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CHALLENGES IN HYDRAULIC ENGINEERING

BOOK OF ABSTRACTS

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PAPERS PUBLISHED IN THE "GOSPODARKA WODNA" JOURNAL

Proposal for the Reconstruction of Asphalt Lining and Drainage System of the Upper Reservoir of the Dlouhé Stráně Pumped Storage Hydropower Plant

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Abstract
Dlouhé Stráně Pumped Storage Hydropower Plant is located in the Jeseníky mountains in northern Bohemia, close to the Polish boundary. Over the last decades, the asphalt-concrete lining has suffered extensive blister-like defects. These defects appear as small craters with diameters of up to 30 mm. Due to their increasing number, a complete repair of the asphalt concrete lining of the upper reservoir was carried out in 2007. However, four years later, during the summer of 2011, the defects reappeared and have been repaired annually ever since. In addition, defects were identified in the drainage system of the upper reservoir. While the existing drainage system below the reservoir bottom provides functionality in water drainage, it does not fully meet the requirements for effective leak detection and long-term seepage regime monitoring.

Based on these findings, the asphaltic lining and drainage system reconstruction is planned after 2030. In this study, three possible variants of the drainage system are discussed. The most efficient variant was chosen, which includes the construction of a drainage gallery along the toe of the upstream slope, encircling its entire perimeter. The asphalt concrete lining reconstruction will involve the partial removal of existing layers and their replacement with new asphalt concrete layers designed to improve long-term durability and resistance and to eliminate local defects in future.

Keywords
Pumped Storage Power Plant, Upper Reservoir, Asphalt-Concrete Lining, Blisters, Drainage System.

Application of BIM Technology for Creating CFD Models in Hydraulic Engineering Projects

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Abstract

The article presents an innovative approach to designing hydraulic engineering structures by integrating Building Information Modeling (BIM) technology with Computational Fluid Dynamics (CFD) analyses. The authors discuss the advantages of creating so-called digital twins—virtual replicas of real-world water structures—used for analysing their performance, safety, and optimisation. In the first section, the importance of hydraulic modelling is emphasised in the context of current legal regulations, highlighting modelling key role in ensuring the safety of structures and their operation, as well as assessing failure risk. The authors then explore the role of BIM technology in hydraulic design, noting its benefits, including precise geometry representation, facilitating interdisciplinary collaboration, and the ability to integrate with CFD tools. Using the example of a hydroelectric power plant modernisation project in Lower Silesia, the article demonstrates how combining BIM and CFD technologies enabled the creation of a detailed 3D model of the facility and the performance of advanced flow analyses. These analyses helped assess risks, including cavitation, energy losses, and potential erosion zones. The final chapters describe the process of integrating BIM with CFD tools, which includes geometry extraction, model simplification, mesh generation, and result analysis. The authors also list commonly used tools such as FLOW-3D HYDRO, OpenFOAM, and HEC-RAS and discuss the benefits and challenges associated with this approach.

Keywords

BIM (Building Information Modeling), CFD (Computational Fluid Dynamics), hydrotechnics, FLOW-3D.

Innovations in Modern Flood Control Reservoir Construction: Szalejów Górny Reservoir, Poland

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Abstract
As climate change accelerates the frequency of extreme hydrological events, flood disasters have emerged as one of the most pressing global challenges. The Szalejów Górny Reservoir in Poland, developed under the Odra-Vistula Flood Management Project (OVFMP), incorporates advanced engineering technologies and intelligent management systems. This paper presents a comprehensive overview of the project's engineering background, major design modifications, key construction technology innovations, and construction management strategies. Particular attention is given to the optimization of anti-seepage systems, implementation of intelligent monitoring technologies, and efforts in ecological restoration. The outcomes of this project offer valuable insights and practical references for flood control initiatives in similar river basins and the development of modern, multifunctional reservoirs.

Keywords
Flood Detention Reservoir; Innovative Technology Application; Intelligent Control; Ecological Restoration; Sustainable Development..

Pumped Storage Power Plants a Challenge for Polish Hydropower Engineering

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Abstract
The development of hydraulic engineering as a field has long been and continues to be closely linked with the goals set for water management. During the ongoing energy transition related to the development of renewable energy sources, characterized by their instability, pumped-storage power plants (PSPPs) are increasingly being discussed worldwide, including in Poland, as excellent large-scale energy storage systems. In this context, among the many challenges faced by modern hydraulic engineering, the construction of PSPPs may prove to be the most urgent.
Energy companies are revisiting PSPP concepts from the 1970s and also searching for new locations that comply with current environmental requirements. An interesting topic is the use of post-mining areas for PSPP.

The construction of PSPPs involves a number of design and implementation issues that require particularly high levels of competence and experience from specialists across various fields. Currently, the focus is mainly on the modernization of existing facilities; however, a growing number of contracts are aimed at re-evaluating the technical and economic feasibility of new PSPPs. In 2023, a special law was passed to support the construction of PSPPs (Act of April 14, 2023, on preparing and implementing investments in pumped-storage power plants and their related investments). Will hydroenergy investments driven by the need for energy storage revitalize hydraulic engineering?

This article presents an overview of the topic of pumped-storage power plants in Poland, starting with a review of studies and concepts from the 1960s and 1970s, moving through current plans for the construction of new PSPPs, and ending with an assessment of the prospects, engineering potential, and the challenges faced by modern hydraulic engineers in the context of PSPPs.

Keywords
Pumped-Storage Power Plants, Hydropower Plants, Hydroenergetic.

Influence of Limestone Dust Based Additive onto Properties of Fresh Concrete Mix and Freeze-Thaw Resistance of Concrete for Hydrotechnical Structures

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Abstract
Hydrotechnical concrete, especially massive concrete, is used for large structures like dams, weirs, locks, and harbour quays and requires cement for low hydration heat. The main type of cement used for these purposes in Poland is blast furnace cement CEM III/A 32,5N-LH/HSR/NA. Concrete mix designs contain coarse aggregates; therefore, the standard method of placing concrete is using buckets moved by cranes.

Nowadays, both the number and assortment of cement available on the local market change quickly. It is caused by clear tendencies to simplify production processes and to reduce carbon footprint. The next tendency is the increased use of concrete pumps instead of cranes and buckets, which requires deliveries of pumpable concrete mixes. Therefore, the main type of blast furnace cement available at the moment is CEM III/A 42,5N-LH/HSR/NA and the content of this cement in mix designs is increased in order to achieve free-flowing, pumpable concrete mixes. Paradoxically, the carbon footprint will increase compared to stiff-plastic, bucket-applied concrete mixes containing coarse aggregates and low cement content. The use of cement additives, which help to reduce cement content without negative influence on the pumpability and durability of concrete, becomes a must. Limestone powder is the most common, cheap, and widely available type of such an additive.

The paper's authors tested a model mix of pumpable concrete for dams replacing up to 20% of blast furnace slag cement by volume using typical ground limestone dust. The scope of the research included the influence of this filler on the workability of concrete mixes and the necessary dosage of admixtures, as well as on the compressive strength and freeze-thaw resistance of hardened concrete. Freeze-thaw resistance was tested according to Polish standards, and both methods, the common method and hydrotechnical method, were used. The results of these tests allow to approximate what replacement ratio of blast furnace cement CEM III/A with such limestone dust can be considered optimal for this type of hydrotechnical concrete.

Keywords
Concrete, Hydrotechnical, Additives, Properties, Workability, Freeze-Thaw Resistance.

Flood Prevention and Adaptation Measures: A Study on Resilience, Efficiency and Sustainability

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Abstract
The urgency for resilient infrastructure has never been greater. Last year, just in 4 days, a storm event hit Poland, the Czech Republic, Austria, Italy, Slovakia, Hungary and Romania and resulted in 22 life losses, and immense destruction of household and infrastructure. Such events are challenging the current way we develop and protect urban areas. Natural phenomena such as hazards have been part of the earth's lifecycle even before humans started shaping it with their activity, however the increased frequency and severity, disasters like flooding, erosion or draught in the recent years makes us all wonder: what adaptation, mitigation and resilience measures should we stand for in terms of strength, efficiency and innovation.

The aim of the study presented in this work is to show how the use of steel sheet piles as reinforcement elements of a normal earth dike. To this end, the results of a large-scale test carried out in the Netherlands near the city of Emedijk and conducted on two dikes, the first built of earth, while the second reinforced with a wall of steel sheet piles, are examined. In the last part of the work, a new system under development for monitoring the structural "health" of sheet piles will be illustrated. The aim is to be able to monitor the actions acting on the sheet piles during the operating phase, in order to detect in advance problems that could compromise, over time, the structural integrity of the entire system.

Keywords
Floods, Dike reinforcement, Steel Sheet Piles, Structural Health Monitoring.

Nachtigal Water Barrage in Cameroon

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Abstract
The article presents the history of the Nachtigal Water Barrage construction on the Sanaga River in Cameroon. The primary function of this structure is the production of electricity. The Nachtigal Hydroelectric Power Plant is a leading investment for the energy system of Cameroon and provides 30% of the current electricity demand of this African country. The work presents hydrological studies and analysis for the Sanaga River basin from the 1970s and describes the establishment of the Nachtigal Hydro Power Company (NHPC), a Cameroonian Public Limited Company. The NHPC mission was to find the foreign capital necessary to implement the investment, design and build a dam and power plant. Nowadays, it has to supervise the maintenance of the facility. The paper describes and illustrates the structural elements of the structure, and presents the stages of construction work. The construction of the Nachtigal Water Barrage began in 2019 and was completed in 2024. The last hydroelectric unit was launched in March 2025.

Keywords
Concrete Dam, Labyrinth Spillways, Hydropower Plant, Nachtigal.

Results from New Methodology – Spectral Ground Penetrating Radar – on Underground Structure Identification in Saturated Coarse Grained Soil

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Abstract
Georadar measurements have an established position among geophysical surveys. However, the depth range of the method, its physical limits connected with soils/rock type, water content, and the low graphic resolution of the results, means that electromagnetic waves are not commonly used for precise geological investigations. Recently developed spectral device named spectral ground penetrating radar (SGPR), as an invention of Polish deep-tech startup WIDMO Spectral Technologies, crosses several pointed barriers and, using frequency modulated continuous waves (FMCW), is beginning to be used in places and tasks where previous barriers blocked the use of electromagnetic wave technology. The non-invasive aspect of the method and the advantage of fast detection are apparent benefits of the ground penetrating radar methodology. Still, this task focused on analysing the possibility of using the device to detect a tunnel object in saturated non-cohesive coarse-grained soils and undertaking the correlation of ground penetrating radar images, intentionally not called echograms, with a geological model below the water table. Such a task is predestined to failure for regular georadar devices due to the shallow depth of the groundwater table, which eliminates the possibility of electromagnetic wave penetration.

Using spectral ground-penetrating radar measurements, the authors demonstrate how modern technology is trying to cross existing barriers, using the example of a riverside beach where a tunnel runs several meters underground, cutting across the beach towards the river. Images obtained from data analysis on randomly selected intervals of time-varying limit frequencies, multiplied by the number of possible conversions and filters, create many images for analysis and interpretation, especially when compared with classic pulse ground penetrating radar. As stated by the authors, the tests conducted in two measurement campaigns reveal verification success and further possibilities for developing the SGPR methodology.

Keywords
Spectral Ground Penetrating Radar, SGPR, FMCW, Geophysics.

Advantages and Disadvantages of Selected Technologies Used for Sealing Earth Hydraulic Structures and Their Foundations

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Abstract
This paper discusses selected sealing technologies for hydrotechnical earth structures and their foundations, including an analysis of their advantages, disadvantages, as well as technical and operational risks associated with the design, installation of sealing elements, and operation of such structures, depending on the chosen technology. The analysis focuses on two types of application: the construction and modernization of flood control infrastructure (including sealing and reinforcement of embankments and their foundations), and the foundations and embankments of water retention reservoirs and tailings dams. The study also presents selected cases of structural and sealing failures that occurred during the 2024 flood events.

Keywords
Embankments, Sealing, Leakage, Sheet Pile Walls, Technical-operational Risk.

Re-Evaluation of Seismic Hazard Design Parameters for Tarbela Dam and its Extension Projects Using Probabilistic Seismic Hazard Assessment (PSHA) Approach

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Abstract
The Tarbela Dam, the world's largest earth-filled dam built on the Indus River, has been operational since 1974. We have re-evaluated its seismic hazard within a 250 km² radius using an earthquake catalogue updated to June 2024 and the latest Next-Generation Attenuation models. The probabilistic result yield PHGA for OBE is 0.18g (145-year return period); DBE is 0.27g (475-yrp), 0.34g (975-yrp), and 0.45g (2475-yrp); and SEE is 0.64g (10,000-yrp), defining critical seismic design inputs. The UHS shows that the spectral acceleration parameter increases from 0 to 0.2sec and then slightly reduces; the level of ground shaking is high at spectral periods 0.05, 0.1, 0.15, and 0.2sec. Deaggregation results indicate that earthquakes with magnitudes 5.5-5.6 occurring at distances 34-26 km around the Tarbela Dam site are considered most influential for the Tarbela dam for the return periods of 145 and 10,000 years, respectively.

Keywords
Probabilistic Seismic Hazard Assessment (PSHA), Tarbela Dam, Peak Ground Acceleration (PGA), Peak Horizontal Ground Acceleration (PHGA), Uniform Hazard Spectrum (UHS), Seismic Hazard Deaggregation (SHD).

Harcov Dam – Overall Reconstruction of the Dam to Guarantee its Safety During Floods and Technical Safety Supervision

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Abstract
The Harcov Dam in the city of Liberec in the Czech Republic was built between 1902 and 1904 primarily to reduce flood flows and flood mitigation in the area downstream of the dam. After more than a century of operation, it was necessary to implement an overall reconstruction of this dam to fulfil the current requirements for safety during floods. An unfavorable fact is also the long-term increased uplift on the foundation joint of the dam body even during normal water levels in the reservoir.

Currently, complex reconstruction works on the Harcov Dam are ongoing. During this reconstruction, significant changes were made in the structures and parameters of this historical dam. The technical solution includes increasing the capacity of the outlet structures, as well as the modification of the stepped chute. The uplift on the foundation joint of the dam body is going to be reduced by sealing the subsoil with the grout curtain made from the new grouting gallery built along the upstream toe of the dam. The contribution generically describes the technical solution and the experience gained from the dam's ongoing reconstruction works and technical safety supervision.

Keywords
Harcov Dam, Masonry, Grouting, Rehabilitation, Watertightness.

Test of the Thixotrophic Properties of Soil in Relation to the Modernization of Floods Embankment

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Abstract
The article addresses the problem of thixotropic properties of soil and the problem of behavior of the soil medium during dynamic actions. It mentioned the lack of research methods to unambiguously determine the occurrence of thixotropic properties of soil and presents a proposal for a method of testing soil for this phenomenon, along with a model of the research apparatus developed in the project. Determination of the soil's thixotropic properties is crucial in assessing the technical condition or application of vibratory dike reinforcement techniques to embankments.

Keywords
Thixotropic Soils, Laboratory Testing, Flood Embankments, Vibration.

Safety Assessment of Hydraulic Structure Veľká Domaša During Extreme Flood Loads

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Abstract

The paper focuses on the safety assessment of the Veľká Domaša dam under extreme flood conditions according to the Methodological Guideline of the Ministry of the Environment of the Slovak Republic. The evaluation includes seepage analysis, slope stability, and flood wave routing through the reservoir. The paper presents partial results of numerical modelling, which was conducted using GeoStudio and HEC-RAS software. The critical and limiting water levels were determined and compared, considering wind wave height, operational procedures, and structural conditions.

Keywords

Flood, Dam, Safety, Stability, GeoStudio, Veľká Domaša.

Opportunities for the Development of Pumped Storages in Ukraine to Increase ENTSO-E Maneuvering Capabilities

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Abstract
Today, the United Energy System of Ukraine and ENTSO-E, into which UES is integrated, are facing the problem of rapid growth of the share of renewable generation by wind and solar power plants in limited maneuvering conditions due to the lack of existing appropriate balancing capacities. Therefore, there is a common urgent need for such capacities, and one of the promising solutions is the construction of pumped storages. However, Europe's capabilities in the development of new PSPs are limited by the number of suitable locations, while there are promising sites for the implementation of such high-pressure PSPs projects in the Western regions of Ukraine, which are the most attractive in terms of relative safety, large solar, wind and hydropower potential, and favorable natural and technical conditions for the development of renewable energy sources, as well as maneuverable balancing capacities.

The article will contain successful cases of PSP projects implemented in Ukraine by UKRHYDROPROJECT PRJSC, such as Kyiv, Dniester and Tashlyk PSPs, which are already in operation and under construction, as well as a number of promising PSP projects for further detailed study, primarily in the Western regions of Ukraine, the construction of which will ensure the balance of electricity in the Unified Energy System of Ukraine and increase the reliability of electricity supply to consumers and energy security, improve the environmental situation by reducing CO_2 emissions at thermal power plants, ensure the socio-economic development of the region, and create optimal conditions for the export of peak and balancing electricity and auxiliary services to the EU.

Keywords
Conference, International, Pumped Storage, Balancing Capacities, Renewable Energy Sources, Energy System.

Digital Twin of Bystřička Dam

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Abstract
This paper summarizes the development of a digital twin for the Bystřička dam, a significant hydraulic structure. A digital twin is a virtual representation of a physical object, designed to accurately represent its real-life counterpart and provide users with contextualized information derived from measured and simulated data. The digital twin of Bystřička dam integrates real-time data from the safety monitoring system with predicted results from the finite element method model created in the ANSYS software. The digital twin is accessible via a web application, allowing real-time monitoring and remote control from any device with an internet connection. The whole digital twin platform is a pioneering software tool in the Czech Republic's water engineering industry, combining advanced technologies from various fields. It offers a valuable contribution to the safety management of significant waterworks.

Keywords
Digital Twin, Dam.

The Issues of the Kakhovka Reservoir Rebuilding

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Abstract
The destroyed Kakhovka reservoir solved many tasks for the economic development of the region: municipal water use, industrial water use, water use in agriculture, water use in transport, hydropower water uses and other types of water use. The main goals of Kakhovka HPP's rebuilding will be to increase renewable energy capacities, output, reliability and safety, to fulfil the requirements of environmental protection, to improve the quality of electricity produced following the requirements of the ENTSO-E, and to create modern working conditions that meet current regulations. The designs of hydraulic structures must consider the real risks of armed attack.

Keywords
Water Use, Dam, Hydropower, Kakhovka Reservoir, Hydraulic Structures.

Monitoring of Small Hydropower Plant Displacements – Law, Real Needs, Practice

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Abstract
Small hydropower plants (SHP) are facilities that are expected to be highly efficient and reliable. Due to frequent changes in the hydrological conditions of watercourses in which they are located, their location in the vicinity of buildings and the minimization of operating costs applied by the owners (limiting the presence of service to a minimum), regular monitoring of the displacement of infrastructure elements, i.e. weirs, channels supplying and discharging water from turbines, derivation pipelines, is necessary to ensure the safety of their operation. The geodetic monitoring control network covers not only the facility itself but also the surrounding areas, outside its impact zone.

The basic problems encountered by monitoring designers and surveyors performing periodic measurements are: lack of legal regulations and guidelines indicating the minimum scope and schedule of observations, difficulties in accessing structural elements in the event of their sharing by different entities: e.g. a channel supplying water from the power plant that is partly on the ground and maintained by the power plant and municipal waterworks, inability to locate reference points on private land or protected areas, linear extent of the power plant itself, ownership of land in the case of underground pipelines. The ownership structure of land adjacent to the facility is an important issue due to the need to ensure the stability of the network reference points, the design of the course of levelling lines and observation views for angular and linear observations. Analogous problems related to the introduction and maintenance of geodetic monitoring concern hydroelectric power plants with higher capacity and pumped-storage power plants.

The problems described in the article are presented on the example of the Kuźnice and Olcza SHPs, partly located within the city limits of Zakopane and partly in the area of the Tatra National Park.

Keywords
SHP, Maintenance of Hydrotechnical Facility, Geodetic Monitoring, Geodetic Measurements.

PAPERS PUBLISHED IN THE "JOURNAL OF WATER AND LAND DEVELOPMENT"

Integrating Bank Reinforcements and Natural Solutions for the Regulation and Protection of the Toplluha River: A Sustainable Approach to Flood Protection

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Abstract
This study examines the management and regulation of a flood prone segment of the Toplluha River in the municipality of Suhareka in Kosovo, focusing on sustainable flood protection through bank reinforcements and natural solutions. The study aims to conduct a hydraulic analysis of the riverbed and identify potential solutions that can improve flood protection and enhance flood resilience. The research was carried out in the Suharekë-Reçan segment, where detailed measurements of cross-sectional profiles were taken, and hydraulic parameters, including discharge and water velocity, were assessed. The existing riverbed profiles were analyzed using advanced software and the designed profiles were developed. These designed profiles were compared with the existing ones in order to gain insight into their bankful discharge. It was suggested that natural solutions, such as constructing natural levees covered with reinforcing vegetation, be used for erosion prevention and long-term flood protection.

Using natural levees and reinforcing vegetation has been evaluated as an effective and sustainable method for stabilizing riverbanks. These solutions maintain water quality and ecological balance and support habitat conservation. The results highlight the cost-effectiveness and environmental benefits of the integration of such solutions in river management. The implementation of natural levees can promote flood protection, but also promote biodiversity conservation and sustainable hydrological balance. This study presents a successful model for integrating natural solutions in river management and promotes an ecological approach to protecting flood-prone areas.

Keywords
River Regulation, Flood Protection, Natural Solutions, Levees, Bank Stabilization.

Application of Trigonometric Leveling for Geodetic Monitoring of Pressure Water Supply at Tereblya-Ritska HPP

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Abstract
Tereble-Ritskaya hydroelectric power plant is a unique engineering structure and the only hydroelectric power plant in the world operating on the waters of two rivers. The power plant is located in the valleys of the Terebly and Rika rivers in the Khust region (Transcarpathia). It was built in 1949-1955. After the construction of the dam (height 46 m, length 153 m), the Vilshan reservoir was created with a volume of 23.7 million m^3 and a water surface area of 1.6 km^2.

Two rivers, Terebla and Rika, lie almost parallel, and their watersheds run along the Bowcarski Ridge, but at different heights. This location allowed the construction of a hydroelectric power plant using the natural difference in the terrain height of 210 m. Between the rivers, in the rocks with a slight slope, a 3.7 km long adit was dug, the adit ends with a 350-meter metal pipe with a slope of 37 degrees.

The paper presents the methodology and results of geodetic monitoring conducted in the years 2014-2023. The observations included GNSS satellite measurements and precise trigonometric levelling measurements. The primary aim of this study is to assess the vertical displacements of the intermediate supports of the pressure pipeline at the Tereble-Rika Hydropower Plant, which is subject to anthropogenic loading due to the plant's cyclical operating regime. These vertical displacements are determined through high-precision trigonometrical levelling of control benchmarks installed on the foundations of the pipeline's intermediate supports. Based on the series of trigonometrical levelling cycles, the study also explores the feasibility of substituting traditional geometric levelling with inclined sightline methods.

The measurements were realized by employees of the Institute of Geodesy of the Lviv Polytechnic, data processing and analysis of results were carried out in cooperation with the Department of Engineering Geodesy and Measurement Systems of the Warsaw University of Technology.

Keywords
Vertical Displacements, Hydraulic Structures, Trigonometrical Levelling, Vertical Refraction.

Water Resources Usage in Kosovo and North Macedonia: Patterns, Trends and Socio-Environmental Drivers

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Abstract
Various challenges and complexities characterize water resource management in Kosovo and North Macedonia due to factors such as rapid urbanization, industrial growth, agricultural activities, and changing climatic conditions. Both countries heavily rely on water resources for domestic, agricultural, and industrial purposes, making the sustainable management of water crucial for ensuring environmental sustainability and socioeconomic development. Studying water usage patterns, socio–environmental drivers, and impacts on water scarcity in the region is essential.

This paper aims to determine the patterns and trends of water usage in these two countries, including predominant sectors and consumption analysis. The impact of climate change and mismanagement on water scarcity and pollution were determined. Results show that the largest water demand goes to the agriculture sector, mainly for irrigation. The second most considerable sectoral demand is the drinking water sector, and the last sector is the industry. Climate models project a steady increase in average annual temperatures for Kosovo and North Macedonia. By 2060, temperatures are expected to rise by 1.11°C, and by 2099, it will be a change of 4.07-4.25°C. Higher temperatures will increase water losses, and uneven rainfall distribution may lead to extended drought periods and increased reliance on irrigation, exacerbating existing shortages.

Without proactive and coordinated management efforts, water scarcity and competition for resources will escalate, exacerbating socio-economic vulnerabilities. Future water management strategies should integrate climate resilience measures, such as the development of drought contingency plans, flood mitigation systems, and nature-based solutions to enhance water retention and biodiversity conservation.

Keywords
Climate Change, Social and Environmental Drivers, Water Resources Management, Water Scarcity, Water Usage.

Reliability-Based Sliding Failure Analysis of a Concrete Dam Using Level II Methods: the Zatonie Dam

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Abstract
Hydraulic structures, with their ability to dam up and store water, perform crucial social, economic, and environmental functions. Their construction cost is usually significant, and the consequences of failure are catastrophic, which incorporates an inherent risk analysis component into their management. However, Poland's current regulatory design approach is essentially deterministic – it does not consider the variability of important design parameters, instead assuming arbitrary safety margins. In comparison, reliability-based methods incorporate random variables based on available statistical data, leading to an estimate of the probability of failure and a relatively straightforward transition to risk analysis. This paper exemplifies the application of the so-called reliability index (β) according to level II methods. The presented analysis concerns potential sliding failure based on the example of the Zatonie concrete dam in Poland, as assessed by both deterministic and probabilistic methods. The calculated safety factor n and the β index are 1.28 and 7.21, respectively, and the probability of failure is of the order of 10-13 per year. The results were discussed in light of various standard requirements and good practices, e.g., Dutch flood protection guidelines.

Keywords
Dam Safety, Reliability Index, Risk Analysis, Failure Probability, Concrete Dam.

Stakeholder Engagement and Participation in Integrated River Basin Management: Individual Perspectives in Malaysia

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Abstract

With the growing recognition of the major challenges facing water security, stakeholder involvement has emerged as a fundamental tool for navigating the river basin's social, economic, and cultural complexities. Integrated River Basin Management (IRBM) is a comprehensive approach that acknowledges the interconnectedness of diverse stakeholders, ecosystems, and socio-economic factors within a river basin. IRBM aims to reconcile competing interests and promote sustainable water resource management practices by fostering stakeholder collaboration and dialogue.

This article identifies key stakeholders and the selection criteria. It examines the factors that contribute to effective engagement from individual stakeholder perspectives in IRBM in Malaysia, focusing on the diverse views and perspectives. A questionnaire survey was designed to address questions related to the type and mechanism of engagement, key stakeholders, selection criteria, and factors contributing to effective engagement. It was distributed online, and 250 responses were received. Based on the respondents' data, factors influencing engagement effectiveness were categorised into 3 stages, namely, pre-engagement, during-engagement, and post-engagement. Statistical analysis on the survey data ensured reliability, with Cronbach's alpha values (>0.7) indicating strong internal consistency. The Friedman test was applied to identify statistically significant differences within the same group of parameters for the 3 different engagement phases.

Findings highlighted the importance of stakeholder inclusion, the selection criteria, and credibility at the pre-engagement stage for developing the IRBM plan. Transparent, structured participatory processes during engagement facilitated the most fruitful collaborative discussions, while post-engagement emphasised implementing stakeholder contributions and feedback, and the need for a monitoring and evaluation mechanism. The work conducted for this study underscores the need for an inclusive and legitimate governance model to enhance the effectiveness and credibility of stakeholder engagement.

Keywords

Water Governance; Stakeholder Engagement, Sustainability, Collaborative Decision Making, Inclusive Governance.

Impacts of Hydraulic Structures on Lake Water Quality Deterioration and Eutrophication in Malaysia

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Abstract

Reservoirs serve many essential purposes, including water resources, hydropower generation, flood mitigation and recreation. However, these reservoirs created by constructing hydraulic structures across the waterways encounter substantial challenges in water quality. Uncontrolled discharges, ongoing developments, and anthropogenic activities in upstream and surrounding areas contribute to these challenges. One of the issues is eutrophication, which demands attention in reservoir management. This study employs a two-dimensional (2D) depth-averaged hydrodynamic model, utilizing DELFT3D, to analyze the spatial distributions and hydro-environmental processes occurring in Putrajaya Lake, Malaysia. The model effectively simulates various scenarios for both dry and wet seasons. Calibration and verification were performed using measured data from 72 points within the lake. The water quality modelling focuses on key parameters such as phosphate, nitrate, and chlorophyll-a.

The findings indicate that increased phosphorus loading to 0.35 mg/l at the upstream inflow will likely trigger eutrophication in Putrajaya Lake. We recommend this phosphorus concentration as a critical threshold value for all drainage inlets to the lake, as it is the best management practice to avert further deterioration of water quality and combat eutrophication. Addressing water quality issues during the reservoir project planning and design stages is vital. A comprehensive assessment of water quality during the feasibility stage, before implementing any hydraulic structures that could jeopardize water quality, should be set as one of the design criteria, not an afterthought. Addressing water quality problems through rehabilitation after the problem arises can be costly and often irreversible.

Keywords

Eutrophication, Putrajaya Lake, Tropical Lake, Numerical Modelling, Water Quality Modelling.

Application of Machine Learning in Management of Water Resources Systems, a Case Study

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Abstract
Emerging as a powerful, state-of-the-art approach in water resources management, the application of machine learning (ML) has been moderately used and explored. It is mostly due to its capability to handle large nonlinear datasets from different sources simultaneously, its lower costs than other methods, and the time needed to perform the analyses. The application of ML is very wide, addressing all kinds of water-related problems such as hydrological modelling, flood forecasting, water distribution, irrigation schemes and much more. ML models provide accurate, efficient, and scalable solutions for predicting hydrological events and optimizing resource allocation by analyzing large-scale datasets from diverse sources such as remote sensing, climate models, and in-situ measurements.

This paper describes the creation of an ML model focused on water management of a complex water economy system. The model includes analyses of extensive data sets derived from the management of the system combined. The analyses are based on different algorithms for machine learning – Artificial Neural Networks (ANNs), Support Vector Machines/ Support Vector Regression (SVM/SVP), Random Forest (RF), Decision Trees (DT), Gaussian Process Regression (GPR) and Boosted regression trees (BT). The results are focused on the combination of different parameters that impact the management of the system, with the target variable – the inflow in the most downstream reservoir of the system, with the largest active volume.

Keywords
Water Supply, Electricity Production, Irrigation, Machine Learning, Python, Water Resources Management.

Stability Analysis of the Racibórz Dolny Dam during the Water Level Changes in the Reservoir

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Abstract
Rapid reduction of the reservoir level may result in the instability of the earth dam due to high pore water pressures, which remain relatively high in both the dam embankment and the abutment. The dissipation of pore water pressures is highly dependent on the permeability of the materials used to construct the dam and the ground in the close vicinity of the dam. Therefore, in the design of embankment dams, an important design consideration is the analysis of stability under conditions of high and then rapid lowering of the water level in the reservoir.

This paper presents some results of geotechnical investigations (field geotechnical soundings and laboratory tests), which were carried out for the assessment of geotechnical parameters for the stability analysis of the interface between the natural slope and the embankment slope of the Racibórz Dolny Dam of the flood control reservoir. The results of the calculations indicated that stability will be maintained in each of the calculation cases, and the minimum value of the factor of safety obtained will be 1.712. In contrast, the minimum safety factor to be achieved is F>1.5. It means that the slope of the Racibórz Dolny Dam flood control reservoir is safe and there is no risk of instability when the analysed cases occur.

Keywords
Flood Protection Reservoir, Head Dam, Geotechnical Investigations, Slope Stability.

Biopolymer-Stabilised Soils: Impact on Water Retention, Plasticity, and Sorption Properties

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Abstract

Due to the interest in sustainable building materials, biopolymers are increasingly used for soil stabilisation. This study evaluates the effectiveness of xanthan gum, chitosan, and carboxymethylcellulose at concentrations of 1%, 2%, and 3% by soil weight when stabilising heavy sandy clay loam. The impact of water saturation on these biopolymers is also examined. Laboratory experiments included analysis of soil plasticity and water content, as well as tests using the vapour equilibrium method with saturated sodium chloride and potassium chloride salt solutions to find the soil's sorption properties and equilibrium moisture content. Findings showed that the addition of biopolymers enhances soil Atterberg limits and plasticity, significantly the liquid limit, while moisture retention characteristics depend on environmental conditions and salt type. These results are valuable for predicting soil behaviour under varying climatic conditions and can be useful in preparing recommendations for their application in construction. The study confirms that biopolymers are effective, eco-friendly additives for improving soil performance in engineering contexts.

Keywords

Biopolymer, Equilibrium Moisture Content, Plasticity, Sorption Characteristics.

Enhancing Urban Catchment Management with Integrated CDS Technology and NbS for Stormwater Quality Improvement

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Abstract

Urban catchments increasingly face stormwater management challenges due to rapid development and climate change. Innovative and resilient solutions are needed because conventional pollutant and sediment management practices are insufficient. This study integrates Continuous Deflection Separation (CDS) technology with a Nature-based Solution (NbS): i.e. biochar produced by pyrolysis and green zeolite. To assess the integrated system's performance, an IoT-based monitoring system records water quality parameters, including pH, turbidity, electrical conductivity, dissolved oxygen, total dissolved solids, and temperature. Other parameters, such as biological oxygen demand (BOD), chemical oxygen demand (COD), and total suspended solids (TSS), are analyzed externally.

Findings indicate that biochar boosts the CDS system's effectiveness by adsorbing micro- and near-nano-sized particles and nutrients while preventing clogging by up to 86% and reducing organic pollutants like BOD, COD, and nutrients. The pollutant removal is substantially enhanced. The study also evaluates the use of floating wetlands with Vetiver grass with green zeolite to remove contaminants, particularly ammoniacal nitrogen and phosphorus, a primary contributor to eutrophication and degraded water quality, while offering economic benefits for urban catchment management. Biomass from these plants is converted into new biochar via pyrolysis, supporting circularity by replacing saturated biochar, which would be recycled as compost material. This combined CDS and NbS approach not only enhances water quality for reuse but also aids carbon sequestration and fosters circular resource use. This innovative and sustainable solution aligns with climate-resilient management to support the United Nations Sustainable Development Goals (SDGs).

Keywords

Urban Stormwater Management, CDS Technology, Biochar, IoT Monitoring, Nature-Based Solutions, Water Quality.

Integration of Multi-Source Geospatial Data for the Assessment of Geoengineering Hazards during Construction and Operation of Hydrotechnical Structures

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Abstract
The essence of monitoring systems is to provide information on changes in the geometry of the examined objects as a result of processing the acquired geospatial data using computational algorithms. Most monitoring systems integrate two different measurement techniques (usually: tachymetry and GNSS), but usually without geotechnical monitoring techniques. Geodetic techniques allow for obtaining the so-called georeference for other data; however, they cannot be used everywhere due to the requirement of optical visibility of measurement points. Non-geodetic (geotechnical) techniques usually provide relative (differential) values without georeferencing, but devices can operate in a location that is visually inaccessible, fully automatically, without constant operator supervision. The problem is the physical integration of devices within different techniques and their diversity in terms of the structure of the geometric data provided and their accuracy: inclinometer sensors and hydrostatic levelling inform about changes without reference to the external reference system of the object.

The article proposes a methodology for integrating geodetic observations (tachymetry, geometric levelling) and data from selected geotechnical sensors. Non-geodetic techniques very often provide data with higher precision compared to the results of geodetic measurements, which allows to some extent to control the results of geodetic measurements, providing the system as a whole with greater reliability, understood as the ability to eliminate outliers, as a result reducing incorrectly interpreted “notifications” and “alerts” about the condition of the object. The result of the team’s work is a proposal to modernize and combine into a single monitoring system: the geodetic control network for examining displacements and ASTKZ elements.

Keywords
Displacement Monitoring, Geodetic Monitoring, Geotechnical Monitoring, Structural Health Monitoring, Inclinometers, Hydrostatic Leveling.

PAPERS PUBLISHED IN THE "LECTURE NOTES IN CIVIL ENGINEERING" SPRINGER SERIES

Applications of Drone-Based Technology for Tackling Geotechnical Risks in Tailings Dams (An Advanced Approach Towards GISTM Compliance)

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Abstract
Tailings dams, critical yet high-risk structures in mining operations, require advanced monitoring solutions to prevent catastrophic failures and align with the Global Industry Standard on Tailings Management (GISTM). Climate change exacerbates geotechnical risks by intensifying extreme weather events – such as heavy rainfall, prolonged droughts, and temperature fluctuations – which can destabilize dam structures through mechanisms like increased pore pressures, accelerated erosion, or altered hydrological regimes. This technical review supported by documented case studies, synthesizing both academic literature and field implementation, explores the transformative role of drone-based technology in addressing both traditional geotechnical risks (e.g., slope instability, seepage) and climate-driven challenges, while advancing compliance with GISTM's principles of safety, transparency, and accountability.

Unmanned Aerial Vehicles (UAVs) equipped with high-resolution imaging, LiDAR, and multispectral sensors enable rapid, large-scale data acquisition in challenging terrains, overcoming limitations of traditional ground-based methods. For instance, UAV photogrammetry combined with convolutional neural networks (CNNs) enhances the identification of climate-induced anomalies, such as altered water saturation zones or vegetation stress linked to drought conditions. Case studies demonstrate UAV-derived 3D models and Web-GIS platforms that simulate climate scenarios, such as extreme flood events or prolonged dry spells, to assess dam resilience under non-stationary climatic baselines. Integration with Cloud Point data technology and ground sensors forms a reliable monitoring system, improving early detection of precursor displacements influenced by climate variability. For example, through regular drone surveys it would be possible to monitor the deformations in a tailing dam embankment with localized precision and estimate the rate of deformation in each direction. Such multi-source data fusion supports GISTM's mandates for real-time monitoring (Principle 7) and adaptive risk management (Principle 3), ensuring alignment with site-specific climate projections and mitigation strategies.

Climate change adaptation is further addressed through UAV-enabled predictive modelling. In Ghana, drone-LiDAR surveys mapped terrain to simulate flood scenarios under projected rainfall increases, enabling pre-emptive infrastructure adjustments to safeguard communities – an imperative step in GISTM's emergency preparedness (Principle 13). However, challenges persist, including algorithm sensitivity to environmental noise (e.g. Vegetation changes) and the need for standardized workflows to harmonize climate data with geotechnical assessments. This study advocates harmonizing drone technology with GISTM's climate adaptation frameworks, emphasizing proactive risk mitigation through iterative monitoring, adaptive design, and transparent stakeholder engagement. By bridging technological innovation with regulatory imperatives, drone-based systems emerge as indispensable tools for achieving GISTM's vision of zero harm in an era of escalating climate uncertainty.

Keywords
Drone, Tailing Dams, GISTM, Geotechnical Risk Assessment.

Dry Reservoirs and Change of Use in the Light of Climate Change

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Abstract
The main objective of the project was to develop a methodological guideline describing the procedure for changing the use of a dry reservoir. The methodological guideline is based on a two-level multi-criteria analysis, which allows for the differentiation of dry reservoirs in terms of suitability for change of use. Another project objective was to carry out a complete record of implemented dry reservoirs and polders in the Czech Republic and present it in the form of a database and map. Such a summary in the form of a database has not yet been developed in the Czech Republic because the implementation of dry reservoirs is financed by various subsidy programs that do not overlap. The project achieved the development of a database of dry reservoirs that is continuously updated and used by river basin managers. A significant output from the project was also the documentation of the technical condition of some dry reservoirs, including inappropriate methods of technical solutions. A consortium of three companies was entrusted with the project, namely the Water Research Institute, VODNÍ DÍLA – TBD and Aquatis.

Keywords
Dry Reservoir, Assessment, Database.

Advances and Challenges in Lime Treatment for Hydraulic Structures: A Comprehensive Review of Field Applications and Long-term Performance

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Abstract
Lime treatment of soil is a widely accepted, safe, and economical method that enables soil reuse in the construction of transport infrastructure. This technique provides significant advantages, including the reduction of landfill waste and the acceleration of construction timelines. Despite this, the application of lime treatment in hydraulic structures remains less common. Hydraulic structures have unique requirements that differ from traditional embankments, such as low permeability to prevent seepage, resistance to both internal and external erosion, and the resistance to high velocity flows.

Over the past twenty years, numerous studies, investigations, and full-scale projects have highlighted the benefits of using lime treatment in hydraulic structures. This method allows for the utilization of locally sourced soils, simplifies the typical design cross-section, and improves mechanical properties, erosion resistance, and overall cost efficiency, including reduced material transport. As a relatively new technology, there is limited documented evidence of its long-term performance and the impact of prolonged exposure to weathering on its specific functional requirements in hydraulic structures. Therefore, it is essential to demonstrate that lime treated hydraulic structures are not only efficient and sustainable but also represent viable long-term solutions.

This paper provides a brief overview of previous experiences in the field, providing details on the construction and monitoring of dikes built in France, Belgium, and the Netherlands using lime treated soils. It presents technical evidence gathered over the years, and draws final conclusions based on this comprehensive data.

Keywords
Lime Treatment, Soil Improvement and Stabilization, Dikes and Levees, Durability, Field Monitoring.

Experimental Evaluation of Distributed Fiber Optic Cables with Fixed-Point Architecture for Monitoring Reinforced Concrete Structures

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Abstract
This paper presents an experimental evaluation of distributed fiber optic strain-sensing cables with a fixed-point architecture, developed for structural health monitoring (SHM) of reinforced concrete (RC) structures. A full-scale bending test was conducted on a 12-meter-long RC beam (400 × 400 mm cross-section) instrumented with a single-mode fiber optic cable featuring internal anchoring points at 2-meter intervals. The cable was surface-mounted using epoxy adhesive and calibrated under controlled laboratory conditions for strain levels up to ±15,000 με.

The test involved stepwise loading with continuous acquisition of strain, temperature, and crack formation data in real time. The results confirmed the sensor's capability to detect distributed strain fields and localized cracking with high resolution and stability. The fixed-point design enabled accurate strain averaging between anchorage locations and demonstrated robustness under civil engineering environmental conditions.

This study validates the effectiveness of fixed-point DFOS technology for monitoring RC foundation elements. The approach supports early-stage damage detection, assessment of differential settlement, and integration into digital twin frameworks for predictive maintenance and life-cycle performance evaluation.

Keywords
Distributed Fiber Optic Sensing, Fixed-Point Architecture, Reinforced Concrete, Structural Health Monitoring, Crack Detection, Strain Measurement, Full-Scale Testing.

Rehabilitation and Optimization of Structural Health Monitoring Systems in Existing Dams

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Abstract
Dams are critical infrastructures that require continuous monitoring to prevent structural failure and ensure long-term stability. Many existing dams, however, rely on outdated manual monitoring systems, resulting in inefficiencies in data collection and analysis. This paper explores the rehabilitation and optimization of structural health monitoring (SHM) systems of some existing dams in Uzbekistan, emphasizing the integration of modern technologies with pre-installed instrumentation.

The evaluation phase includes reviewing operational and non-operational instruments, verifying the quality of existing sensors, reviewing data acquisition methods, and determining the feasibility of automation. Case studies from Uzbekistan, including the Charvak, Akhangaran, Hisorak, Andijan, and Tupalang dams, illustrate successful implementations of upgraded SHM systems. These upgrades involved the integration of automated wired and wireless data loggers, the installation of new sensors such as piezometers, tiltmeters, crackmeters, tele-pendulums, and the implementation of remote access for real-time data visualization.

Automation of existing instrumentation has improved data accuracy, reduced manual labor, and enabled nearly-real-time alerts to be received in case of abnormal conditions. Installation of new equipment has filled monitoring gaps, improving the overall safety and operational efficiency of the barrage facilities. Integration of historical data with automated systems has improved trend analysis and early detection of anomalies.

Challenges such as compatibility between old and new tools, budget constraints, data management, cybersecurity, and staff training were also discussed. This paper finally concludes that the modernization of dam SHM systems improves safety and decision-making capabilities. Future advances in IoT and AI-driven analytics are expected to revolutionize dam monitoring further, ensuring resilience against structural hazards.

Keywords
Monitoring System Rehabilitation, Dam Structural Health Monitoring, Dam Safety, Dam Instrumentation, Instrument Automation.

On the Calibration of a Numerical Model of Homogeneous Earth Dam Using Permeability Zoning Based on Seepage Monitoring Data

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Abstract
Seepage monitoring is a critical aspect of safety assessment and risk management for earth dams. Numerical modelling, particularly using the Finite Element Method, is a powerful tool commonly used to study the seepage performance of dams, as it relies on physics-based equations. Calibration of a numerical model with observational data is a crucial step in this process. It involves adjusting the model to reproduce observed performance, thereby gaining insights into the seepage behaviour of the dam. The calibration process is complex, multi-factor, and multi-stage. It can vary significantly depending on the assumptions and tuning techniques employed, the available data, the analysis's objectives, and the structure's specifics. In the case of a homogeneous dam, the calibration procedure can be hindered by the inability to reach calibration goals, particularly if the set of adjustable parameters is defined based solely on the dam's structural arrangement.

This paper discusses an approach to calibrating the numerical model of a homogeneous earth dam, focusing on the most reliable actual data available, which is obtained through consistent piezometric monitoring. The approach is founded on the assumption of generalized hydraulic conductivity in specific zones of the dam-foundation system. Perm permeability zoning corresponding to seepage domain sections controlled by individual piezometers was introduced to facilitate model calibration. The objective of this paper is to present the expediency of the technique for homogeneous dams. The approach is demonstrated through its application to a case study, supporting its reliability and practical value in dam safety evaluation.

Keywords
Earth Dam, Model Calibration, Monitoring Data, Finite Element Method, Permeability Zoning, Seepage Analysis.

Compressive Strength of Selected Hardening Slurries Containing Ash from Municipal Waste Incineration

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Abstract
Hardening slurries are thixotropic mixtures predominantly composed of water, cementitious binder, and clay material (e.g., bentonite), often supplemented with additional components depending on their intended use (e.g., fly ash, blast furnace slag). In the case described, municipal solid waste incineration ash from the Warsaw region was used as an additive, aligning with current trends in utilizing such ashes in construction materials. This article presents compressive strength tests of a sample material with a known composition.

The measurements were conducted on cylindrical specimens at two curing intervals using both uniaxial compression in a press and under triaxial stress conditions. Uniaxial compressive strength after 28 days ranged from 32 kPa to 114 kPa, and after 92 days, from 67 kPa to 232 kPa. Given the slurry's intended application – as part of a cut-off wall for seepage control – detailed triaxial tests were conducted under a broader range of loads to simulate in-situ stress and strain conditions at various depths below ground. Triaxial tests yielded compressive strengths (at confining pressures of 200 and 400 kPa) ranging from 248 kPa to 848 kPa after 28 days and from 382 kPa to 943 kPa after 92 days. These results indicate the material's correct load-bearing capacity and tightness, confirming its suitability for use in cut-off walls.

Keywords
Unconfined Compression Device, Triaxial Compression Apparatus, Construction Engineering, Circular Economy, Waste Incineration Ash.

Strengthening Measures Adopted for the Retrofitting and Safety Concern of People in the Downstream of Mullaperiyar Dam in Kerala, India

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Abstract
Older dams face increased safety risks, higher maintenance costs, and reduced functionality due to sedimentation. Climate change-induced concentrated rainfall patterns, landslides, and siltation further exacerbate these risks, reducing storage capacity and compromising dam stability. Mullaperiyar Dam, a 129-year-old masonry gravity dam, is crucial for water supply in Tamil Nadu, India, particularly for irrigation purposes and power generation. Despite strengthening measures since 1979, safety concerns persist due to its location in Seismic Zone III. Recent revisions of codes for critical structures and studies indicate significant seismic threats, suggesting the dam is vulnerable to earthquakes above magnitude 6.

This paper outlines the strengthening measures undertaken to prolong the dam's life and proposes a solution involving the construction of a new tunnel to reduce the dam's water level carrying capacity, thus improving stability while meeting water needs. The existing tunnel allows reservoir drawdown only to 32.46 m; storage below this level cannot be accessed. The proposed tunnel, 4 km long and 6 meters wide, would be constructed at a height of 15.24 m to evacuate water from this level. It would divert excess water from the reservoir to the Vaigai River, where it could be stored in small reservoirs. This approach ensures effective water management for Tamil Nadu while enhancing dam safety, potentially mitigating seismic threats for at least 50 years. The study emphasises the need for a cooperative, sustainable solution that balances environmental, engineering, and humanitarian considerations in addressing the Mullaperiyar Dam crisis.

Keywords
Masonry Gravity Dam, Deterioration, Rainfall Patterns, Siltation, Tunnel.

Application of an Unsteady 3D Computational Fluid Dynamics Model for Forecasting Local River Erosion: A Case Study of Ukrainian Carpathian Rivers

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Abstract

A method for predicting local riverbed and bank erosion based on computer simulation modelling has been proposed. It was demonstrated that an essential factor in predicting local erosion based on natural riverbed features is a thorough understanding of the types of riverbed processes occurring in the relevant river sections, as well as the availability of up-to-date geospatial data on river hydromorphology. Key parameters are considered to include riverbed width at the location of an obstacle, river depth, hydraulic slope, average water current velocity, and the weighted average diameter of sediment particles. Detailed information is also required for simulation modelling on the geometry of river formations adjacent to the banks, particularly those deviating from the shores downstream at a certain angle. Various types of fluvial-morphological processes can be identified using remote sensing data.

The simulation modelling of turbulent flow kinematics behind bottom barriers, as well as bottom resistance strength, which characterizes the intensity of turbulent flow development, was conducted for the most common types of fluvial-morphological processes (including incomplete, limited, free meandering, and focal types) observed in rivers of the Ukrainian Carpathians. The boundary (minimum possible) deviation angles of obstacles from riverbanks downstream were determined, indicating areas where the intensification of local river erosion is most likely to occur. The results of the computer simulation modelling were verified using examples from well-studied rivers of the Ukrainian Carpathians. Prompt identification of river sections where local riverbed and bank erosion is highly probable during floods is enabled by the developed method.

Keywords

Local Channel Deformations, Simulation Modelling, Forecasting, Channel Process, Spatial Analysis, Reynolds Equations.

Dynamic Response of the Ariklikaş Earth Fill Dam

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Abstract
The major earthquakes that occurred in Turkey in February 2023 once again revealed the vital importance of the seismic design of dams. The earthquake records in critical locations in affected areas clearly show that the direction and relative magnitudes of the recorded accelerations have created findings that need to be re-evaluated. During the earthquakes, serious damage occurred in several earthfill dams due to liquefaction or excessive lateral spreading in the foundation soil and dam body, stability problems in the embankment slopes, and excessive crest settlements.

This paper assesses the dynamic performance of the 40-meter-high homogeneous earthfill Arıklıkaş Dam, situated in the city of Osmaniye in southern Turkey, following its exposure to the destructive effects of the February 2023 earthquakes. For this purpose, a series of dynamic finite element analyses are performed to evaluate the dynamic response of the dam, considering the near-fault effects and acceleration directions. Through a comparative analysis of the observed damages in the dam following the Maraş earthquakes with the analysis results, this study investigates the primary causes and mechanisms underlying the damages. A possible rehabilitation alternative is also evaluated to satisfy the required safety level for returning the dam to service.

Keywords
Dams, Earth fill Dams, Earthquakes, Numerical Model.

Influence of Cyclic Pressure Changes on the Mechanical Behaviour of Polyethylene Pipes

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Abstract
This paper presents the effect of cyclic pressure loading on a polyethylene pipe and the resulting changes in its mechanical parameters over time. The research utilized a specially designed and constructed test rig, which enabled the generation of pressure oscillations using a valve by inducing the water hammer phenomenon. This process accelerates the aging and fatigue of the material. The water hammer phenomenon occurred in cycles lasting several seconds, and the number of cycles was recorded. The aim of the article is to compare the material parameters of pipes subjected to cyclic loads with those of pipes that were not exposed to such influences. In total, the tested pipe was subjected to several million load cycles, which allowed for the assessment of the long-term effects of pressure fluctuations, serving as an equivalent to years of loading under real operating conditions.

The tests were conducted on a specially designed test rig, where a DN32 HDPE pipe with a total length of 29.5 meters was used. The rapid closing shutoff valve generated pressure waves on the test stand. Deformations and stresses were monitored in real time using piezoresistive pressure transducers and foil strain gauges. Data was recorded at a frequency of 400 Hz. Additionally, during the measurements, the flow rate and water temperature were also monitored. The research results showed a significant impact of cyclic pressure changes on the material parameters of the pipe, such as hoop stiffness. These parameters are important for the reliability and safety of water supply systems.

Keywords
Water Hammer Phenomenon, Pipe, Material Aging, Reliability.

Structural Crack Formation in a Swiss Dam Affected by Swelling due to Alkali-Silica Reaction

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Abstract
This paper describes the temporal evolution and spatial variation of structural cracks in the Roggiasca double-curvature arch dam in south-eastern Switzerland. This dam, which has a very slender design, is undergoing swelling due to Alkali-Silica Reaction (ASR). Intensive monitoring of dam deformations and strains revealed the history of structural cracking as well as the evolution of spatial ASR strain variation. The crack formation and behavior are dictated by the ASR strains and the static constraints of the arch.

Keywords
ASR Strains, Structural Cracks in Dams, Strain Distribution.

Monitoring the Levees Condition of Pumped Storage Power Plants Under the Formation of Abrupt Fluctuations of Water Level in the Upper Reservoir

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Abstract
The article considers the issue of monitoring the condition of levees in pumped storage power plants (PSPPs). The specifics of the operation of contour earth-filled levees of the upper reservoir associated with various fluctuations of the water level in the reservoir during the operation of the plant's units in turbine and pumping modes are highlighted. The seepage modes of earth-filled levees and the influence of these modes on the stability of the upstream and downstream slopes are considered. The article provides the designs of levees' anti-seepage and drainage devices, as well as the upstream slope protection. Measures to ensure the stability of the valley bank slope, where the main structures of the Dniester PSPP are located, are described.

The paper also covers measures to monitor the condition of the levees of the upstream reservoirs of PSPPs to prevent water overflow through their crests. The results of experimental and theoretical studies of the characteristics of translation waves generated during start-up, shutdown, and operation of the Dniester PSPP units in turbine and pumping modes are described. The influence of wind waves is also taken into account. The equipment used in the experimental studies is described. Theoretical studies of the characteristics of the translation waves generated in the upper reservoir are based on the Saint Venant's differential equations.

Keywords
Levee, Technical Monitoring, Seepage, Translation Waves, Stability.

New Approaches in Flood Levees Management Following the EU 2030 Biodiversity Strategy

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Abstract
Flood levees, similar to large dams, have a key role in Flood Risk Management. It is estimated that there are more than half a million kilometres of flood levees across the world, disconnecting rivers from adjacent floodplains. To improve this situation, the EU Parliament and Council Regulation on Nature Restoration (2022/0195(COD)) and the EU 2030 Biodiversity Strategy call for the restoration of freshwater ecosystems and the natural functions of rivers, e.g. by removing outdated and redundant barriers, restoring floodplains and reconnecting them to rivers. This paper searches for appropriate concepts, methods and criteria for decommissioning obsolete and non-functional reaches of flood levees. Three steps are proposed, particularly a preliminary classification of the levee system, a proposal of possible variants and multicriterial optimization, including flood risk approaches. In this paper, only the first step is discussed in more detail. The proposed methodology is demonstrated in the Morava River sub-basin in the Czech Republic.

Keywords
Flood Levee, Floodplain, Reconnecting Floodplains, Restoring Rivers and Floodplains.

Insights from Research on Concrete Dam Drains Clogging and Its Management

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Abstract

This article provides an overview of the findings from a Hydro-Québec research project aimed at improving the management of concrete drain clogging. The project began by characterizing deposits found in structural drains at various dams, identifying them as calcium carbonate in the form of calcite. The study examined the chemical removal of calcite by evaluating the efficiency of different acids and their potential impact on concrete. An alternative method to camera-based drain inspections is also proposed, utilizing acoustic signals measured from the drains to detect blockages, offering faster results compared to traditional camera inspections. A predictive method for the rate and quantity of calcite accumulation inside drains is proposed, based on chemical equilibrium equations for calcite formation and hydraulic models.

The benefits and challenges of the studied methods – chemical cleaning, inhibitors and coatings to reduce calcite formation, prediction of calcite accumulation, and inspection of drains – are presented in comparison to traditional maintenance methods, such as mechanical cleaning with water jets and camera inspection.

Keywords

Concrete Dam, Calcite, Drains, Acoustic Signal, Pronostic.

A Methodological Framework for Investigating Textile Waste Fibre-Reinforced Soil in Embankment Applications

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Abstract
Earth embankments are increasingly vulnerable to deterioration due to natural aging, external factors, and the effects of climate change, requiring more effective and sustainable repair strategies. Conventional reconstruction or low-pressure injection often introduces structural discontinuities and requires large volumes of material. At the same time, the textile industry faces growing pressure to manage waste more responsibly. Repurposing textile waste fibres in geotechnical applications offers a promising dual benefit. This contribution presents a methodological framework for investigating the hydro-mechanical behaviour of mixtures of textile waste fibres and natural soil based on laboratory tests conducted on embankment soil treated with linen and viscose fibres. Procedures for soil–fibre mixing, fibre distribution inspection and sample preparation are proposed. Key parameters, such as fibre content and geometry, are identified, and guidelines to investigate fibres effect on shear strength, hydraulic conductivity, and water retention are provided.

Keywords
Fibre-Reinforced Soil, Textile Waste, Embankment Repair, Sustainable Geotechnics.

Mechanical Weakness and Accelerated Erosion in Rock Mass along Active Faults

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Abstract
This paper addresses the significance of a fault under dam sites. While seismic shaking was the main theme of past efforts for seismic safety of dams and other infrastructures, fault dislocation deserves attention as well. Shigang Dam, affected by the 1999 Chi-Chi earthquake in Taiwan, revealed the overwhelming effects of fault dislocation. Since many dams are prone to such fault effects, a question arises why the valley of the dam has a fault. This question should be revised to be "how does a fault produce the valley?"

A geological answer is that the fault dislocation disturbed the surrounding rock mass, making it more prone to erosion and landslide. From an engineering viewpoint, there is a need to make this answer more quantitative. The first attempt in this direction is a proposal of the idea of process zone with mechanical disturbance in which slope instabilities along active faults are distributed within 1% of the fault length. As a second attempt, the size of watersheds in the upstream area of rivers is compared against the amount of sediment deposits in the downstream area. It is found that the rate of erosion and sediment production is several times higher near the faults than in areas away from faults. These quantitative findings help us capture the extent of fault effects and sediment production rate in many engineering scenes.

Keywords
Fault, Dislocation, Erosion.

Experimental Investigation of Internal Erosion under Triaxial Shearing using X-ray Micro-Computed Tomography

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Abstract
Internal erosion refers to the long-term, progressive process wherein seepage flow carries fine particles through the interstices between coarse particles, leaving empty voids within the soil structure. Triaxial shearing can change the pore structure of the coarse particles and destroy stable clogging formed by fine particles. Two groups of samples, including one glass beads (GB) sample and one Leighton Buzzard sand (LBS) sample with the same initial fines content in each group, are selected to characterise sample- and pore-scale internal erosion behaviour. The experimental outcomes underscore that internal erosion remains limited without triaxial shearing, yet escalates quickly upon the imposition of triaxial shearing. Besides, compared with artificial round glass beads, a sample composed of natural irregular LBS sand demonstrates higher resistance to internal erosion and slower seepage channel formation.

Keywords
Internal Erosion, Triaxial Shearing, CT Images, Fines Content, Glass Beads, Natural Sand.

Modelling Framework for Supporting Water Management in Small Catchments in Hungary

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Abstract
A modelling framework for simulating hydrological and hydrodynamic processes in small catchments in Hungary has been developed. The framework incorporates the HEC-HMS and HEC-RAS modelling tools for simulating rain-fall-runoff and streamflow processes in the catchments. The framework is used operationally by the Hungarian water management service. It is applied for various purposes ranging from supporting water resources management and hydrological forecasting, to predicting the impacts of planned modifications in the water management infrastructure.

Keywords
Framework, Modelling, Small Catchments, Reservoirs, Water Supply, Flood Control, Recreation, Forecasting.

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