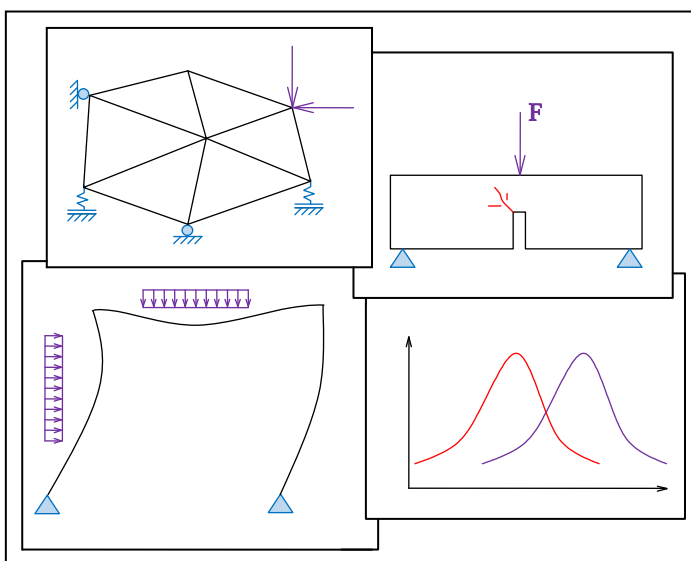


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Simplified Cement Bound Granular Mixture (CBGM) Design Method Based on Continuous Ultrasonic Wave Measurement

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Materials incorporating cementitious binders typically consist of a composite of mineral soils, such as fine and medium sands, with the addition of a relatively small amount of cement binder, usually ranging from 4% to 8%. The compressive strength of these materials varies from a few to several MPa, with practical values most commonly falling within the range of 1.5 to 5 MPa. Increasingly, waste materials are being incorporated into the composition of Cement-Bound Granular Materials (CBGM). Given the substantial consumption of these mixtures in construction processes, they present a viable method for waste utilization. CBGM is primarily used as a sub-base or improved subgrade in road pavement structures. This material exhibits characteristics that are intermediate between rigid and flexible materials. The present study introduces an innovative approach employing ultrasonic wave propagation to monitor the strength development process at an early stage (within a few days). This method enables the determination of the required cement content based on small-scale trial mixes alone. Such an approach has the potential to simplify and accelerate the design process. The research conducted has demonstrated the applicability of this method and confirmed the initial assumptions.

Causes of Failures and Collapse of Gabion Walls Above Roads

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In civil engineering and building construction, so-called gabion retaining walls made of stones placed in wire baskets made of galvanized wires are very often used today. These walls have a natural appearance, favorable conditions for attaching climbing plants, and their greening contributes to improving the environment. The gaps between the stones also allow water to flow and, under certain conditions, can also reduce its pressure on the wall. Wire baskets filled with loosely placed quarry stone also withstand uneven subsidence of the subsoil, because, compared to concrete or brick retaining walls, they do not generate additional internal forces and cracks. However, for their reliable function and to ensure structural integrity, it is necessary to correctly determine the load, design the structure, assess the load-bearing capacity, stability and anchoring of the wire baskets. There is currently no technical standard for this type of load-bearing structure that would regulate the method of their design and assessment. The article presents the principles of calculating the bearing capacity by analytical and numerical methods, including the principles for determining the decisive load components. It also presents examples from construction practice, when incorrectly designed walls have caused their collapse.

The Significance of Experimental Testing in the Static Design of Timber Structures

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The design of timber structures in most European countries is governed by the common standard Eurocode 5. The standard provides basic information on the design of partial elements, composite parts and also their connections, but it lacks some important knowledge, arising mainly from requirements of scientific research, but also from the rapidly developing construction practice. Thus, experimental testing plays an important role in the verification of load-carrying timber structures. The aim of the paper is to present test results of selected timber structures and their comparison with standard approaches and numerical models within static design in practice. It deals with the determination and comparison of the horizontal load-carrying capacity and stiffness of wall panels in the system of a lightweight frame structure with OSB sheathing. Wall panels with different types of load-carrying sheathing were loaded with a horizontal force in order to monitor their deformation response to the load. The results of experimental tests were subsequently compared with analytical standard calculations and numerical models. Experimental tests demonstrated the suitability of using some sheathing methods in practice. Numerical models showed good agreement with measured data.

Application of Eurocode 2 in Predicting Shrinkage of 3D-printed Concretes: Challenges and Model Optimization

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The article examines the suitability of the Eurocode 2 (EC2) model for predicting shrinkage in 3D-printed concretes. As legally binding shrinkage prediction model in Poland, EC2 provides a universal framework for estimating total shrinkage, including autogenous and drying shrinkage, under varying thermal and moisture conditions. EC2's analytical approach calculates total shrinkage as the sum of autogenous and drying shrinkage components. Drying shrinkage is modeled as a function of concrete age, environmental humidity, and effective specimen dimensions. Autogenous shrinkage, on the other hand, depends on the compressive strength and hydration progress of the concrete. The study incorporates EC2's formulas and assumptions to evaluate its accuracy in predicting shrinkage for the 3D-printed concrete mix, which features non-standard material properties and geometry configurations. Experimental results from the 7-day maturation of specimens were compared with EC2 predictions. The findings indicate that while EC2 offers reasonable estimates for conventional concretes, its application to 3D-printed mixtures may require recalibration due to unique factors such as altered hydration kinetics and microstructural differences. Parameters like relative humidity, compressive strength, and specimen size showed significant influence on the prediction accuracy. The study concludes that EC2 remains a practical choice for shrinkage estimation but highlights the need for further research to refine its adaptability to emerging materials like 3D-printed concretes.

Tank Analysis Under Load Effects

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Tanks and reservoirs are structural systems designed for storing various liquids, gravels, granular or other bulk materials. Special attention is devoted to potable water storage. Regarding the increasing scarcity of clean water and the recent lack of it in some regions worldwide, it is essential that these structures have to be carefully analyzed and properly designed. Water tanks are significant architectonic works. They are typically constructed from steel or reinforced concrete, and they most commonly adopt a cylindrical shape. Considering their future utilization and regarding other essential circumstances related to the site of their planned placement, they can be situated on the ground, above the ground, partially buried, or fully underground. Due to the expected static and dynamic effects, both static and dynamic analysis has to be carried out within the designing process of the construction.

The paper provides numerical analysis of a cylindrical surfaces-mounted water reservoir by using the Finite element method in Ansys acoustic system. Fluid elements were employed to simulate the internal fluid domain. The static and dynamic analysis was carried out under the hydrostatic load. The results were compared with a simplified static analysis including a short modal study and impulse frequency response evaluation.

Simple Design Methodology for Clinch Joint of Steel Structures

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Clinching is a method of joining different metal parts by a process of local deformation without use of any additional elements. Is very useful for thin-walled steel sections used for load-bearing structures, such as purlins. In this paper, a simplified method of clinch joint verification using an analytical approach is presented. The basic cross section of the clinch connection is considered at the level of identification of geometric and material properties. The assessment of the specimen subjected to shear and tension is presented separately. Example calculations with realistic parameters are prepared for both types. The results are compared with experiments from the research program. This procedure is conservative compared to the experimental results and the load capacity estimates obtained by this procedure are 45% and 26% lower, respectively, than those obtained experimentally. Thus, it is possible to obtain a sufficiently safe and fast estimate of the clinch joint capacity for engineering calculations.

Approximation of a Tensile Member with Large Strain

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The article presents the derivation of an analytical expression for describing the response of an elastically stretched prismatic bar with linear material under large strains, solved by the finite element method with models of various dimensions.

Non-destructive Maturity Method in Zeolite-based High-performance Concrete

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The purpose of this research was to analyze the effectiveness and accuracy of the maturity method to estimate concrete strength for the variety of zeolite-based high-performance concrete (HPC) mixtures. The maturity method uses structure's unique temperature history to predict concrete strength at any given time, based on the empirical strength-maturity relationship derived from laboratory testing. Ten different binary and ternary mixtures were chosen to show the effects of using various doses of zeolite, along with the addition of numerous supplementary cementitious materials (SCMs) like metakaolin, silica fume, pumice, and slag. For each mixture, 17 cylindrical specimens (4 in $\times$ 8 in) were prepared and cured in a lime water tank at room temperature. Strength development was monitored through destructive testing at 1, 3, 7, 14, 28, and 56 days, while maturity measurements were recorded using maturity meters and SmartRock sensors. The time-temperature history thus obtained were converted to maturity using Nurse-Saul and Arrhenius maturity function. Additionally, exponential, logarithmic, and hyperbolic functions were used to estimate the strength gain in concrete, and the accuracy of each function were analyzed. The results demonstrated a close alignment between the experimental and estimated concrete strengths- most of them lying within the 20% of the actual strength. Additionally, the Arrhenius and the exponential function proved to be the most accurate for strength estimations. On the other hand, datum temperature of 00c and the activation energy of 37500 J/mol was computed to be the most optimum for strength estimation of both binary and ternary zeolite-based mixtures.

Impact of Geometrical Variables and Concrete Strength Variations on Steel-concrete Composite Connections Using Script-based Material and Geometrical Modeling

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The performance of steel-concrete composite structures is largely determined by the effectiveness of shear connectors that facilitate the interaction between the two materials. This study investigates the behavior of stud shear connectors, with a particular focus on how different concrete grades influence key geometry parameters governing the composite connection.

A numerical model was developed using Python to systematically analyze the impact of these parameters on structural performance. The computational framework allows for dynamic adjustments of geometry properties, where predefined variables ensure seamless modifications without introducing errors. This adaptability enhances the accuracy and efficiency of the analysis, enabling precise evaluation of different design configurations. The parametric model, implemented in ABAQUS, incorporates geometric nonlinearity and the Concrete Damage Plasticity (COP) model to achieve a detailed simulation of structural behavior. Critical geometric factors identified in previous research - such as stud diameter, stud height, head dimensions, and spacing in both longitudinal and transverse directions - were assessed across various concrete strengths to evaluate their impact on the steel-concrete interaction. The findings of this study provide valuable insights into the real-world behavior of composite structures, particularly in cases where the actual concrete strength deviates from the intended design. Such variations may arise due to long-term material degradation, leading to a reduction in strength, or due to the use of higher-quality concrete than originally specified, for instance, as a result of improved manufacturing processes. Understanding these influences is essential for optimizing composite connection design and ensuring the long-term reliability of steel-concrete structures.

Numerical Parametric Study of 3D Printed Joints

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Numerical modelling of 3D printed joints suitable for joining timber frame structures brings with it many unexpected tasks and challenges. Unstable material properties, delamination and more. Therefore, it is desirable to extend the knowledge in this area appropriately. This paper presents part of a research aimed at comparing the results of several different geometry variants of connections. Parametric study can be used for experimental verification by tensile and compression tests and three-point bending tests. The intention was to alternate the locations of the holes in the 3D printed element prepared during printing for the pins. This paper presents the results of the numerical analysis of 5 joint variations with different hole locations for 4 pins. The numerical model consists of wooden prism, a plastic 3D printed joint and steel pins. The boundary conditions were set according to the designed experimental tests. The aim of the parametric study was to find the most suitable variant for each type of test. The evaluation was carried out at the level of the limits of each material. The results of the comparison of the variants show quite large differences in the behavior when the performance is transferred between the materials.

Mechanical Performance of 3D-printed Joints for Timber Frames

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The possibilities of 3D printing are wide and its involvement in structural engineering is a current issue. The aim of this study was to experimentally verify the mechanical properties of 3D printed joints for timber frames using compression testing. Five specimens were tested, each with differently positioned holes for three pins. The samples were fabricated from a 3D printer and were fitted with wooden prisms to which they were connected by steel pins. The experiments were performed on a universal testing machine and the progress of the testing was recorded in a force-displacement diagram. The design, manufacture and testing are part of an extensive research program looking at the suitability of 3D printing in the construction industry. The experimental results are complemented by a simplified numerical model that assumes boundary conditions. The study provides valuable insights for the optimization of the design of 3D printed joints and highlights the importance of the geometric arrangement of the holes to improve mechanical properties.

Timber Semirigid Frame Connection with Improved Deformation Capacity and Ductility

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All specimens were made of glued laminated timber. Dowel-type mechanical fasteners, a combination of bolts and dowels, and full-threaded screws were used for the connection. The main goal of this research was to replace the typical solution (common dowel-type fasteners) with a more modern, faster, and easier solution in order to improve the load-carrying capacity, ductility, and deformation capacity of this type of frame connection. This article also aimed to provide a detailed evaluation of the mechanical properties of the used glued laminated timber and fasteners in order to comprehensively evaluate the research task. For the design solution, a frame connection created from a system of two struts and a partition was chosen as the basis of the experimental program. Dowel-type mechanical fasteners, as well as combinations of bolts and dowels, were used for the connection; however, in addition to these standardly used mechanical fasteners, full-threaded screws were used. The article describes the use of static destructive testing to determine the ductility of the connection, considering different variations in the strengthening of the individual segments of the mentioned connection means. In the first variation, the individual components of the frame were not reinforced in any way. In the second, the crossbar was reinforced with two full-threaded bolts. In the third, the webs and the crossbar were reinforced with two full-threaded bolts. In the article, these ductility values were compared with each other and the procedure was set by the currently valid standard.

Inverse Analysis of Material Properties of Special Shapes of 3D Printed Samples

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Research in the area of property analysis of 3D printed structural components raises many new questions. A major challenge is the understanding of material behavior, as the raw material and the resulting printed sample cannot be considered the same in this respect. In 3D printing, the properties of the sample change due to high temperatures, change in the state of the raw material and different setups. Currently, there is no standard for determining certain properties, which leads to the need for appropriate use of experimental and numerical tools. The present study highlights the results of tensile testing and numerical analysis of a special 3D printed shape. Different material settings were used in order to perform a complete inverse analysis of the specimen behavior and calibration between experiment and model. The model was created in Ansys software and was prepared in several variations in order to be as close as possible to the real specimen.

Assessment of the Quality of the Joint of the Old Protective Layer of Mastic Asphalt with the New One on Engineering Objects

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The protective layer of the pavement on an engineering object, usually made of mastic asphalt, protects the waterproofing and additionally protects the construction from the damaging effects of water. The paper describes tests of the joint of old mastic asphalt with new ones. The resistance of the joint in small-sized elements under bending conditions was used. The test results obtained were used to assess the cooperation of the joints of old mastic asphalt with new ones with the use of bituminous tape and without the tape. Thanks to the use of bituminous tape, the combined mastic asphalt mixtures obtained greater monolithicity.

Analysis of Damping of a Ball Absorber From Experimentally Obtained Data

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This paper focuses on the analysis of the damping of a ball absorber's motion based on experiments with free oscillation. The experiments were conducted with a ball absorber restricted to planar motion, where its free oscillations were recorded using a video camera. The video footage was then analyzed with an algorithm that tracked the center position of the ball over time, enabling the creation of displacement curves of the ball over time. The paper investigates the influence of viscous damping and friction on the motion of the ball, with a particular emphasis on the interaction between the rolling track surface and the ball. A key aspect of the analysis involves comparing two surface variants, one featuring rubber tubing applied to the surface and the other remaining smooth. Additionally, the effect of variations in the ball's radius on damping was examined. The findings of this study enhance the understanding of damping mechanisms and provide valuable insights for selecting the appropriate damping type in the design of new absorbers or for choosing damping models in numerical simulations.

Influence of Traffic on the Dispersion of Water Mist in the Road Surroundings

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The durability and service life of the structures of transport structures and structures in their immediate vicinity is affected, among other things, by corrosion due to aerosol exposure from salt solutions used in winter to treat the roadway against ice and snow. This paper focuses on the computational modelling of the dispersion of water mist particles during the passing of one and two vehicles at different wind directions. The amount of potentially captured particles in the immediate vicinity of the road is evaluated in control surfaces at three different distances. The amount of potentially captured particles in the immediate vicinity of the road is evaluated at control surfaces at three different distances. The results of the CFD calculations showed that the quantity of captured particles is influenced not only by the traffic density, but also by the wind direction and the shape of the road profile and its immediate surroundings.

Application of a Computational Interface Damage Model to a Concrete-FRP Shear Connector

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The paper explores utilization of fiber-reinforced polymer (FRP) composites in bridge construction. Key advantages of FRP as construction material are highlighted in relation to conventionally used materials to evaluate its effectiveness in applications to different structures. The analysis of computations for varied geometrical parameters of a jigsaw puzzle type of continuous shear connector is also provided. For the concrete-FRP shear connector interface, a cohesive bilinear interface damage model based on a variational formulation has been chosen and implemented. The implementation introduces a interface damage variable to cope with degradation of the connector. The model also ensures the load- displacement relationship which locally provides a softening zone. During debonding, it may affect the smoothness and continuity of the computed structural response for analyzed quantities such as stress and interface damage variable. Assessments based on the presented results guarantee suitability of the computational variational model as a tool for predicting failure, having potential for application in material design, in design of specific construction details, and structural elements.

The Influence of Frame Structure Parameters on Its Natural Frequencies

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The moment-resisting frame (MRF) structures are well-known for having high lateral stiffness; they are made up of the rectilinear assemblage of beams and columns with the beams rigidly connected to the columns. These structures are designed to withstand lateral loads such as those from earthquakes or wind. The paper discusses the influence of the parameters of the MRF structures on their natural frequency. The relationship between the natural frequencies of the MRF structure and its total weight, lateral dimension in the direction of vibration, total height, and the number of columns in each floor of the frame structure is monitored. Free vibration analysis is applied to determine the natural frequencies and modes of vibration of the structure. MRF structures are analyzed numerically to obtain the aforementioned. A method of stiffness constants is used. So, for a structure, a stiffness matrix and mass matrix are defined, and based on their knowledge, the natural frequencies and mode shapes are determined.

Experimental and Numerical Analysis of Atypical Shape of NPP Structures and Ventilation Chimney on the Effects of Extreme Wind Load

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One of the important parameters for the interaction between wind load and the structure is the distribution of wind pressure on the structure. Some of the effects of wind, especially interference, are still the subject of research and experimental measurements. EN 1991-1-4 can only provide external wind coefficients for standard building or chimney shapes without consideration of mutual interaction. Wind flow around a chimney with nearby buildings is based on the distances between them and local wind speeds. This article discusses the effects of wind flow around the ventilation stack and nuclear power plant buildings. From the experimental measurements in this location, extreme wind loads with a probability of occurrence of 10^{-4} per year were determined based on the requirements of the IAEA and NRC standards. In this paper, CFD numerical analysis was performed to investigate the perturbation effects in turbulent wind flow. The results of wind pressure distribution above the chimney were compared between the numerical CFD analysis and the European standard EN 1991-1-4. The effects of physical and geometric nonlinearity in the ANSYS system on the ventilation chimney and steel structures of NPP hall in extreme wind conditions are also compared.

Analysis of the Clinch Method for Joining Structural Components

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Due to the wider use of thin-walled steel structures, alternative methods of connection are currently being sought to replace bolts, nuts, or welds. One attractive option is cold joining, known as clinching. This is a mechanical connection of two or more thin-walled steel plates formed by cold forming using a punch and die. The present paper provides background information on the ongoing research on the mechanical behavior of clinch joints. Tensile tests of the raw material were performed for the purpose of inverse analysis of steel. Furthermore, tensile tests of a set of specimens with one clinch joint were carried out and analyzed and compared with the outputs of a numerical model in finite element method-based software at the force-displacement diagram and limit mode levels. The verification of the models provides detailed information about the behavior of the joint, which is a suitable basis for more complex numerical models.

Numerical Modelling of 3D Printed Atypical Components of Glass-steel Detail

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With the increasing demands of modern architecture, glass is becoming an increasingly common construction material, which has an irreplaceable place thanks to its transparency. One of the most problematic areas in the design of glass structures is the connection between the individual elements of the structure. The linear fixings used in the past have been replaced, mainly for aesthetic reasons, by more subtle systems of point joints. There are two main basic types of point connections for glass structures, namely mechanical and adhesive. Although glass structures are widely used, the design of their connections is still based on the knowledge of the designer and the results of experiments. Atypical glass-steel structural details are challenging to manufacture, and one possible solution could be additive manufacturing by 3D printing metal parts of the joints. 3D printing of metal parts can simplify the production of details that may not be constrained by previously known shapes. New, more aesthetic or organic shapes can be created. However, the modelling of 3D printed features has its own specificities that are not identical to the traditional numerical modelling of conventional steel. Exploring the field of metal 3D printed structural components in glass-steel details can significantly contribute to the variability and safety of glass structure design.

Numerical Simulation of Crack Propagation in Clinch Joints

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The mechanical clinching process can be used for the load-bearing structures of thin-walled steel frame halls. Numerical simulation of crack propagation in a clinching joint using finite element method (FEM) software is an important tool for the analysis and prediction of the behavior of materials under load. This study focuses on clinch joints that must withstand high loads and repeated load cycles. Crack propagation in these joints can lead to failure of the entire structure, therefore it is important to understand the mechanisms of crack propagation and predict their behavior. Using specialized software, a numerical simulation of crack propagation was prepared, including modelling of joint geometry, definition of material properties and application of loads. The output of the analysis will be compared in future with experimental data. The simulation provides valuable information on the crack propagation velocity, which allows optimization of the behavior of the whole structure and the reliability of the clinch joints.

Fatigue Durability of Flexible Pavement Structures with Cement-bound Granular Material

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This paper presents a method for calculating the fatigue life of flexible pavement structures with a cement-bound granular material (CBGM) base, along with calculation examples. The most commonly used fatigue criteria for this type of pavement layer are discussed. In mechanistic pavement design calculations, which allow for determining stresses and strains in individual pavement layers, the primary material constants used are the modulus of elasticity and Poisson's ratio. In the case of cement-bound materials, the modulus of elasticity depends on the cement content and, consequently, on compressive strength. Another challenge associated with such layers is the variability of the elastic modulus during pavement operation. The assumed modulus value in mechanistic calculations depends on the operational stage of the layer. For a cracked layer, the modulus of elasticity is several times lower than in the uncracked stage. The study also compares the results obtained by considering different CBGM layer stages with those derived using the methodology applied in the Polish Catalogue of Typical Flexible and Semi-Rigid Pavement Structures from 2004.

Parametric Analysis on Concrete Cone Failure

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Structural anchors are often used to connect various elements of structures to a substrate material. Thus, an important part of the recent research deals with investigations of the parameters affecting the behavior of anchors embedded in the substrate material. According to the requirements and the method of their installation, cast-in anchors (fixed before casting) and post-installed anchors (fixed into drilled holes after casting) are distinguished. Generally, anchors may be subjected to either tensile or shear loading. For each case of loading, different behavior of the anchor can be observed, then various failure modes are spoken about; either pull-out failure, steel failure, side-face blowout, concrete cone failure and concrete splitting for anchors subjected to tensile loading or concrete pry-out failure, concrete edge failure and steel failure for anchors subjected to shear loading. This work is devoted to the concrete cone failure mode typical for anchors subjected to tensile loading. To design cast-in anchors, numerous experimental and numerical fracture analyses have been performed to suggest a theoretical prediction model and to determine the behavior of such structural elements. Investigations on this topic are included in this paper.

Identification of Fracture Characteristics of Concrete Mixtures with Waste Material Using Sara Stochastic Software

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The article delves into an advanced investigation focused on determining the fracture-plastic material model parameters of concrete, employing a robust numerical simulation approach. This research is particularly relevant given the increasing need to understand the mechanical behavior of concrete under various conditions, especially when modified with sustainable materials. The study centers around the use of three-point bending tests, a well-established method for assessing the fracture properties of materials, which are further enhanced by the integration of stochastic analysis. This combination allows for a more comprehensive evaluation of the material parameters by accounting for the inherent variability in concrete properties. The numerical simulations in this study are executed using two sophisticated software tools, ATENA and SARA. These tools are used in the field of civil engineering for their ability to simulate the nonlinear behavior of concrete structures with high accuracy. Two distinct types of concrete mixtures are investigated: a conventional reference concrete and a modified version in which 100% of the fine aggregate fraction is replaced with waste material sourced from CETRIS board production. This substitution represents an innovative approach to promoting sustainability in concrete production by recycling industrial waste materials. The findings of this research are significant, as they provide a deeper understanding of the potential for incorporating waste materials into concrete without compromising its structural integrity. The results suggest that such modifications could lead to more sustainable construction practices, aligning with global efforts to reduce the environmental impact of building materials while maintaining performance standards.

Fatigue Behaviour of Concrete: From Low-cycle to High-cycle Fatigue Properties

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This contribution focusses on the fatigue damage assessment of concrete samples using wide-range experimental data. Within this study, the concrete samples were tested under various loading conditions: static fracture, low-cycle and high cycle fatigue. This allowed us to obtain static load-CMOD, S-N curves for fatigue lifetime assessment, and mainly CMOD-N curves showing the stiffness degradation at high-cycle fatigue load regime. Additionally, acquisition of CMOD during the cyclic loading allowed for evaluation of fatigue crack growth rate by Paris law. The low-cycle fatigue resistance is assessed from stepwise load-CMOD curves or hysteretic loops with increasing CMOD value every step, allowing to analyze damage growth between each load cycle. Moreover, such experimental results provide irreversible CMODIR value, which has similar meaning as the plastic zone in metallic materials. This study investigates the fatigue resistance of concrete samples by combining all of these experimental data and could provide useful recommendations for structural design.

Numerical Analysis of Heat Transfer in the Surface Boundary Layer

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Energy consumption is one of the main focuses in civil engineering and has become increasingly relevant in recent decades due to environmental concerns. The presented analysis focuses on the numerical solution of the heat transfer of the building surface, represented here by a flat structural element placed on a heated plate under realistic weather conditions. The problem is solved using CFD codes in Ansys Fluent 2023 R2 software. The turbulent statistical RANS model Standard k- ω is used for the calculation, which includes modifications for the boundary layer solution. The parameters that enter the energy equation as dependent on the actual air temperature are density ρ [$\text{kg}\cdot\text{m}^{-3}$], specific heat capacity of the air c_p [$\text{J}\cdot\text{kg}^{-1}\cdot\text{K}^{-1}$], thermal conductivity λ , [$\text{W}\cdot\text{m}^{-1}\cdot\text{K}^{-1}$] and dynamic viscosity [$\text{kg}\cdot\text{m}^{-1}\cdot\text{s}^{-1}$]. For the calculation of buoyancy forces, the Boussinesq model was used, which adds a source term describing the change in current density to the momentum equation. The other equations treat the density as a constant value of the operating density. The ambient temperature is assumed to be 20 °C, and the surface temperatures of the component shell are assumed to be 20 °C (the plate is unheated), 40 °C and 80 °C. The calculations are performed for air velocities of 0.9 $\text{m}\cdot\text{s}^{-1}$ and 2.5 $\text{m}\cdot\text{s}^{-1}$. The obtained data clarify the correlation between temperature and wind speed and direction.

Elasto-plastic Truss Optimization Under Geometric Nonlinearity Using a Genetic Algorithm

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In this paper, a genetic algorithm-based approach is presented for the elasto-plastic optimization of trusses, with the primary objective of enhancing structural performance while minimizing weight. The mechanical capability of the structure is evaluated by calculating plastic deformations using the complementary strain energy of residual internal forces. The methodology integrates material and geometrical nonlinear finite element analysis (FEA) with a genetic algorithm (GA) in a custom-developed framework, enabling the determination of optimal cross-sectional areas for the individual bar members. Additionally, the proposed method is capable of accounting for initial geometric imperfections, further improving the accuracy of the design. The potential of the approach is demonstrated through a detailed numerical example, which shows that significant reductions in both plastic deformations and material usage can be achieved, thereby ensuring a safer, more sustainable, and highly efficient structural design. These promising results highlight the effectiveness and practical applicability of advanced optimization techniques in modern truss design and engineering practice.

Physical and Numerical Analysis of Corrosion Damage of Prestressing Tendons of the Collapsed Roof Structure

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This conference paper presents the results of a physical and numerical analysis of the effect of corrosion damage on the material properties of prestressing tendons, which were taken from the wreckage of collapsed prestressed roof truss. The main objective of the research described was to evaluate the effect of the depth of corrosion damage on the material properties of prestressing tendons, which were formed by untwisted bundles of patented wires. Corrosion damage was artificially initiated on prestressing tendon samples in a corrosion chamber under the accelerating influence of temperature and salt spray. Test samples of prestressing tendons were stored in a corrosive environment for three exposure time intervals of 60, 100 and 140 days. Corrosion-damaged samples were subsequently subjected to precise spatial scanning with a 3D profilometer, to obtain spatial model of the corrosion-altered surface topography. Subsequently, tensile tests of corrosion-damaged samples and a reference set of samples without corrosion damage were carried out. The data were used to create numerical models of individual test samples and were verified with physical tensile strength tests, evaluated the possibilities of predicting the location of sample failure based on the 3D scan and the shape of corrosion defects, and last but not least, verified the actual weight loss of the material and the volume loss obtained from the 3D model.

Certain Issues in the Analytical Integration of the Boussinesq Problem

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The Boussinesq solution, one of the fundamental problems in the theory of elasticity, enables an analysis of stresses and strains (displacements) in a semi-elastic space subject to surface loads. This solution has a form of formulas for displacements evoked by a concentrated force; these formulas can be treated as Green functions for calculation of displacements (and then – stresses) in a half-space loaded in any way at its surface $z = 0$. The study presents difficulties met during the analytical integration of the Green functions in the Mathematica environment as well as methods of coping with these difficulties. The authors are going to present particular issues which can be quite surprising and confusing, for example a failure to obtain a close result for definite integrals in Wolfram Mathematica or differences between results of calculations of the sum of integrals and the integral of the sums. The results of the study can help in establishing more exact benchmarks for the numerical methods applied in the analysis of settlement under foundations as well as other contact issues of the theory of elasticity based on the Boussinesq solution.

Making Reliability Analysis Easy Using MS Excel and FReET Software

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The paper describes a recent achievement of multipurpose reliability software FReET development. A new interface between the software FReET and MS Excel has been developed enabling easy and understandable statistical, sensitivity and reliability analyses possible. The contribution should be considered as an informative technical note on new feature for both present and future users of software. The interface logic is described and illustrated by an example.

Numerical Verification of Typical Connection of High Thin-walled Purlins

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The presented paper deals with numerical analysis focused on the behavior of high thin-walled purlins of 300 mm height and mainly on the way of their connection to other structural elements. In previous publications, numerical models of purlins with and without a reinforcing clip were presented and verified by a large experimental program. This paper then presents results from numerical models modified so that the purlin is bolted to the clip only at the standoff. This method of connecting the trusses is one of the commonly used methods of truss placement, yet it has not been tested in the experimental program. The numerical models used have optimized and verified boundary conditions and parameters. In this paper, purlins of 300 mm height, 1.89 mm plate thickness and 200 mm bearing width are selected. Two spans of support, 3.0 m and 5.1 m are investigated. According to the results, there is a significant effect of the reinforcing clip on the overall load carrying capacity of the detail of the high thin-walled purlins. The effect of additional bolting of the web of tall thin-walled purlins in the connection detail to the supporting structure has a positive effect on the overall load capacity.

The Present Study of Research Methodology to Assess the Degradation State Through the Analysis of Vibration Signals

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The comprehension of a system's dynamic state and structure facilitates the delineation of its behavior and the formulation of prognostic models of its behavior in relation to dynamic evolution time. These models are derived from the model of technical state symptoms growth. In many cases, there is an absence of established equations that delineate the system's behavior in relation to dynamic evolution time. This predicament underscores the necessity for the employment of novel methodologies to scrutinize the dynamic state. Consequently, there is a necessity to empirically validate analytical technical models, as the ideal model is one that has been verified in practice. An experiment serves as a catalyst for subsequent research, which in turn leads to the optimization of the construction.

In this article, the authors present a selection of problems in technical state diagnosis, employing identification and technical diagnostics methods, such as experimental modal analysis. The article further elucidates the interrelationships between methodologies employed for dynamic state evaluation and those utilized for technical state evaluation. The results of an example modal analysis illustrate the complexity of projecting dynamic state research into diagnostic research of state evaluation.

Towards Resistant and Durable 3D Printed Structures – Summary of SONATA (NCN) Project

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The aim of this presentation is to summarize the outcomes of the research project entitled “The development of complex nanometric structures for tailoring the shielding and rheological properties of cement-based mixtures used in 3D printing technology” funded by National Science Centre, Poland. The aim of this project was to develop a lead-free complex nanostructure, for tailoring the gamma and neutron attenuation as well as rheological properties of cement-based mixtures suitable for 3D printing. To achieve this goal through a bottom-up approach, a nanostructure composed of bismuth oxide (Bi_2O_3), gadolinium oxide (Gd_2O_3) and silicon oxide (SiO_2) were developed. The overall objective of the project was to combine materials containing the high electron density (high Z) needed for gamma attenuation (Bi_2O_3) and the high interaction probability required to slow neutrons (Gd_2O_3), with a material which will improve their immobilization within the cementitious matrix (SiO_2). By adjusting the nano- SiO_2 content in the nanostructure, the rheological properties of a printable mixture can be optimized (controlled). As an outcome a set of mixtures and testing methodologies were developed including printable heavyweight concrete mixture as well as method for determining the pore sphericity index using X-ray micro-computed tomography.

Predicting Future Ground Snow Loads and Basic Wind Speeds Using Recurrent Neural Networks

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In response to the growing need for accurate climate predictions due to changing global weather patterns, this study focuses on the application of Recurrent Neural Networks (RNNs) to forecast climatic variables critical for reliability of civil engineering structures: ground snow loads and basic wind speeds. This study utilizes long-term time series data from a specifically selected Czech meteorological station – a reference station for which the records are verified by detailed checks. The presented analysis refines the prediction accuracy of these essential parameters, which play a crucial role in determining structural loads and ensuring the resilience of infrastructure. The dataset comprises several decades of recorded climatic conditions, providing a strong basis for training the sequential neural network model. RNNs, known for their efficiency in handling sequence prediction problems, are ideal for this purpose due to their ability to maintain a memory of previous inputs while processing new data. This characteristic is particularly beneficial for weather-related data, which is inherently sequential and highly dependent on preceding conditions. This contribution presents the methodology employed in developing the RNN models, discusses the challenges and solutions encountered in dealing with time series climatic data, and evaluates the performance of these models in predicting future weather conditions. The findings highlight the potential of deep learning methods to enhance predictive capabilities, offering valuable insights for urban planning, disaster management, and the design of climate-adaptive structures.

By highlighting the specific use of data from the meteorological station with the climate characteristic for Czech lowlands (i.e. main Czech inhabited and industrial areas), this study not only contributes to the regional understanding of climate impacts but also demonstrates the global applicability of machine learning in addressing complex climate forecasting challenges.

On Modelling of Snow and Wind Loads – Lessons Learnt From Czech Meteorological Records

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Climatic actions on structures can be described on the basis of the loading chains which comprise the climate characteristics of the region, surrounding environment, structural characteristics, and the development mechanism affected by the complex interaction of location-specific climatic influences. Datasets for such analyses are commonly derived based on the statistical assessment of long-term meteorological measurements or obtained by simulating the physical processes in the atmosphere combined with the numerical weather prediction models. Climatic maps in standards which were developed on the basis of datasets collected approximately two decades ago, exhibit significant differences across the borders. Despite being characterized by low measurement uncertainty and better reflecting current conditions in light of potential non-stationary behaviors arising from climate changes, recent measurements are not reflected in current maps. In Ultimate Limit States verifications, fractiles corresponding to return periods of hundreds or thousand years are predicted. New measurements unaffected by measurement uncertainty may significantly improve such predictions. Based on the data from a few selected Czech meteorological stations, this contribution discusses needs for updating of characteristic and frequent ground snow load and basic wind speed values. Duration of extreme values is also investigated to provide the basis for load combination modelling. Main challenges in climatic load modelling are finally discussed.

Degradation Effects of Chloride Ions on Structures

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Building structures are exposed to atmospheric effects which can be increased by corrosion stimulants. This corrosion stimulant can be sulphur dioxide, which has become a minor corrosion stimulant in the vicinity of roads due to industrial desulphurization units. In contrast, chloride ions have become the major corrosion stimulant for structures close to the roads. Structures in the vicinity of the roads are exposed to increased concentrations of de-icing salts, especially in winter, when road passability is of great importance. The main type of de-icing salt used to lower the freezing point of water or to melt a layer of snow or frozen ice is road salt. Chemically, the main type of road salt used is NaCl, which dissolves in water solution to form sodium and chlorine ions. Passing cars release the NaCl solution into the atmosphere in the form of an aerosol, which is then deposited on structures. Once the aerosol containing chloride ions is deposited, the corrosion process begins immediately and is active until the electrolyte dries. As the chloride ion content of the solution increases, the corrosion process becomes more aggressive and accelerates. This process poses a significant risk to the long-term durability of building structures and requires increased attention to maintenance and protection.

Identification of the Deformation Area Moving Vehicle on Concrete Pavement by FEM

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The road with any surface treatment is theoretically an infinitely long structure from the point of view of structural mechanics. The deformation wave moves along the road along with the moving load.

Therefore, it is sufficient to monitor the course of changes in stress states and deformation states in time only in one cross-section or at one point only. In this article, is presented a computational model of concrete pavement allowing to track the road response to the effects of the moving load at one point only - in the center of the analyzed slab. Such a model has its advantages and disadvantages. The benefits are that the numerical solution of such a model is not time-consuming, and it is accurate enough. The disadvantage is that the results refer only to one point of construction - the center of the slab. Experiment is often also tracking the pavement response at just one point, so for the purpose of comparing the results of the numerical solution with the experiment, such a model will provide us good identification of deformation area on the specific concrete pavement.

Diagnostic and Experimental Analysis of 3D-printed Concrete Structural Elements

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The article presents a proposed approach to the diagnostics of structures and structural elements manufactured using 3D printing technology with cement-based composites (3DCP). As part of the research, real structural elements—specifically columns made of 3D-printed concrete—were experimentally tested. These elements featured varying print quality and intentionally included typical printing imperfections, such as weak interlayer bonding and geometrical deviations. A significant part of the experiment focused on comparing traditional and modern methods for measuring the geometry of the test specimens. After performing destructive flexural tests on the full-scale elements, fragments were extracted from the failed columns for further laboratory testing. These included compressive strength, flexural tensile strength (both parallel and perpendicular to the print direction), bulk density, water absorption, and ultrasonic pulse velocity. The results were statistically analyzed, with an emphasis on identifying correlations between individual parameters and on linking material-level and structural-level properties. The experimental data also served to validate a simplified numerical model. Based on the analysis, a diagnostic framework for 3DCP structures is proposed. This framework accounts for the specific characteristics of the material, such as mechanical anisotropy, print orientation, and the quality of interlayer bonding. The methodology enables indirect assessment of the condition and load-bearing capacity of real 3DCP structures.

Model of the Cross-border Footbridge Karviná – Hažlach

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Numerical analysis in civil engineering is an important part of design work. The aim is to grasp the behavior of the structure during its entire lifetime, i.e. during construction and operation. Considering all boundary conditions defined by the customer, static and dynamic analysis was carried out on simple and complex numerical models using the finite element method in the programs MIDAS Civil and IDEA StatiCa. The subject of the paper is a presentation of numerical models of a suspension footbridge, their outputs and limits and a reference to the current possibilities of modelling such a structure.

The design challenge was not only the modelling of the global structure, but attention was also paid to monolithic reinforced concrete pylons, which form fixed points for hanging the suspension cable, and anchor cables, which eliminate stress on the pylons. A separate problem is the construction of a steel structure, which consists of one part of the steel bridge deck and therefore cannot be hung gradually. The design of the lightweight steel structure of the bridge deck also brought problems in dynamic analysis, where it was necessary to evaluate the effects of vibration of the structure on the comfort criteria. A separate analysis was performed, including the prediction of the use of the vibration damper. All outputs of numerical analysis and checks of partial elements reflect the requirements of currently valid standards (Eurocodes).

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