were recorded and analysed.

A multi-criteria analysis of the built environment should be prepared using neuro-decision tables and values (e.g., investments, economic aspects, etc.). Thus, the scientific problem expands and deepens compared to previous studies. The research method will promote the development of monitoring human emotions in analyzing the influence of various design parameters on the emotional reactions of stakeholders. This project involves the development of a new set of methods using biostatistical and sensory technologies. The main idea is to integrate virtual space using sensor networks and technologies into the physical world. The results can be used as a modernized type of DSS and can provide a new perspective on current planning processes.

# The scientific novelty of the dissertation

During the preparation of the dissertation, the following new results were obtained for the science of sustainable renovation of a built environment:

- 1. A system of recommendations and big data analysis were integrated into the provided research.
- 2. Multicriteria analysis and decision-making systems, biometric methods and systems are integrated into the process of intelligent and efficient building renovation.
- 3. A multi-criteria methodology for sustainable renovation of a built environment has been proposed and applied in practice.
- 4. The presented system has a decision support system integrated with a multilayer artificial neural network for urban development.

### Practical value of the research findings

The proposed approach and the developed decision support system also can be applied in the different fields of civil engineering, (e.g., construction, environmental, structural, transportation and water resources engineering etc.). The presented methodology can be practically used in two main contexts: scientific and commercial. At the same time, this methodology can assist engineers and architects in the decision-making process of designing a building environment before construction begins, and the implementation of proposed findings leverages significant gains over traditional construction techniques.. The results of this study are related to digitalisation in construction and the introduction of innovations in the construction industry, which can, directly and indirectly, affect the economic sector. The developed spatial decision-support system with methods proposed in this dissertation can support the decisions of

municipalities, real estate and project developers for efficient design of the built environment, thus leading to sustainable construction.

### **Defended statements**

The following statements based on the results of the current dissertation can serve as official hypotheses to be defended:

- 1. Sustainable development should be understood as the integration of environmental, social and economic indicators, and as the holistic creation of a safe, healthy and green built environment.
- 2. The developed system and recommendations for multi-criteria evaluation solutions for green and energy efficient buildings allow for determining the health class of buildings and assessing the risks in housing.
- 3. The developed recommendation system is an effective tool for risk management that allows homeowners, residents and other interested parties to evaluate emerging threats and reduce the possibility of them.
- 4. Developed method and system for sustainable renovation of a built environment enable stakeholders to solve housing issues more accurately, quickly and efficiently

## Approval of the research findings

Four scientific articles were published on the topic of the dissertation.

# Editor's comments

Dear EWG-ORSDCE members, dear friends,

In year 2024 all members of EWG-ORSDCE are welcome to participate in the forthcoming 19<sup>th</sup> Colloquium "Innovative Solutions in Sustainable Construction Management", and 9<sup>th</sup> meeting of EURO working group OR in Sustainable Development and Civil Engineering that will be held on 28-29 of May, 2024 in Poznan University of Technology, Poland. In addition, you are invited to the 33<sup>rd</sup> European Conference on Operational Research (EURO 2024) to be held on 30th June – 3rd July 2024 in Technical University of Denmark (DTU), Copenhagen, Denmark. The papers presented in these meetings are welcome for publishing in scientific journals: *Technological and Economic Development of Economy, Journal of Civil Engineering and Management, Journal of Business Economics and Management, International Journal of Strategic Property Management*, and *Engineering Structures and Technologies*.

On behalf of the Editorial Board of EWG-ORSDCE Newsletter Audrius Banaitis

EWG-ORSDCE Newsletter Editorial Board: Edmundas Kazimieras Zavadskas, Tatjana Vilutienė, Audrius Banaitis