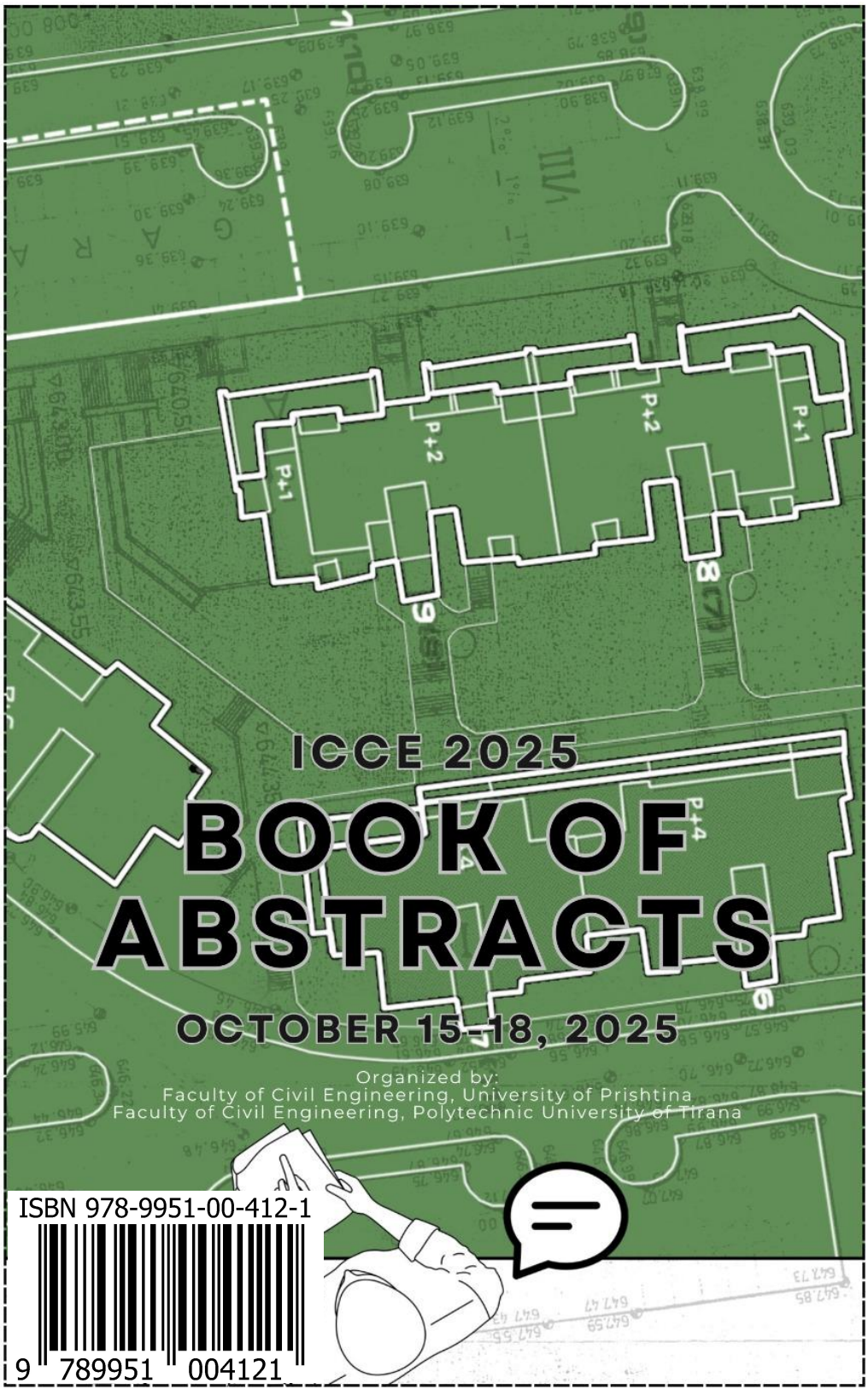
ICCE 2025 | International Conference of Civil Engineering



ICCE 2025

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FOREWORD

It is with great honor and profound pleasure that I welcome you to the International Conference of Civil Engineering 2025 (ICCE2025), co-organized by the Faculty of Civil Engineering at the University of Prishtina and the Faculty of Civil Engineering at the Polytechnic University of Tirana. This gathering represents not only an academic milestone but also a platform where ideas, knowledge, and innovations converge to address the pressing challenges and future opportunities in civil engineering. The Book of Abstracts you now hold is a testament to the dedication, creativity, and intellectual rigor of scholars, researchers, and professionals from across the world. Each contribution reflects the continuous pursuit of excellence in civil engineering and its allied fields, highlighting the role of our discipline in building sustainable, resilient, and inclusive societies. Conferences such as ICCE2025 embody the spirit of collaboration and exchange. They provide an invaluable opportunity for dialogue among academics, industry experts, and students, fostering networks that extend beyond borders and disciplines. I am particularly proud that our faculty is hosting this event, reaffirming our commitment to advancing knowledge, supporting young researchers, and strengthening international cooperation in the engineering sciences. I extend my deepest gratitude to all contributors, keynote speakers, reviewers, organizing committees, and supporting institutions whose commitment and effort have made this conference possible. Your engagement has ensured that ICCE2025 will serve as both a scientific forum and a source of inspiration for future endeavors in civil engineering.

On behalf of the Faculty of Civil Engineering and as Conference Chair, I warmly welcome all participants and wish you fruitful discussions, new collaborations, and an enriching experience throughout this conference.

Sincerely,

Prof. Ass. Dr. Florim GRAJÇEVCI

Dean of the Faculty of Civil Engineering, University of Prishtina .

Conference Chair

On behalf of the Organizing Committee.

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The Relevance of Cartography and the Impact of Artificial Intelligence

Georg Gartner

Technical University Vienna, Austria

INTRODUCTION: CARTOGRAPHY AS A LANGUAGE OF SPACE

Cartography, like language, is a foundational tool through which humanity conceptualizes and communicates its understanding of the world. While language allows humans to express thoughts and narratives across time and space, cartography translates the spatial dimensions of those realities into structured, interpretable forms. Both are systems of symbolic abstraction, central to civilization's development and survival. In the 21st century, cartography remains essential—but its forms and functions are being rapidly transformed by artificial intelligence (AI). This extended abstract examines the enduring relevance of cartography across multiple dimensions and explores how AI is reshaping its production, interpretation, and societal role. We argue that while AI augments the efficiency and scope of cartographic practice, it also introduces critical ethical, epistemological, and geopolitical challenges that must be addressed to ensure equitable and responsible use of spatial technologies.

THE ENDURING RELEVANCE OF CARTOGRAPHY

Just as spoken and written languages are crucial for articulating thought, building community, and transmitting knowledge, cartography serves as a language of space—a semiotic system that allows people to perceive, represent, and act upon their environments. From ancient Babylonian tablets to dynamic satellite interfaces, maps frame reality, transmit knowledge, and influence human behavior. Understanding the parallels between language and cartography foregrounds the latter's continued relevance in an increasingly data-driven society (Gartner 2025).

Practical and Operational Relevance

Cartography is embedded in the infrastructure of contemporary life. Urban planning, transportation networks, environmental monitoring, and public health logistics depend on geospatial data and visualization. The proliferation of smart

technologies has further integrated maps into everyday decision-making—whether through GPS navigation, logistics optimization, or emergency services.

Cognitive and Epistemological Relevance

Maps function as cognitive tools. They support spatial reasoning and shape how people construct knowledge of their environments. Cartographic choices—classification, scale, projection—are epistemological decisions that influence what is seen, emphasized, or erased. As in language, these choices reflect subjectivity and power.

Socio-Political and Strategic Relevance

Cartography has long served as a tool of political authority. Maps delineate borders, define jurisdictions, and assert control. Contemporary cartographic platforms continue to influence elections (e.g., gerrymandering), refugee logistics, and military operations. They are not neutral representations but sociopolitical instruments.

Cultural and Symbolic Relevance

Cartography also has expressive power. It transmits cultural values and identity. Indigenous mapping, counter-mapping, and participatory GIS initiatives show how spatial representation can resist dominant narratives and affirm marginalized perspectives. These practices emphasize the symbolic, narrative, and ethical dimensions of maps.

AI AND THE TRANSFORMATION OF CARTOGRAPHY

Automation and Analytical Capacity

AI systems accelerate map production by automating data classification, feature extraction, and topographic analysis. Algorithms can process satellite and drone imagery far faster than human analysts, enabling continuous updates and finescale resolution (Jobst et al 2021).

Predictive and Real-Time Mapping

AI enables spatial forecasting and adaptive visualization. From flood modeling to real-time traffic systems, AI-infused maps no longer represent static snapshots but dynamic, evolving environments that support anticipatory governance.

Semantic Integration and Accessibility

Natural language processing (NLP) and multimodal AI interfaces allow broader public access to mapping technologies. Users can generate custom maps using

plain-language queries, enabling wider participation in spatial analysis and decision-making.

ETHICAL AND EPISTEMOLOGICAL CONCERNS

Despite its benefits, AI raises significant risks in cartographic applications (Griffin et al. 2025):

- Bias: AI can replicate spatial inequities if trained on biased data sets, excluding marginalized regions or misrepresenting demographics.
- Opacity: AI-generated maps often lack transparency about how visualizations are produced, complicating attribution and accountability.
- Surveillance: Real-time geospatial tracking can erode privacy and civil liberties.
- Geopolitical Control: Major platforms (e.g., Google Maps, Baidu) can enforce contested territorial claims and restrict alternative representations.

These concerns demand ethical oversight, transparent methodologies, and participatory frameworks.

TOWARD A HUMAN-CENTERED CARTOGRAPHIC FUTURE

The role of the cartographer is shifting from technical draftsman to interdisciplinary mediator. Ethical AI-infused cartography must integrate spatial science with critical thinking, social justice, and user-centered design. Future developments may include:

- Augmented and virtual reality mapping
- Emotionally responsive maps for crisis navigation
- Decentralized, open-source mapping platforms
- Participatory AI training for community cartography

AI should not replace human agency in mapping but extend its reach—grounded in equity, inclusivity, and truth.

Conclusion

Cartography, like language, continues to shape how humans understand, organize, and navigate the world. In the digital era, its relevance is heightened by new technologies, especially artificial intelligence. While AI brings efficiency and innovation to cartographic processes, it also demands a renewed ethical commitment. We must critically examine who maps, what is mapped, and for

whom maps are made. Only then can AI serve as a tool for empowerment and spatial justice in an increasingly complex world.

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Mitigating the Impact of Climate Change on Drought: The Potentiality of a Precipitation Enhancement Project. [Example: Project DAPHNE – Thessaly, Greece]

Theodore S. Karacostas

Department of Meteorology and Climatology, School of Geology, Faculty of Sciences, Aristotle University of Thessaloniki, Thessaloniki, Greece.

The project DAPHNE aims at tackling the problem created from the impact of climate change and the continued increase in water needs for urban and agricultural use, which have largely exhausted the water supplies in the most vital agricultural area of Greece, Thessaly, by scientific means of Weather Modification. The Thessaly plain is known to be a vital agricultural area in Greece, and thus the weather and climate play a very important role in its socio-economic status. Anthropogenic climate change is expected to further deteriorate the problem of drought and water shortage, posing a serious threat in human and agricultural activities. Thus, it appears to be a necessity to investigate the potential impact of present weather and climate change on drought, in order to suggest effective ways of tackling the already existing -and for sure- future problem.

Taking into consideration the aforementioned, the main objective is the development of a Conceptual Model, through the necessary scientific tools, to support the potentiality and applicability of a well-designed precipitation enhancement program, to investigate its importance and assess thoroughly the impact of its implementation on the environment. This integration of all the well-known contemporary scientific components stems to a very comprehensive state-of-the-science modulation, in the form of a Conceptual Model, emerging throughout the analyzed and studied data information. Some of these components are: the use of the state-of-the-art WRF numerical model with sophisticated microphysical parameterizations, the adaptation of the 3D cloud model for performing simulations of cloud seeding experiments, the radar information from the C-band (5-cm) weather radar through the TITAN algorithm, the conduction of instrumented aircraft flights for in-situ measurements and to carry out actual cloud seeding experiments on suitably chosen appropriate clouds.

The database of the project DAPHNE includes: a) surface observations from the available meteorological stations, b) radiosonde data from the airport of Thessaloniki, c) weather radar images received and analyzed from the C-band

weather radar, d) specially equipped aircraft measurements, e) meteorological data from the Larissa weather station for a period of 60 years (1950-2010), f) weather charts of daily analyses from ECMWF at 500 hPa at 1200 UTC, for the 10-year period 2001-2010, g) gridded analyses from the ECMWF/IFS system for the period 2001-2010, h) gridded projections of RegCM3 regional climate model (25km x 25km) carried out during ENSEMBLES project under the IPCC scenario A1B, for the period 2041-2050, i) chemical samples of soil and water from the seeded and unseeded areas, for environmental impact assessment studies.

The project DAPHNE integrates all contemporary components to invent the most comprehensive state-of-the-science results. These components include the use of the state-of-the-art Weather Research and Forecasting (WRF) numerical model at very high resolution (1km x 1km), considering the different types of hydrometeors through sophisticated microphysical parameterizations, the adaptation and redevelopment of a 3D cloud model for performing simulations of seeding material dispersion, and high-performance research-seeding aircraft. It is the first time that these state-of-the-art tools and aircraft observations are combined to create the fundamental principles for the development of the Conceptual Model that define the feasibility potential of a rain enhancement program in Thessaly. The conceptual model will define if, when, where and how a precipitation enhancement program would be applicable over the examined area. It sets the spatial, temporal and meteorological conditions that must be met, so as cloud seeding of appropriate cloud types will be feasible, aiming in precipitation enhancement and mitigation of drought in the examined area of Thessaly.

The non hydrostatic WRF model with the Advanced Research (WRF-ARW) dynamic solver is installed on a parallel computing platform (cluster) and all the necessary pre and post-processing modules have been created. It was configured using telescoping nesting and focusing within the area of interest. Three interactive model domains (2-way nested) cover Europe, Greece and the wider area of Thessaly, at horizontal grid-spacing of 15kmx15km, 5kmx5km and 1kmx1km, respectively, utilizing the staggered Arakawa C grid. Fine-resolution data (30”x30”) were used in the definition of topography and land use. The initial and boundary conditions of the coarsest domain are optionally provided by: a) the NCEP/GFS analyses and forecasts, b) the ECMWF/IFS analyses and c) the RegCM3 regional climate model. The sea-surface temperatures are provided daily by NCEP at a horizontal resolution of 1/12°x1/12°, ECMWF analyses or by the RegCM3 fields. The NCEP SSTs are produced on a daily basis through the

assimilation of the most recent 24-hours sea-surface observations and satellite SST measurements. In the vertical, 39 sigma levels (up to 50 hPa) with enhanced resolution at the boundary layer are used by all nests. The Goddard scheme, the Betts-Miller-Janjic scheme, the RRTMG, the Monin-Obukhov (Eta), the Mellor-Yamada-Janjic and the NOAH Unified model are employed in all nests to represent microphysics, sub-grid scale convection, longwave/shortwave radiation, surface layer, boundary layer and soil physics, respectively. The Goddard microphysical scheme contains separate variables for the calculation of cloud water, rain water, ice, snow and graupel (or hail).

The WRF model is used to produce very high spatiotemporal resolution simulations of the atmospheric conditions in the area of interest and provide the forcing fields to the 3D cloud model, which is applied to representative cases of past/present-weather and future projected conditions, using the actual radiosonde data and the output of the WRF simulations. The cloud model sensitivity to the different sources of input data (radiosonde, WRF) is assessed for the present-weather cases.

Storm characteristics are obtained and identified from weather radar reflectivity images received and analyzed from the C-band weather radar, being located within the area of interest. The cell tracker TITAN has been used to retrieve convective storm tracks and characteristics from radar reflectivity measurements that roughly have 750x750m spatial and 3.5min temporal resolution. The storm characteristics include: initiation time, duration, direction, speed, volume, area and precipitation area, rain rate, maximum reflectivity, cloud top and many more parameters.

The prevailing synoptic conditions in the greater area of central Greece, during the examined 10-year period 2001-2010, have been classified, one by one day, according to the general circulation pattern of the middle troposphere. This information was retrieved by daily analyses of ECMWF at 500 hPa at 1200 UTC. The classification methodology procedure was also adopted for the mid-tropospheric synoptic circulation patterns, projected by RegCM3 regional climate model, under the IPCC scenario A1B, during the period 2041-2050. The resulting daily synoptic circulation patterns are statistically analyzed and compared, in order to investigate the prevailing near-present and future synoptic conditions. To meet the project objectives, representative cases of the near-present and future synoptic conditions are selected for the model simulations.

The core experimental work, during the measurement campaigns, incorporates surface and upper air meteorological measurements, weather radar images and

aircraft flights, conducted by specially instrumented and equipped aircraft, with specialized on the subject pilots, in order to perform in-situ measurements. At the same time, and after meeting pre-specified criteria, cloud seeding experiments are carried out on selected clouds. Chemical samplings of soil and water from the seeded area are conducted, in order to perform the impacts of the study analysis. Sampling from background areas is also taken place for comparison purposes.

It is strongly believed, that it is for the first time, that all these state-of-the-art tools and aircraft observations are combined, in order to create the necessary fundamental principles for the development of the Conceptual Model that will define the feasibility potential and applicability of a rain enhancement program in Thessaly. The Conceptual Model (DAPHNE) will define -if, when, where and how- a precipitation enhancement program would be applicable over the examined area. It sets the spatial, temporal and meteorological conditions that must be met, so that cloud seeding of appropriate cloud types will be feasible, aiming in precipitation enhancement and mitigation of drought in the area of Thessaly, Greece.

The role of supplemental damping systems in optimizing the serviceability performance of tall buildings

Challenges and Lessons Learned

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Over the last two decades, global attention has been focused on the use of innovative supplemental damping systems to mitigate the dynamic effects of wind forces on the serviceability performance of tall buildings. Historically, tall building designers did not consider using damping systems, as this was associated with inferior structural design. However, significant advances in supplemental damping systems have been made, and these systems are now more cost-effective, readily available, and proven to deliver the required performance. They can be effectively incorporated as an integral part of the structural system, in close coordination with the structural and architectural design teams. A notable example of this trend is the exponential increase in the number of supplemental damping systems installed in tall buildings in New York City over the last twenty years (Figure 1).

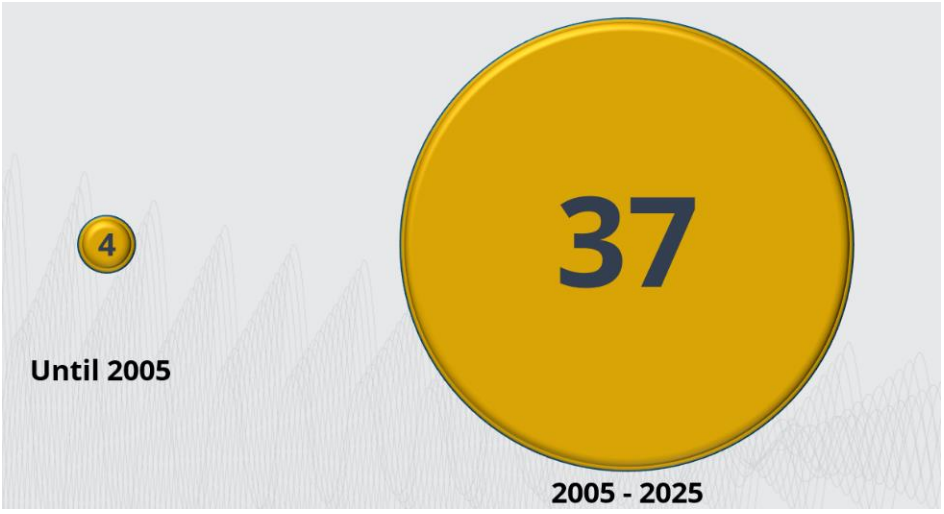

Figure 1: Increasing trend of supplemental damping systems implementation in New York City

Tuned damping systems have proven to be the most viable and cost-effective solutions to reduce wind-induced motions of tall buildings to acceptable levels for occupant comfort. In addition to achieving the target motion comfort performance, the implementation of supplemental damping systems in tall buildings provides additional serviceability performance improvements related to the reduction of inter-story drifts, elevator cable vibrations, and wind-induced creaking noise.

All of the supplemental damping systems implemented in the recently completed tall slender buildings in Manhattan (Figure 2) are tuned mass dampers (TMDs) or Tuned Sloshing Dampers (TSDs). Both of these systems are passive systems that operate without the need for an external power supply and at low maintenance cost.

Figure 2: Supplemental damping systems skyline of Manhattan

While Manhattan is known for its high density of tuned-damping systems implementation to optimize the serviceability performance of tall buildings, other regions worldwide have continuously expanded the use of these systems for mitigating wind-induced motions (Figure 3).

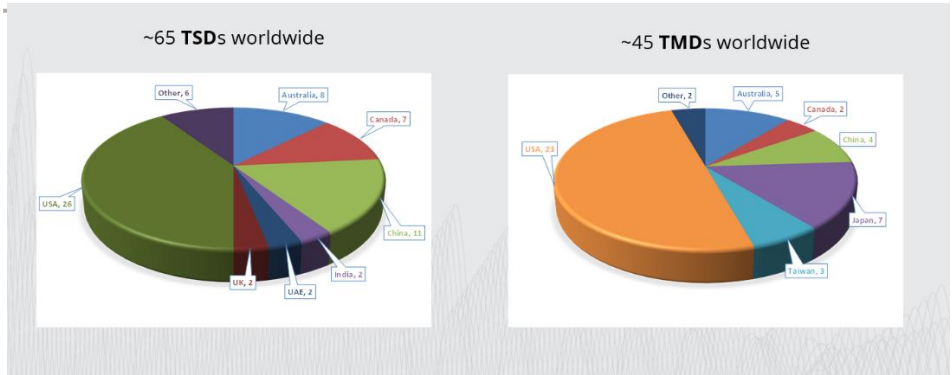

Figure 3: Illustration of the worldwide application of tuned-damping systems

This keynote presentation will focus on the role of supplemental damping systems in optimizing the serviceability performance of tall buildings and will include:

- A brief introduction to wind-design-related issues in tall buildings
- A brief overview of inherent damping in tall buildings and dynamically sensitive structures
- Observations from recent damping measurements in tall buildings
- Impact of excessive wind-induced motions on serviceability performance of tall buildings
- The need for supplemental damping system implementation
- Types of widely used supplemental damping systems for wind-induced motion control
- Examples of post-construction performance verification of supplemental damping systems

The key steps and lessons learned from the implementation of a supplemental damping system in tall buildings will also be discussed.

Keywords: *tall buildings, wind-induced motions, occupant comfort, supplemental damping systems, serviceability performance.*

Constructed wetlands for circular wastewater management: International examples and case studies

Alexandros Stefanakis[1,2]

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[2]*President, International Ecological Engineering Society, CH-8820 Waedenswil, Switzerland*

Today we know that the linear economic model resulted in global environmental issues due to the linear management of resources such as energy, food, and water. Circular economy calls for a shift to a new paradigm of resources management, focusing on the significant limitation of the virgin natural resources consumption and to the drastic reduction of waste production (Nikolaou et al., 2021). In the circular model, the use of finite natural resources is optimized and reaches its maximum efficiency, while the recovery and reuse and/or remanufacturing of materials, components, and products at the end of their life cycle is central in a new design approach. The circular economy is a novel approach that will provide the necessary tools to accelerate the transition to a sustainable society and to tackle climate change-related impacts (Nikolaou et al., 2021; Stefanakis et al., 2021). However, the global circularity index remains at low levels, i.e., 8.6% in 2020 (Circle Economy, 2021), thus there is a lot to do and adapt actions and interventions that would focus not only on decarbonization but also on the restoration of degraded land and water ecosystems, and on a radical change of the design approach for new infrastructure, particularly in the urban environment.

One of the main elements in the transition to a circular economy is to create and implement more sustainable management practices for raw materials, resources, and waste. In the current linear economic model, water is abstracted from natural sources (rivers, lakes, groundwater), consumed in households, industries, agriculture, etc., and finally "returned" to the natural sources directly or after a treatment process. This model, however, created several limitations in the availability of freshwater sources, in addition to the production of wastewater and environmental degradation due to climate and non-climatic changes. The water sector and the management of water resources and mainly wastewater (e.g., rainwater, urban runoff, sewage, industrial effluents) has not attracted the attention it deserves in the context of the circularity principles as is the case for

example for solid waste. In general, it can be said that wastewater (human waste, rainwater, runoff) remains the largest unutilized category of waste, which is, however, characterized as a pillar of the circular economy by the European Commission. Currently, initiatives for wastewater exploitation have been manifested mostly in countries that face more acutely the problem of reduced availability of water resources, due to climatic conditions and climate change. The European Union published in 2020 a new regulation on water reuse with limited application in agriculture. A comprehensive plan for the sustainable and efficient use of wastewater is therefore missing.

Centralized wastewater management in large treatment plants, in which as a rule reuse has not been foreseen and their location is usually prohibitive for the development of such plans, does not promote any circular interventions (Stefanakis, 2020). However, the further adoption of the decentralized wastewater management characterized by the dispersion of smaller treatment facilities within the hydrological basin or the wider urban/peri-urban area would favor not only the use of alternative treatment technologies such as nature-based solutions (NBS), but it would also bring treated water closer to areas where it can be used. Treated wastewater can be recycled and reused multiple times. In a circular economy, it is viewed as a valuable resource. Treated wastewater can be an important new source to the local-regional water balance in terms of both quantity and quality. Therefore, treatment and reuse of wastewater is part of the UN's Sustainable Development Goal 6 to ensure the availability and sustainable management of water and sanitation for all. In order to promote a circular water economy, collection, treatment, and safe reuse of wastewater are needed. In this context, ecological engineering has a key role to play.

In this context, nature-based solutions such as the green technology of Constructed Wetlands are sustainable systems that utilize natural processes. NBS are considered more and more as advantageous solutions for sustainable and cost-effective water and wastewater management. In the transition towards circular economy, proper wastewater management and sanitation are central to water circularity as clean water production, nutrients and materials recovery, and energy production can be integrated in NBS interventions. Circular wastewater management would integrate NBS and effluent reuse to close the loop between water supply and sanitation. Additional services and beneficial interventions that can be part of circularity in the water sector include energy efficiency and recovery of raw materials, treated effluent reuse in irrigation of commercial crops

(Stefanakis et al., 2018), rainwater and greywater use for toilet flushing, car-washing, and garden irrigation (Sgroi et al., 2018), or nutrient recovery.

Since a key circular economy principle is the change of the process itself and not just the reuse of the treated effluent, the implementation of NBS and other ecological engineering advances fulfills this critical principle (Stefanakis et al., 2021). The significant rise of constructed wetland technology over the last two decades indicates that wastewater management can be viewed from a different perspective. The goal of wastewater management strategies is no longer one-dimensional (i.e., treatment), but is further extended to the provision of multiple benefits such as ecosystem services, habitat creation sites, heat island mitigation, wildlife refuges, recreation, and landscaping (Masi et al., 2018; Stefanakis, 2019). Focusing on this point, this abstract provides a series of different case studies from different parts of the world that demonstrate the role of constructed wetlands in promoting circularity in the water sector. The relevant case studies presented cover different scales and countries and come from the

- Czech Republic (mixed wastewater treatment and reuse in crops irrigation, 17 m^3/day),
- Oman (municipal wastewater treatment and reuse, 50 m^3/day)
- UK (municipal wastewater treatment, 1250 m^3/day)
- Mexico (wastewater treatment in constructed wetlands and further treatment to convert it to drinking water, 8600 m^3/day),
- Saudi Arabia (treatment municipal wastewater and reuse, 16,000 m^3/day)
- Brazil (5 CWs treating mine drainage and runoff, >40,000 m^3/day)
- Oman (oily produced water from oil exploration, treatment and reuse for crops irrigation, 175,000 m^3/day).

Keywords: *constructed wetlands; nature-based solutions; water production; wastewater treatment; reuse; circular water management; water scarcity*

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Seismic Vulnerability of RC Residential Buildings: An Empirical Fragility Perspective Informed by the 2023 Earthquake Sequence in Türkiye

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Although earthquakes occur less frequently than other natural disasters, they affect large areas for a long time and cause devastating consequences. Mitigation of destructive consequences is only possible with accurate risk estimations. In this framework, fragility curves expressed as analytical functions are widely used to assess seismic risk. Fragility curves are defined as the probability of reaching or exceeding a damage level for a given building type under a given ground motion intensity. In general, fragility assessment is performed by analytical, empirical, or hybrid methods.

In this study, empirical fragility curves are derived based on post-earthquake damage observation data. In this approach, statistical models are established by using the database containing the data for the buildings obtained as a result of the damage assessment studies carried out after the earthquake. This database may include information such as damage photographs, construction year, number of stories, building type, and geographical coordinates of the building.

The high seismic-intensity earthquakes that have affected Türkiye in recent years have highlighted the seismic fragility of the existing building inventory considered. This fragility has been evidenced by significant loss of life and financial losses due to severe damage to both structural and non-structural components. On 6 February 2023, a sequence of earthquakes, notably Pazarcık (Mw = 7.7) and Elbistan (Mw = 7.6) hit southeast Türkiye. The earthquakes directly affected more than 10 provinces and millions of people.

The Ministry of Environment, Urbanisation and Climate Change conducted a damage assessment immediately after the earthquake. The damage assessment of millions of buildings was carried out in a very short period of time. In this study, seismic damage data of 1,004,221 reinforced concrete buildings in all provinces are investigated by using the database established as a result of damage assessment studies after the Pazarcık (Mw = 7.7) and Elbistan (Mw = 7.6) earthquakes.

Considering that the impact area of the earthquake is enormous, it is reasonable that errors may occur in damage assessments. Therefore, in the first step of the study, the officially determined seismic damage levels of all buildings, were verified and revised by damage photographs which were taken by damage assessment staff. Some buildings were excluded from the assessment due to insufficient evidence to verify or revise the structural damage level (insufficient photographs, lack of data on construction year or number of stories, etc.). When many buildings in the undamaged, slight damaged, and collapsed damage categories were examined, an accuracy close to 100% was observed. Therefore, the re-evaluation of building damage levels through the analysis of damage images was conducted only for the damage classes of to be urgently demolished, heavy damage and moderate damage. Furthermore, within the scope of this study, buildings at the damage level to be demolished immediately were categorised as heavy damage. Since the buildings belonging to both damage classes have lost their pre-earthquake performance capacity to a substantial extent and demolition is a more appropriate option instead of retrofitting. In addition, observations have shown that buildings classified as moderately damaged can generally be repaired economically (and strengthened, if necessary). Therefore, moderately damaged buildings have also been classified as slight damage level. In fact, a significant portion of these buildings have been determined to have slight damage level. As a result of the assessment, a dataset of 976,940 buildings, which are reinforced concrete buildings with intended use for residential purposes, was utilised.

The peak ground acceleration (PGA) and Modified Mercalli Intensity (MMI) at the locations of all buildings were determined using shake maps produced by the ShakeMaps application developed by the United States Geological Survey (USGS).

In general, parameters defining building classes should be selected based on two criteria: (1) impact on seismic damage susceptibility and (2) availability of such information when using fragility curves for seismic fragility assessment. Collecting “number of stories” and “construction year” data from buildings is relatively simple and has an important role in defining a building's seismic behaviour. For the number of stories, buildings with 1-3 stories were classified as low-rise ‘L’, buildings with 4-6 stories as mid-rise ‘M’, and buildings with more than 7 stories as high-rise ‘H’. The construction years were classified into three categories: pre-2000, 2000-2011, and post-2011. The year 2000 marked a significant milestone in building behaviour, primarily due to the awareness raised by the 1999 Kocaeli earthquakes, the implementation of new reinforced concrete

and seismic design regulations, and the widespread use of ready-mixed concrete and ribbed reinforcement. In 2001, the new building inspection law began to be implemented in 19 pilot provinces. The nationwide implementation of the building inspection law in 2011 marked that year as a significant milestone in terms of building behaviour.

Based on these typologies defined as a function of number of stories and construction year, the probability of residential reinforced concrete buildings in all provinces exceeding various damage levels (slight damage, heavy damage, and collapse) were calculated according to the specified construction year and number of stories classification. Using the log-normal cumulative distribution function and maximum likelihood estimation regression technique, which are widely used in the literature, both PGA-based and MMI-based empirical fragility curves were derived. The Py2 goodness of fit test was performed to demonstrate the compatibility of the PGA and MMI-based empirical fragility curves with the observational data. Subsequently, the obtained empirical fragility curves were compared with both analytical and empirical fragility curves proposed in the literature for reinforced concrete structures.

When the results are evaluated, the reassessment showed a two-thirds reduction in heavy damage and a 50% reduction in moderate damage. The cumulative damage distributions showed that damage increased as the number of stories increased, and damages are decreased as the building age decreased. The goodness of fit test showed the MMI and PGA ground motion intensity yielded very similar results with only minor differences. In other words, both ground motion intensities reflected the observational data at the same level of significance. It can be stated that the proposed fragility curves could provide a useful assessment for the seismic fragility evaluation of existing reinforced concrete buildings in Türkiye.

The role of treatment wetlands in rural wastewater management

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Rural wastewater service delivery is a challenge in all countries of the Danube River basin (DRB). Main reasons for this are a lack of financial, technical and staff resources, but also a lack of awareness in society. As all countries in the DRB as all are either EU Member States, Candidate Countries or Potential Candidates, the EU legislation is applicable for the whole DRB. The recast of the EU Urban Wastewater Treatment Directive requires more efforts also in rural areas. Operation and maintenance are key for long-term functioning wastewater treatment systems and thus has to be considered from the start. Local communities should be able to operate and monitor the systems, i.e., technologies that are simple and robust and that have low operation and maintenance requirements and costs are required. Experience shows that treatment wetlands – if properly designed, constructed & operated – can achieve the same (if not a better) treatment level as technical solutions. Treatment wetlands have lower operation and maintenance requirements compared to technological solutions and can be designed for specific ware reuse requirements as defined in the EU Water Reuse Ordinance. Financing rural wastewater solutions poses a significant challenge for countries. Besides investment costs, which are often supported in the form of subsidies, also coverage of costs for operation, monitoring and maintenance needs to be considered. Experience from other countries on successful models can help to develop suitable models for operation, monitoring and maintenance for specific DRB countries, e.g., water and wastewater cooperatives with regional umbrella organisations and/or larger utilities that take over the operation and monitoring of small systems. Capacity building for safely managed rural service is essential. Training of owners/operators is key for operation, monitoring and maintenance and thus to achieve safely managed rural services. The contribution reviews general requirements for sustainable rural wastewater management and presents experiences from Austria as an example how these requirements can be implemented.

Keywords: *operation, monitoring and maintenance; rural wastewater management, service delivery models, treatment wetlands.*

Rare Earth Elements in the city and their relation to landscape features

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The rapid development leads to changes in the environment, including increasing pollution and changes in the landscape. Rare Earth Elements play an important role in the IT industry and their presence in the urban environment is more and more obvious. However, there is little knowledge about contamination in the living organisms in the urban areas and relation to land use, as well as to the landscape characteristics. Our previous studies revealed the possibility of bioindicator function of some herb species. This was especially valid for plants analysed along the roads. We have found some plant species which might be treated as good bioindicators as well as phytoremediators. Moreover, we have analysed the concentrations of REEs in potential sources of primary and secondary emissions, such as asphalt, brake pads and road dust. The other investigators revealed a relation to land use, so the next step was to examine whether it is possible to relate the REEs accumulation in plants and soils to the landscape features of urban areas.

The aim of the last research was to analyse the content of rare earth elements (REEs) and yttrium in soil and Taraxacum officinale in various representative cities for Europe (in term of size, population, specific economic and spatial conditions), as well as to evaluate their content in relation to the land use and landscape. Descriptive statistics and Spearman correlation were performed to identify the relationship between REE and Y content and land use, as well as landscape pattern. The relationship between landscape metrics and analysed elements was more pronounced for dandelion leaves than for roots or soil. However, two landscape metrics – largest patch index and Shannon's diversity index implied that landscape diversity might contribute to reduction of REE and Y content in the environment.

Keywords: *Rare earth elements; plant bioindicators; landscape metrics; contamination of living organisms; phytoremediation.*

Performance-Based Optimisation of Cold-Formed Steel Strap-Braced Wall Systems in Seismic Regions

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Light steel-framed buildings with cold-formed steel (CFS) profiles are widely used in low- to mid-rise construction, where CFS strap-braced frames serve as the main lateral force-resisting system. This study focuses on the seismic behaviour of CFS strap-braced walls, in which studs are optimised as column and beam–column elements to enhance both seismic performance and design efficiency. A reference cross-section derived from commercially available profiles is selected and subsequently optimised to maximise load-bearing capacity while satisfying market availability and standard design constraints. Two distinct finite element (FE) models are developed for the walls, incorporating either conventional or optimised sections for both chords and studs. The role of the P-Delta effect, often overlooked in conventional CFS strap-braced wall design, is examined by applying varying gravity load levels corresponding to the total compressive strength of the commercially available stud and chord sections. Seismic performance is assessed by verifying compliance with maximum allowable drift limits while avoiding premature failures induced by P-Δ effects in the chord studs. The outcomes of this research provide a framework for optimising CFS strap-braced frames, offering improved ductility, safety and stability, and supporting the advancement of seismic design strategies for CFS systems in earthquake-prone regions.

Keywords: *Cold-Formed Steel, Strap-Braced Wall, Optimisation, Gravity Loading, P-Delta Effect, Seismic Performance*.

Design of underground workouts in thermo-hydro-mechanical coupling conditions

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The underground workouts are among the most significative geotechnical realizations of humanity used for various purposes. In nowadays, besides the traditional ways of their use for natural resources extractions and transport infrastructures, there is an exponential increase of them as a key structures in environmental and energy-related problems such as waste disposals, gas and high pressure conservation etc. The design and constructions of underground workouts, are based on traditional approaches of tunnelling , but singularly distinguished from them in order to respect strong constraints of their use : these infrastructures are designed taking into account complex interactions of thermo-hydromechanical couplings, they are very often deep construction in tight rocks, in geological conditions of anisotropy of rocks and/or in stress situ; their service life is often some hundreds of years at least for which the propagation of uncertainty are taken into account in order to assure the protection of nature and life over long time periods. In this paper after presentation of principal modification of traditional design approach and equations governing THM coupling behavior of rock masses, some applications of modified convergence-confining method are presented and compared with the same design neglecting the coupling mechanisms. It is shown that diffusion process of temperature and modification of pore pressure lead to e redistribution of stress around the tunnel that significantly modify the design of support schema. The long time behavior of such infrastructures are strongly impacted by excavation method that is one of the key factor of the damage developed around the tunnel. In fact the shape and the intensity of damage around the tunnel developed in close relation with the excavation and initial lining, for given in field conditions, govern the kinetics of pore and temperature distribution leading to significant different patterns of stress and displacements cartographies.

Keywords: *Multiphysics coupling, underground workouts, damage, design, long time behavior.*

Novel approaches towards a sustainable management of existing civil infrastructures

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The sustainable management of existing infrastructures has become a critical priority as urban populations grow, resources become scarce, and climate change intensifies operational challenges. Traditional monitoring and maintenance approaches often fall short in addressing the complexity, scale, and dynamic nature of ageing infrastructure systems. In this context, digital twins—virtual replicas of physical assets enriched with real-time data—offer a transformative solution. When powered by machine learning, digital twins surpass static representations to deliver predictive, adaptive, and autonomous decision-support capabilities. By continuously integrating sensor data, historical records, and operational parameters, machine learning algorithms can detect anomalies, forecast performance degradation, and optimise maintenance schedules with high accuracy. This reduces unnecessary interventions, minimises downtime, and extends the service life of assets, thereby lowering environmental footprints and economic costs. Moreover, digital twins can simulate the impact of alternative management strategies, enabling decision-makers to assess trade-offs between energy use, emissions, resilience, and lifecycle costs. Such data-driven insights support proactive planning and align infrastructure management with sustainability goals. The integration of digital twins and machine learning thus represents a paradigm shift from reactive maintenance toward intelligent, sustainable asset management. Ultimately, these technologies enhance resilience, reduce waste, and ensure that infrastructure systems continue to serve societal needs efficiently while minimising ecological impact.

Keywords: *Digital Twin, machine learning, damage classification, structure assessment, hybrid 1DCNN–LSTM, data reconstruction.*

Nuclear Safety, Security, and Safeguards Design Considerations for New Advanced and Small Modular Reactors

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Advanced and small modular reactors (SMRs) represent a new generation of nuclear technologies designed to support decarbonization and electricity goals through flexible deployment, enhanced safety, and reduced construction times. Their success depends not only on innovative reactor physics but also on the integration of nuclear safety, security, safeguards (N3S), and environmental considerations into the design and construction phases. Safety innovations in advanced reactors often rely on inherent and passive features such as negative reactivity feedbacks, high-temperature fuel resilience, and natural circulation cooling, which extend coping times and reduce reliance on operator intervention. These features allow designers to tailor containment and confinement strategies, including underground siting, modular shielding, and high-integrity fuel forms, to specific reactor concepts. From the security perspective, compact footprints, hardened structures, and advanced digital protections mitigate both physical and cyber threats, while transportable designs introduce new challenges for secure logistics and international cooperation. Construction methods are equally critical. Factory fabrication of modular components enhances quality assurance, shortens on-site assembly, and lowers costs compared to conventional nuclear builds. Standardized modules also enable repeatability and scalability across different sites. Underground or semi-buried construction not only improves physical protection but also minimizes environmental impact by reducing surface infrastructure. Designers must also account for groundwater protection, corrosion management, and coolant containment to align with environmental sustainability goals. By integrating N3S and environmental responsibility at the design and construction stages, advanced and SMR developers can enhance public confidence, streamline licensing, and position nuclear energy as a key contributor to future clean energy systems.

Keywords: *Small Modular Reactors (SMRs), Advanced Reactor Design, Nuclear Safety, Nuclear Security, Nuclear Safeguards, Modular Construction*

Automated Production of Precast Carbon-reinforced Concrete Elements

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Carbon-reinforced concrete (CRC) is a quite young and innovative construction material being able to replace ordinary steel bar or steel mesh reinforced concrete in wide application fields. CRC is characterized by the application of specialized reinforcing elements made from carbon fibre reinforced polymer (CFRP). The CFRP reinforcement offers many advantages, especially in the context of its corrosion resistance and the high tensile strength of the used carbon fibers. In the result, it is possible to substantially reduce the concrete cover, to realize lower member dimensions, and to save material. Thus, CRC is an important component in the overall measures to improve sustainability in civil engineering.

Currently, the main practical applications of CRC are the strengthening of existing structural concrete members and the production of precast concrete elements. In precast concrete industry, mainly prefabricated grids are used as textile CFRP-reinforcing elements. The commercially available grids are produced according to a fixed delivery program, with pre-defined dimensions (width, length) and reinforcing ratios (yarn size and spacing), and must be transported from the supplier to the precast company. There, the grids are cut to needed size, causing waste, especially in cases where there are openings (e.g. for doors or windows) in the precast concrete element.

To overcome this negative impact and to conserve resources, an automated yarn placing process was developed using the possibilities of robotics. By robotic technology, the carbon yarn is drawn from a roll, transported through an impregnation unit and finally placed on the formwork table. So, the value chain is changed because the prefabrication of grides can be avoided and the yarn placement is advantageously executed in the precast concrete plant.

Keywords: *Carbon-reinforced concrete, CFRP-reinforcement, precast concrete elements, automatization, robotics*

Energy Harvesting from Earthquakes and Its Impact on Earthquake Isolation Systems and Sustainable Power Sources

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This manuscript explores the transformative potential of energy harvesting (EH) from seismic events, particularly earthquakes, and its profound impact on earthquake isolation systems and sustainable power sources. We delve into the fundamental principles of EH, contrasting traditional energy sources with sustainable alternatives and highlighting the vast, yet largely untapped, potential of seismic energy. The study reviews various energy conversion technologies, including piezoelectric, electromagnetic, and electrostatic converters, discussing their design considerations, advantages, and limitations for seismic applications. A significant focus is placed on the integration of EH into earthquake isolation systems, examining conventional technologies, self-powered sensors, active damping enhancement, and regenerative base isolation. Case studies and proposed designs illustrate practical applications. Furthermore, the feasibility of earthquake energy as a sustainable power source is analyzed, considering its potential for small-scale power generation (e.g., for remote sensors and critical infrastructure emergency power) and the challenges of grid-scale deployment. The environmental benefits, carbon footprint reduction, economic viability, and scalability issues are thoroughly discussed. Finally, the manuscript addresses key challenges and limitations, such as the intermittency and unpredictability of earthquakes, efficiency of conversion technologies, and durability in extreme conditions. It concludes by outlining future directions and research opportunities in materials science, smart grids, multi-source EH systems, and international collaboration and policy development, emphasizing the critical role of EH in building a more resilient and sustainable future.

Keywords: *Energy Harvesting; Earthquake Isolation Systems; Seismic Energy; Sustainable Power Sources; Wireless Sensors.*

30 Years of Experience in Research and Implementation of Constructed Wetland Wastewater Treatment Plants

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The study presents a review of the research and experiences about the application of constructed wetland systems (CWs) in Poland in 1995-2024. On the basis of the obtained data the results of the efficiency of pollution removal in one-stage and hybrid CWs was compared. The problems regarding the operation of these treatment plants were also presented. Data from various objects indicate that one-stage constructed wetlands with horizontal and vertical flow are characterised by a quite high (80-89%) efficiency of BOD5, COD and total suspended solids removal, and lower efficiency of biogenic compounds removal (nitrogen an phosphorus) – respectively 59 and 66%. However a significantly higher efficiency of the basic pollutants removal (above 92%) were observed in the hybrid constructed wetland systems with VF-HF bed configuration. Those objects ensured ca. 65% efficiency of removal of total nitrogen and 89% effectiveness of elimination of total phosphorus. The statistical analysis revealed that hybrid CWs of the VF-HF type are characterised by very high - about 99% reliability of operation. Lower reliability was achieved for the one-stage CWs, especially of the VF type. 30 years of research and experiences about the application of constructed wetlands in Poland indicate that one-stage CWs can be used on a larger scale in Polish conditions in rural areas with scattered housing structure. Hybrid systems, on the other hand, can be applied successfully for recreational centres or in protected areas, especially in national parks where high efficiency of removing pollutants is required. It has been shown that the use of hybrid CWs is consistent with the idea of sustainable development. In the last years constructed wetlands systems are determined as nature-based solutions limiting the effects of climate change.

Keywords: *constructed wetlands; domestic wastewater; wastewater treatment; rural areas; national parks*

Step Forward Toward Smarter Severe Weather Forecasting and Alert Systems

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Climate change is accelerating the frequency and intensity of extreme weather events, posing growing challenges to civil infrastructure, water management, and public safety. Reliable and timely forecasting of severe convective systems has therefore become a critical component of disaster risk reduction and resilience planning.

This study presents an advanced approach to forecasting and early warning of severe weather, integrating innovative diagnostic and prognostic techniques capable of detecting convective development from local to synoptic scales. The upgraded algorithm, adapted for diverse climatic regions, demonstrated strong performance in predicting the evolution, trajectory, and intensity of several high-impact events, including hurricanes, typhoons, and flash-flood–producing storms. The system achieved high temporal and spatial accuracy in identifying extreme rainfall zones and potential flood risk areas across different climatic environments—from tropical to mid-latitude regions.

The results highlight the potential of next-generation forecasting and alert platforms to support decision-making, enhance hydrometeorological preparedness, and protect communities and infrastructure against the growing threats of a changing climate.

Keywords: *Severe weather forecasting; early warning systems; convective storms; climate change; disaster risk reduction; hydrometeorological hazards; predictive algorithms; flash floods; resilience planning; real-time monitoring.*

Telceker-Uzengili Mud Flow; Seismically triggered landslide and earthquake hazard-structural destruction of Uzengili Village, Dogubayazit-Agri, East Turkiye

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Telceker located at about 20 km South of Great Ararat Volcano, E. Turkiye. Muddy Debris Flow started by Iran border at South and flowed northwards till Agri-Iran highway. Three main lithological formations comprised of Telceker Flish Sequence at bottom; Ophiolite Complex including mica schists-radolerite-gabro, horblend/pyroxene basalts-calc schists, spilitic basalts; basaltic aglomera etc. At top youngest beds formed by very rich bivaves, corollas, tiny fractures of shallow marine fossils (sponges, etc, coralls, travertens). DB Faults strike NW-SE and dominant trends of bedding has the same orientation. Very thick, grey-dark green aglomera/ignimbrite lens shaped members thrusted over Flysch Deposits. Structures dominantly are syncline - anticline axes are roughly parallel to DB faults, and asymmetric even thrusted N-wards. A third new evidence is the Tectonic Breccia beds which strike approximately perpendicular to Mashar Fault. Tectonic breccia beds represent friction surfaces between South Block (ophiolite complex) and over Flysch Sequeens. At the centre of village exist limestone ridge western slope of ridge is topographically gently dipping-therefore this slope selected as new settlement area formed by limestone beds – interlayered with marble and coral riff beds. Old Village was situated on basement consisting of Slope Debris and landslide material. Therefore, South part of basement lose ground topographically inhabited from historic landslides. Whereas North part, formed by high strength recrytalline limestone, marble, calc-schist intercalations. Village buildings constructed by low strenght materials without cement matrix, and almost no foundations projected into ground. Generally, Adobe buildings, easily destroyed with roof and wall collapses. Some buildings slided approximately eastward. New Village formed on limestoe beds N-S extending ridge and gently westward dipping slopes. Which are selected as most durable ground conditions – anti seismic and gravity flows. Besides mechanical strenght of carbote rocks and parallel bedded structure another factor reducing the site effect of seismic shocks.

Keywords: *Telceker; Mud Flow; Earthquake Hazard; Structural Destruction; Uzegili Village.*

Self compacting grout and concrete. How it is produced and why it is needed?

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Using non-traditional concrete in engineering applications such as the construction of nuclear reactor shields, dams, massive under water bridge piers and repairs of building foundations…etc., have been considered as an efficient solution to overcome challenges of limitations of the use of normal conventional concrete. The types of concretes which have been developed and produced are completely dissimilar from the conventional concrete in the method of mixing, handling, pouring, consolidation, behaviours, cost …….etc. Based on the technology of ready-mixed self-compacting concrete (SCC), two types of concrete been introduced and named as: two-stage concrete (TSC) and rock-filled concrete (RFC), where a self-compacted grout (SCG) injected or poured to fill the void space of preplaced or self-compacted aggregate (SCA) or rocks. By other words, TSC (Pre-placed Aggregate) unlike normal concrete (NC), it is made by first placing the coarse aggregate in the formwork and then injecting a grout consisted of sand, cement and water to fill the voids between the aggregate particles. The main benefits of the method are widely appreciated as Low heats of hydration, high compressive strengths and density, economic savings, practically no mass shrinkage, low coefficient of thermal expansion, excellent bond to existing structures. Similarly, the construction technology of RFC mainly consists of two processes: filling the working space with large scale rock mass and pouring the SCC into the pre-packed rock body. Less cement in the composite, which results in less heat of hydration, makes the temperature control of RFC much easier, and this new construction method leads to fast construction speed, high concrete quality and improves the economics and environmental performance of massive concrete structures. Generally, the properties of two-stage concrete are thus influenced by the properties of the coarse aggregate, the properties of the grout, and the effectiveness of the grouting process. This paper illustrates the importance, advantages and special requirements of introducing TSC and RFC to be used in the concrete industry.

Keywords: *Two-Stage Concrete, Rock Filled Concrete, Self Compacting Concrete, Mass Concrete Construction*

Structural and Earthquake Engineering

Geometric Shear Wall Changes during construction on the Highrise Buildings

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As a result of Designs for structures that have not been sufficiently studied—or even due to later requests arising related to fulfilling the functionality of the building, its equipment, the organizing the areas, etc.—it is not uncommon that re-evaluations of the geometric changes in the structural elements must be performed. Every structural engineer and architect are aware that such geometric modifications require extra efforts, calling for additional analysis of the proposed changes. As a motivation for this study, a case study was analyzed for a building with 25 floors above ground level, which is in the construction phase and nearing completion, located in Prishtina. The functional requirement of the user and the client was to create additional elevator openings in the shear walls as well as to expand some of the existing openings. Since shear walls are responsible for resisting the horizontal forces generated by earthquakes or wind, the creation of new openings in their mass—or, equivalently, the reduction of their stiffness—will lead to a decrease in the building's lateral stiffness. This reduction, in turn, increases the lateral displacements of the structure as a whole or even enhances the torsional response at its base. In this work, the walls are analyzed—both the originally designed walls and those with newly created openings or reduced stiffness—by calculating their horizontal displacements, load-bearing capacities, and overall performance. To this end, advanced nonlinear static analyses (pushover analyses) were performed using ETABS software to evaluate key parameters such as capacity, stiffness, ductility, and deformability of the dual structural systems. The research methodology includes the development of precise mathematical models that integrate material properties, the geometry of the elements, and the load combinations as defined by the Eurocode. The linear and nonlinear analyses conducted in ETABS assess the structural response by identifying changes in stability, stiffness, ductility, and deformability resulting from the modifications in the shear walls. The results show that additional openings lead to a reduction in stiffness and stability, while simultaneously increasing ductility and deformability.

Keywords: *Shear walls, stiffness reduction, capacity of structure, structural response.*

Experimental and numerical behavior of extended end-plate bolted connections subjected to monotonic loading

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End-plate bolted connections are widely used in framed structures due to their simple design, easy reproduction, and convenience during fabrication. These connections usually have two rows of bolts in the tension zone, with each row consisting of two bolts. However, using joints with four bolts per horizontal row is more appropriate when the beam is made from an I or H section. The theoretical model guiding the application rules of Eurocode 3 is broad and can be extended to connections with four bolts per horizontal row. This study presents experimental findings from full-scale beam-to-column connection specimens featuring extended end-plates. It focuses on testing bolted connections with extended end-plates, comparing configurations with two and four bolts per horizontal row. Additionally, the research involves calibrating a finite element (FE) model of a beam-to-column extended end-plate using experimental data. The primary objective is to assess the impact of using four bolts per row on key connection properties, including moment resistance, initial rotational stiffness, and rotation capacity. The results show that incorporating four bolts significantly affects these properties. A comparison between experimental and numerical results reveals a strong correlation in analyzing the monotonic behavior of this connection type.

Keywords: *Extended end-plate connection, two and four bolts per row, experimental investigation, FE model.*

The calculation of reinforced concrete elements under the action of shear force, according to Eurocodes and US code ACI 318

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Even though Albania, or other countries in Balkan, have their National Design Codes for the design of reinforced concrete structures, Eurocodes are widely used as the primary code of choice by structural engineers during the design process of various type of structures. This choice is made because of the European aspirates of the Balkan countries and also, what is more important, because the Eurocodes offer the best European practice for the design of engineering structures. For this reason, the structural engineers in Albania, Kosovo, or other Balkan counties are very familiar with Eurocodes. In order to expand the knowledge on the design of reinforced structures and also the impact that US construction companies have in Balkan countries, in this article, the authors, are presenting, as an alternative of Eurocodes, the US code ACI 318. In the same way as Eurocodes, ACI 318 code brings the best USA practice for the design of engineering structures, a practice which is reflected on many and many buildings across USA. In order to highlight the design philosophies of each Code, a comparison between Eurocodes and ACI 318 is presented. This comparison is done for a flexural element, and specifically for a beam under the effect of shear force, knowing the importance of this action on all structural elements.

Keywords: *Eurocodes, ACI-318, beam, shear force.*

The Impact of Confined Masonry Infill on the Seismic Performance of RC Frame Structures

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Confined masonry (CM) is a hybrid structural system that integrates unreinforced masonry walls with horizontally and vertically reinforced concrete (RC) elements. This configuration enhances a building's seismic performance by increasing lateral strength and reducing lateral displacements. The study focuses on buildings constructed in the 1960s—typically RC frame structures with masonry infill. Using calibrated nonlinear static analysis, supported by field data, it was found that CM significantly improves base shear capacity and overall structural stiffness. When properly designed, detailed, and integrated, confined masonry delays progression through key damage states—Damage Limitation (DL), Significant Damage (SD), and Near Collapse (NC)—by enhancing both strength and ductility. The study explores several influential factors including construction sequence, masonry material properties, structural configuration, reinforcement detailing, and the interaction between RC elements and masonry. These findings underscore the critical role of accurately identifying and modeling CM elements, particularly along perimeters and main corridors, where they have the greatest impact on seismic resilience. Effective assessment and retrofitting strategies should prioritize these elements to ensure reliable performance in earthquake-prone regions.

Keywords: *Confined Masonry, Seismic behavior, ductility, structure modeling*

Ulpiana Neighborhood Case Study: Urban Seismic Risk Assessment

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The Ulpiana neighborhood in Prishtina was selected as a representative case study to demonstrate the Urban Seismic Risk Assessment Methodology. Spanning 37.5 hectares with 163 buildings (approximately 4,051 dwellings) and about 18,000 residents, Ulpiana represents one of the first urban developments in Prishtina. The building stock is dominated by structures from the 1960s–1980s era, built under low or no seismic design codes, making it an ideal case for assessing seismic vulnerability in a challenging context. The study applied the full methodology: all buildings were surveyed and classified into the ten Model Building Typologies, then analyzed for their expected performance against the defined earthquake scenarios. Local seismic hazard inputs were derived from a Seismic Microzonation study of Ulpiana performed prior this study by Institute of Earthquake Engineering and Engineering Seismology of Skopje (IZIIS), ensuring that the ground motion characteristics (PGA and spectral shape) reflect Ulpiana's site conditions. The risk results shown that under the Frequent Scenario (72-year return period), many buildings sustain moderate damage, leading to over 1,400 dwelling units becoming uninhabitable and approximately 6,500 people displaced. For the Rare Scenario (475-year return period), the model predicts that roughly *70% of unreinforced masonry buildings* and *39% of RC buildings* would reach collapse or near-collapse damage states. Consequences at this level are catastrophic – the worst-case estimates (night-time event) approach 1,200 fatalities, with over 14,000 people left homeless in the neighborhood. These outcomes highlight a stark contrast between newer and older construction: even some recently designed buildings struggle to meet life-safety performance, but the pre-code masonry structures are unequivocally the most vulnerable. The Ulpiana case study thus validates the methodology's capability to identify the critical points and provides valuable data for authorities. It underscores an urgent need for targeted seismic retrofitting of the most vulnerable buildings and enforcement of building codes in design. Moreover, the insights gained for Ulpiana can be generalized to similar urban areas in the region, demonstrating how localized studies can inform national seismic risk reduction strategies.

Keywords: *Urban Seismic Risk Assessment, Seismic Vulnerability, Seismic Microzonation, Damage States, Seismic Retrofitting, Building Codes*

Use of Nonlinear Static and Dynamic Analysis in Evaluating Structural Performance

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To evaluate the structural performance, the study employed analytical modeling and conducted combination of nonlinear static and dynamic analysis for each representative Model Building Type (MBT). Detailed finite element models were constructed for all ten MBTs, capturing the essential geometry, material properties, and lateral-force resisting mechanisms. The models were first calibrated against experimental evidence, e.g. in-situ Ambient Vibration Tests (AVT) that were conducted prior this study by Institute of Earthquake Engineering and Engineering Seismology of Skopje (IZIIS), to measure each building's fundamental frequency, ensuring the developed analytical models correctly reproduce the initial elastic behavior. Using these validated models, Nonlinear Static (Pushover) Analyses were performed to generate capacity curves for each building type, revealing their post-elastic strength and deformation capacity. In parallel, Nonlinear Dynamic Analyses (Time-History Response Analyses) were carried out using representative earthquake records scaled to the site's hazard levels. The dynamic analysis results provided insight into the peak responses (e.g. maximum base shear and drift demands) and were used to refine the pushover evaluation – specifically, the time-history outcomes informed the selection of target displacement levels for the pushover curves. By applying a Modified Capacity Spectrum Method with these results, the study determined performance points for each structure under different seismic intensities. The combined use of nonlinear static and dynamic analyses proved very effective: the time-history analysis captured complex dynamic effects and potential failure modes, while pushover analysis offered a simpler means to evaluate global capacity up to collapse. This dual approach yielded a thorough understanding of each typology's seismic performance. The findings displayed clear trends – for example, older unreinforced masonry buildings exhibited limited ductility and would likely fail to meet life-safety criteria, whereas well-designed RC frames had higher reserve capacity. Quantitatively, the majority of modeled buildings did not achieve the desired performance targets: under the rare 475-year earthquake, only ~30% of masonry typologies and ~60% of RC typologies met the life-safety performance level . These results underscore the importance of nonlinear analysis in revealing vulnerabilities that linear methods would miss, and they directly inform the prioritization of retrofitting measures for the most deficient structures.

Keywords: *Nonlinear Static and Dynamic Analysis, Lateral-Force Resisting Mechanisms, Capacity Spectrum Method, Seismic Performance.*

Seismic Performance and Structural Integrity Evaluation of an Existing Building

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Recent earthquake events over the past two decades have demonstrated that, despite being designed following conventional seismic design principles, many structures still suffer significant damage. The situation highlights the limitations of current seismic codes, which do not always guarantee the expected performance of buildings during earthquakes. Performance-Based Earthquake Engineering (PBEE) provides a more comprehensive approach to assessing a building's seismic response, ensuring life safety while minimizing economic losses, compared to traditional force-based design methods.

This study has four main sections: (1) background theory; (2) on-site structural investigation; (3) finding dynamic properties through on-site testing with ambient vibration tests; and (4) assessing the structure's earthquake performance based on EN 1998-1 and EN 1998-3. The analytical model is created using SOFiSTiK software, which includes results from lab tests, and a nonlinear static pushover analysis is done to assess the building's ability to withstand earthquakes.

Keywords: *Earthquake, performance-based earthquake engineering, performance objectives, pushover nonlinear analysis, performance evaluation.*

Using 'DASISedu' program for seismic response history analysis of 2D frame structures with different seismic protection systems

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Over the past couple of decades, a lot of effort has been put in the study of the mechanical behavior of various base isolation and energy dissipation devices subjected to a wide range of extreme design situations. This led to the development of validated theories that can describe the dynamic behavior of various seismic base isolators (with the lead-rubber and friction pendulum isolators being amongst the most prominent types being used widely throughout the USA). This developed theory is of outmost importance as it provides the basis for analyzing the dynamic behavior of seismically isolated structures.

The author of this paper took these developed theories as basis for developing a computer program for interactive simulation of the dynamic behavior of typical planar structures (both multistory building frames and bridges) integrated with various seismic isolators and/or energy dissipators.

This program, named DASISedu, is an extension of program 3pleANI (MCEER report 13-0010). Key features of the program DASISedu include advanced models for friction pendulum, lead-rubber and elastomeric isolators with and without heating effects, added linear and nonlinear viscous dampers in the isolation system, added viscous or hysteretic dampers in the superstructure, quick generation and visualization of structural models, and interactive visualization and animation of computed response. Building and bridge models may be analyzed. DASISedu program includes a large database of ground motions for use in analysis. Also, the program can perform complex eigenvalue analysis to compute damping ratios for damped superstructure buildings based on linearization of behavior for dampers when they are not linear viscous.

This program will be available free in the public domain together with a User Guide and Reference Manual and a Verification Manual.

Keywords: *DASISedu, MATLAB , seismic base isolation, dampers, energy dissipators*

Cost-Benefit Analysis of Seismic Retrofitting for Mid-Rise Buildings in Albania and the Balkan Region

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The seismic vulnerability of mid-rise buildings in Albania and the wider Balkan region presents a significant challenge due to the area's high seismic activity and a large number of aging structures. Many of these buildings were built before modern seismic design standards were established, making them highly susceptible to damage or collapse during earthquakes. This study conducts a cost-benefit analysis of seismic retrofitting interventions for these buildings, emphasizing the financial implications as well as the potential improvements in structural resilience. Using case studies from Albania and the Balkans, the research evaluates retrofitting projects in terms of total costs, implementation feasibility, and expected performance improvements during seismic events. The analysis includes direct costs, such as materials, labor, and time required for the implementation, as well as indirect benefits, including reduced repair costs, lower risk of casualties, and improved building usability after earthquakes. The methodology combines engineering and economic perspectives to assess the long-term value of retrofitting efforts. The findings indicate that although retrofitting involves substantial upfront investments, the long-term benefits, both in terms of risk reduction and economic savings, often justify these costs, especially in densely populated urban areas. Furthermore, the study highlights the importance of adapting retrofitting approaches to local building typologies, economic conditions, and regulatory frameworks. This research aims to inform policymakers, engineers, and property owners about the financial and societal value of investing in seismic risk reduction. It offers practical insights that can support the development of targeted retrofitting programs and funding strategies across the Balkan region, ultimately contributing to safer and more resilient communities.

Keywords: *cost-effectiveness, seismic resilience, cost-benefit analysis, context retrofitting, seismic risk reduction, regional strategy*

Evaluation of Seismic Vulnerability Assessment for a Masonry Structure

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Earthquakes as a natural phenomenon are unpredictable. Despite the great amount of energy released, the magnitude 6.4 (Mw) earthquake that occurred in 2019 in Durres caused less damage than might be expected. This is an indication of the appropriate design criteria. However, some considerable damage in structures with diverse typology were noticed. In this study a seismic vulnerability assessment of a structure located in the Tirana area, is developed. The object of this study is a masonry building, which suffered some damage during the aforementioned earthquake. Its complex structure, the quality of work and some problems of its structural scheme, have been identified as the trigger of the damage.

This study includes a qualitative assessment of vulnerability indices according to European Standards and then continues with a Nonlinear Static Analysis (Push-Over). The results of this study according to the developed numerical model, clearly reflect the Seismic Vulnerability Assessment.

Keywords: *seismic vulnerability, earthquake, masonry building, vulnerability assessment, etc.*

Evaluation of the Seismic Response of Masonry Structure

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Tirana and Durres city, along with the surrounding areas, were hit by two earthquakes in September and November 2019. The first earthquake with a magnitude of 5.8 on the Richter scale, dated 21.09.2019, and the second even a more powerful one on 26.11.2019 with a magnitude of 6.4 on the Richter scale. The earthquakes caused a series of damage to many residential, social, cultural, educational, and industrial facilities. Among all these objects is also the "Building No. 152", in "Haki Stermilli" street, Kombinat area, Tirana. The building is made of silicate brick with wall thickness varying from 38cm to 25cm over the five floors. The object of the study will be the assessment of the damages caused by the earthquakes (especially the one dated 26.11.2019), the analysis of the object's constructive stability, and the project of the necessary reinforcing interventions. For the evaluation of the supporting structure of the building we will rely on numerical calculations with finite elements (M.E.F) of 3-dimensional models, realized by commercial software. Seismic assessment was performed on this existing ceramic masonry structure according to European code and standards. Moreover, a static nonlinear analysis (Pushover) was conducted to investigate the Seismic Response of this building. Moreover, some possible retrofitting techniques are proposed.

Keywords: *masonry structure, seismic response, seismic vulnerability, structural damage, seismic capacity, earthquake resistance, pushover analysis, assessment, estimation, intervention. etc.*

A Comparison Study Between Beams Reinforced with Convencional Steel and CFRP Bars

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Polymer rods reinforced with carbon fibers (CFRP) have been developed as an alternative to replacing steel as the main material in various reinforced concrete structures, as they are more suitable for resisting aggressive environments, where steel reinforcement tends to be affected by rust and corrosion. The need for replacing conventional reinforcement is the result of analyses aimed at improving the overall behavior of reinforced concrete structures and particularly of concrete beams under bending, with a focus on enhancing their longevity parameters. The use of polymer rods reinforced with carbon fibers (CFRP), compared to conventional rods, aims to provide a clearer picture of the behavior and performance of the elements and structures that replace conventional reinforcement in specific locations. The experimental phase of the study has evaluated significant data, such as deformations due to deflections and crack openings, which are key qualitative parameters during the operation of structures reinforced with polymer rods.

In various study cases, beams reinforced not only with conventional reinforcement (Steel) but also with CFRP bars have been studied. Analytical, experimental studies and those conducted through computer programs have shown a significant improvement in the behavior of these beams. Improvements are observed in the increase of load-bearing capacity in bending, shear, and torsion. CFRP reinforcement leads to the prevention of crack formation as well as reducing the frequency and magnitude of cracking. The comparison has been made by studying beams reinforced with one layer and calculating them analytically (according to EUROCODE), experimentally, and through computer programs (ETABS)

Keywords: *carbon fiber reinforcement, flexural behavior, conventional steel, CFRP bars.*

A targeted seismic upgrading method for precast roof beam–column connections using adaptable seismic safety key devices

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In this investigation, a new targeted seismic upgrading method (TSU method) for roof-beam column (RBC) connections was introduced, based on created innovative seismic safety key (SSK) devices, assuring their much better and more reliable seismic safety. The SSK upgraded connection will replace the classical method for upgrading of pin-based roof beam column connections, which provided very limited seismic upgrading effects of precast structures. The results obtained from the authors experimental tests of 1/2 scale prototype models of classical RBC connections and results obtained from the conducted extensive refined FEM based nonlinear analytical studies, clearly demonstrated the superior seismic upgrading performances of the RBC prototype connection upgraded with SSK devices. This study introduces technical procedure how the SSK, an innovative device newly developed by the authors, can be applied for targeted seismic upgrading of RBC connections in modern precast N systems. Specifically, for the newly assembled SSK-upgraded RBC connection, a high increase in safety was confirmed by the results of the studies performed using experimentally verified nonlinear three-dimensional micro-analytical model. The design feature ensures capability of the TSU method for efficient seismic upgrading of existing and newly designed precast industrial hall structures.

Keywords: *precast structures; connections; SSK-device; SSK upgraded connections; model testing; seismic performance*

Nonlinear Dynamic Analysis of RC Bridges with Steel and GFRP-Reinforced Piers Calibrated Using Experimental Results

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GFRP bars offer a durable and lightweight alternative to conventional steel reinforcement in reinforced concrete (RC) structures, with advantages including corrosion resistance, high strength-to-weight ratio, and electromagnetic neutrality. This study presents the experimental and numerical investigation of six RC columns reinforced with varying ratios of steel and GFRP bars, tested under combined axial and reversed cyclic lateral loading until failure. The hysteretic behavior observed from testing is used to calibrate a detailed numerical model in SeismoStruct, employing the fiber section approach to simulate nonlinear response. The calibrated modeling approach is then extended to the seismic analysis of a reinforced concrete bridge with piers reinforced using both steel and GFRP bars. The bridge includes piers of three different heights to assess the influence of geometric variability on structural behavior. The study demonstrates the applicability of the validated column models in predicting the seismic response of Steel and GFRP-reinforced RC bridge piers.

Keywords: *Glass Fiber-reinforced polymer (GFRP) bars, Nonlinear dynamic analysis, durability, confinement, Fiber section approach*

Probabilistic Seismic Vulnerability Assessment Using Fragility Functions and Maximum Likelihood Estimation

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Assessing the vulnerability of existing buildings in seismically active regions is critical for ensuring public safety and protecting infrastructure. Many of these structures were constructed prior to the implementation of modern seismic design standards and therefore lack adequate resistance to earthquake-induced forces. Evaluating their behavior under extreme seismic events requires an integrated, scientifically grounded approach. This paper investigates the seismic vulnerability of building structures using a probabilistic framework that combines seismic hazard assessment, fragility functions, and statistical estimation based on nonlinear structural analysis. Initially, the research explores mathematical methods for calculating exceedance probabilities over various time intervals and employs return periods to characterize the likelihood of high-impact seismic events on both annual and multi-year bases. Using data from the SYNER-G project, fragility functions for masonry and reinforced concrete building classified by the number of stories and damage levels are assessed. The analysis focuses on interpreting the exceedance of damage thresholds based on observed peak ground acceleration (PGA) values from recent seismic events. Finally, fragility curves for four characteristic damage states: slight, moderate, extensive, and collapse, are developed using the Maximum Likelihood Estimation (MLE) method, based on the lognormal cumulative distribution function. The resulting fragility curves offer valuable insights for seismic risk assessment and serve as a foundation for modeling structural response.

Keywords: *Seismic vulnerability, probabilistic hazard assessment, fragility curves,*

Seismic Analysis of Infilled RC Frames with Irregular Wall Distribution Using Macro-Modeling Techniques

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Reinforced concrete (RC) frame buildings with infill walls are widely used in seismic regions of Southeastern Europe and beyond. Despite their structural importance, infill walls are often neglected in seismic assessments, usually treated simply as added loads or non-structural components, which can result in inaccurate predictions of lateral stiffness, strength and overall structural performance during earthquake events. Wall infills can increase stiffness and resistance, but can also cause brittle failure modes, especially when their distribution is irregular or involves large openings. As is recognized in the literature, proper modeling of these elements is critical for realistic structural analysis. This paper investigates the nonlinear seismic response of a typical three-story reinforced concrete frame with and without infill walls, using macro-modeling techniques to evaluate a range of different infill configurations. The analysis examines a various of infill cases - full, partial, irregular distributions, openings, and soft story conditions representing typical construction situations commonly seen in practice. The findings highlight the importance of masonry walls in the behavior of structures under seismic loads and demonstrate the importance of modeling assumptions in the real behavior of the structure. The study supports the need for a more accurate representation of masonry walls for the design of new structures or the assessment of the seismic performance of existing buildings.

Keywords: *RC frame, Masonry infill walls, Seismic performance, Nonlinear analysis, Macro-modeling, Seismic assessment.*

Anchorage Techniques for Vertical Structural Continuities and the Impact of Defects on Joint Performance

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The paper will focus on a part of the research into behavior of vertically extended reinforced concrete frame structures that was conducted recently. The hypothesis of the entire research was that the connecting joints between the vertical extension and the earlier existing base building do not behave as a completely rigid connection as is frequently assumed in the design calculations, and this will in turn have a significant effect on the performance of the entire extended structure under dynamic loading, such as seismic action. The issue was researched and the stated hypothesis tested through a combination of literature review, a testing campaign on a total of nine scaled RC frames and complementary numerical analyses to assess the test results, as well as evaluate the global structural behavior. This paper will provide insight into one part of this research which is related to the anchorage techniques, and specifically execution deficiencies and anchoring defects whose cumulative effect compromises the performance of the anchorage system employed to secure the rigid connection between the vertical extension and the base structure. The paper will systematize the issues that were encountered during concreting, drilling of anchorage holes and potential misuse of chemical additives.

Keywords: *vertically extended buildings, concrete anchors, post-installed anchors, anchoring defects, joint performance*

Design of RC structures with Torsion Dominant Vibration Mode using Displacement Based Design

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Torsion is a vibration mode not very preferred as the dominant mode for RC structures, due to the extra moment and shear forces it introduces in structural elements. Structures with torsion dominant vibration mode may also have unfavorable failure modes in case of seismic events. However, in some circumstances it is unavoidable to have a structural layout with a dominant torsional mode. Eurocode 8 makes due provisions for these situations. Displacement based design (DBD) is relatively new design approach which uses target displacements and ductility demand as guides for the design of structures. This design method allows for the inclusion of the inelastic behavior of the materials, which results in more economic designs, and gives control to the design engineer regarding the failure mode of the structure. In this study, DBD will be implemented for the design of a RC structure with torsion irregularity. The structure selected as an example will be designed also per the common design practice in Albania, which is the Equivalent Lateral Force (ELF) approach based on Eurocode 8. The aim of this study is to obtain a better structural solution and reduce the reinforcement amount on this structure using DBD. Additionally, a streamlined procedure is aimed to be presented for DBD applications on complex structures, as the case study of this paper.

Keywords: *Displacement Based Desing, Torsion Irregularity, RC Dual System, Displacement Ductility Demand, Pushover*

Structural behavior of masonry-infilled RC frames under axial and lateral loading

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The aim of this study is to investigate the structural behaviour of reinforced concrete (RC) frames with and without masonry infill under combined axial and lateral loading. Using advanced finite element software and detailed micro-modelling techniques, the performance of RC frames of varying spaces both frame and infilled is assessed in terms of stiffness, ductility, and load-bearing capacity. Brick masonry units were used as the infill material in the corresponding frames. All frames are designed in accordance with Eurocode standards, ensuring regulatory compliance and analytical reliability.

The analysis reveals that both frame space and the presence of infill significantly influence the lateral stiffness and strength of RC structures. Infilled frames demonstrate enhanced resistance to lateral loads, resulting in reduced displacements and improved stability. In contrast, bare frames exhibit lower stiffness and reduced load-bearing capacity, especially under lateral loading conditions.

The findings highlight the critical role of infill integration and frame geometry in optimizing the seismic performance of RC structures. Across all frame spaces, infilled configurations consistently outperform bare frames in terms of stability and lateral resistance. This research contributes to the development of improved design strategies for RC frames in seismic regions, offering practical guidance for both new constructions and retrofitting of existing structures.

Keywords: *Reinforced concrete frames, infill walls, axial and lateral loading, structural performance, seismic performance, analytical investigation.*

Strengthening of Earthquake-Damaged Masonry Buildings with Beam-Column Frame Interventions

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This study focuses on the structural evaluation and retrofitting of a two-story unreinforced masonry building located in Kruja, Albania, which experienced moderate to severe damage during the November 2019 earthquake. The building typology is representative of many similar structures across the region, characterized by traditional masonry construction with limited seismic resistance. The goal of the study is to assess the building's existing seismic performance and propose an effective retrofitting solution to enhance its safety and resilience.
A dual analytical approach is employed using ETABS and 3Muri software. ETABS is used to model and simulate global behavior under seismic loading, while 3Muri allows for more detailed nonlinear analysis specific to masonry systems, including the generation of capacity curves and performance point evaluations. The structural capacity, inter-story drifts, and potential failure mechanisms are analyzed under both static and seismic load conditions. To improve the structural performance, a retrofitting intervention is proposed involving the addition of reinforced concrete beam-column frames, carefully integrated to respect the architectural integrity of the original structure. The retrofitted model is then reanalyzed using the same software platforms, and the results are compared with those of the original damaged state. Key parameters examined include base shear capacity, displacement demands, vulnerability index, and overall seismic performance. The study concludes that the proposed intervention significantly enhances both stiffness and ductility, reducing the building's vulnerability to future seismic events. The findings offer practical recommendations for engineers and decision-makers dealing with the rehabilitation of similar masonry buildings affected by earthquakes in Albania and other seismic-prone regions.

Keywords: *Seismic vulnerability, masonry buildings, earthquake damage, structural analysis, ETABS, 3Muri, retrofitting, beam-column frames, seismic performance*

Seismic Performance and Behavior Factor Evaluation of Different Types of Vertical Extensions on RC Structures

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Given the lack of space in densely populated areas of the world, vertical extensions on existing structures are very popular. The problem with the vertical extensions becomes more pronounced in the seismic active areas, especially in older buildings which are designed with old codes or little or no seismic guidelines. This study presents a comparative seismic performance assessment of various vertical extension systems applied to existing reinforced concrete frame structures. The research focuses on evaluating the behavior factor (q) and fragility characteristics of RC buildings with added floors with steel (STL), light-frame timber (LTF), cross-laminated timber (XLAM), and hybrid glass-timber (GLS) extensions. Nonlinear static pushover analyses were conducted to derive bilinear approximations of structural capacity curves, from which behavior factors were analytically calculated based on ductility. Additionally, incremental dynamic analyses (IDA) were used to develop fragility curves and assess the collapse vulnerability of each system under increasing seismic intensity. The results demonstrate that the structural typology and material characteristics of the added stories significantly influence both the seismic capacity and ductility demand of the base structure. Steel and XLAM extensions exhibited higher q-factors due to their favorable post-yield performance, while LTF and GLS systems showed moderate values consistent with their lightweight and flexible behavior.

Keywords: *Vertical extensions; Adding floors; Behavior factor; Fragility curves*

The calculation of reinforced concrete elements under the action of bending moment, according to Eurocodes and US code ACI 318

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Even though Albania, or other countries in Balkan, have their National Design Codes for the design of reinforced concrete structures, Eurocodes are widely used as the primary code of choice by structural engineers during the design process of various type of structures. This choice is made because of the European aspirates of the Balkan countries and also, what is more important, because the Eurocodes offer the best European practice for the design of engineering structures. For this reason, the structural engineers in Albania, Kosovo, or other Balkan countries are very familiar with Eurocodes. In order to expand the knowledge on the design of reinforced structures and also the impact that US construction companies have in Balkan countries, in this article, the authors, are presenting, as an alternative of Eurocodes, the US code ACI 318. In the same way as Eurocodes, ACI 318 code brings the best USA practice for the design of engineering structures, a practice which is reflected on many and many buildings across USA. In order to highlight the design philosophies of each code, a comparison between Eurocodes and ACI 318 is presented. This comparison is done for a flexural element, and specifically for a beam under bending moment, knowing the importance of flexure on all structural elements.

Keywords: *Eurocodes, ACI-318, beam, bending*

Influence of ductility class on seismic performance and construction costs of reinforced concrete structures

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This study addresses the influence of ductility class on the seismic performance and construction costs of reinforced concrete frame buildings designed in accordance with Eurocode 8 provisions. While the standard (EN 1998-1, 2004) defines three ductility classes—low (DCL), medium (DCM), and high (DCH)—it provides limited guidance on how to select the most appropriate class to achieve an optimal balance between structural safety and economic efficiency.

A typical eight-story reinforced concrete moment resisting frame building, located in Durrës, Albania, a region with high seismic hazard, was selected as a case study. The building was designed for each of the three ductility classes and analyzed using ETABS software through modal response spectrum analysis to evaluate story shear distributions, interstory drift ratios, and overall structural behavior.

The results show that while DCM can provide acceptable seismic performance, the high-ductility class (DCH) achieves the best balance between structural safety and material cost. Although DCH requires more transverse reinforcement for confinement, its total reinforcement is lower than DCM due to reduced longitudinal steel, resulting in both effective seismic performance and cost efficiency.

This study highlights the importance of an analysis-based design approach for optimal selection of ductility class, considering local seismic conditions and project-specific requirements, in order to maximize both safety and economic efficiency.

Keywords: *Ductility class; seismic performance; construction costs*

Experimental and Numerical Study on the Structural Behavior of Various RC Slab Systems

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The selection of an appropriate slab system is a fundamental consideration in the structural design of reinforced concrete (RC) buildings, particularly in seismic regions where horizontal elements critically influence both mass distribution and seismic response. Key factors influencing slab system selection include span dimensions, load transfer mechanisms, regional construction practices, material availability, and advancements in construction technologies. This study presents a comprehensive evaluation of various slab systems, namely solid slabs, ribbed slabs incorporating Styrofoam, Cobiax systems, Styrofoam-filled slabs, and styro-concrete sandwich configurations. The comparative assessment addresses parameters such as displacement characteristics, impact on the seismic performance of vertical structural elements, concrete consumption, and environmental considerations.

A case study framework is employed to implement and assess the different slab systems within a standardized building model, enabling direct comparison under controlled conditions. Complementary experimental investigations are conducted using 2/3-scale simply supported slab specimens, each measuring 3 meters in length and 1 meter in width, subjected to vertical loading, providing empirical validation of the numerical findings. Additionally, finite element method (FEM) analysis is performed to validate and complement the experimental results. The outcomes of this research aim to support the selection of slab systems that optimize structural performance, sustainability, and construction practicality, while also identifying opportunities for innovation within contemporary structural engineering practice

Keywords: *concrete , slabs, Styrofoam , cobiax, FEM*

AI and Computational Methods in Civil Engineering

Enhancing Dike Resilience: Reinforcement techniques and advanced monitoring systems for Climate Change Adaptation

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Earth dikes have been protecting urban areas, infrastructure, and households for centuries. However, the increasing frequency and severity of flood events due to climate change have highlighted the necessity for reinforcement techniques and monitoring systems to ensure dike structural performance. This paper aims to provide an overview of the various failure mechanisms to which dikes are particularly susceptible, especially external erosion and hydraulic failure. Depending on the type of failure mechanism, different engineered solutions, along with the necessary methodologies, machinery, and materials, will be discussed. To enhance decision-making accuracy regarding dike performance, an innovative monitoring system called SmartSheetPile will be highlighted. This system leverages advanced technologies such as embedded sensors, digital twins, and AI to offer real-time monitoring and predictive alerts for infrastructure integrity when facing natural hazards like floods, erosion, storms, and droughts. These events can include rising water levels, soil movements, deformations, and other critical factors that could impact the structure's stability. By enabling early detection and proactive response, SmartSheetPile enhances the resilience and longevity of critical infrastructure, supporting informed decision-making that helps save lives and protect valuable assets. Furthermore, the paper will display case studies that demonstrate the effectiveness of these techniques in real-world scenarios. These case studies will give us more insight on projects in the Balkan region, where steel sheet piles have been used in innovative solutions to help with the construction of canal embankments and dike reinforcement, that will protect not only against potential floods but also act as a preventive solution against further erosion.

Keywords: *Dike reinforcement, Dike failure mechanisms, Structural Health monitoring, Flood protection, Corrosion, Galdovo Sisak, NIN Canal Zadar*

Fire Resistance of Continuous Two Span Reinforced Concrete Slabs

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The aim of this paper is to investigate the behavior of one-way continuous reinforced concrete (RC) slabs supported by three points under fire conditions, focusing on the impact of various parameters on their fire resistance. The slabs are subjected to a standard ISO 834 fire exposure. This analyze is focused on the slab span, external load intensity, reinforcement ratio, and fire scenario. Nonlinear numerical analyses are conducted using SAFIR2016 software, which applies the Finite Element Method. Two approaches are employed for the analysis: a 2D approach using beam elements for discretization and a 3D approach using shell elements. Additionally, fire resistance is assessed using the simplified method and tabulated data from EN 1992-1-2 (2004) to evaluate the accuracy and reliability of fire safety regulations in the design of continuous slabs. The fire resistance of the RC slabs is determined based on the "ultimate strength design" criteria, as outlined in actual concrete design codes. The findings indicate that the fire scenario plays a crucial role in the fire resistance of RC slabs. The simplified calculation method is effective for determining the fire resistance of continuous RC slabs, yielding satisfactory results that prioritize safety, particularly for individual members. Increasing the reinforcement ratio improves the fire resistance of RC slabs. While enlarging the slab span reduces fire resistance in terms of deformation limits, it does not affect the fracture behavior. The 3D analysis results show higher deflections compared to the 2D analysis.

Keywords: *Continuous two span RC slab, Fire Resistance, SAFIR 2016, Simplified Calculation Method*

Integrating Interpretable Machine Learning and Adaptive Sampling for Nonlinear Dynamic System Modeling

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Traditional modeling of nonlinear dynamic systems is time-consuming and requires expert knowledge. This can be overcome by the use of black-box approaches, such as artificial neural networks, which offer fast and accurate solutions. However, being black boxes, they come with well-known drawbacks such as lack of interpretability, non-uniqueness and inconsistency in performance. Furthermore, they require a training data set which contains sufficient information about the system behavior in the desired operating range. Hence, the accuracy of neural networks depends, among others, on the chosen architecture, initial parameters and the provided data. Since the architecture and initial parameters are often chosen through trial and error or by grid search, the parameters usually have no physical meaning and the architecture does not correspond to the physical model. Furthermore, the training data is not assumed to be readily available in the structural dynamics applications which poses a further limitation. Recently, a number of studies tried to address the aforementioned problems with Interpretable Machine Learning, attempting to eliminate the black-box approach by assessing meaning behind the neural network's architecture and parameters. On the other hand, the problem of training data sampling and generation has been addressed by sampling methods which aim to minimize the experimental effort to obtain the data. However, a general approach that combines the sampling method with IML has not been implemented. In this paper, it is aimed to combine IML and adaptive data generation, leading to a quasi-deterministic procedure for defining the architecture and initial parameters, while keeping a systemic approach for choosing the sampling data. The IML approach was implemented in combination with adaptive sampling for a Duffing oscillator system. The combined approach did not only remove the necessity for the NN ensemble, thus reducing the required computing power, but it also improved the performance of the sampling method.

Keywords: *Interpretable Machine Learning, Adaptive Sampling, Nonlinear Dynamic Systems, Neural Networks, Duffing Oscillator*

Artificial intelligence (AI) in civil engineering – A case study on perception and application

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Artificial Intelligence (AI) is increasingly recognized as a transformative force in civil engineering, enabling smarter design, planning, supervision, and infrastructure management. From automated modelling through BIM platforms to AI-driven site monitoring and predictive maintenance, these technologies offer substantial benefits. However, in developing regions, the actual adoption, understanding, and perceived value of AI remain insufficiently examined.

This paper presents the results of a case study that investigated the perception and practical engagement with AI among civil engineers, students, professionals, and academic staff in Kosovo and the surrounding region. The study employed a structured survey methodology to assess levels of familiarity with AI tools, their integration in professional activities, and the perceived opportunities and challenges associated with their use.

The findings reveal both a strong interest in AI and notable barriers to its integration, including limited access to training, insufficient institutional support, and regulatory uncertainty. Despite these challenges, respondents expressed optimism about AI's potential to improve efficiency, accuracy, and decision-making in civil engineering practice.

This study provides timely insights into the region's readiness for digital transformation in engineering and emphasizes the urgent need for targeted educational programs and supportive frameworks. By grounding the discussion in local realities and professional experiences, the paper contributes to a deeper understanding of how AI can be effectively embraced in civil engineering across developing contexts.

Keywords: *Artificial Intelligence (AI), civil engineering, digital transformation, developing regions, technology adoption*

Analytical Computation of the Shear Correction Factor in Layered and Heterogeneous Sections

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The shear correction factor κ is critical for accurate predictions in Timoshenko beam and Mindlin plate theories, especially when accounting for transverse shear deformation. Classical values of κ apply to homogeneous, prismatic sections, but real structures often exhibit material inhomogeneity, internal layering, or orthotropic behavior—necessitating more general formulations. This paper presents an analytical and semi-analytical framework for determining "κ" in nonhomogeneous, layered, and orthotropic cross-sections. The method relies on the principle of strain energy equivalence, where the actual shear stress field is replaced by an energetically equivalent uniform distribution. The formulation accounts for spatially varying shear modulus $G(x,y)$ and, in the plate case, orthotropic shear stiffness components $G_{xz}(x,y)$ and $G_{yz}(x,y)$. Closed-form expressions are derived for selected layered geometries with piecewise-constant material properties. For continuously graded or microstructurally heterogeneous sections, a numerical integration scheme is proposed, based on pointwise evaluation of stress and stiffness fields. This allows application to composites with dispersed inclusions or stochastic mesostructures. Comparisons with finite element models confirm the accuracy of the proposed approach for both beams and plates. The results highlight the sensitivity of "κ" to material layout and anisotropy, especially when stiff inclusions or weak layers are located in high-shear regions. The developed methodology provides a versatile and efficient tool for improving shear deformation modeling in complex structural elements, with direct relevance to layered composites, sandwich structures, and advanced timber systems.

Keywords: *shear correction factor, nonhomogeneous cross-section, Reissner-Mindlin plates, Timoshenko beams, layered materials, analytical homogenization*

Experimental and Numerical Performance Analysis of Steel Scaffolding Systems with Height of 300cm

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Scaffold design has become an important research topic in recent years due to the frequent cases of collapse, which cause hundreds of fatalities worldwide. These incidents have made scaffold safety a key priority in the construction sector. This study analyzes modular steel scaffolds with a height of 300 cm, made of circular cold-formed profiles connected through a tube-in-tube system. A full-scale experimental test was carried out to measure the load-bearing capacity, vertical and lateral displacements, stress distribution, and deformation patterns under vertical loading. In addition to the experimental investigation, a numerical model based on the Finite Element Method (FEM) was developed to analyze the structural behavior of the scaffold. The results obtained from both experimental tests and numerical simulations were compared with the requirements of the current generation of Eurocodes (EN 1993-1-1:2005) as well as with the draft of the second generation (prEN 1993-1-1:2023).

Keywords: *System Scaffold; Circular Hollow Section; Critical Load; Strain Gauges.*

Flexural Behavior of Reinforced Concrete Beams Retrofitted with Fiber-Reinforced Polymer (FRP)

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This study explores the flexural performance of reinforced concrete (RC) beams retrofitted with fiber-reinforced polymer (FRP), focusing on how variations in the amount and positioning of FRP affect structural behavior under bending. The growing use of FRP in structural rehabilitation is driven by its advantageous properties, including high tensile strength, corrosion resistance, and ease of application. Numerical analyses were carried out using specialized structural modeling software, examining RC beams with consistent geometric and material characteristics (C25/30 concrete and B500C steel reinforcement). Two groups of beams were considered: unretrofitted beams as control specimens and beams retrofitted with FRP in different configurations. The study evaluates parameters such as load-bearing capacity, stiffness, and deformation response to determine the effectiveness of FRP in enhancing flexural performance. Comparative results highlight the significant improvements in structural behavior achieved through retrofitting, supporting the practical application of FRP in strengthening and extending the service life of existing RC elements. The findings contribute to the development of effective retrofit strategies, offering insights for engineers and researchers involved in structural upgrading and seismic rehabilitation.

Keywords: *Fiber-reinforced polymer (FRP), reinforced concrete beams, flexural capacity, structural retrofitting, numerical analysis*

Static analysis of a tilted sinking well in the context of safe operation

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Sinking wells are widely used engineering structures, particularly in urban environments or in areas with limited construction space and difficult soil conditions. They are constructed using the "cut and sink" method, where the lowermost segment of the well is equipped with a cutting edge that enables the structure to penetrate the soil under its own weight. This technique allows for safe and efficient installation without the need for extensive excavation. However, during the sinking process, uneven soil resistance or improper execution can lead to tilting of the well, which poses structural and functional risks. This paper addresses key design and construction considerations, emphasizing the importance of accounting for the staged execution and three-dimensional behavior of the structure. A comprehensive analysis is presented regarding well tilting during installation, including causes, monitoring techniques, and methods for assessing the degree of tilt. The study proposes practical criteria for evaluating whether a tilted well can remain in service without compromising safety. It includes analytical formulas for calculating tilt angles and determining their impact on stress distribution in the surrounding soil. Through a detailed investigation, it was determined that a controlled and limited tilt may be acceptable, provided that the additional stress transferred to the ground does not exceed 20% compared to an ideally vertical well. Methods for real-time monitoring of tilt progression during construction are also discussed, aiding engineers in decision-making processes on-site. In the final section, a numerical example is provided to demonstrate the application of the discussed methods and criteria in a practical engineering scenario. This example illustrates the evaluation process of tilt acceptability and highlights the importance of early detection and correction during construction to ensure the long-term safety and performance of the structure.

Keywords: *sinking well, structural tilt, geotechnical design, soil stress, construction monitoring, cut and sink*

Construction Technology and Management

Design of Transfer Structures: Lessons Learned from Implemented Projects

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The architectural requirements for placing planted columns at different levels pose significant challenges when designing transfer structures. These structures must accommodate architectural creativity while ensuring structural integrity and load redistribution. This paper studies several executed projects to explore the relationship between architectural needs and structural engineering solutions.
Particular focus is given to design considerations such as geometric configurations, shear resistance calculations, and the control of deflection and cracking, all of which are crucial for long-term durability. Additionally, the stability of transfer structures under seismic forces is discussed as an essential factor to ensure safety and resilience in dynamic conditions.
Through the analysis of real-world case studies, this research highlights innovative strategies for overcoming these challenges, offering valuable insights for engineers facing similar complexities. The findings aim to enhance the understanding of transfer structure design, balancing architectural aspirations with structural and safety demands.

Keywords: *transfer structures, structural design, load redistribution, structural stability, architectural challenges, construction feasibility*

Relation between construction scheduling and cash flow in the construction of infrastructure projects

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The successful completion of construction projects is predicated on the appropriate integration of three key parameters: quality, time, and cost. To ensure the required quality, construction designs must correspond to nationally mandated standards and technical specifications as defined in relevant construction codes and laws. The project timeframe is often established through mutual agreement among stakeholders and documented in precise construction schedules. The project cost is the contractually agreed-upon financial commitment formed through competitive bidding or negotiation, and it indicates the amount the investor disburses to the contractor.

While payment structures appear simple in theory, the practical dynamics of cash flow in construction projects have a considerable impact on the pace and continuity of project execution. Under contractual terms stated in the Red FIDIC conditions, the contractor completes various work stages, which are then verified by the supervisory authority and compensated by the investor. However, in many infrastructure projects, notably in the railway sector, contractors frequently build their schedules to lock in a significant portion of their profit in the early stages. This strategy allows them to fund the procurement of high-cost materials without jeopardizing their own capital. Such scheduling tactics may deviate from the anticipated construction timeframe and disrupt the projected cash flow structure, potentially leading to contractual disputes. These disruptions can have a negative impact on both the project's quality and completion time.

This study investigates the relationship between construction schedule and cash flow management in the context of a railway infrastructure project. It also examines the ramifications of alternative payment scenarios, highlighting their respective advantages and drawbacks, and emphasizes the importance of coordinating cash disbursements with construction progress to ensure project success.

Keywords: *Construction Scheduling, Cash Flow, Infrastructure Projects, Financial disbursements, Quality of works*.

Comparative analysis of housing design standards in Albania, Kosovo and the EU countries

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Building design standards, particularly those concerning residential buildings, are essential tools for ensuring quality of life, energy efficiency, and structural safety. These standards are shaped by diverse factors such as historical evolution, cultural practices, climate conditions, legal frameworks, and the socio-economic development of each country. In recent years, their role has expanded to include alignment with sustainability goals and resilience to climate change.

This paper presents a comparative analysis of architectural, structural, and energy efficiency standards in Albania, Kosovo, and selected European Union countries. The study focuses on core aspects such as spatial functionality, accessibility, seismic resilience, energy use, and thermal performance. This comparative approach identifies key similarities and differences in regulations, highlighting gaps that hinder the alignment of Albanian and Kosovar standards with EU norms. The analysis draws attention to the fragmented and outdated nature of some national standards in Albania and Kosovo, particularly regarding energy performance and seismic safety. These discrepancies pose challenges to sustainable development, social inclusion, and integration into broader European urban planning frameworks.

The paper advocates for the modernization and harmonization of building regulations in these countries, recommending the adoption of updated, performance-based standards inspired by the Eurocodes and EU directives. Such reforms would not only improve housing quality but also advance long-term objectives of environmental sustainability and regional integration.

Keywords: *Design standards, Housing quality, Energy performance, Seismic safety, Albania, Kosovo, EU building regulations, Eurocodes.*

Heavy- duty pavements design methodologies for port, airports and highways

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Heavy-duty pavements, such as those found at ports, industrial regions, and airports, are those that support large vehicles subjected to extreme loading conditions and high tire pressures. These pavements cannot be constructed using conventional pavement design techniques. In order to support extremely heavy loads, pavement that meets these requirements must have a well-designed asphalt-aggregate mixture, particularly in the surface course, an intermediate asphalt layer with higher compaction levels, and a thick enough layer to prevent overstressing of all unbounded layers and subgrade. The aim of the design process is to ensure the pavement structure withstand over a specified amount of time or number of cargo movements, increasing vehicle weight and truck volumes by comparing and discussing various design approaches, proper material selection, aggregate sizing, and asphalt mixture design. In this study, the Heavy Duty Pavement manual procedures used by the British Ports Association chart-based methodology and empirical based design are examined. By comparing models of design pavement sections with elastic granular materials and elasto -plastic granular materials, a finite element analysis is carried out to determine the pavement design.

Keywords: *heavy duty mix, pavement design, asphalt pavement, granular materials.*

Analysis on the financial effects in the field of construction, of the implementation of the technical pricing manual in Albania and comparison with the methodology used in Kosovo

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The construction industry is undergoing significant developments, not only globally and regionally, but also in Albania, as a developing country. The significant development of technology is widely impacting the efficiency and quality of construction. Therefore, the codes and manuals used in this industry require continuous updates to adapt to recent developments.

The same applies to Construction Price Manuals in Albania. Pricing manuals serve as guidelines and references for annual budget planning, as well as the budget limit for new constructions procured. These manuals are developed based on the cost structure of construction works, including labor, machinery, transportation, and materials.

The Pricing Manual approved by Decision of the Council of Ministers No. 629, dated 15.7.2015, was repealed, with the approval of the new Pricing Manual by Decision of the Council of Ministers No. 216, dated 13.04.2023. This manual aims to create an integrated system for computerizing the price manual for construction work items, which standardizes the methodology of calculation and the presentation format of estimates, as well as technical analyses of prices, to facilitate the activities of public or private entities, as well as to facilitate technical and financial control in the construction field.

The purpose of this study is to find the advantages and disadvantages in the use of the technical price manual approved by the Decision of the Council of Ministers in 2023, as well as to compare the prices of the work items included in this manual with market prices, thus identifying the financial effect in determining the construction cost of construction work. To have a more realistic approach to achieving this goal, a comparison was also made with the methodology used in Kosovo for determining the prices of construction labor items.

Keywords: *Construction budget, pricing manual, financial effect, pricing market*

Adaptive Reuse of Industrial Buildings: Structural Assessment and Rehabilitation

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In Albania, industrial buildings constructed prior to the 1990s have largely become disused due to the economic unviability of industries established during the communist era. This paper addresses the critical need for the structural analysis and rehabilitation of these disused buildings, aiming to facilitate their reuse. It begins by presenting a concise historical overview of these buildings, highlighting their evolution from the end of World War II to the early 1990s, and summarizing the specific structural details characteristic of each construction period. Subsequently, the study investigates the construction characteristics, focusing on the materials and structural systems employed, and analyzes the structural safety of these aging industrial buildings. This analysis is driven by the necessity to rehabilitate these structures for contemporary applications, addressing time-dependent degradation and adapting them for new functional demands. The ultimate goal is to develop a concrete methodology for the structural assessment and rehabilitation of these buildings, enabling their transformation into modern living and working spaces. To achieve this, the study proposes the following steps: conducting comprehensive structural and seismic assessments, implementing architectural adaptation and urban planning in collaboration with local municipalities and stakeholders, and prioritizing the revitalization of heritage buildings and those with monumental value.

Keywords: *Disused Industrial Buildings, Structural Assessment, Structural Rehabilitation, Structural System, Structural Safety*.

Construction Materials

Rheological Characteristics of Hybrid Steel- Synthetic Fibers Reinforced Concrete Beams

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This paper presents both experimental and numerical data on the influence of fiber types on the rheological characteristics of concrete, focusing on their effect on strain, displacements, and crack formation in reinforced concrete beams. This study examines the role of fibers in enhancing the material's mechanical properties. The nonlinear numerical analysis is performed using DIANA software. While concrete is known for its high compressive strength, it is relatively weaker in tension, prompting the use of various fibers to absorb tensile stresses. Fiber-reinforced concrete has gained widespread application, with extensive research dedicated to its performance. This study explores three types of fibers—macro-fibers, microfibers, and steel fibers—used in a concrete mixture of the same grade. The paper presents results on the mechanical characteristics of concrete samples incorporating these fibers, including the long-term rheological behavior under sustained loading, such as creep and shrinkage deformations. Additionally, the study evaluates the deflections observed at the mid-span of the beams for the three concrete types. These findings provide valuable insights into the performance of fiber-reinforced concrete under different loading conditions, offering guidance for its use in practical applications.

Keywords: *Fiber-Reinforced Concrete, Modulus of Elasticity, Shrinkage, Sreep, Diana Software*

Modelling and experimental evaluation of adhesion Strength in cement-based tile adhesives

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In this work we presents a detailed experimental examination of cement based tile adhesives (CTAs) formulated as C1T, C1TE, C1TES1, and C2TES2, We conducted experimental sets to test key properties like initial adhesion strength, open time, resistance to water immersion, heat aging, and freeze cycles, all under controlled conditions as temperatures between 20 and 25°C and humidity levels from 45 to 55%. The main objective was to understand how these adhesives perform in different scenarios, especially in building projects where reliability is very important.

We used the experimental data we collected to run a linear regression model in order to predict adhesion strength, focusing mainly on water content as the main variable. We used the water percentage as input and observed a reliable estimate. The model results showed a coefficient of $R^2 = 0.915$ and a root mean square error of 0.12 MPa, which is reasonably acceptable for everyday use. Our results show that product development and efficiency boosting are possible in formulating adhesives, which leads to speeding up the construction sector. Another factor, as tweaking water levels slightly, can make a big difference in how well the adhesive holds up over time. This way, phenomena like cracking or peeling are avoided. Overall, this method simplifies predictions without sacrificing precision, making it helpful for engineers and manufacturers.

Keywords: *Cement-based tile adhesives, adhesion strength, linear regression model, environmental analysis.*

Geotechnical Engineering

Comparative Evaluation of Stone Column Performances in Soil Improvement

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The treatment and reinforcement of soils with the replacement and vibration method (vibro replacement) is one of the compaction techniques, through which friable or weak soils are improved with the aim of being used as a supporting base for foundations. With replacement and vibration improvement the benefits and results that can be achieved guarantee the required behavior of the foundation base. This paper presents the works made for the construction of stone (gravel) columns in two construction sites in Durrës, Albania. Both of these sites reflect subsoils with weak engineering properties. The reinforcement with gravel columns is projected to reduce consolidation settlements and to avoid liquefaction that is present in these construction sites. The calculations in analyses of settlement and bearing capacity follows the procedures summarized in Priebe's methodology. The results confirm the increase in bearing capacity of the mat foundations after the realization of the reinforcement with gravel columns in the mentioned sites within these projects.

Keywords: *Soil improvement, Stone column, Bearing capacity, Settlements*

Reliability Analysis of the Axial Bearing Capacity of pile foundations using Monte Carlo simulation

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Uncertainty and risk have always been an integral part of the geotechnical engineering practice. The source of the uncertainties relates mainly to the complex nature of soils and rocks combined with challenges and potential errors in investigation and characterization processes. Conservative approaches and observational methods are some of the strategies that geotechnical engineers have developed in order to deal with such issue (Christian, 2004). With the considerable advancements in computational methods the recent approaches are directed towards the quantification of the uncertainty and reliability analysis. One widely used technique is the Monte Carlo simulation which uses random sampling and statistical modeling to estimate uncertainties by simulating the process through a defined number of iterations. The aim of this paper is to integrate the Monte Carlo simulation in the verification process of the axial bearing capacity of a pile foundation using the well-established analytical methods, where the geotechnical parameters are derived from CPT in-situ testing. Such approach provides additional insights in the performance of the pile foundation by determining the probability of failure and reliability index in addition to the ultimate limit state (ULS) verifications according to Eurocode 7.

Keywords: *reliability, bearing capacity, Monte Carlo simulation, uncertainty, probability of failure, pile foundation*

Evaluating Differences in Predicted Settlements: A Comparative Analysis of Soil-Structure Interaction Models

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The reaction that the soil under the foundation causes to the object above it, which is called the soil-structure interaction, essentially affects the behavior of the object (load distribution, foundation displacements, internal forces in structural elements, etc.). In the practice of structural design for several years now, with special emphasis on multi-storey ones, a inadequate approach to the treatment of the soil-foundation-structure interaction has been observed. All that is done regarding the interaction is the determination of the soil subgrade modulus under the foundation and its application in structural analysis softwares (the substructural approach). In addition to the inadequate approach approach, the determination of the modulus of subgrade reaction itself and its application are often done incorrectly, usually for two main reasons: if the determination of the modulus of subgrade reaction is done using the Winkler method, the assessment of the soil-foundation settlements is incorrect, while in the case when the modulus of subgrade reaction is determined according to the Bowels expression which relates it to the ultimate bearing capacity of the soil under the foundation, for any level of stress under the foundation, it is assumed that the soil is in the elastic deformation zone which is far from the real state. We will try to make a connection between these two common approaches through numerical modeling, treating the soil as nonlinear, to see how suitable they are for describing the soil-structure interaction.

Keywords: *Soil-structure interaction, modulus of subgrade reaction, Winkler method, Bowels method.*

Comparative Analysis of Soil Liquefaction Potential in the Kune Vain Area (Lezhë)

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Soil liquefaction is a hazardous seismic phenomenon that occurs in water-saturated soil deposits. Under dynamic loads, such as earthquakes, the soil loses its bearing capacity and behaves like a liquid, leading to severe structural and infrastructural damage, particularly in coastal areas with soft sediments.
The Kune Vain area, located in Lezhë Municipality, consists mainly of alluvial deposits with a high groundwater table, making it susceptible to soil liquefaction during seismic shaking. This study aims to assess the liquefaction risk in this region by analyzing the experiences and methodologies presented in Italian and Japanese literature. Through the Sand Compaction Pile (SCP) method proposed by Kitazume and the liquefaction analyses documented by Bruschi, this study will identify high-risk areas and propose engineering measures for soil stabilization. The results of this study will contribute to seismic risk assessment and the development of sustainable construction strategies in the Kune Vain area, ultimately helping to mitigate the potential impact of earthquakes on buildings and infrastructure.

Keywords: *Soil liquefaction, Kune Vain - Lezhë, seismic hazard, Sand Compaction Pile method (SCP).*

Pile analysis as geothermally active structural elements

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The application of thermo-active structures represents a sustainable solution for utilizing shallow geothermal energy, with significant environmental and economic benefits. The main advantage of this innovative concept is that underground structural elements have a dual function, where their primary function is to provide load-bearing capacity and stability to the structure, while their secondary function is heat exchange with the ground. This type of construction includes tunnel linings, underground diaphragms, piles, shallow foundations, and others. One of the challenges arising from the application of these constructions is the analysis of temperature effects and thus the thermo-mechanical behavior of the structures themselves. A numerical modeling using Plaxis 2D software axisymmetric model of two piles was performed to determine their thermo-mechanical behavior under the influence of mechanical and thermal actions, as well as to determine the effects of temperature changes on the structural elements. In the analysis, two piles were considered, namely a free-head pile and an end bearing pile subjected to thermal actions of cooling and heating, where the main goal of the analysis is to determine their behavior under thermo – mechanical loading. Mechanical actions were applied based on a previously proposed program, while thermal actions were taken depending on the time. The behavior of piles under the influence of dual loading was obtained, as well as the effect of such action on the stress-deformation state of the pile foundation. Then, recommendations for design aspects and procedures are provided based on the analysis of numerical results in accordance with the recommendations of Eurocode 7, which take into account additional thermal actions of cooling and heating of the pile, along with the existing mechanical actions, a state for which there are no rules and standards yet.

Keywords: *Geothermal constructions, energy piles, thermo-mechanical behavior, Eurocodes, numerical modeling.*

Optimizing Soil-Structure Interaction for Offshore Wind Turbines: Experimental Insights and Numerical Modeling

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The constantly increasing demand for energy, coupled with the effects of climate change, makes the expansion of sustainable energy capacities even more crucial. In the northern hemisphere, energy from offshore wind turbines presents a promising alternative that aligns with the goal of reducing greenhouse gas emissions. For certain water depths, multi-pile solutions (such as jacket or tripod structures) have proven to be effective platforms for mounting wind turbines. One critical aspect that requires special attention in numerical modelling for such foundations, is the soil-structure interaction behaviour. This paper aims to show how various factors, including pile roughness, normal stress, stress conditions, and relative density, influence the interface behaviour for cyclic axially loaded foundations. This investigation was conducted through an extensive experimental campaign via ring shear device. Additionally, a novel interface model was derived from an existing soil model, with its theoretical formulation calibrated against the experimental results. In conclusion, the results of a large-scale test were numerically modelled using the newly enhanced interface model, showing good compatibility with experimental results.

Keywords: *Multi-pile foundations, Cyclic axial load, Soil-structure interaction, Interface modelling, FEM, Ring shear testing*

Analysis of Lateral Loading on Pile Groups

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Pile groups are commonly used to support offshore jacket structures, which are often subjected to significant lateral loads due to wind and wave actions. A precise understanding of the lateral response of pile groups is essential for the optimal design of deep foundations, ensuring the stability and safety of offshore structures. Experimental studies, both at full and reduced scale, have shown that the lateral capacity and stiffness of a pile within a group can be lower than that of a single isolated pile, due to soil-pile and pile-pile interaction effects. These effects significantly influence the group behavior and load distribution among the piles. However, the understanding of the extent of the negative group effects remains limited. Industry guidelines (such as DNV, ISO, API) for pile group design have not been substantially updated over the years.

Most pile group testing has been conducted on linear configurations with standard pile spacing (S/D = 3), whereas jacket platforms typically use only 2 to 4 piles with closer spacing. This makes the group's response more sensitive to load direction and dynamic actions. Furthermore, complex factors such as pile installation methods and aspect ratio make it challenging to separate the effects of other parameters, such as load angle and pile spacing, in field tests.

Given the high cost and technical challenges of full-scale testing, finite element analysis offers a more affordable and comprehensive alternative. With current computational power and advanced geotechnical models, it is possible to perform analyses with sufficient accuracy to evaluate the impact of pile group configuration and load direction on offshore platform foundations, thus contributing to the optimization of deep foundation designs for offshore applications.

Keywords: *Pile Groups, Offshore Structures, Lateral Load, Finite Element Analysis, Soil-Pile Interaction, Foundation Design*

Evaluation of Pile Bearing Capacity Based on In-Situ Data from CPTu and SPT

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The evaluation of pile bearing capacity is a key aspect in the design of deep foundations, especially under different geotechnical conditions. This study aims to assess the pile bearing capacity using in-situ data obtained from CPTu (Cone Penetration Test with pore pressure measurement) and SPT (Standard Penetration Test) conducted in a specific area.

Through the analysis of these data, separate assessments were made for each testing method, comparing the bearing capacity of the piles. CPTu provides a detailed and continuous evaluation of soil characteristics and force distribution along soil layers, offering more accurate and reliable information on the pile bearing capacity. On the other hand, SPT, although faster and simpler, provides more general data that aids in determining the bearing capacity but with a lower level of accuracy compared to CPTu.

The study results show that using both methods together allows for a more comprehensive and reliable evaluation of pile bearing capacity, contributing to a safer and more efficient design of deep foundations.

Keywords: *Pile bearing capacity, CPTu, SPT, In-situ testing, Geotechnical conditions, Deep foundations, Soil characterization, Load distribution.*

Theoretical Application of Wick Drains: A Case Study from Durrës

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In areas with soft, water-saturated soils—such as the coastal region of Durrës, Albania—the settlement of engineering structures can be slow and unpredictable, which can significantly impact construction timelines, structural integrity, and safety. The process of soil consolidation, especially in such challenging geotechnical conditions, often takes several years, leading to delays and increased costs. Prefabricated vertical drains (wick drains) are an established technique designed to accelerate the consolidation process and reduce the long-term settlement of soft soils. This study investigates the theoretical application of wick drains on a construction site in Durrës, focusing on the design parameters, preliminary calculations, and expected performance of the system. While the implementation of the system has not yet occurred, the calculations indicate a substantial improvement in the rate of consolidation and a significant reduction in settlement time. These preliminary findings highlight the potential of wick drains to enhance construction efficiency and safety in soft soil regions. The study also provides valuable insights into similar future projects, offering a foundation for the eventual application of wick drains in areas with comparable geotechnical challenges. This research contributes to the broader understanding of ground improvement techniques and their role in accelerating the development of infrastructure projects in soft and water-saturated soils.

Keywords: *Wick drains, soil consolidation, soft clay, ground improvement, Durrës*

Parametric Study for Mechanically Stabilized Earth (MSE) wall

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Mechanically Stabilized Earth (MSE) walls are earth-retaining structures, which combine granular backfill soils with tensile reinforcements, such as geosynthetics (geogrids or geotextiles) or metallic strips. The aim of these tensile reinforcements is the improvement of the performance and the stability of the walls. MSE walls are increasingly being used because they are cost-effective, quick to construct, and can withstand significant deformations without failing. Using this structure has proven efficient for supporting embankments, slopes, and retaining walls in different civil engineering applications such as transportation infrastructure, roadways, and bridges. The design and analysis of MSE walls can be based on analytical methods (which follow the recommendations of FHWA-NHI and AASHTO, National Concrete Masonry Association (NCMA) etc), on Limit equilibrium methods (such as Bishop's, Spencer's, and Janbu's methods), or on Finite element methods using specialized computer programs. Included in the design procedure of MSE wall are the internal stability analysis (evaluation of tension and pullout resistance in the reinforcing elements) and external stability analysis (checks for overturning, sliding, and bearing capacity failure). In this study, a parametric analysis of MSE walls is carried out using GEO5 MSE Wall software and AASHTO recommendations. The impact of the design parameters such as, the friction angle and unit weight of backfill soil, the friction angle of foundation soil, reinforcement length and wall height on both internal and external stability, is analyzed. The analysis illustrates that, as the backfill friction angle increases, the maximum reinforcement force decreases. Furthermore, the safety factors for internal and external stability increase. It is also observed that, increasing the length of the geogrid reinforcement enhances external stability and pullout resistance. Additionally, the friction angle of foundation soil does not affect the maximum reinforcement force but improves the external stability, preventing sliding and bearing capacity failures. In conclusion, carefully considering the above-mentioned parameters is significant for MSE wall design.

Keywords: *MSE wall, reinforcement, internal stability, external stability, factor of safety*.

Analytical and Numerical Estimation of Pile Capacity in Soft Soils: A Comparative Study Using Classical Methods and Plaxis

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Prediction of pile behavior in soft soils remains a critical challenge in geotechnical engineering, particularly where soil strength and stiffness are highly variable. This study presents a comprehensive comparative analysis of axial pile performance using three distinct methodologies: the semi-empirical LCPC method, the analytical Nakazawa method, and advanced numerical modeling with Plaxis. The comparison is based on Cone Penetration Test (CPT) data from a soft clay site. All methods are calibrated and validated using high-resolution Cone Penetration Test (CPT) data obtained from a soft clay site. The analysis evaluates capacity components (shaft and base), and settlement predictions. Pile capacity, load-settlement response, are presented based in this tree methods. The results demonstrate the strengths and limitations of each method, with Plaxis providing the most realistic displacement profiles under service loads.

This comparative framework provides recommendations for pile design in soft, and underscores the importance of integrating CPT data with multi-method modeling for performance-based pile design.

Keywords: *Caly soil, settlement, CPT data, LCPC method, Nakazawa method*, Plaxis

Hydraulic and Coastal Engineering

Determination of the flow resistance force for flexible flood plain vegetation

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Effect of flexible plants on flow conditions depends, in addition to hydrodynamic parameters, also on plant elasticity. The flexible plants to be tilted by flowing water. It is the modulus of elasticity, that determines how much force is needed for deflection to occur. Based on laboratory studies, the main aim of our research was to evaluate the resistance of wicker deforming elastically under the water flow. To analyze this phenomenon, a flow resistance model for a seagrass was adapted to determine the resultant resistance forces of the flexible wicker. The first stage of the study was determination of the biomechanical parameters of wicker branches. The modulus of elasticity of the plants was determined by analyzing the deflection line of a cantilever beam under static bending in a variable axially symmetric cross section. The study consisted of measuring the deflection arrow of rigidly fixed plants. The second stage were experiments in a hydraulic flume. The hydraulic response to water pressure was studied for the following wicker twigs: fresh with leaves, fresh without leaves and dry. The number and area of leaves for each plant twig tested were included in the study, a.o. parameters, the Leaf Area Index was measured. Based on the plant bending under the water flow, the values of the bending angle and the relative strain were also determined. Knowing the average flow velocity, the total drag force was calculated. It was shown that the magnitude of flow resistance for flexible plants, in addition to their stiffness, is significantly affected by the presence of leaves. They cause an increase in the drag force. The bending of plants requires consideration of the frictional force on the leaf surface. The results of our study allowed positive verification of the adopted model for determining the drag force of flexible floodplain vegetation.

Keywords: *rivers; flow resistance; floodplains with plants; vegetation stiffness.*

Hydraulic research of water damming by flow through floodplain vegetation

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Effect of plants on flow in a riverbed manifests itself as a significant reduction in its capacity. The flow resistance increases and the position of the water table in the channel changes (damming up above the plant zone). In addition to hydraulic parameters, the effect of the plant zone on flow conditions depends on a number of factors, e.g. species, plant community density, stem diameter and spacing, spatial configuration of plants. The flexibility of the plant community plays a very important role in this case. The measure of these flexibility is the parameter "MEJ" (M - plant community density, E - modulus of elasticity, J - modulus of inertia of the stem cross-section). The laboratory tests presented here focused on studying the damming of the water table (ΔH) in front of a plant zone with different biomechanical properties (MEJ). Three variants of plant zones were tested in the hydraulic channel for different values of flow (q). These plant zones were constructed using: rigid steel cylinders, plastic substitutes for benthic vegetation, and natural flexible wicker branches. The experimental relationship ΔH = f(q; MEJ) was analyzed. For relatively small specific flow rates q, the type of material simulating vegetation (different plant elasticity) doesn`t cause pronounced differences in the function of water damming ΔH = f(q; MEJ), e.g. for comparable variants of plant obstacles built of rigid steel bars, flexible plastic elements, or natural branches of wicker: ΔHsteel ≈ ΔHplastic ≈ ΔHwicker. The hydraulic effect of plant elasticity becomes significant only at higher flow velocities. This was confirmed by observations and measurements in the laboratory. Hydrodynamic push forces of water are then able to bend plant stems in the direction of flow. The laboratory tests conducted made it possible to determine the limiting magnitudes of the hydraulic parameters (e.g. v > 1 m/s).

Keywords: *rivers; flow conditions; floodplains with plants; water damming; hydraulic tests.*

Laboratory studies on the sedimentation of river debris in a fish ladder

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A great many fish ladders built to ensure ecological river continuity demonstrate all sorts of exploitation problems. Fish passes are highly sensitive to any changes in the hydrological conditions. The transport of river debris, which also takes place in a fish ladder, is another important source of problems (silting up, sedimentation). In hydraulic laboratory, the model tests of the vertical slot fish ladder was conducted. On the fish ladder a device used for sediment dispense was installed. The sediment was dispensed to each chamber of the ladder. Measurements of approx. height of the water table, measurements of flow rate, observation of line streams in chambers were carried out during the studies. The flows of sediment and hydraulic parameters inside designed fish ladder, single compartments and their connection with sedimentation process in individual chambers were also studied.

With established parameters (fixed flow and appropriate sediment grain size) it was possible to notice places in which sediment deposition was held. With grains about diameter 0.125, 0.5 and 1.0 mm in quite a short time the phenomenon of sedimentation and sediment deposition (70% of all grains) was observed. Particularly the bigger grains with diameter 1.0 mm sedimented relative fast. About 60% of smaller grains were transported downstream to the next chambers. There is a clear relationship between the hydraulic flow conditions and sediment transport in the fish ladder: sediment transport and sedimentation significantly depend mainly on the sediment properties and spatial distribution of flow velocity; much lower mean velocities appear most often in first 3 chambers of the fish ladder; the only zones of increased velocity rate are places in vicinity of intake and outlet slot; sediment deposition appears in the middle of chamber and by side partition walls; the course of sediment transport in time in the fish ladder is not homogeneous.

Keywords: *rivers, fish pass, sediment, modeling, flow conditions.*

Local Scour Around Bridge Piers –Case Study Ura e Zogut

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The Zogu Bridge is an important structure of the time due to many engineering factors: spans, Arch structures, specific concrete structures and design implementation conditions. In the scope of today's situations, the bridge was under different environmental conditions and no maintenance, therefore it is in the collapsed state of bridge piers caused by local scour around the bridge. The main factors that have influenced the local scour of the pier are: hydraulic parameters, which include the flow of the river and flooding caused by precipitation over the years; the structural parameter, specifically the rectangular shape of the pier, which makes it more affected by local scour compared to other shapes such as the circular one; geotechnical parameters, which include the low bearing capacity of the soil where the pier is founded. After collecting and analyzing the data related to the local scour of the fifth pier in particular, we conclude that the initial Riprap method had its effect by slowing down the local scour; however, since this process has advanced to its final stage, the total replacement of the pier has been proposed as a method recently, however other methods are also being considered, such as foundation design and scour countermeasures. All the data analyzed for this case study will be oriented in an adequate method for replacing the damaged pier, but always in relation with other piers in the bridge structure.

Keywords: *Local Scour; Fifth Pier; Riprap; Foundation Design*

Discharge Rating Curve Estimation for Drini i Bardhë River using a Bayesian Hierarchical Model

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Accurate estimation of river discharge is essential for hydrological analysis and water resource management, yet direct measurement of discharge remains challenging and resource-intensive. This study presents a robust methodology for modeling the relationship between river water elevation and discharge—known as the discharge rating curve—using advanced Bayesian hierarchical models. Four model structures are considered: the classic power-law model and its generalized form, each with constant and variable error variances. The approach leverages paired observations of water elevation and discharge to fit rating curves, focusing on the generalized power-law model for its superior flexibility and ability to capture complex river behaviors. The Bayesian inference framework provides not only point estimates but also credible intervals for model parameters and predictions, thus quantifying the uncertainty in discharge estimates. The methodology includes comprehensive model diagnostics, visualization of posterior parameter distributions, and residual analysis to ensure model convergence and reliability. This paper demonstrates the application of these models to Drini i Bardhë River in Albania, illustrating their practical value in Albanian hydrological practice. The results offer improved predictive accuracy, interpretable uncertainty bounds, and a reproducible workflow for river discharge estimation, with implications for flood risk assessment and river basin management in the region.

Keywords: *Discharge rating curve, Bayesian Hierarchical Model, Generalized power-law model, Uncertainty quantification.*

Assessment of oil pollution in surface and groundwater through Geostatistical Methods, the case of Gjanica River basin in Fier

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Oil pollution in surface and groundwater represents a major environmental concern, especially in areas located near petroleum industry activities.
This study focuses on the Gjanica River Basin in the city of Fier and aims to assess the extent and spatial characteristics of pollution using geostatistical methods.
The analysis is based on existing environmental data collected by responsible institutions for environmental quality monitoring, including recorded pollutant concentrations at specific monitoring sites. By applying spatial analysis techniques and interpolation methods within a GIS environment, the study seeks to identify potentially polluted areas and understand the spatial distribution of contamination.
The results are expected to contribute to a better understanding of the current environmental condition and serve as a basis for planning and decision-making in environmental management.
The approach used in this study can serve as a model for similar cases by developing pollution maps and analyzing its spatial distribution.

Keywords: *oil pollution, surface water, groundwater, Gjanica River, GIS, geostatistical methods.*

Hydrology, Flooding and Resource Management

Sustainable Flood Protection of the Toplluha River: Integrating Bank Reinforcements and Nature-Based Solutions

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This study examines the management and regulation of a flood prone segment of the Toplluha River in the municipality of Suhareka, focusing on sustainable flood protection through nature- based solutions. The aim of the study is to conduct a hydraulic analysis of the riverbed and identify potential solutions that can contribute to improving flood protection and enhance flood resilience.

The research was carried out in the Suharekë-Reçan segment, where detailed measurements of cross-sectional measurements were taken, and hydraulic parameters including discharge and water velocity were assessed.

Using advanced software, the riverbed profiles were developed and analyzed, and natural profiles were compared with regulated ones. Nature-based solutions for bank stabilization, such as the construction of natural embankments covered with reinforcing vegetation, are the main proposed interventions for preventing erosion and providing long-term flood protection.

The use of natural embankments and reinforcing vegetation has been evaluated as an effective and sustainable method for stabilizing riverbanks. This approach provides long-term protection and eliminates the need for complex infrastructure, such as detention basins.Unlike detention basins which require large land areas and may disrupt the biodiversity, Nature based solutions maintain ecological balance, improve water quality and support habitat conservation.

The results highlight the cost-effectiveness and environmental benefis of integration of Nature based solutions in river management. The implementation of natural embankments can promote flood protection but aslo promotes biodiversity conservation and sustainable hydrological balance. This approach not only offers flood protection but also contributes to the conservation of biodiversity and the improvement of water quality, ensuring sustainable river management. This study presents a successful model for integrating nature-based solutions in river management and promotes an ecological approach to protecting flood-prone areas.

Keywords: *River regulation, flood protection, nature based solution, embankments, bank stabilization, detention basins*

Sustainable Water Resource Management in Kosovo: Trends, Challenges, and Future Strategies

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Water resource management in Kosovo faces various challenges due to rapid urbanization, industrial growth, agricultural activities, and changing climatic conditions. The country relies heavily on water resources for domestic, agricultural, and industrial purposes, making sustainable water management crucial for ensuring environmental sustainability and socioeconomic development. This paper aims to determine the patterns and trends of water usage in Kosovo, including predominant sectors and consumption analysis. The impact of climate change and mismanagement on water scarcity and pollution were assessed. Results show that the largest water demand is for the agriculture sector, primarily for irrigation, followed by drinking water supply, and lastly, industry. Climate models project a steady increase in average annual temperatures for Kosovo. By 2060, temperatures are expected to rise by 1.11°C, and by 2099, the increase could go up to 4.25°C. Higher temperatures will lead to increased water losses, and uneven rainfall distribution may result in longer drought periods and increased reliance on irrigation, exacerbating existing shortages. Without proactive and coordinated management efforts, water scarcity and competition for resources will escalate, further increasing socio-economic vulnerabilities. Future water management strategies should integrate climate resilience measures, such as drought contingency plans, flood mitigation systems, and nature-based solutions to enhance water retention and biodiversity conservation.

Keywords: *water usage, socio-environmental drivers, climate change, water resources management, water scarcity.*

Assessment of Hydromorphological Elements in the Ishëm, Erzen, and Mat River Basins

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This study aims to analyze the hydromorphological elements of the Ishëm, Erzen, and Mat river basins using an integrated methodology to assess key elements defining the physical and functional characteristics of rivers. In detail, the analysis focuses on evaluating river channel geometry, riverbed composition, channel profile (both longitudinal and cross-sectional), and their impacts on natural flow dynamics. The methodology employs a multidimensional approach, beginning with the collection of hydrological and morphological data from diverse sources, including field measurements, aerial analyses, and computer modeling. These data enable the detailed identification of flow regime parameters, essential for determining water volume and velocity. A significant portion of the study focuses on the impact of engineering structures and constructions on the longitudinal continuity and the flow regime of rivers. The analysis highlights that structures within the riverbed and modifications to bank morphology, including changes in land cover along the banks and riparian zones, have led to noticeable alterations in hydrological dynamics. These modifications directly affect the rivers' capacity to convey water and maintain natural flow characteristics. Additionally, the study examines the interaction between rivers and floodplains, assessing how this connectivity influences the functioning of associated ecosystems. This multidimensional analysis aims to provide a comprehensive framework for interpreting the effects of both anthropogenic and natural impacts on the hydromorphological status of river basins in Albania. This work contributes to existing literature by offering a thorough analysis of methodologies used to assess hydromorphological status, serving as a foundation for planning documents in river basin management. The study's results can also guide river management and restoration policies, promoting the preservation of natural characteristics and functionality in the context of modern hydrological challenges.

Keywords: *Hydromorphological Elements, Channel profile, Flow regime, Land cover, Floodplains, River Basin Management.*

Water Resources Management in the Ishem, Erzen and Mat River Basins

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Effective management of water resources is crucial for preserving ecosystems and ensuring the availability of clean water. This study examines the pressures and risks faced by water bodies in three major basins in Albania: the Ishem, Erzen, and Mat basins. The analysis highlights the methods used to identify key factors affecting water quality and quantity, considering hydrological, physico-chemical, and biological data, along with human activity impacts. The study presents an integrated approach that combines statistical analysis, hydrological modeling, and environmental impact assessment to identify pollution sources and evaluate the effects of agricultural, industrial, and urban activities, as well as climate change, on water basins. It also examines the role of environmental legislation in managing water resources in Albania. Water quality in the Ishem, Erzen, and Mat basins is mainly affected by nutrient pollution, heavy metals, organic contaminants, and hydrological changes from hydrotechnical constructions. Agricultural practices and industrial discharges have further degraded water quality, and the absence of continuous monitoring has hindered proper risk assessments. Based on the main findings, this study recommends an approach rooted in integrated water resources management. Key suggestions include strengthening the monitoring system, implementing new wastewater treatment technologies, and developing more efficient policies to reduce environmental pressures. The study also highlights the importance of involving various stakeholders, such as government institutions, local communities, and the private sector, in the decision-making process for water management in the Ishem, Erzen, and Mat basins. This paper offers a detailed analysis of the anthropogenic and natural impacts on the water resources of three basins and proposes sustainable management solutions. The findings can guide policymakers and environmental experts in creating effective strategies for water protection at local and regional levels.

Keywords: *Water Resources, RBMPs, Pressures, Agriculture, Integrated Management*

Watershed prioritization of Lumbardhi i Deçanit river basin, based on morphometric parameters and land use/land cover change

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Watershed prioritization is gaining importance in relation with management and conservation of natural resources, especially aquatic and soil resources. One of the main ways that is applied for watershed prioritization is based on morphometric parameters and land use and land cover change over years. This form of watershed prioritization was also used in the case of prioritizing sub-catchments of Lumbardhi i Deçanit river basin. Firstly, the watershed was separated into 8 sub-watersheds, based on which the morphometric parameters were calculated and land use/land cover change analysis were carried out. Delineation of Lumbardhi i Deçanit watersheds and its sub-watersheds was done based on topographic maps, scale 1:50.000, DEM with a spatial resolution of 12,5 meter per pixel, downloaded from ALOS PALSAR – ASF, was used to find and calculate morphometric indices, using ArcMap 10.8 GIS software. Land use and land cover change analysis was done based on Supervised Image Classification techniques, using satellite imagery from Landsat 7 and Landsat 8, for years 2000 and 2021 respectively, which have spatial resolution of 30 meters per pixel. Based on the results gathered from calculations of morphometric indices, it has resulted that sub-watershed 7 and 6, fall into high priority category for soil and water conservation, sub-watersheds 3, 4 and 5 have a medium priority, whereas sub-watersheds 1, 2 and 8, fall into low priority category. Meanwhile, based on the land use/land cover change analysis, sub-watersheds 1,6 and 8 fall into high priority category, sub-watersheds with medium priority are 2, 4 and 5, whereas sub-watersheds 3 and 7 are part of low priority category.

Keywords: *Lumbardhi i Deçanit, prioritization, subwatershed, morphometric analysis, land use/land cover*

Spatial analysis of the dynamics of the Vjosa river

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The Vjosa River is one of the most important and richest rivers in Albania, known for its rich biodiversity and its key role in the natural ecosystems of the region. Over the past decades, this river has undergone significant changes in its course and extent due to natural factors and human activities. This study aims to examine these changes through the use of advanced GIS technologies and satellite imagery, providing a clear picture of the dynamics of the Vjosa River over different time periods. The digital map to be created will include the key elements of a map, such as relief, roads, cadastral parcels, and hydrography, for a specific segment of the river and an area 1 km on both sides of it. This map will serve as a strong basis for spatial analysis of the changes that have occurred in the river's course and the impact of various activities in recent years. By using satellite imagery and spatial data, it will enable visualization of the changes and assess the impacts these changes have had on the surrounding environment. Finally, the affected areas will be identified, and flood-prone zones will be assessed, contributing to the development of water management strategies and the prevention of natural disasters. This study aims to provide a solid foundation for the sustainable management of the Vjosa River and the protection of its natural environment and the surrounding areas. It also aims to provide valuable information for the development of public policy strategies and the improvement of land-use planning and natural resource management.

Keywords: *Dynamic, Vjosa river, GIS, spatial analysis, satellite imagery*

An Overview of Water Footprint Assessment of Olive Oil Production

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Olive oil production plays a vital role in the agricultural economies of Mediterranean regions, yet it poses significant environmental challenges, particularly regarding water resource management. The water footprint assessment WFA provides a comprehensive framework to quantify the freshwater used throughout the production extraction of olive oil. The total water footprint consists of three components: Green Water (Rainwater stored in the soils and used by plants), Blue Water (Irrigation water drown from surface of ground water), and Grey Water (The volume to assimilate pollutants to meet water quality standards). It examines how factors such as irrigation practices, climate conditions, cultivation techniques, and processing methods influence the overall WF. The analysis highlights regional disparities and emphasizes the importance of sustainable water use strategies to reduce environmental impact.

Keywords: *Water footprint, Green Water, Blue Water, Grey Water*

Assessment of Rainfall Contribution to the Water Level Changes of Mirusha Lake

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Intense atmospheric precipitation plays a crucial role in raising the water level of lakes. A clear example of this phenomenon is represented at Mirusha Lake, during two events recorded in January 2016 and January 2021, when heavy rainfall caused flooding of the lake's dam. This study aims to assess the contribution of rainfall to the rise of the water level of Mirusha Lake through an integrated analysis that combines precipitation data from the meteorological station in Malisheva with the characteristics of the lake's catchment area. In this context, the study involves the development of a hydrological model based on empirical data to forecast future water level changes. Intensity-Duration-Frequency (IDF) curves are constructed to determine rainfall intensities, and Geographic Information Systems (GIS) are utilized to define the physical features of the catchment. Additionally, the Hydrognomon software tool is applied to forecast changes in the lakes' water level. Subsequently, based on the lake's volume and recorded water levels, the critical rainfall intensities that may lead to dam overtopping are identified. The results provide a scientifically grounded basis for decision-making, supporting efforts to improve dam safety and protect surrounding populated areas. Moreover, forecasting the water level changes at Mirusha Lake, aids in the adoption of preventive measures and the development of emergency response plans.

Keywords: *IDF curves, Hydrognomon, rainfall intensity, hydrological modeling, water level changes*

Climate Variability and Its Impact on Flood Risk in the Vjosa River Basin: An Analysis of Precipitation Trends and Vulnerability

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This paper analyzes climate variability and its impact on flood risks in the Vjosa River basin. It first provides an overview of the current water flow situation in the Vjosa River and the natural disasters that have occurred in the area during the period analyzed. Precipitation is identified as the primary cause of flooding in the basin. The distribution of precipitation over the years is examined, and an analysis of anomalies reveals that since 2000, the river basin has experienced a period of increased precipitation. Vulnerability to flooding in the basin has grown significantly, considering physical, social, economic, and environmental factors. The methodology employed in this paper relies on detailed data analysis. Historical disaster data are analyzed using the DesInventar methodology, developed by UNISDR and implemented in Albania in 2013[16]. This methodology is a key component of the Sendai Framework for Disaster Risk Reduction (2015-2030), which is to be adopted by all UN member states [2]. The results of the analysis highlight the areas most affected by the municipality. Furthermore, as maximum precipitation values continue to rise, an increase in flood frequency in the river basin is anticipated.

Keywords: *heavy precipitation; discharge; flood; disaster; flood risk; disaster data losses.*

Hydrological and Morphological Assessment of the Desivojcë Dam Site: A Case Study from Eastern Kosovo

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This study presents a hydrological and morphological assessment of the Desivojcë Dam site, part of the proposed Kike-Kremenata multipurpose reservoir system in the Morava e Binçës basin, eastern Kosovo. The study synthesizes the results of technical assessments performed to support early-stage planning and design, focusing on watershed behavior, runoff generation, sediment dynamics, and catchment morphology specific to the Desivojcë River and its basin.

The analysis is based on data and methodologies outlined in the official project reports, including physical and meteorological characterization of the basin, validation of long-term hydrometric and rainfall records, and estimation of daily and annual flow series using regional analysis and rainfall-runoff modeling (HBV). Special attention is given to the morphological assessment of the Desivojcë River, including sediment yield and deposition risks that influence reservoir sustainability.

Design flood events were derived through empirical methods and hydrological modeling, including the estimation of probable maximum flood (PMF) using derived hyetographs, and the implications of projected climate change were also considered in defining hydrological design parameters. Sediment yield was evaluated using the Revised Universal Soil Loss Equation (RUSLE) to estimate long-term sedimentation impacts on reservoir capacity.

The study underscores the importance of integrated hydrological and morphological evaluations in dam design, particularly in data-scarce and climatically sensitive regions like southeastern Kosovo. The findings provide a valuable technical reference for water resource planners and engineers engaged in similar infrastructure projects across the Western Balkans.

Keywords: *Hydrological Assessment, Morphological Analysis, Runoff Modeling, Sedimentation, Climate Change Impact, Multi-purpose Reservoir Planning*

Hydro-Morphological and Hydrological Analysis of the Osum River Basin in Albania

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Human interventions along river systems have significantly altered the natural dynamics and ecological state of many rivers, especially in the Western Balkans region, often referred to as the "Blue Heart of Europe" due to its pristine fluvial environments. However, increasing anthropogenic pressure has caused noticeable changes in river channel configurations and bed morphology throughout the region.

This study focuses on the Osum River Basin, one of the most significant river systems in Albania, aiming to analyze both its hydrological behavior and morphological condition. The research places special emphasis on the river's main tributaries and the geomorphological evolution occurring over recent years. The research was conducted during a three-month period in collaboration with the University of Trento, involving theoretical and practical coursework, fieldwork, and laboratory analysis. The core of the study is the application of the Morphological Quality Index (MQI), a geomorphological assessment tool that evaluates river health based on functionality, artificial modifications, and deviation from natural conditions.

Using hydraulic and morphological measurements, the study applies scientifically supported models to estimate the river's natural evolution and assess the influence of human-induced changes. The results offer a catchment-scale understanding of river morphology and hydrology, supporting strategies for sustainable river basin management in Albania, where data scarcity remains a critical challenge.

Keywords: *River, rainfall, discharge, temperature, evapotranspiration, reservoir, hydrology, morphology, Osum River Basin.*

Nature-Based Solutions for Sustainable Water and Climate Resilience

Application of Nature-Based Solutions in Urban Environment, Case Studies

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This study explores the application of Nature-based Solutions (NbS) within urban environments, highlighting their role in addressing climate change, supporting the circular economy, and enhancing urban resilience. NbS, as defined by the European Commission, are cost-effective, environmentally adaptive strategies inspired by natural processes that deliver multiple co-benefits across environmental, social, and economic domains. Four case studies illustrate the diversity and efficacy of NbS implementation. The first case involves a Reed Bed System (RBS) in Swarzewo, Poland, processing nutrient-rich beach wrack (BW). The pilot system demonstrated effective dewatering and organic matter stabilization, particularly when compost was added, enhancing nutrient content and aligning with circular economy principles. The second case addresses urban stream syndrome mitigation using a multistage constructed wetland (MCW) in Gdańsk. The system effectively removed pollutants—including heavy metals, PAHs, and microplastics—from urban stormwater under varying hydraulic loads. Notably, PAH removal reached 100%, while microplastic and heavy metal removal efficiencies varied between 26% and 100%. The third case evaluates rain gardens in Gdańsk for indirect stormwater reuse. These gardens showed high efficiency in removing suspended solids (up to 97.3%) and other pollutants (e.g., COD, nitrogen, phosphorus). Additionally, rain gardens contributed to urban cooling, biodiversity support, and improved infiltration, mitigating flash floods and enhancing the local microclimate. Lastly, the Extreme Weather Layer (EWL) tool demonstrated potential for integrating climate risk into urban planning by quantifying flood risks and pollutant loads during extreme weather. It serves as a decision-support mechanism for optimizing the spatial deployment of green infrastructure. These case studies confirm that NbS offers multifunctional, cost-effective alternatives to conventional grey infrastructure. NbS can transform urban infrastructure from conventional grey systems into resilient, ecologically integrated solutions for adaptive and sustainable urban development.

Keywords: *Nature-based Solution (NbS), ecosystem service, urban pollution, water management, extreme weather layer as a smart tool for NbS, stormwater management*

Transportation Engineering

Forecasting Transport Demand: A Predictive Modeling Approach for Sustainable Mobility in Fushë Kosova

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This paper addresses the current transport demand situation in the road network of the city of Fushë Kosova, and provides forecasts of future transport demand, with the aim of promoting sustainable mobility development. The main objective is to establish a predictive model capable of anticipating and responding to future transport demand through the application of advanced modeling methodologies. The model has been built in PTV VISUM software, using key variables such as residential population, employment, workplaces, and traffic flow data in the enter and exit of the city. After the modeling process, it can be used to forecast transport demand for city of Fushë Kosova in coming years. Based on this model, and considering the relevant variables, various scenarios have been analyzed as alternative options compared to the existing road network. The evaluation for selecting the optimal alternative was carried out using several traffic indicators. The paper employed applied an innovative methodology that integrates various techniques within a predictive modeling approach to assess the future mobility in Fushë Kosova city.

Keywords: *Transport demand, modeling, forecast, mobility, PTV Visum.*

Challenges in the Transportation Sector in Albania During the Last Decade and Future Remediations

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Transport sector remains one of the most challenging sectors requiring integrated policies that combine technological, infrastructural and social changes. As a sector that plays a key role in enhancing economic growth, interurban development and social mobility, the EU has progressively implemented a comprehensive regulatory system over the last two decades, including high-level strategies and objectives. This paper, through a detailed analysis, examines a picture and argues in depth about the Albanian transport sector in the last decade, covering road transport. This sector continues to be a critical societal concern and a fundamental element of sustainable development, although underfunded it is a priority for the government. Moreover, an assessment of the existing infrastructure conditions is been made, outlining the main problems such as traffic congestion, lack of maintenance of interurban and urban roads, and the increasing lack of funding. Aiming to provide actionable insights and detailed recommendations for an efficient and sustainable transport infrastructure in the country, the paper highlights the connection between the country's domestic policy reform and community outreach activities. These findings have concluded the critical need for integrated planning and novel solutions for the future challenges facing the transport sector in Albania, in order that this sector can contribute in the long term to the economy and quality of life of the country. We suggest, for a novel and sustainable transport solution in the case of Albania, traffic management systems to be improved, public transport have to be expanded and modernized, investments in road infrastructure maintenance and information infrastructure increased, and integration of transport and information infrastructure have to be promoted, as in many developed countries in the world.

Keywords: *transport challenges, novel solutions, high-level strategies, Albania.*

Environmental Quality and Management

Impact of Urban Land Use on Atmospheric Microplastic Deposition in Pristina, Kosovo

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Microplastics (MPs) have become widely distributed pollutants across various environments, including urban settings. These tiny plastic particles, typically less than 5 millimeters in size, originate from the fragmentation of larger plastic debris or are directly released from consumer products. This study aims to examine whether land use influences the concentration and characteristics of MPs found in atmospheric deposition. Atmospheric deposition samples were collected over a ten-day period at seven strategically selected sites in the city of Pristina, Kosovo, each representing distinct land use categories such as highways, residential areas, parks, and commercial zones. The collected samples were processed and analyzed in the laboratory, where MPs were identified and measured using light microscopy. Subsequently, statistical methods were applied to categorize MPs by type and size and to explore their relationship with land use patterns. The findings revealed notable differences in MP abundance among the sites, with the highest levels detected near the highway and the lowest near the urban park. A significant positive correlation was observed between the abundance of MPs and the proportion of land dedicated to roads and associated infrastructure. Conversely, a negative correlation was found with the extent of green urban areas. These results indicate that land use plays a crucial role in shaping the distribution and deposition of airborne microplastics in urban environments. This preliminary research underscores the importance of considering land use factors in future monitoring and mitigation strategies addressing microplastic pollution.

Keywords: *microplastics, atmospheric deposition, urban land use, air pollution, Pristina, environmental monitoring*

Fundamental Principles of Biogas Product

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Biogas is a mixture of gases (containing 50 - 75 % Methane, and 25 – 50 % Carbon dioxide while 0 – 10 % Nitrogen, 0 – 3 % Hydrogen disulphide and 0 – 2 % Hydrogen may be present as impurities) produced by anaerobic digestion (fermentation). The sequential enzymatic breakdown of biodegradable organic material (Biomass) in the biodigester occurs in four major steps i.e. hydrolysis, acidogenesis, acetogenesis and methanogenesis. The micro organism and enzymes plays a vital role in the biogas production which is usually not taking advantage of in other to increase the yield per digester thereby commercializing the production and sale of biogas.

This paper highlighted the sequential role played by each micro organism and enzymes in the biodigester in other to identify each by the role it plays which is a way of enhancing further research in the field of biogas production where the isolation of these enzymes and micro organism and their artificial production will help in more output per digester when introduce into it artificially.

Keywords: *fermentation, biodigester, hydrolysis, acidogenesis, acetogenesis, methanogenesis*

Assessing Air Quality and Environmental Management in Civil Engineering Projects: A Case Study of the Durres–Prishtina Railway Infrastructure

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As urbanization and industrial activities accelerate, ensuring effective air quality management in civil engineering projects is essential to mitigate environmental and public health impacts. This paper explores the implications of large-scale infrastructure projects on air pollution, focusing on the planned railway connection between Durres (Albania) and Prishtina (Kosovo). The study examines key air sources of emissions, including construction machinery, material transportation, land excavation, and dust generation, as well as their cumulative effects on ambient air quality.

To address these challenges, the paper evaluates mitigation strategies such as the use of low-emission construction equipment, dust suppression techniques, optimized logistics planning, and the adoption of green construction materials. Furthermore, it highlights the role of regulatory frameworks and environmental permitting requirements in aligning railway infrastructure development with air quality standards and climate resilience goals.

An essential aspect of this research is the assessment of air quality monitoring methodologies, including real-time air pollution sensors, satellite data integration, and dispersion modeling techniques to predict pollutant spread. These tools help in quantifying environmental impacts and ensuring compliance with national and international environmental standards.

By integrating sustainable air quality management practices into railway infrastructure projects, this study provides insights into how civil engineering can contribute to greener, more sustainable transportation networks. The findings emphasize the importance of proactive environmental planning in large-scale infrastructure developments, ensuring that economic growth is balanced with ecological responsibility.

Keywords: *Air Quality Management, Railway Infrastructure, Sustainable Construction, Pollution Control, Regulatory Frameworks, Dispersion Modeling.*

Sustainability of Oxygenation Technologies Integrated into Drip Irrigation Systems - Case study: South-eastern Spain and South Western Albania

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Integrated into drip irrigation system is a new concept for Albania specially for the south western part of Albania in Saranda, specially with the objective to increase the area irrigation and drainage for Xarra and to establish the essential shift towards a more sustainable, healthier, and economically viable global agricultural system. The oxygenation of irrigation water has emerged as a promising approach to optimize the use of water, fertilizers, and phytosanitary products. Introducing oxygen into irrigation water temporarily improves its physicochemical properties, resulting in several significant advantages for agricultural activities. These advantages include: (i) promoting healthy root development, (ii) preventing diseases and enhancing the plant's defense mechanisms, (iii) improving nutrient absorption efficiency, and (iv) boosting crop growth and yield. This, in turn, enhances the resilience of crops to environmental changes and improves their survival rates during floods, which have become more severe due to climate change. However, while the application of this technology can lead to enhanced production efficiency and economic returns, it also presents environmental challenges that require careful consideration. These challenges include the potential overuse of materials and energy resources, increased carbon emissions, waste generation throughout the lifecycle of the equipment, and possible harm to ecosystems. Thus, to evaluate the feasibility of oxygenation technology from a comprehensive standpoint, it is important to strike a balance between agronomic benefits and environmental sustainability. Therefore, the overall research provide an overview of the main benefits of this technology in EU countries by assessment of the effectiveness of oxygenation technology integrated into the drip irrigation systems of commonly grown crops in southeastern of Spain country, taking into account environmental factors. Preparing the estimation and comparison conditions in Xarra area in Albania.

Keywords: *Oxygenation, Irrigation, Systems, Spain, Albania*

Levels of Priority Substances in the Port Area of Porto-Romano

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Priority substances are toxic organic compounds that are resistant to chemical, biological, and photolytic degradation. Due to their persistence, they can be transported over long distances, bioaccumulate, and cause harmful effects on both humans and the environment. In the past, most of them were used as pesticides or were produced as byproducts of industrial processes. The study area is the Port of Porto-Romano, known for its industrial and maritime activities over the years. Before the 1990s, this area was influenced by several industrial activities, particularly the lindane production plant, which operated for more than 20 years. During that period, its waste was discharged into the sea, a phenomenon that continued even after the plant's closure and is suspected to still contribute to pollution. Currently, this area receives urban wastewater from a part of the city that is not connected to the Durres wastewater treatment plant, and it also hosts a hydrocarbon port, creating pressures with a direct impact on marine water quality. This study presents data on the concentrations of HCHs, Aldrin's, DDTs, polychlorinated biphenyls (PCBs), and polycyclic aromatic hydrocarbons (PAHs) analyzed in water samples collected from nine stations in the Porto-Romano port area (five within the port and four outside it) in July 2024. The quantitative and qualitative analysis of organochlorine pesticides and PCBs was conducted using the GC/ECD technique, while PAH determination was performed using the GC/FID technique. The analysis results indicated the presence of organochlorine pesticides and PCBs in all analyzed samples, while PAHs were detected in most of the samples. However, it is important to note that the levels of these priority substances in the Porto-Romano water samples were within the allowable limits set by EU Water Directives and were higher or comparable to those reported in previous studies on the marine waters of the Adriatic and Mediterranean Seas.

Keywords: *Priority substances, Organochlorine pesticides, PCB, PAH, GC/ECD/FID, Porto-Romano*

Analysis of Multi-Criteria Evaluation Method of Landfill Site Selection in Dibra Region, Albania

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Landfill is a common solution for the final disposal of municipal solid waste (MSW) in Albania. Landfill siting is an extremely difficult task to accomplish because the site selection process depends on different factors and regulations. To ensure that an appropriate site is chosen, a systematic process should be developed and followed.

Unsuccessful landfill siting is typically the result of strong public opposition. In this study, 10 candidate sites for an appropriate landfill area in Dibra Region are determined by using the multi-criteria evaluation (MCE).

This study, through a methodology that uses multifactorial evaluation of a set of alternatives and based in the Albanian and EU legislation on urban solid waste landfills, makes the classification of three best sites for the construction of a regional landfill in Dibra Region.

From the application of the exclusion criteria provided in the study methodology, it was able to find the best three alternatives and after the evaluation of development criteria the application of this method has led to the identification of the most suitable site for the landfill construction in the Dibra Region.

Keywords: *Landfill siting, Multi-criteria evaluation, Solid waste, Site selection*.

Environmental Sustainability Through Circular Economy - Bridging Academia, Businesses and Government

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In the context of unsustainable production and consumption originated from the current linear economy system (take—make—dispose), the circular economy topic gains momentum to decouple economic growth from resource use and environmental degradation. In essence circular economy practices, which are focused on resource efficiency, waste reduction, lower carbon footprint, extended product lifespan, renewable resources are often presented as strategic measures to support climate change mitigation efforts through reduced GHG emissions, efficient use of resource and less environmental degradation. This study aimed to determine the readiness of stakeholders for the successful implementation of CE practices and development of the circular economy in Albania. Three different expert surveys were conducted among representatives of business, academic and local government units. Government can create and enforce regulation and instruments that promote circular economy, like EPR, waste reduction targets, incentives for recycling and sustainable design. To stimulate adaptation and innovation, grants, subsidies and tax incentives are other instruments that can be provided. Governments can run campaigns and educational programs to raise awareness about the benefits of a circular economy and encourage sustainable behaviors among consumers and businesses. Businesses can develop and adopt circular practices, such as designing products for longevity, implementing recycling programs, and creating close loop supply chains. They can also drive innovation in sustainable technology and business models. initiatives. By promoting sustainable products and practices, businesses can influence consumer behavior and build market demand for circular economic solutions. Companies can work together with other businesses, government bodies and academic institutions to share knowledge, develop new solutions and scale up circular economy. Academic Institutions provide education and training on circular economic concepts preparing students and professionals to implement these practices in their careers. They conduct research to advance circular economy technologies, models and practices. Higher Education Institutions can collaborate with businesses and governments to address practical challenges, test new approaches and translate research findings into actionable solutions. To foster the transition toward the circular economy requires involvement, alignment, and cooperation between all stakeholders at all levels. The synergy of multiple actors' collaborations like government, business and academia contribute to creating a supportive ecosystem for ensuring successful implementation of circular economy.

Keywords: *Environmental sustainability, circular economy, triple helix, government, academia, business*

Water and Wastewater Treatment

Greener Drying: constructed wetland beds for sustainable sewage sludge dewatering

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Constructed wetland (CW) beds represent an environmentally friendly alternative to conventional mechanical and energy-intensive sewage sludge dewatering methods. This review synthesizes available research and operational experiences from Poland, where CW systems have been implemented at both pilot and full scale in the last years. The study outlines their design principles, operational performance and sustainability outcomes in comparison with conventional sludge handling. Polish experiences demonstrate that CW beds can effectively reduce sludge water content by 70–85%, yielding dry solids concentrations up to 25–35% depending on local climate, sludge loading rate, and system configuration. In addition to dewatering, CW beds contribute to partial stabilization, odor reduction and pathogen decline, thus improving sludge quality for subsequent use, particularly in agriculture. Long-term studies indicate that properly managed systems can operate continuously for 8–15 years without the need for frequent sludge removal, thereby lowering operational costs. Key case studies, such as facilities in southeastern Poland, reveal successful integration of CW beds into small- and medium-sized municipal wastewater treatment plants, offering a low-cost and low-energy solution compatible with circular economy goals. However, limitations include seasonal variability in drying efficiency, land requirements and the need for trained operation to prevent clogging and ensure uniform sludge distribution. Overall, constructed wetland beds provide a sustainable, nature-based approach to sewage sludge management in Poland, combining effective dewatering with ancillary ecological benefits such as habitat creation and landscape integration. The review highlights that wider adoption requires tailored design to local conditions, regulatory support, and stakeholder awareness. In the context of EU environmental policy and rising energy costs, CW technology stands out as a resilient and greener sludge drying option.

Keywords: *constructed wetland beds, sewage sludge, dewatering, sustainability, nature-based solutions*

Application of 'Digital Twin' Technology in Wastewater Treatment: Enhancing Efficiency and Sustainability

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In recent decades, the pollution of surface and groundwater has emerged as a critical environmental issue across Europe and beyond. Rapid urbanization, industrial growth, and population increase have placed tremendous pressure on wastewater treatment systems, exposing their limitations in meeting environmental and public health standards. In response to these challenges, the integration of advanced digital technologies, particularly the "Digital Twin," offers a transformative approach to improving the efficiency, sustainability, and resilience of wastewater treatment plants (WWTPs). This thesis explores the application of Digital Twin technology in wastewater treatment, focusing on its technical and operational benefits, environmental and social impacts, and real-time decision-making capabilities. A Digital Twin is a virtual replica of a physical asset, updated in real-time using IoT sensors, AI algorithms, and cloud computing platforms. When implemented in WWTPs, it enables predictive maintenance, dynamic process optimization, and data-driven management, ensuring better pollutant removal, energy efficiency, and reduced operational costs. The research employs a comparative methodology, analyzing both traditional and innovative treatment methods, and reviews several European case studies—such as Evides Waterbedrijf (Netherlands), Thames Water (UK), and Veolia (France)—that demonstrate significant improvements in water quality, energy use, and system reliability. These cases illustrate how Digital Twins contribute to proactive monitoring, early fault detection, and sustainable water management in urban settings. Moreover, the thesis evaluates the regulatory framework at both national and European levels, assessing compliance with directives such as 91/271/EEC for urban wastewater treatment. The study also highlights the current situation in Albania, identifying gaps in infrastructure, legal harmonization, and digital capability, while proposing recommendations for the adoption of smart water solutions in line with EU environmental standards. The findings suggest that Digital Twin technology has the potential to redefine wastewater treatment by enabling real-time control, reducing environmental impact, and enhancing public health protection. Its implementation is a critical step toward digital transformation in the water sector and a key enabler for smart and sustainable urban development.

Keywords: *Pollution, Digital Twin, Wastewater Treatment, Sustainability, IoT Sensors*

Motile algae motility and their environmental application

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Microalgae, especially motile algae like Chlamydomonas Reinhardtii (CR), show phototactic behavior, therefore they show motility in the presence of light stimulation. This characteristic has opened new opportunities to achieve environment sustainability. Studying algae motility can be done by using different models, but the most common used is light-controlled flows. By using models to understand better algae motility, there is a great potential to optimize it for practical application. During experimentations, it is realized that light has a great effect in algae motility, especially in controlled environments like photobioreactors.

Even though there are a lot of advantages, producing microalgae in a greater scale has its own challenges. The future of algae application is depended by the development of photobioreactor technologies and improvement of genetic engineering. The aim of this study is to use models to understand microalgae motility and how to control it.

Keywords: *microalgae, phototaxis, photobioreactor, motility*

Eenergy Efficiency and Renewable Energy

Exploring Hydrokinetic Power: Opportunities for Albania's Energy Transition

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With the growing concerns of global warming, more governments, research centers, and corporations are committing resources to advance towards renewable energy technologies. In order to transition from fossil fuel-based energy resources, our human society must tap into a variety of renewable resources. As each country evaluates its possible options, many have recognized hydrokinetic energy as a significant contributor to its renewable energy portfolio.

Hydrokinetic systems are a class of 'zero-head' hydropower whereby energy is extracted from the kinetic energy of flowing water, similar to wind turbines, rather than the potential energy of falling water. The applicability of hydrokinetic technology within rivers, tidal and ocean currents and man-made channels enables installation at sites which do not hold possibilities for other technologies. Unlike traditional hydropower plants, hydrokinetic turbines operate without requiring large infrastructure, minimizing environmental impact while utilizing untapped energy resources.Their efficiency depends on factors like flow velocity, blockage ratio, and turbine design. Case studies highlight the importance of optimal placement for maximizing energy output and while environmentally friendly, these turbines impact sediment transport and local hydrodynamics so further research is required to optimize this technology.

In this paper we will examine Albania's hydrokinetic energy potential and propose practical solutions for integrating hydrokinetic turbines into the country's renewable energy background, contributing to a cleaner and more sustainable energy future.

Keywords: *hydrokinetic turbines, renewable energies, environmental impact, hydrokinetic systems, hydropower plants.*

The Impact of (Humidex) on the Calculation of Cooling Degree Days

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The humidex (short for humidity index) is a Canadian metric used to describe how hot the weather feels to the average person by combining the effects of heat and humidity. It gives you a better idea of the perceived temperature rather than the actual air temperature. When the air is humid, sweat doesn't evaporate as easily. Since sweat is your body's way of cooling down, this makes you feel hotter. The humidex takes the air temperature and the dew point (a measure of humidity) to calculate this perceived heat.

Cooling Degree Days (CDD) are a way to measure how much (and for how long) outside air temperatures are above a certain threshold — typically used to estimate energy demand for air conditioning. For calculating cooling degree days, we use data that includes the average monthly outdoor temperatures. It is precisely the impact of humidity on the average outdoor air temperature that will lead us to recalculate the colling degree days because of recalculating the average monthly temperatures.

In this paper for the fist time give an innovation in calculating cooling degree days based on humidex. So, we can compare how change the energy demand for cooling when have days with high humidity.

Keywords: *Humidex, humidity, Cooling Degree Days, Energy Demand.*

Small hydropower projects: sustainable energy or biodiversity risk?

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Small hydropower projects contribute to reducing greenhouse gas emissions by providing a cleaner energy source. They help decrease reliance on fossil fuels, leading to significant reductions in carbon emissions. However, at the same time they are considered one of the biggest current threats affecting the hydromorhological status of the rivers. Aiming towards fostering best operation practices in hydropower engineering, the following research assesses the impact of seven different small hydropower plants (SHPPs) in protected areas in Republic of North Macedonia towards the macroinvertebrate communities and their habitats in the affected river ecosystems. The fieldwork was conducted in September 2017 when macroinvertebrates were collected above and below the intake and the powerhouse on seven small hydropower plants (SHPP Lipkovo, SHPPs Tearce 97, 98, 99, SHPP Tresonecka, SHPPs Brajcino 1 and Brajcino 2). All collected biological material was transferred to the Laboratory of Invertebrate zoology at the Institute of Biology in Skopje, for further processing of the material. The results obtained during this study show that the sampling sites above the intakes remained in favorable and undisturbed conditions. Good populations of the Natura 2000 species stone crayfish Austropotamobius torrentium and Balkan goldenring dragonfly Cordulegaster heros also occurred above intakes. On the other hand, biodiversity and ecological status assessment based on macroinvertebrates showed that almost all investigated SHPPs cause drastic reduction of species, severe drop in the abundance of the benthic community, even disappearance of sensitive taxa and endemic species. Additionally significant deterioration of the ecological status (poor or bad) of the rivers below the intake and above the powerhouse confirms the harmful impact of the investigated SHPPs, which according to WFD, is not allowed in protected areas. Therefore, it seems that hydropower is only renewable and sustainable at first glance, in the sense of the water cycle, but not necessarily when it comes to endangering associated natural resources. The influence of small hydropower plants on the environment is not negligible, in fact, it is often profound and can cause permanent damage to watercourses if not operated properly.

Keywords: *Small hydropower plant, aquatic ecosystems, macroinvertebrates, impact, R. North Macedonia.*

End-of-Life Photovoltaic Panels in Coastal Albania: A Case Study on Circular Economy Potential in Dhërmi

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The global energy transition has elevated solar photovoltaic (PV) technology as a key instrument in reducing greenhouse gas emissions and fostering a low-carbon future. With decreasing costs and improving efficiency, solar panels have become central to renewable energy policies across the world. However, the large-scale deployment of solar panels brings with it a looming environmental concern: the management of end-of-life (EoL) PV modules. As the first generation of solar installations approaches decommissioning, it is estimated that PV waste could reach 78 million metric tons globally by 2050, raising critical issues related to material recovery, hazardous waste handling, and resource efficiency. As Albania accelerates the deployment of solar photovoltaic (PV) systems—particularly in tourism-intensive coastal areas—the issue of end-of-life (EoL) solar panel waste is becoming increasingly relevant. This study focuses on the village of Dhërmi, a high-density tourist destination along the Albanian Riviera, home to over 110 hospitality structures. Based on field surveys and secondary data, it is estimated that by 2030, more than 2,000 PV panels installed between 2008 and 2012 will reach the end of their functional life, generating approximately 50–60 tons of solar waste in this zone alone.

Using the IRENA PV Waste Management Tool and regional market values, we find that recovering materials—such as aluminum (up to 12 tons), glass (40 tons), and silicon (2 tons)—from these decommissioned panels could reduce the demand for virgin resources by 26–30% and yield up to €14,000–€20,000 in resale value. This recovered value could partially offset the cost of replacing systems, which is estimated at €150,000–€180,000 for the area.

The paper proposes a circular model tailored for coastal tourism zones, combining extended producer responsibility (EPR), mobile collection units, and local processing nodes. Results highlight that, in addition to environmental benefits, circular PV waste management offers measurable economic returns and aligns with Albania's EU-aligned sustainability roadmap.

Keywords: *photovoltaic waste, Albania, Dhërmi, circular economy, solar panel recycling, coastal tourism, sustainability, material recovery*

Climate Changes, Adaptation & Mitigation

Greenhouse gas emissions in Municipality Rahovec and necessary measures to achieve Net Zero emissions by 2050

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This paper presents an assessment of greenhouse gas emissions (GHG) in the Municipality of Rahovec and identifies the necessary measures to achieve net-zero emissions by 2050, in line with Kosovo's national commitments under the Energy Community Treaty and the Berlin Process.

Using 2018 as the baseline year, GHG emissions were estimated across key municipal sectors, including: buildings, transport, agriculture, public lighting, and non-energy emissions. From the assessment made, the emission inventory was developed following the methodology of the Covenant of Mayors for Sustainable Energy and Climate Action Plans, relying on sectoral activity data and emission factors recommended by the International Panel for Climate Changes. Total baseline emissions were calculated at 221,785.5 tCO_2eq/year.

A set of energy efficiency (EE) and renewable energy sources (RES) measures were proposed, including retrofitting municipal and residential buildings, improving public lighting, installing PV panels, developing wind and solar parks, introducing biomass and heat pump heating systems, and addressing emissions in non-energy sectors. The projected outcome after full implementation of the measures by 2050 is a significant reduction to 68,249.75 tCO_2eq/year—an overall reduction of nearly 70%. The total investment required is estimated at approximately 505 million euro. This study provides a practical framework for local climate action planning aligned with national and international decarbonization goals.

Keywords: *Greenhouse gas emissions, Net-zero emissions, Energy efficiency, Renewable energy, Climate action, Emission inventory, Covenant of Mayors*

A view of carbon market policies and implementation practices and assessment of opportunities for alignment in the Albanian context

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As economies around the world transition to low-carbon development, carbon markets have emerged as essential instruments for reducing greenhouse gas emissions. The implementation of Emissions Trading Schemes (ETS) and Voluntary Carbon Markets (VCM) has facilitated emission reductions through market-based mechanisms, however, challenges such as carbon leakage, allowance allocation and regulatory uncertainties remain. This paper attempts to look at international carbon market policies, analyzing the main compliance mechanisms, offset project structures and the role of blockchain technology in increasing transparency and efficiency. Albania, despite its low industrial emissions, faces increasing pressure to align with EU climate policies and integrate carbon pricing into its environmental governance framework. The study assesses the feasibility of establishing an internal carbon market by analyzing economic incentives, regulatory readiness and the potential for participation in regional trading mechanisms. It will also look at the potential to leverage Albania's renewable energy sector and afforestation projects to generate high-quality carbon credits, supporting both mandatory and voluntary markets. By addressing policy gaps and implementation barriers, this study seeks to lay the foundations for a strategic roadmap to contribute to Albania's integration into global carbon markets. The findings highlight the need for strong institutional frameworks, transparent measurement, reporting and verification (MRV) systems, and stakeholder engagement to create a functioning and credible environment for carbon trading.

Keywords: *Carbon markets, Emissions Trading Scheme, voluntary carbon markets, policy implementation, carbon pricing*

Landfill Gas Generation and Emission Models Model Options for Recovery System Design and Greenhouse Gas Inventories

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This article provides an overview of various landfill gas (LFG) generation and recovery models, vital for the design of LFG control/recovery systems, including the U.S. Environmental Protection Agency's (EPA) Landfill Gas Emissions Model (LandGEM), the Intergovernmental Panel on Climate Change (IPCC) Waste Model, and alternatives, like the Capturing Landfill Emissions for Energy Needs (CLEEN) Model, as well as the recently-validated California Methane Inventory Model (CALMIM), currently the only field-validated landfill cover emission model that can be used to assess landfill contributions to climate change.

Keywords: *landfill gas, generation and recovery models, waste*

Geodesy, Cartography, Photogrammetry and RS

The application of remote sensing techniques to identify land subsidence in Albania

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Remote sensing and GIS have been key for subsidence estimation, but InSAR has revolutionized this by offering wide coverage and accurate data without the need for ground instruments. The Dhrovjan salt mine, situated in southern Albania (39.8894° N, 20.2175° E), has experienced ground deformation over recent years, raising concerns about underground stability and its potential surface impact. Purpose: The goal is to detect, model, and monitor ground motion in South Albania from March to December 2021 and to assess land subsidence in the mine zone over four years (March 2021 – March 2025). We aim to combine InSAR and DinSAR to achieve detailed terrain information. Method: We applied InSAR analysis to Sentinel-1 SLC data for multiple acquisition dates. We used two-pass interferometry with two radar images, calculating the phase difference to create an interferogram, which is then converted into a ground deformation map. Three algorithms were used for InSAR processing, DInSAR processing, and making the Displacement map of the southern zone in Albania. The area of interest in the Dhrovjan mine spans approximately 7.1 hectares, and nine control points (P1–P9) were selected across the mine zone. Temporal interferograms and ground displacement heatmaps were generated using Python-based geospatial processing. Results: During preprocessing, we split the products to save time. In InSAR processing, we generated an interferogram showing both topography and deformation. DInSAR processing removed topography, leaving only deformation. Phase unwrapping provided displacement measurements and geocoding to produce a terrain-corrected displacement map. The 4-year analysis revealed progressive ground subsidence across the entire site, with point P5 showing the most significant change (- −37.8 mm). Overall, displacement values increased by 65–68% from 2021 to 2025. Heatmaps and statistical graphics confirmed a concentration of subsidence in the central part of the mine, which correlated with the extraction zones. Conclusions: SAR interferometry is effective for detecting surface deformations. The Dhrovjan salt mine demonstrates consistent downward ground movement, with visible acceleration in key areas. This study highlights how interferometric processing can track changes in the radar line-of-sight, with each processing stage requiring precise interpretation, especially when using SNAPHU.

Keywords: *InSAR, DInSAR, Phase unwrapping, Interferogram*

Photogrammetric Documentation and 3D Modeling of the "Goddess on the Throne" Using Low-Cost Techniques

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The documentation of historical objects plays an important role in preserving cultural heritage. History is discovered through the traces left behind, and today, in addition to recording these objects, the creation of 3D models has become an important part of their presentation, study, and preservation.
Modern technologies now make it possible to generate detailed digital models. These models serve as powerful tools for education, museum exhibitions, virtual access, and long-term conservation. This study focuses on the photogrammetric documentation of the Goddess on the Throne, a terracotta figurine discovered at the Tjerrtorja site in Prishtina, Kosovo. Representing a female deity and the cult of the great mother idol, this artifact is one of Kosovo's most valuable archaeological symbols and serves as the logo of the Kosovo Museum and a symbol of the city of Prishtina.
In this study, we applied low-cost techniques and close-range photogrammetry for data collection. A Canon EOS M50 digital camera was used to capture images of the artifact. These images were processed using Agisoft Metashape to generate a dense point cloud and create a 3D textured model. The point cloud was then further analyzed in CloudCompare, where specific geometric features were examined in detail. The results demonstrate that low-cost photogrammetry techniques can produce accurate and reliable digital models of small archaeological objects. This confirms that photogrammetry is an affordable and efficient method for documenting cultural heritage.

Keywords: *photogrammetry, cultural heritage, 3D model, Agisoft, CloudCompare.*

Length Differences between Topography, Geoid, Ellipsoid and Map Projection at KosovaRef01 plan coordinate referent system

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The transformation of spatial distances from the Earth's topographic surface to a planar map projection, via intermediate geoid and reference ellipsoid models, has been significantly enhanced through the application of modern digital technologies. This advancement enables more efficient, precise, and in-depth geodetic computations. A critical prerequisite for such analytical workflows is the availability of accurate, high-resolution geospatial datasets. Historically, spatial reductions within coordinate systems have been addressed in a segmented manner, with each transformation stage, namely, from the topographic surface to the geoid, from the geoid to the reference ellipsoid, and from the ellipsoid to the map projection, handled independently. As a result, comprehensive assessments that integrate the cumulative effects of all transformation layers have been limited. Previous studies have primarily concentrated on distortions between the reference ellipsoid and the final map projection, without incorporating the compounded influence of the topographic surface and its relation to the ellipsoid. This oversight limits the accuracy of deformation analysis and spatial referencing, particularly in regions with complex terrain. This study presents a detailed investigation of actual length distortions between the topographic surface and the corresponding map projection. The analysis was conducted across the territory of Kosovo, utilizing optimal geodetic models and datasets for the region, including the WGS84 reference system, Shuttle Radar Topography Mission (SRTM) Digital Elevation Model, and Earth Gravitational Model 2008 (EGM08). A grid-based approach was applied with a spatial resolution of 1 km, covering a total of 10,892 georeferenced points. From the processed data, a series of thematic maps were generated, illustrating isolines of length distortions. These were supplemented by statistical evaluations and interpretative conclusions regarding the magnitude and spatial patterns of deformation. Findings from the analysis demonstrate that the development of Kosovo's national coordinate system did not adequately account for the full spectrum of length transformations from the surface to the map projection. This is evidenced by the observed discrepancies in linear deformation values, which frequently diverged from theoretical expectations. Specifically, the results show that extreme values of length distortion lacked symmetrical distribution, the average linear discrepancies were significantly offset from zero, and the spatial dispersion of errors failed to meet the criteria for statistical uniformity. In some cases, negative linear deformations reached magnitudes of up to –50.25 cm/km, indicating notable inconsistencies in geodetic modeling and map projection implementation.

Keywords: *Ellipsoid, Geoid, Map Projection, Kosova, Kosovaref01*

Application of Geodetic Technologies in the preservation of Butrint Archeologic Site

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Archaeological sites, monumental and historical buildings play a very important role as they shed light on the relationships between different populations and contribute to the increase of knowledge of the development of different cultures around the world.

Currently geoinformation science and geodetic technologies are offering extraordinary opportunities to benefit from representations of these historical objects not only with authenticity but also with great opportunities to establish relationships between objects within these archaeological works and helping archeologists create a better representation of the sites.

The archaeological site of Butrint, (called Ancient Buthrotum), which lies on Ksamil hill in the south of Albania, is the first archaeological settlement of the Republic of Albania on the UNESCO World Heritage list. The National Park of Butrint is one of the most important areas of our cultural, archaeological, environmental and touristic diversity of the country.

Due to the importance of the objects and ruins, where in addition to the priority of the geodetic works, I have tried to obtain 2 and 3 dimensional products from all measurements and PointClouds to adapt in H-BIM, which I think will increase the interpretation of the archeology of Butrint Archaeological Site by the relevant specialists themselves.

This paper is focused on the assistance provided by geodetic techniques that may have an application in archaeology, with particular knowledge on the use of photogrammetric and remote sensing methods.

Giving these sites the right importance is essential in the protection and preservation of the Albanian cultural heritage.

Keywords: *Archaeological Site, PointCloud to BIM, Phogrammetry, Remote Sensing, H-BIM.*

Communicating the spatialization of textual descriptions of landscape changes using the storytelling approach in a 3D environment

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The use of three-dimensional (3D) modeling and visualization has become essential in civil engineering, especially in urban development, environmental studies, and infrastructure planning.
This study will give a view of 3D terrain model and a projection with a storyline, with a specific focus on Prishtina as a case study.
The main aim is to show an artistic cartographic product by combining two different methods, traditional and modern mapping methods that will depict one of the most significant historical periods of square of Prishtina. By combining a 3D terrain model and a projection that is allocated in a horizontal position, it will give the model the best perceivable 3D effect to map-reader to observe the model and discover the story from any angle.
The study involves use of a variety of textual data and media, including cadastral maps, orthophotos, graphics, and sound.
As a result of this study, a prototype consisting of a 3D model (wood model) with a project lightshow overlaying the 3D model for the area in Prishtina Municipality.

Keywords: *3D modeling, storytelling, textual description, Projection.*

Geo-information and NSDI

The use of GIS technologies for urban development: building a digital map of the city of Kamza

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The urban development of modern cities requires advanced tools for efficient space management and planning. Multi-purpose digital maps are among the most important instruments for spatial data analysis and organization, assisting decision-making in infrastructure, transportation, and public service management. This study focuses on building a digital map of the city of Kamza, which will serve as an integrated tool for urban development and analysis. The use of GIS technologies will enable the collection and processing of spatial data, including roads, buildings, public spaces, and green areas. The digital map will help identify rapidly developing areas, infrastructure needs, and the optimization of urban spaces. Moreover, it will create a standardized database that can be used by local institutions for better planning and management. The results of this study aim to provide a replicable model for other cities in Albania, emphasizing the importance of digitalization for sustainable urban development and improving residents' quality of life.

Keywords: *GIS technologies, urban development, digital map, spatial data*

Development of a WebGIS platform for public access to NSDI and property data management

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The National Spatial Data Infrastructure (NSDI) is a crucial framework for managing and distributing spatial data, particularly in property administration and urban planning. However, limited public access and inefficiencies in data retrieval often hinder effective decision-making. This study proposes the development of a WebGIS platform that facilitates open and interactive access to cadastral and property data, enhancing transparency, accessibility, and efficiency in land management. The platform will integrate NSDI's WMS/WFS services, allowing real-time visualization of cadastral parcels, property boundaries, land use classifications, and ownership details.

By utilizing PostgreSQL/PostGIS for spatial data storage, GeoServer for web-based data distribution, and OpenLayers for dynamic map visualization, the system will offer advanced spatial analysis tools, including property search by location, ownership, and zoning regulations. The platform will serve as a valuable resource for citizens, investors, urban planners, and government agencies, enabling informed decision-making and reducing bureaucratic delays.

Furthermore, adopting INSPIRE standardization ensures interoperability with international geospatial datasets, while blockchain integration enhances the security and immutability of cadastral records. The study highlights the role of WebGIS in modernizing land administration systems and demonstrates how innovative geospatial technologies can support sustainable urban development. The proposed platform offers a replicable model for enhancing transparency and efficiency in property data management, ultimately contributing to improved governance and spatial planning.

Keywords: *NSDI , WebGIS, PostgreSQL, PostGIS, Geoserver, Inspire*

Comparative analysis between the land consolidation guide and current legislation in Kosovo

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Agriculture is one of the most important and influential branches of our society. Its development should be a priority for every country. One of the instruments with which this development can be achieved is land consolidation. This instrument helps us to solve the problems caused by the excessive fragmentation of the land, which results in small plots with an irregular geometric shape. With the help of land consolidation, all the owner's plots are united into one or a few larger and regularly shaped plots, and also in some cases the technical infrastructure (roads, irrigation system, sewage system, etc.) is arranged around them. This allows farmers to have larger and more productive farms. In order to have the best possible land consolidation process, the most complete legislation is needed to deal with this issue. Based on the fact that many Central and Eastern European countries do not have specific legislation to deal with land consolidation or have no experience in this regard, FAO has published a "Legal Guide on Land Consolidation" which is based on the best practices of European countries and addresses all stages of consolidation and the legislation necessary for them. Since the main goal of Kosovo is integration into the European Union (EU), we always try to have practices that are as similar as possible to those of integrated countries in all fields. The same should be aimed at the land consolidation process. Therefore, in this paper we have presented a comparative analysis between the guide for land consolidation and the current legislation in Kosovo, to see the commonalities and differences, as well as the necessary improvements in our legislation to achieve the highest standards and process of consolidation as best as possible.

As a result, we have gained some conclusions and recommendations on the necessary improvements of the current legislation in Kosovo on the issue of land consolidation and how they should be handled.

Keywords: *consolidation, legislation, guide, project, owner.*

Historical and Monumental Buildings

A Sustainable Model for Heritage Property: Revitalizing a house in Berat Castle

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Masonry, as one of the oldest construction techniques, is used in all the building blocks of the Castle of Berat. The city of Berat has been on the UNESCO World Heritage List since 2008.

This paper discusses the opportunities and issues associated with the rehabilitation of heritage buildings to be sustainable and green, presents technical recommendations for the method of stabilization, repair used for structural restoration through the use of construction iron, wrought iron, wood and concrete. It also explores the potential synergies between heritage conservation and sustainable development. Through theoretical analysis and case study example, the paper illustrates how the most appropriate intervention can be made in ways that respect the heritage value of buildings and how this relates to the scale of intervention undertaken to achieve sustainable conservation.

Structural conservation and restoration is a multidisciplinary enterprise involving the architect, engineer and historian. Following a methodology that includes research, diagnosis, safety analysis and the determination of effective reinforcing intervention techniques must be done in respect of the historical values and the original conception of the building.

Keywords- *masonry; heritage; sustainable buildings; development*

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