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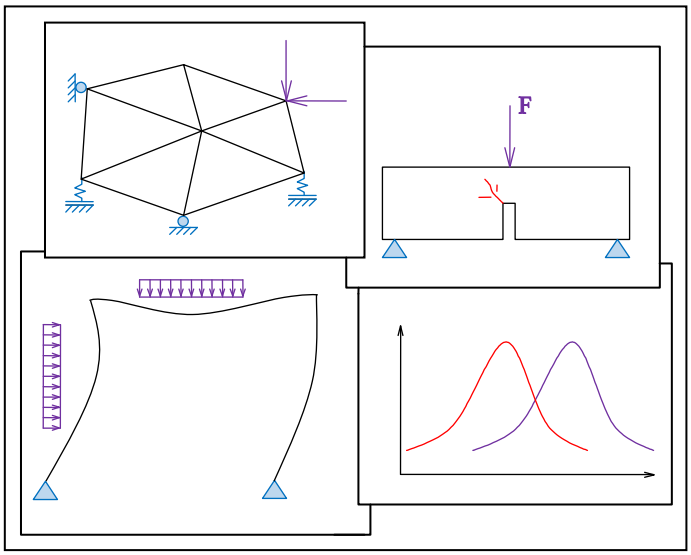

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TABLE OF CONTENTS / OBSAH

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V4SHM - VISEGRAD PROJECT ON AUTONOMOUS SYSTEMS FOR STRUCTURAL HEALTH MONITORING

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Introduction

The goal of the project (http://v4shm.ippt.pan.pl) is the development of methodology for reliable identification of different structural defects, including concrete cracks, spalling and delamination [1, 2]. The basic idea of this project combines machine learning and image processing techniques to localize and quantify stiffness degradation with concrete structures. The overall system is intended to operate in fully autonomous way [3]. it is allowed by recent advancement in image capturing utilizing the unmanned ground or aerial vehicles and artificial intelligence.

The following presentations will be delivered within our thematic session *"V4SHM - Visegrad project on autonomous systems for structural health monitoring"*:

1) B. Blachowski and P. Tauzowski (IPPT PAN, PL) - *Characterization of the V4SHM project: main assumptions and expected results*

2) P. Koteš (UNIZA, SK), P. Konečný (VŠB-TUO, CZ), P. Lehner (VŠB-TUO, CZ), M. Zahuranec (UNIZA, SK) - *Long-term measurements of reinforcement corrosion on real bridge structure*

3) Janos Mate Lógó and Árpád Barsi (BME, HU) - *Evolution of road map topology*

4) P. Tauzowski (IPPT PAN), P. Jarosik (IPPT PAN), M. Zarski (IITiS PAN), B. Wojcik (IITiS PAN), M. Ostrowski (IPPT PAN), B. Blachowski (IPPT PAN), L. Jankowski (IPPT PAN, PL) - *Computer vision-based inspections of civil infrastructure*

5) M. Ostrowski and B. Blachowski (IPPT PAN, PL), M. Zarski and B. Wojcik (IITiS PAN, PL), P. Tauzowski and L.Jankowski (IPPT PAN, PL) - *Computer vision-based vibration measurement*

6) Patrik Kotula (UNIZA, SK) - *Poster presentation devoted to arch bridges*

Keywords

Computer vision-based inspections, deep learning-based crack identification, structural health monitoring.

Acknowledgements

The authors are grateful for the financial support received from the project *"Development of regional network on autonomous systems for structural health monitoring"* financed by the Visegrad Fund, granted under the grant agreement 22110360.

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LONG-TERM MEASUREMENTS OF REINFORCEMENT CORROSION ON REAL BRIDGE STRUCTURE

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Abstract. *Real bridge structures are affected by environmental conditions, in which they are located. It is well known that the aggressive environment around bridges causes environmental loads and then the degradation of concrete and reinforcement over time in the case of reinforced concrete and prestressed concrete bridges. Diagnostics of the real condition of existing bridges is very important due to actual degradation and corrosion of the reinforcement. In the frame of research activities of Department of Structures and Bridges, Civil Engineering Faculty, University of Žilina, the real bridge structure is observed for 16 years. It is the girder reinforced concrete bridge near town of Žilina in Slovakia.*

Keywords

In-situ measurements, bridge, diagnostics, reinforcement, aggressive environment.

Fig. 1: Measurements of corrosion losses – measurement station (exposure) in the town of Martin, Slovakia.

Knowing the values of corrosion losses (corrosion rates r_{corr}) and the corrosion model is an important input parameter when evaluating existing structures and bridges. On the basis of these data, it is possible to determine not only the current resistance of the RC member, but also the change in resistance during time t (based on the corrosion model) and thus the remaining lifetime.

The paper presents the measured values of corrosion losses in a real bridge structure, while they were measured at different cross-sectional locations. The article presents measurements on only one characteristic reinforcement, but several measurements on other reinforcements will be presented at the conference. The results show that the position of the reinforcement affects the corrosion losses. At the same time, it was confirmed that the linear corrosion model is a sufficiently accurate model, but the results correspond better to the model described by the second-degree polynomial function.

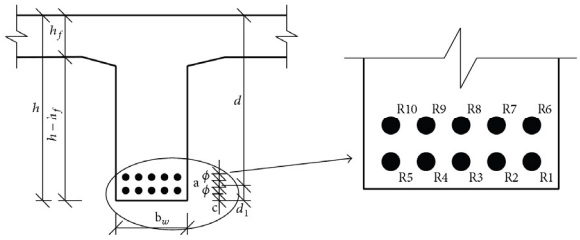

Fig. 2: Girder cross section - identified number of bars from diagnostic.

Acknowledgements

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The authors are grateful for the financial support received from the project "Development of regional network on autonomous systems for structural health monitoring" financed by the Visegrad Fund, granted under the grant agreement 22110360.

This work was supported under the project of Operational Programme Interreg V-A Slovak Republic – Czech Republic: Assessment of the impact of the environmental load on the bridge structures condition of the cross-border transportation network, No. 304011Y277. The project is co-funding by European Regional Development Fund.

EVOLUTION OF ROAD MAP TOPOLOGY

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Abstract. Autonomous and highly automated driving is a hot topic not only in the automotive industry but also in the mapping community. Self-driving vehicles have undergone a significant evolution over the last few years, and with it the process of mapmaking. The initial models are evolving at a faster and faster pace and so simulations are needed. In order to apply these maps in a live environment, increasingly accurate map representations are required, including the examination of the topology of nodes in the process. The most important element of any realistic map format is to be able to conveniently check the connectivity on the map, hence the need for topology. Topology refers to properties such as the connectivity of roads, not only through their axes or reference lines, but also at the level of the lanes. The description of nodes in HD maps poses a significant challenge to format designers, as they are fundamental yet complex topological elements. In this paper, we will look at both the representational possibilities and the advances that have been made in recent years.

HD map, OpenStreetMap, road network, simulator.

Acknowledgements

The authors are grateful for the financial support received from the project "Development of regional network on autonomous systems for structural health monitoring" financed by the Visegrad Fund, grant no. 22110360 and NKFI (no. K138615).

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COMPUTER VISION-BASED INSPECTIONS OF CIVIL INFRASTRUCTURE

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Abstract

Maintaining the civil infrastructure in good technical condition is a key element of rail and road traffic safety. The expansion of the infrastructure increases the problems related to the maintenance of facilities. Therefore, there is a need for intensive monitoring of the technical condition of a large number of objects. The intensive development of vision techniques together with artificial intelligence allows for effective automation of the inspection process of traffic infrastructure facilities. Cameras installed on autonomous vehicles or remotely controlled drones can independently monitor by capturing the image. The next step is, image processing by artificial intelligence systems based on deep learning which recognizes whether a structure has some damages or not. To carry out the task, it is necessary to train deep neural networks capable of recognizing damage in the image. It is also necessary to distinguish parts of the structure in the image to properly identify their importance as well as precisely locate their damage.

The aim of this study is to train a neural network in such a way that it is able to distinguish structural components of a railway viaduct as: nonbridge (everything on the picture which not belong to the bridge), slab, beam, column, nonstructural components (poles, cables, fences), rail, sleeper, other components. This task will be carried out using the method called semantic segmentation.

The first application of U-Net based semantic segmentation was in the field of medical image analysis [1]. Ronneberger and his coworkers applied semantic segmentation to images of HeLa cells to classify particular instances of the cells. In the structural monitoring application, other convolutional neural network architectures are frequently used [2] therefore it is worth to examine if U-Net is also suitable for purposes of computer vision techniques for health monitoring of viaducts.

To train a neural network model, a substantial set of training and verification data is needed. This task uses a set of over 7,000 images artificially generated images of viaducts with application of computer graphics based on 3D models [3]. The data also includes a depth channel and eight channels with a segmentation mask. The number of masks corresponds to the number of types of structural objects being detected in the images and indicates where these objects are located in the images. This data forms the basis for neural network training. Several images of semantic segmentation distinguishing abovementioned parts of the structure of viaduct are presented in the paper.

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COMPUTER VISION-BASED VIBRATION MEASUREMENT

Mariusz OSTROWSKI [1], *Bartlomiej BLACHOWSKI* [1], *Mateusz ZARSKI* [2], *Bartosz WOJCIK* [2], *Piotr TAUZOWSKI* [1] *and Lukasz JANKOWSKI* [1]

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Abstract

Structural Health Monitoring (SHM) is an intensively researched topic in the recent years. Despite a variety of proposed methodologies available in SHM there are still some issues that require the attention. One of the most important is monitoring of large-scale structures that involves a network of sensors. Providing the synchronization and power supply for such a monitoring system is a challenging task [1]. Today, in the time of a rapid growth of computer efficiency and image processing methods, it is possible to overcome this problem with the aid of the Computer Vision-based Structural Health Monitoring (CV-SHM). Since several digital cameras can observe the whole structure, this technique allows structural displacements to be extracted from the video without the use of traditional contact sensors.

However, Computer Vision (CV) methods for estimation of structural displacements are subject to a higher measurement noise comparing to the traditional methods [2]. Another problem that makes the development and implementation of CV methods in SHM more challenging is the difficulty of their comparison and testing. Availability of representative benchmarks is limited in this field. This problem can be avoided with the use of synthetic, but realistic video data generated with the aid of structural models. Recently, such data, called physics-based graphical models (PBGM), were used for development of a CV method for structural displacement estimation [3]. PBGM-based video allows for reliable assessment of the accuracy of CV-based measurement methods, because exact displacements can be extracted from the structural model and used as a baseline.

In the present study a comparison of selected CV-based methods is performed. The comparison is based on PBGM-based video. The attention is paid to the applicability of the tested methods in CV-SHM, hence measurement dynamic displacements of a truss structure is considered. CV-based measurement is performed with template matching (TM). Tested TM methods are based on normalized cross-correlation which can be classified as area-based TM, and on Kanade-Lucas-Tomasi algorithm which is one of the feature-based TM methods. Both approaches have pros and cons. Area-based methods provide slightly better accuracy of displacement estimation, but they are significantly slower. This study was performed during "*The 2nd International Competition for Structural Health Monitoring*" (IC-SHM, 2021).

Keywords

Computer vision, Structural health monitoring, Physics-based graphics models (PBGM).

Acknowledgements

The authors are grateful for the financial support received from the project "*Development of regional network on autonomous systems for structural health monitoring*" financed by the Visegrad Fund, granted under the grant agreement 22110360

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DIAGNOSTICS AND ANALYSIS OF SELECTED MASONRY RAILWAY BRIDGES ON SLOVAK RAILWAYS

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Abstract

On ŽSR lines, we usually distinguish between steel bridges, which make up approximately 22% of the total number of bridges, and a large group of massive 78% bridges, in which we also include brick and stone bridges. There are 407 bridges over the age of 100, and among them we can find bridges from 1848 – these are the oldest bridges in Slovakia, which were built during the construction of the Central Hungarian Railway in 1840-1850. The most important bridges of this type include: Hanuš Viaduct, Chmarošský Viaduct, Telgárt Viaduct, Marchegg Viaduct.

The choice of material for the supporting structure of the bridge, especially for single-pole arch bridges, was conditioned by the availability of local resources and the time of track construction. The first railway lines in Slovakia, which were built in the years 1844-1850 (Central Hungarian Railway) preferred brick. The Hungarian-Galician Railway (1860-1873) and the Hungarian Northern Railway (1864-1873) again used stone for the vaults. Arched bridges made of plain or reinforced concrete can be found on the Košice-Buhumín Railway in sections that were built in the 1950s.

At present (2022), we have in operation both the original and the reconstructed and reinforced bridges, the extent of which resulted from failures or the current need to expand from a single-track to a double-track system, respectively as part of the modernization of ŽSR lines to a higher line speed of 160 kmh^{-1}.

Diagnosis of these types of bridges is usually focused mainly on monitoring faults, deformations, measuring and monitoring cracks in joints or in masonry elements, obtaining current material characteristics. In particular, destructive methods (taking of nuclear cylindrical samples, followed by compressive strength tests on the samples taken in presses), semi-destructive tests (tear-off tests, Schmidt hammer strength tests, penetration tests) and non-destructive testing methods (ultrasound, radar, tomography, thermography) are used.

Furthermore, experimental measurements on bridges on site are applied (measurement of absolute deformations and relative deformations under the bridge load - static load test, vibration measurement - dynamic test). The following methods are suitable for measuring the geometric properties of the monitored bridge object: photogrammetry, and the terrestrial laser scanning method (geodetic observation method, which is based on determining the spatial coordinates of detailed points by the spatial polar method). This method was used to survey the railway bridge on the Margecany-Červená Skala line at km 82,589 - Chmarošský viaduct.

The mentioned methods are suitably combined depending on the monitored bridge object, the extent of observed faults, and data collection for numerical modelling in suitable software. The LimitState Ring was used for the numerical analysis of single-pole masonry railways. Variant models were chosen to take into account the failures and material characteristics of the reference bridge object.

Although some of these types of bridges (masonry and stone arch bridges) are more than a hundred years old, they are still a reliable element of the railway infrastructure and therefore deserve our attention, but care must be taken to ensure that they are properly maintained.

Acknowledgements

This research was supported by Research Projects No. 1/0623/21 of the Slovak Grant Agency.

The authors are grateful for the financial support received from the project “Development of regional network on autonomous systems for structural health monitoring” financed by the Visegrad Fund, granted under the grant agreement 22110360.

STRENGTH DEVELOPMENT OF DIFFERENTLY CURED CONCRETE

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Curing of concrete has a crucial influence to properties of hardened concrete. Usually water curing is considered as a best way of curing. However, the appropriate curing depends also on properties of concrete. The basic parameter of concrete is water to cement ratio w/c. The value w/c = 0.40 is considered as a boundary between usual concrete and high performance concrete. Concrete with higher w/c contains enough amount of water for fulfilling capillary pores. If a loss of the water is prevented, there is not necessary to use water curing. Water is consumes to hydration of cement and shrinkage of concrete is low. There is necessary only to prevent evaporation of water from relatively porous concrete. In the case of w/c < 0.4, the water in capillary pores is also consumed by hydration and larger capillary pores become empty, water remains only in very narrow capillary pores, create menisci with very small diameter. This evokes high attractive forces, which are the most important reason of shrinkage. Penetration of curing water through dense structure of concrete is significantly limited and arising self-desiccation is the most important compound of autogenous shrinkage. From this point of view, concrete with pores fulfilled with water seems to be an optimum concrete. However, during testing of strengths the water inside of concrete support damage. The water is non-compressible and the inter pressure helps to break structure of concrete. Probably also other processes - especially C-S-H gel swelling thanks to interlayer water - can affect values of strengths. As a result, compressive and flexural strengths of specimens without water curing and without evaporation of water (enveloped with PE-foil) show better strengths than that water cured. Nevertheless, progressive evaporation of water after removing specimens from water has beneficial influence on strengths development, see Fig. 1. The compressive strengths are the same for specimens cured in water and in foil, but if the water-cured specimens are additionally left on the air, the strengths increase about 20 % with comparison with foil cured specimens. Similarly bending strengths. The reason of this behavior is probably water in porous structure of concrete. This water is non-compressible and helps to destroy specimen from inside. The results also show importance of humidity of tested specimens.

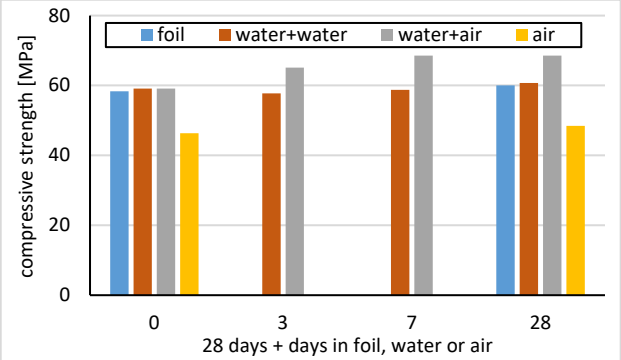

Fig. 1: Compressive strength of concrete with w/c = 0.4 cured 28 days in water, foil or air and subsequently again in water, foil or air.

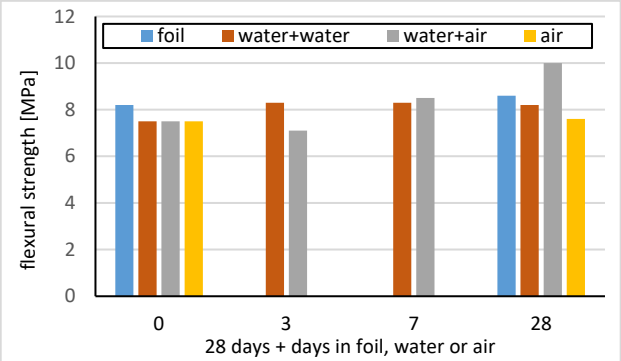

Fig. 2: Flexural strength of concrete with w/c = 0.4 cured 28 days in water, foil or air and subsequently again in water, foil or air.

Acknowledgements

This article has been prepared with support of the project no. 304011Y277 “Impact of environmental burden on the condition of bridge structures of the cross-border transport network” in frames of the Interreg V-A SK-CZ programme and co-financed by European Regional Development Fund.

Fatigue analysis of structural details with use of the Monte software and its comparison with DOProC approach

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Abstract. *The paper discusses implementation of probabilistic fatigue analysis of given detail of steel structure. The Monte Carlo approach is used and analytical formulation of problem was selected. This particular case – which is the three-point bending of laboratory sample with initial crack – was previously studied with use if the DOProC method. The main aim of the presented works is thus comparison of the developed solution with the more traditional approach. In-house developed Monte Carlo-based software "Monte" was used and obtained results, along with their discussion, are provided.*

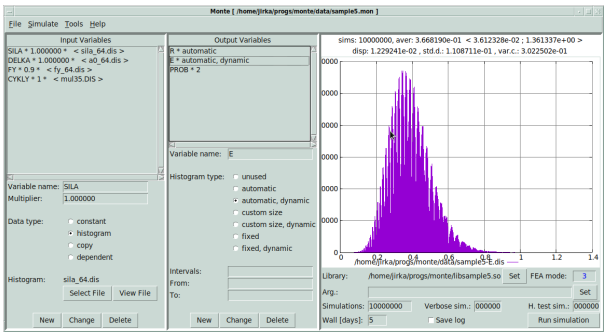

Fig. 1: Monte Software with results

Keywords

Fatigue, analytical solution, Monte Carlo, programming.

1. Problem definition

A three-point laboratory sample with pre-defined crack a was studied. This particular problem was thoroughly experimentally investigated by the IPM of the Czech Academy of Sciences thus input data for numerical analysis have been available.

The analytical formulation was based on the Paris-Erdogan law.

2. Implementation

The Monte software has been used. It is a general software tool for Monte Carlo-based simulations written in the C programming language (the whole program has about 9000 lines of code including supporting tools).

The beam data were obtained from experiment geometry. There were defined four random variables: the number of cycles, the yield stress of material, the initial crack length span and the loading force.

3. Conclusion

The paper discussed a simulation-based implementation of probability of failure analysis of a three-point bending sample with pre-defined crack. This problem was previously analysed with use of the DOProC method. During computations, several issues in both used software implementations have been identified.

Acknowledgment

This contribution has been developed as a part of the research project of the Czech Science Foundation 21-14886S "Influence of material properties of high strength steels on durability of engineering structures and bridges."

COMPARISON OF EXPERIMENTAL TESTING AND NUMERICAL MODELLING OF DOUBLE-SHEAR BOLTED CONNECTIONS WITH SLOTTED-IN STEEL PLATES IN SQUARED TIMBER

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Keywords

Connection, experimental testing, load-carrying capacity, numerical modelling, squared timber, steel plate.

1. Introduction

Proper design of connections is one of the most important areas in timber structures. The commonly used connections are dowel-type connections with steel plates slotted into cut-outs in timber members. The presented research deals with the behavior of double-shear bolted connections of squared timber with slotted-in steel plates. Several variants of bolted connections with different end distances were selected for experimental testing in order to investigate the actual load-carrying capacity and the failure mode, and also to compare their load-deformation response with numerical models.

2. Materials

Specimens for tension tests parallel to the grain were made of spruce timber with cross-sectional dimensions of twice 60 × 120 mm of three different lengths - 400 mm (H1), 480 mm (H2), and 560 mm (H3). High-tensile bolts M20 8.8 were used as fasteners, which were placed at three different distances from the loaded end - 140 mm (=7*d*), 180 mm (=9*d*), and 220 mm (=11*d*). The slotted-in steel plates with a thickness of 10 mm were made of S235J0.

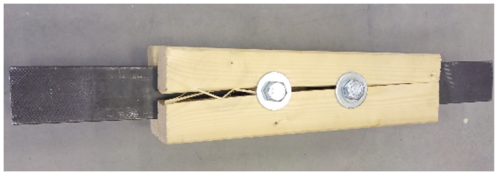

Fig. 1: A specimen of a squared timber connection after failure.

3. Results

The physical properties of timber were determined by non-destructive methods (bulk density ρ_{12}, moisture content w). Load-deformation diagrams were recorded during the testing to evaluate the load-carrying capacity F_{max} for individual geometric modifications H1, H2, H3.

Tab.1: Comparison of the results for all types of specimens.

	H1	H2	H3
ρ_{12} [kg/m^3]	415	411	414
w [%]	12.8	12.6	13.2
F_{max} [kN]	66.10	75.43	72.62

H1-type specimens were selected for the nonlinear numerical analysis. The graph in Fig. 2 illustrates a comparison of load-deformation curves of the tested connections and the results from the numerical analysis.

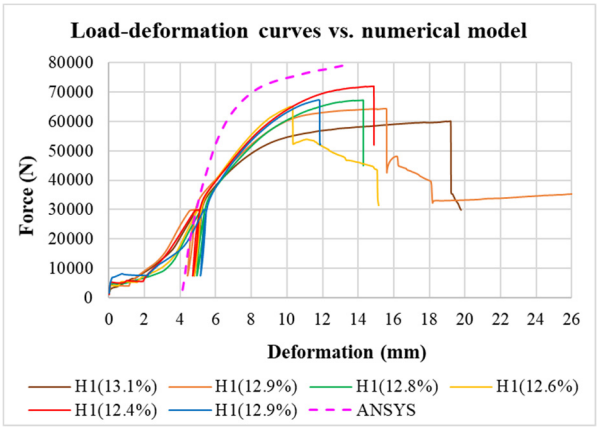

Fig. 2: Comparison of the real curves with the numerical analysis.

The failure of most specimens occurred by splitting the timber element under the bolt, when the tensile strength perpendicular to the grain was exceeded. The numerical model showed a slightly higher stiffness and load-carrying capacity compared with the experimental curves.

Causality Modeling in Keypoint Descriptor Classification for Industrial Image Processing Problems

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Abstract.

One of the most common problems in image processing in industrial applications is the automatized processing of images. In this case, the aim of the algorithm is the detection and classification of key features of interest, e.g., the corrosion in images of metal constructions for fatigue detection, or crack detection in concrete structures. With such an algorithm, one can, for instance, automatically identify problems and provide a warning suggesting a deeper human inspection.

Nowadays, the most straightforward and commonly used choice to handle the problem is to use neural networks. The parametric model composed of neurons connected in layers of a priori chosen type is fitted onto given data by regression. At the end of this learning phase, this supervised learning method provides optimal parameters of neurons and edges between neurons such that the input data (in this case image) provides the given output (feature classification) as accurately as possible. With each new given image, the algorithm applies the neural network with the optimal model parameters to this new data and provides the feature classification. Although the method provides sufficient results, the real meaning of classification rules remains hidden in a neural network. The interpretation of individual neuron parameters is not straightforward and the network has to be interpreted only as a complex unit. Therefore, the neural networks are able to mimic the behavior of the real system but do not provide the answer to how the process internally works.

In our work, we focus on parametric models, where each individual parameter has a specific interpretable meaning in the classification process. We propose a method based on causality detection, i.e., conditional probabilities, between the type of key points and their affiliation to a certain type. The method is formulated as an optimization regression problem with an objective function consisting of the Kullback-Leibler divergence with the feasible set consisting of separable simplexes. In the contribution, we describe the methodology and present the preliminary classification results in image data from selected engineering problems.

Keywords

Causality Modeling, Keypoint.

VYBRANÉ EXPERIMENTÁLNE MERANIA ORIENTOVANÉ NA ANALÝZU DEGRADÁCIE A SKUTOČNÉHO PÔSOBENIA KONŠTRUKČNÝCH PRVKOV EXISTUJÚCICH MOSTOV

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Abstrakt. *Existujúce mostné objekty predstavujú stavby, ktoré odzrkadľujú nielen úroveň spoločnosti, v ktorej vznikli, ale aj kultúrnu a ekonomickú silu súčasných generácií, nakoľko sa v nich odzrkadľuje starostlivosť o tieto zdedené inžinierske diela. Zároveň sa jedná o kritické prvky dopravnej infraštruktúry na miestnej aj celoštátnej úrovni. Stav mnohých mostných objektov na Slovensku a v Českej republike je pomerne vážny, čo dokazujú aj viaceré prípady havárií, prípadne náhlych vynútených uzavretí mostov a lávok pre peších. Dôvodov prečo dochádza k týmto javom je viacero. Sú to predovšetkým dôsledky zanedbávanej údržby, pôsobenia dlhodobých degradačných procesov, nevhodných konštrukčných riešení, nárastu intenzity dopravy a v neposlednom rade aj nedostatočného financovania zo strany štátu či samospráv. Jedným zo spôsobov riešenia tejto problematiky je aj vzájomné prepojenie inovačného potenciálu výskumných inštitúcií a subjektov zo stavebnej praxe, ktoré sa profesionálne zaoberajú statickými prepočtami, diagnostikovaním, návrhom a realizáciou rekonštrukcií, obnovou protikoróznej ochrany na existujúcich mostoch, prípadne i návrhom nových mostných objektov. Príkladom takejto spolupráce je aj spoločný cezhraničný projekt ENVIMOS (Hodnotenie dopadu environmentálneho zaťaženia na stav mostných objektov cezhraničnej dopravnej siete, 304011Y277). Jeho zámerom je cielené zmapovanie najdôležitejších degradačných procesov a nimi spôsobených porúch, a to od ich príčin, cez diagnostiku, vplyv na aktuálnu zaťažiteľnosť mostov až po predpokladané následky do budúcnosti a analýzu možností ich vhodnej rekonštrukcie. Predkladaný článok referuje o vybraných spoločne riešených experimentálnych a výskumných aktivitách v rámci vyššie uvedeného projektu.*

1. Úvod

Najdôležitejšie informácie o mostných objektoch sa získavajú z ich experimentálneho overovania, z diagnostických prieskumov a z dlhodobého monitoringu. Všetky experimentálne a diagnosticky zistené údaje je možné následne vhodne doplňať alebo porovnávať s ďalšími teoretickými analýzami, a to na numerickej alebo analytickej báze. V rámci experimentálnej analýzy degradácie a skutočného pôsobenia konštrukčných prvkov existujúcich mostov prebiehajú v súčasnosti merania a výskumné aktivity podrobne opísané v predkladanom príspevku, ktoré je možné rozčleniť do troch oblastí:

- degradačné procesy – ich mapovanie a zrýchlené skúšky,
- skúšky skutočného pôsobenia mostných objektov a ich konštrukčných prvkov,
- zber údajov o poruchách a stave vybraných mostných objektov in situ.

Poďakovanie

Táto publikácia vznikla vďaka podpore v rámci operačného programu Interreg V-A Slovenská republika – Česká republika pre projekt: Hodnotenie dopadu environmentálneho zaťaženia na stav mostných objektov cezhraničnej dopravnej siete, 304011Y277, spolufinancovaný zo zdrojov Európskeho fondu regionálneho rozvoja.

INFLUENCE OF TENSILE STRUCTURE CURVATURE ON THE RESULTING INTERNAL FORCES OF THE SUPPORTING STEEL STRUCTURE

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Abstract. *Tensile structures have been widely used recently for their low self-weight, high flexibility, and to show impressive visual effects. Coated fabrics act as a building envelope, and also as the main load-bearing components. The woven fabric creates a membrane adapted to the flow of forces which is able to sustain only the tensile stress. This contribution is focused on the analysis of the effect of the curvature on the resulting internal forces in the main supporting steel structure in the case of a tensile structure in the shape of a parabolic hyperboloid. This topic is useful for the effective design of these types of structures because if the lower internal forces appear, then slimmer profiles of the steel components may be designed.*

Keywords

Curvature, internal forces, membrane structures, numerical modelling, tensile stress, hyperbolic paraboloid.

1. Introduction

The tensile structure includes special woven membrane material, continuous steel ropes for tensioning the fabric, steel anchoring elements for attachment to the supporting structure and the steel supporting structure itself. The aim of the paper is to determine the effect of the membrane curvature to the internal forces in the supporting steel load-bearing system with different shape parameters.

2. Numerical Models and Loading

Two numerical models with 10 % different shape parameters were analysed – $SP_1 = 0.18$ (see Fig. 1), $SP_2 = 0.22$ (see Fig. 2). The analysed structures were loaded by snow load as the most threatening load case.

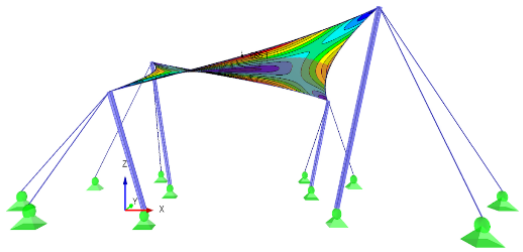

Fig. 1: Numerical model with SP_1=0,18

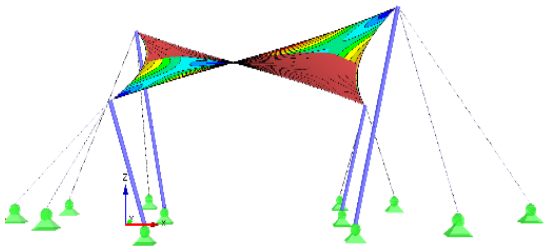

Fig. 2: Numerical model with SP_2=0.22

3. Conclusions

In this contribution, a membrane structure in the shape of hypar with two different shape parameters were analysed in terms of the influence of the membrane curvature on the resulting internal forces in the supporting system. It was found out that the design with a higher curvature had smaller maximum forces – about 19 % for columns, 58 % for anchoring ropes, and 45 % for ropes along the fabric.

Acknowledgements

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VPLYV KORÓZIE NA ZAŤAŽITEĽNOSŤ NITOVANÝCH ŽELEZNIČNÝCH MOSTOV

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Korózna degradácia konštrukčnej ocele má významný vplyv na spoľahlivosť mosta, najmä jeho bezpečnosť a životnosť. Korózne úbytky znižujú účinnú plochu prierezu nosných prvkov a tým znižujú ich mechanickú odolnosť voči účinkom zaťažení pôsobiacich na nosnú konštrukciu mosta. V závislosti od úrovne bezpečnosti jednotlivých nosných prvkov sa počas životnosti mosta môže stať, že prvok zdegradovaný progresívnou koróziou už nie je schopný prenášať účinky zaťaženia, najmä prevádzkové zaťaženia, pre ktoré je most primárne navrhnutý. Schopnosť mostnej konštrukcie prenášať účinky dopravného zaťaženia je kvantifikovaná tzv. zaťažiteľnosťou, ktorá je základným kvantifikačným ukazovateľom pre hodnotenie existujúcich mostov.

V článku sú prezentované výsledky štúdie zameranej na sledovanie vplyvu koróznej degradácie oceľových nitovaných železničných mostov na ich zaťažiteľnosť. V štúdii boli stanovené zaťažiteľnosti prvkov s typickými nitovanými I-prierezmi troch starších existujúcich železničných mostov v prevádzke. Namerané korózne úbytky boli zohľadnené v procese analýzy mostov a overovaní prierezov. Hlavné nosníky dvoch mostov sú plnostenné, zatiaľ čo tretí most má priehradové hlavné nosníky so zakrivenými pásmi. Všetky tri mosty majú typickú otvorenú prvkovú mostovku.

Na globálnu analýzu správania sa každej mostnej konštrukcie bol spracovaný priestorový numerický výpočtový model zohľadňujúci reálne geometrické, tuhostné a materiálové charakteristiky. S využitím MKP modelov boli pomocou lineárnej globálnej analýzy stanovené vnútorné sily potrebné na určenie zaťažiteľnosti.

Na spresnenie vývoja zaťažiteľnosti v čase by bolo potrebné poznať údaje o rýchlosti korózie na danom mieste ako aj o obnovách a opravách náterového systému v minulosti. Vzhľadom na absenciu týchto údajov boli na porovnanie poklesu zaťažiteľnosti a jeho predikcie v budúcnosti použité percentuálne hodnoty korózneho napadnutia D' vztiahnuté k skutočným nameraným hodnotám.

Výsledky štúdie preukázali prakticky lineárny priebeh zmenšovania prierezovej plochy a zaťažiteľnosti sledovaných mostných prvkov v dôsledku nárastu koróznych úbytkov počas životnosti. Podobná závislosť bola pozorovaná pri stanovení zaťažiteľnosti nitovaného I-profilu s ohľadom na:

- ohybovú odolnosť prierezu v prípadnej kombinácii s osovou silou;
- odolnosť pri namáhaní momentom, normálovou a šmykovou silou;
- šmykovú odolnosť prierezu;
- rovinné namáhanie steny.

Limitujúce kritériá pre zaťažiteľnosť sa môžu časom meniť v dôsledku koróznych úbytkov. Tým môže byť lineárna závislosť narušená, najmä v prípade veľmi závažných poškodení prierezu v dôsledku korózie. Rýchlosť znižovania zaťažiteľnosti bola približne 1,5 až 3,0 krát vyššia ako rýchlosť korózneho procesu vyjadrená koróznymi úbytkami v rámci prierezu. To poukázalo na dôležitosť sledovania vplyvu korózie na statickú bezpečnosť mostného objektu. Zanedbanie pravidelných prehliadok mostných objektov môže viesť k značnej degradácii a následnému zníženiu zaťažiteľnosti. Len dokonalá aktuálna ochrana ocele spolu s pravidelnými kontrolami a základnou bežnou údržbou tak môže zabezpečiť požadovanú životnosť.

Táto publikácia vznikla vďaka podpore v rámci operačného programu Interreg V-A Slovenská republika – Česká republika pre projekt: Hodnotenie dopadu environmentálneho zaťaženia na stav mostných objektov cezhraničnej dopravnej siete, 304011Y277, spolufinancovaný zo zdrojov Európskeho fondu regionálneho rozvoja.

INTERREG V-A SLOVENSKÁ REPUBLIKA ČESKÁ REPUBLIKA SK-CZ 14-20
EURÓPSKA ÚNIA EURÓPSKY FOND REGIONÁLNEHO ROZVOJA SPOLOČNE BEZ HRANÍC

Tento príspevok vznikol za podpory Grantovej agentúry VEGA SR v rámci riešenia úlohy 1/0623/21.

ANALÝZA KRITICKÉHO DETAILU A JEHO DOPAD NA ZAŤAŽITEĽNOSŤ MOSTA

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Abstrakt. *Železničné mosty predstavujú kľúčové body v rámci železníc pre ich strategický význam v dopravnej infraštruktúre. Počas desaťročí exploatácie na mostné konštrukcie útočia degradačné procesy a vonkajšie vplyvy. V príspevku je analyzovaný typický 70-ročný nitovaný železničný most s hlavnými plnostennými nosníkmi a hornou mostovkou. Bola stanovená zaťažiteľnosť, možné rezervy nosnej konštrukcie a analýza kritických detailov. Pri posudzovaní sa uplatnili ustanovenia novej smernice na stanovenie únosnosti železničných mostov. Údaje potrebné pre numerickú analýzu a následný výpočet boli podporené rozšírenou diagnostikou a meraniami. Skutočné správanie celej konštrukcie a vybraných prvkov bolo overené statickými a dynamickými zaťažovacími skúškami.*

Pre analýzu nosnej konštrukcie mosta bola vybraná typická konštrukcia oceľového železničného mosta. Jednopoľový nitovaný plnostenný most s hornou mostovkou na hlavnej trati Košice – Žilina bol postavený v roku 1950.

Na základe vstupných dát bol vytvorený model nosnej konštrukcie pre stanovenie zaťažiteľnosti hlavných nosných prvkov konštrukcie. Po overení celkového správania sa konštrukcie, boli vytvorené aj modely časti konštrukcie, ktorých úlohou bolo skúmať vplyv niektorých defektov konštrukcie na jej zvyškovú životnosť.

Podrobná diagnostika oboch nosných konštrukcií bola zameraná na zmapovanie korozívnych úbytkov a identifikovanie ďalších porúch, ktoré by mohli mať vplyv na ďalšiu exploatáciu konštrukcií. Reálne pôsobenie mosta bolo overené pomocou zaťažovacích skúšok, statickej aj dynamickej. Namerané údaje boli použité na kalibráciu numerických modelov.

Na základe numerickej a experimentálnej analýzy a následného posúdenia je zrejmé, že mostný objekt vyhovuje pre potrebné podmienky trate kategórie D4 s maximálnou traťovou rýchlosťou 120 km/h. Za predpokladu dodržiavania štandardnej údržby a vykonávania pravidelných prehliadok, súčasný stav mosta dostatočne spĺňa podmienky pre zvyškovú životnosť mosta do 30 rokov.

Vytvorenie výstižného numerického modelu reálnej mostnej konštrukcie bolo dosiahnuté za pomoci kombinácie správnej voľby konečných prvkov, zohľadnenia záverov z diagnostického prieskumu a výsledkov experimentálneho overenia správania sa konštrukcie. Článok opisuje aj možnosti, ktorými sa dajú zdokonaliť takéto výpočtové modely v bežne používaných softvéroch na báze MKP.

Odborne vykonané diagnostické prieskumy, ktoré sa zameriavajú na mapovanie korózie a vyhľadávanie ďalších nedostatkov oceľovej konštrukcie mosta by mali byť neoddeliteľnou súčasťou pre posudzovanie existujúceho mosta. Ak môžu byť tieto dáta rozšírené experimentálnym meraním skutočného správania sa mosta alebo jeho častí, komplexnejšia analýza môže obvykle ušetriť správcom veľa drahocenného času a finančných prostriedkov.

„Táto publikácia vznikla vďaka podpore v rámci operačného programu Interreg V-A Slovenská republika – Česká republika pre projekt: Hodnotenie dopadu environmentálneho zaťaženia na stav mostných objektov cezhraničnej dopravnej siete, 304011Y277, spolufinancovaný zo zdrojov Európskeho fondu regionálneho rozvoja“

COMPARISON OF ELECTROCHEMICAL PROPERTIES OF METALLURGICAL SLUDGE WASTE CONCRETES ON DIFFERENT SAMPLES SHAPE

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Abstract. *The present study shows results of resistivity measurements of four types of concrete mixtures; two of them are reference concretes and the other two contain metallurgical sludge waste (MSW) as a partial replacement of fine aggregate. Furthermore, an air-entraining additive was used for one type of reference and MSW concrete. Two types of specimens were prepared from every mixture – cylindrical (Ø100 x 200 mm) and prismatic (100 x 100 x 200 mm). Surface and bulk electrical resistivity were measured on all specimens. The results showed that the ratio between bulk and surface electrical resistivity varied relatively little for the different concretes. The difference between the resistivity measured on cylindrical and prismatic specimens is negligible. The electrical resistivity was slightly lower in the case of the MSW concretes than the reference ones. These findings will facilitate further planned testing of the large-scale research on MSW concretes.*

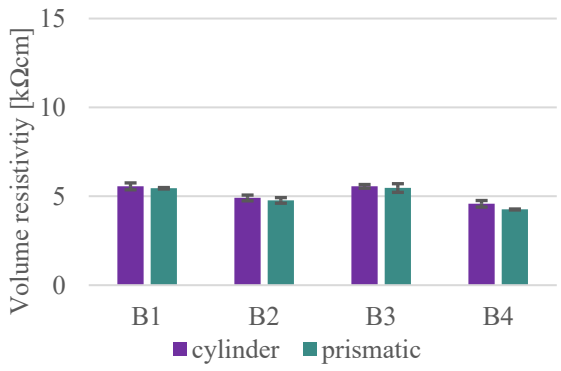

Fig. 1: Volume electrical resistivity of concretes.

The values of measured resistivities are very similar; however, the resistivity of MSW concrete shows lower values, which indicates better durability of concrete in aggressive environments. The finer grain size of the MSW concrete created a thicker density; and therefore, the liquids are less capable of permeating into the structure of concrete. The lowest values can be seen in the case of MSW concrete with air entraining admixture. Interestingly, the standard concrete deteriorated when the air entraining admixture was applied, probably due to the increased amount of water-filled pores, but in the MSW concrete the air entraining admixture helped to provide even better durability. This is probably due to the consistency of the aggregate, which itself prevents more pore formation.

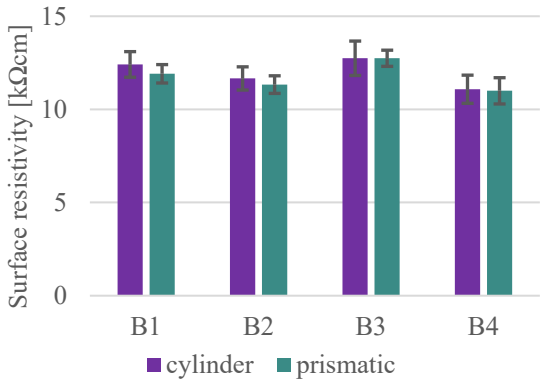

Fig. 2: Surface electrical resistivity of concretes.

The paper is focused on the determination of electrical resistivity of two MSW concretes with superplasticizer and air-entraining admixture, and comparison to two reference concretes. The MSW was used as a 30% replacement of sand in the concrete. Surface and volume resistivity were measured, and their ratios were determined for two types of specimens. It was found out that MSW concrete with admixtures shows the best results in terms of resistivity.

The research was funded by the Ministry of Education, Youth and Sports of the Czech Republic through VSB - TU Ostrava (SGS SP2022/45).

STATISTICAL EVALUATION OF THE FRACTURE-MECHANICAL TEST OF TWO DIFFERENT FIBRE REINFORCEMENT CONCRETE

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Abstract. *The proportion of fibre reinforced concrete is increasing and testing methods are improving to obtain its exact properties. However, it is necessary to improve the knowledge about the preparation, testing and, above all, the statistical evaluation of the test results, as there are still questions to which there are no known answers. This article demonstrates the possibilities of statistical evaluation of crack mouth displacement (CMOD) tests performed on 24 samples. Beams with dimensions of 150 × 150 × 550 mm were prepared from C25/30 grade concrete reinforced with two different types of steel fibres: 38 mm length and 52 mm length. It should be mentioned that longer fibres have lower tensile strength than shorter ones. Therefore, a statistical evaluation of the CMOD test results is presented.*

Materials, experiments, and results

A total of 2 x 12 samples of the same composition were tested. The dimensions of samples were 150 × 150 × 550 mm and concrete grade C25/30 was used. Two types of steel fibres were used, both at a rate of 30 kg/m^3. The fibres were of the same geometry, only different lengths and tensile strength: 38 and 52 mm. The measured values were analyzed with respect to several hypotheses and procedures.

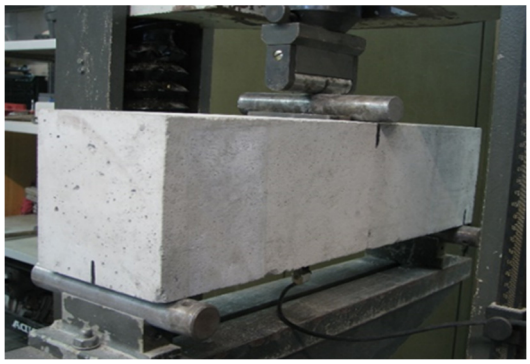

Fig. 1: The concrete specimen in the CMOD test setup.

The first step was to obtain statistical parameters such as mean, standard deviation, minimum, and maximum from two sets of 12 tests.

Tab.1: Results of the residual tensile strength in bending.

Residual tensile strength	Fibres 38 mm		Fibres 52 mm	
	Mean	Standard deviation	Mean	Standard deviation
$f_{R,0.5}$ [MPa]	2.08	0.43	3.04	0.76
$f_{R,1.5}$ [MPa]	1.77	0.46	3.03	0.87
$f_{R,2.5}$ [MPa]	1.58	0.41	2.95	0.88
$f_{R,3.5}$ [MPa]	1.43	0.40	2.76	0.81
$f_{R,0.5}$ [MPa]	2.08	0.43	3.04	0.76

The conclusions can be drawn from Table 1, which shows the calculated residual capacity for the initial CMOD values. It´s evident that steel fibres 52 mm always have better values than type 38 mm by about 50%.

Conclusions

In this paper, the residual strengths of concrete mix with two types of fibres were verified. It can be said that the smaller the decrease in strength after reaching the ultimate flexural capacity, the more effective the fibres are in the cross-section, as shown by the results. The results showed a large variance in values, although the samples have the same composition with the same amount of fibres. The different results are due to the fact that after macrocrack formation, the tensile strength is transferred to the steel fibers that are not uniformly dispersed in the beam. This illustrates the general information about the need for better dispersion and precise placement of fibres.

Acknowledgements

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INTEGRATING POROUS MATERIAL IN LIGHT WEIGHT TOPOLOGY OPTIMIZATION DESIGNS

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Abstract. A new innovative framework is proposed based on multiscale optimization to design lightweight components that are formed of graded isotropic microstructure of a given shape that can be exported as a printable geometry for AM. In the proposed formulation, a set of two density variables are used in each finite element of the design domain. The first variable is the local graded density, that sets the elastic properties of the graded porous material, which in turn are obtained by using numerical homogenization of representative volume elements of the Hexagonal close-packed arrangements [1] of circular/spherical holes that define 2D/3D isotropic/transversely isotropic microstructures that can be graded by varying the radius of the cavities. The second variable is a standard TO macro density variable, which defines if the element should be treated as a void or contain the graded porous material by letting this variable be governed by SIMP method. By using such density variables for all elements, A displacement-constrained minimum volume problem is herein implemented. To design lightweight components with local constraints on the displacement field, a multi-constrained optimization problem must be solved efficiently. Recent contributions in the field of stress-constrained TO have shown that a very large number of local enforcements can be efficiently tackled by combining sequential convex programming [2] and the augmented Lagrangian method [3]. This numerical approach is implemented herein to solve minimum volume problems with multiple displacement constraints, including the additional constraint governing the amount of graded porous material. Moreover, an efficient procedure is proposed to post-process the achieved optimal density field to give the printable geometry for AM as output. Finally, the new multi-scale topology optimization framework is utilized to generate an optimal design combination in 2D/3D examples.

Keywords

Porous material, AM, Topology Optimization.

Acknowledgements

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ANALYSIS OF THE IMPACT AND MECHANICAL PROPERTIES OF A DAMPER MADE OF HYPERELASTIC MATERIAL

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Abstract. *The analysis of mechanical properties in the proposed model of the vibration damping element through the use of a layer of hyperelastic material was presented in the paper. The aim of the study was to analyze the behaviour of the structure under the influence of external forcing forces with the use of hyperelastic materials, which are characterized by high compressive fatigue strength. The model in its construction assumes the use of rubber as a material that acts as a vibration damper. The results presented in the paper include the stress-strain relationship and the vibration analyzes. The paper contains the conclusions of the comparative analysis in relation to the reference model. The studies was performed using the finite element method using the ANSYS program. The Mooney-Rivlin material model was adopted in the work.*

Keywords

Damper, stress-strain relation, Mooney-Rivlin model, dilitation.

Introduction

A hyperelastic material reflects the characteristics of an ideally elastic material for which the stress-strain relationship is non-linear. Very large deformations are reversible, which affects a wide range of applications of this type of materials. Research on the use of hyperelastic materials is based on theoretical models. In numerical modelling of linearly elastic materials, two material constants are given. From the definition of the hyperelastic material model, which was derived from the strain energy density function, additional material parameters should be defined [1]. Additional material parameters are determined empirically. In this work, the Mooney-Rivlin model was adopted. The aim of the study was to analyse the behaviour of the structure under the influence of external forces with the use of hyperelastic materials, which are characterized by high compressive fatigue strength, as a vibration damping layer. Rubber as a material that acts as vibration damping was applied in the model. Elements of building structures undergo deformation during operation. In order to avoid negative irreversible effects of deformation in the form of scratches and cracks, and consequently its destruction, dilatation gaps should be used. This will ensure the independent operation of individual parts of the building. The paper proposes a model of filling, a fragment of an expansion joint or a technological break, transferring the service loads. The analysis of stresses, strains and vibrations of the modelled element was included in the paper.

Model Description and Summary

The subject of the analysis was schematically presented in Fig. 1.

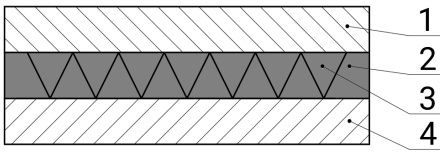

Fig. 1: Model of a vibration damper with a layer of hyperelastic material.

Layers 1 and 4 were made of polymer concrete. Layers 2 and 3 were modelled from a hyperelastic material, and the cross-section was proposed in the shape of cuboids arranged along the element, with a triangle (middle) and trapezoidal (at the beginning and end) base. The layers were stacked on top of each other in a constant manner. After completing the entire structure, the layers adhere tightly to each other.
The paper presents the results of numerical tests carried out in the ANSYS / Mechanical program, and on their basis, an analysis of the model's behaviour in comparison to the reference model was carried out.

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NUMERICAL MODELING OF A TIMBER SEMI – RIGID CONNECTION

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Abstract. *The paper describes with the determination of the rotational stiffness of a timber semi-rigid connection. The rotational stiffness was calculated on the basis of the currently valid standard, experimental test and numerical model. The connection was made of a standard combination of bolts and dowels.*

1. Introduction

Modeling connections of timber structures with ductile or brittle failure is still a major challenge. Strong anisotropy of timber can lead to numerical modeling problems. From the very beginning of the use of computer technology for the purposes of numerical modeling, it was necessary to constantly compare and calibrate numerical models according to experimentally obtained data. The paper therefore describes the numerical analysis of the rotational stiffness of a timber semi-rigid connection. The connection was made from a combination of bolts and dowels. The load was static repeated up to the ultimate limit strength. To validate the results of the numerical model, an experimental connection test was performed, followed by tests to determine the mechanical properties of timber and fasteners. These subtests were used to introduce material properties into the numerical model.

Fig. 1 shows a scheme of a solved connection, fig. 2 shows a numerical model and fig. 3 shows a deformation-load diagram of individual outputs.

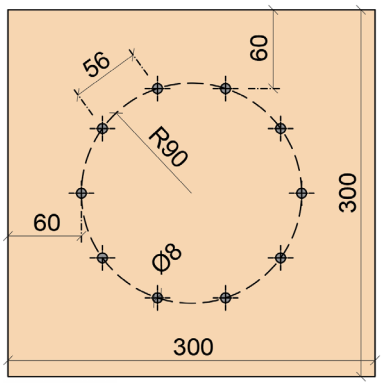

Fig. 1 Connection detail.

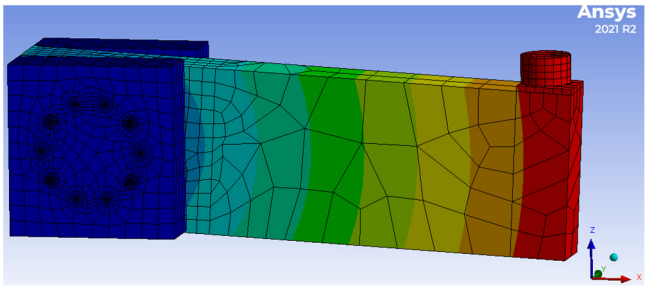

Fig. 2 Numerical model.

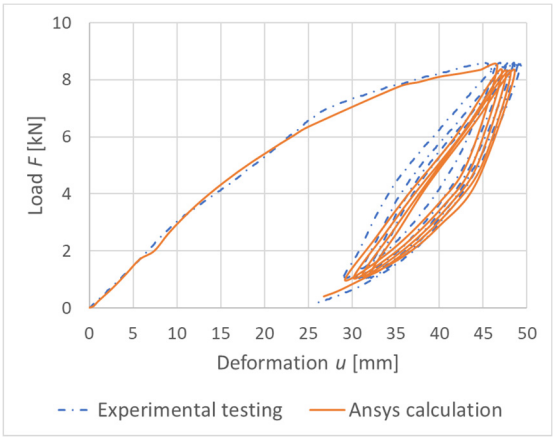

Fig. 3 Deformation – load curve.

2. Conclusion

The paper presents and compares the results obtained by experimental testing and numerical modeling of a semi-rigid connection. The numerical model shows a relatively high accuracy of the results compared to experimental testing.

Acknowledgement

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ZJEDNODUŠENÝ POSTUP STANOVENÍ SEISMICKÉ ODEZVY KRUHOVÝCH NÁDRŽÍ

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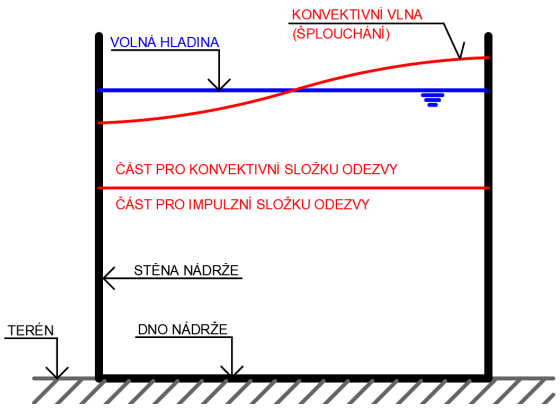
Abstract. *This paper is aimed at a simplified method for determining the seismic response of circular ground supported liquid storage tanks, which allows calculation of total as well as local response components. The described procedure can serve as a practical tool for obtaining initial information about the behaviour of the structure during a seismic event. In this article, the components of the total response are specified together with the formulas used for their computation. The theoretical parts are complemented by results obtained on an example of a roofed water tank.*

Klíčová slova

Seismicita nádrží, zjednodušený postup, celková seismická odezva, lokální seismická odezva.

1. Úvod

Nádrže patří k typickým součástem průmyslových komplexů. Jedno z dominantních namáhání, které ovlivňuje dimenzování konstrukce, je účinek kinematického buzení základu vyvolaný seismickou aktivitou. Pro popsání celkových účinků buzení je odezva rozdělena do dílčích částí (viz Obr. 1).



Obr. 1: Schématické zobrazení rozdělení kapaliny na část pro konvektivní a část pro impulzní složku odezvy.

Předkládaný článek si klade za cíl seznámit čtenáře s výpočtem seismické odezvy nádrží s použitím kombinace zjednodušeného postupu dle [1] pro celkovou odezvu a upravených vzorců z [2] pro lokální odezvu. Výklad je doplněn vzorovým výpočtem na příkladu ocelové nádrže.

2. Závěr

Seismicita je jedním z rozhodujících zatížení při procesu dimenzování nádrže napuštěné kapalinou. Stanovit zatížení, jenž je tímto kinematickým buzením vyvoláno, je obtížné z důvodu interakce mezi nádrží a kapalinou. Jedna ze zjednodušených metod byla popsána v tomto příspěvku. Představený postup výpočtu umožňuje stanovení celkové i lokální odezvy konstrukce. Analýzou nádrže jsou stanoveny celkové síly a momenty společně s její lokální odezvou. Výsledkem výpočtu je rovněž průběh maximálního tlaku na stěnách nádrže.

Poděkování

Děkujeme za finanční podporu grantového programu financovaného Ministerstvem školství, mládeže a tělovýchovy ČR prostřednictvím VŠB – TU Ostrava (SGS SP2022/43).

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Effect of gaseous and traffic induced pollutants on the durability of selected construction materials

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Abstract. *The paper gives brief overview of the research project that is aimed to describe and understand the effect of gaseous and traffic induced pollutants on the durability of selected construction materials as well as to design and test a knowledge-based approach for assessing the deposition and diffusion processes of gaseous atmospheric pollutants and chlorides in concrete-based building structures.*

Keywords

Durability, pollution, highway environment, reinforced concrete, corrosion, gases, chlorides, diffusion, carbonation, freeze thaw, deposition, CFD, particle flow, experiment, GASMAS.

1. Introduction

The paper gives brief overview of the research project that is aimed to describe and understand the effect of gaseous and traffic induced pollutants on the durability of selected construction materials as well as to design and test a knowledge-based approach for assessing the deposition and diffusion processes of gaseous atmospheric pollutants and chlorides in concrete-based building structures.

2. Project aims

The aim of project is to describe and understand the effect of gaseous and traffic induced pollutants on the durability of concrete as well as to design and test a knowledge-based approach to assessing the deposition and diffusion processes of gaseous atmospheric pollutants in concrete. The promising Gas in scattering media absorption spectroscopy (GASMAS) procedure introduced in [1] will be studied in order to develop testing conditions suitable for concrete.

Moreover, the effect of local highway environment on the deposition of industrial and traffic induced pollution to concrete will be studied including validation of mathematical models for the simulation of particle flow whirled by the traffic. The effect of carbonation, freeze thaw and chloride ingress effects on durability will be studied as well utilizing combination of laboratory, in-situ experiments complemented with numerical models. Research of the non destructive, yet reliable detection of the penetration of aggressive agents to concrete, would bring also new light on the spread of pollutants in the nearby the roads.

Acknowledgment

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DETERMINATION OF LONGITUDINAL YOUNG'S MODULUS OF CFRP COMPOSITE

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Abstract. *The mechanical characterization of composite materials is nowadays a major interest due to their increasing use in the industry. The design of most of these new materials is based on their excellent material characteristics, which are mainly obtained by experimental tests. This paper presents different approaches for thin laminated CFRP composites based on tensile tests, three point bending tests and the Impulse Excitation Technique. Experimental results are compared to results obtained from numerical homogenization techniques and manufacturer data for evaluation of the accuracy of the different approaches.*

Keywords

Carbon fibres, micro-mechanics, laminates, longitudinal modulus, tensile test, three point bending test.

1. Introduction

Fibre-reinforced composites are widely used for many structural applications. The primary benefits of the composite components are their excellent stiffness and strength to weight ratios. The determination of the mechanical properties is essential for ensuring performance in designing composite structures. In addition, the knowledge of the complete elastic stiffness matrix is important for modelling and evaluating the mechanical behaviour of composite materials under several loading conditions [1].

For heterogeneous materials, a large number of material properties is needed. The increasing complexity of microstructural mechanical and physical behaviour of composite materials, along with the development of computational methods, made the class of so-called "unit cell methods" more attractive. This approach has been used in a large number of different applications [2]. The unit cell methods serve a twofold purpose: primary they provide valuable information on the local microstructural fields and secondly, they provide the effective material properties. The stiffness properties are generally determined by fitting the averaged microscopical stress-strain fields. They result from the analysis of a microstructural representative cell subjected to a certain loading path on macroscopic closed-form constitutive equations. In a finite element model, all layers can be modeled separately. This, however, requires a huge number of degrees of freedom in the numerical model, hence large memory needs and consequently also huge computer time consumption. A more economical solution is representing the laminates by their global laminate stiffness's.

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Determination of critical length parameter of notched specimens for fatigue lifetime predictions

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Abstract. *This paper reviews the research results to date on critical length parameters of notched aluminum specimens with various notch radii. The Theory of Critical Distances (TCD) was applied in form of the Line Method for determination of the critical length parameter. This parameter can be used for lifetime predictions of notched components under fatigue. The output is a comparison of critical length parameters of specimens with various notch radii.*

Keywords

Theory of Critical Distances, notches, critical length parameter, Line Method, very high cycle fatigue, lifetime predictions.

Introduction

Fatigue lifetime predictions can be realized by means of the Theory of Critical Distances [1]. These predictions use the lifetime curve of smooth specimens, the distribution of the axial stress in the notched specimen, and the critical length parameter. The S-N curve of smooth specimens is an approximation of experimental data, and the axial stress distribution can be determined by using FEA. There are several ways how to determine the critical length parameter l. In this review, the parameter l is determined from S-N curves of smooth and notched specimens and their stress distributions. Each pair of smooth and notched lifetime curves has its critical parameter. Examined notch radii are 0.1 mm, 0.2 mm, 0.8 mm and 3 mm.

In Figure 1, it is obvious, that this parameter differs for varying notch radii and decreases with the increasing number of cycles to fracture. If this fact is neglected and the constant value of the length parameter is used for lifetime predictions, the fatigue lifetime of a component may be overestimated or underestimated depending on whether the selected constant value is greater or smaller than the real value of the length parameter. In the region beyond 10^7 cycles, there are large differences between values of critical parameters. For specimens with larger radii, the critical parameter decreases to zero value for specific N_f. Beyond this N_f we can consider the value $l = 0$, but the prediction will be on the unsafe side if compared to the results coming from experiments.

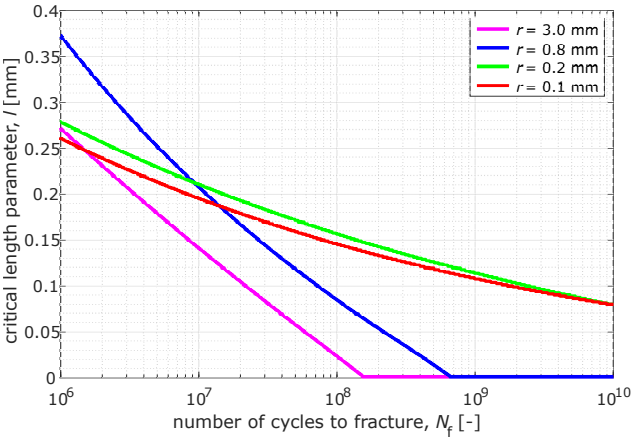

Fig. 1: Critical length parameters of notched specimens

Acknowledgment

The research was supported by the Czech Science Foundation, project No. 21-14886S.

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FLEXURAL RESPONSE OF FORMWORK-MATRIX SPECIMEN – NUMERICAL STUDY

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1. Introduction

3-D printing (or in other words additive manufacturing (AM)) is currently very widely used tool in various branches, e.g. field of art, home use, public healthcare, consumer goods, weapons development, industry etc. This tool enables to produce objects and products of practically any shape and geometry with the use of different printing materials, but primarily plastics. In the last years, 3-D printing began to be applied in the fields of structural and civil engineering too. Today, the use of 3-D printing in civil and structural engineering takes various forms, especially in terms of a scale of printed construction and printing material used. Cases of whole constructions and buildings created by 3-D printing are known. Also, cases of using the technology of 3-D printing of fresh concrete mix to produce concrete constructions with complicated curved geometry are known. However, authors of this paper focus on the use of 3-D printing for the development of plastic formworks for concrete which can substitute traditional steel reinforcement (rebars and stirrups) [1]. Although this technology has its limitations, for now, it is suited for the numerical investigation which will be necessary for practical designing of concrete structures reinforced by 3-D printed plastic reinforcement in future. And the numerical investigation is precisely the aim of this paper.

Within this paper, research is focused on the numerical analysis of mechanical behaviour of concrete element shaped and reinforced by 3-D printed ABS (acrylonitrile-co-butadiene-co-styrene) formwork with no reinforcing ribs. The flexural strength (three-point bending) test is numerically simulated for this purpose. The best result from the performed numerical simulations is compared with the result of the practical flexural strength test which was obtained from a former experimental investigation conducted by Jacek Katzer and Tomasz Szatkiewicz [1]. In this paper, author thus follows up on previous research of them. Based on the result comparison, provisional insufficiencies of the used numerical approach are finally discussed.

2. Result and Discussion

Comparison of the best result from the performed numerical calculations with the experimental data used is depicted in Fig. 1. It can be seen from Fig. 1 that obtained numerical data exhibit a good degree of agreement with the experimental data in terms of the first peak in the F-Δ diagram, and in terms of the whole response of the numerical model which is undoubtedly quasi-plastic. However, within the first part of the diagram (between the load beginning and the first peak), it can be seen that the numerical data are much less nonproportional than the experimental data. They are almost proportional. This means that the numerical model used is not able to affect the necessary nonproportionality of the first diagram part data. This brings with it a pitfall in the form of necessity to define Young's elasticity modulus of the Drucker-Prager Concrete model by an unrealistic value. And this pitfall brings with its worse convergence of the solution. The solution convergence can be improved with using greater value of specific fracture energy of the Drucker-Prager Concrete model but unfortunately, the response of the used numerical model is then quite ductile after reaching the first peak on the diagram (after cracking), see Fig. 1. The maximum load-bearing capacity of the numerical model is more conservative than in the case of the experiment, see Fig. 1.

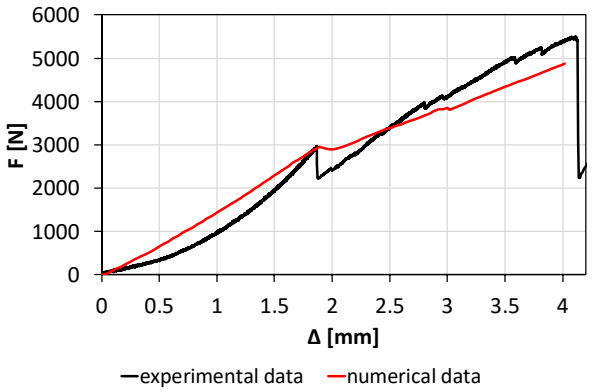

Fig. 1: F-Δ diagram.

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PROBABILISTIC ASSESSMENT TO ANALYSE OF SOIL STRUCTURE INTERACTION OF HIGH-RISE BUILDING

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Abstract. *This paper presents the results from the deterministic and probabilistic analysis of the accidental torsional effect on seismic resistance of the tool building. The methodology of the seismic analysis of the structures in Eurocode and JCSS is discussed. The possibilities of the utilization the RSM and LHS method to analyse the extensive and robust tasks in FEM is presented. The influence of the uncertainties of the input and output parameters is considered. The deterministic and probability analysis of the seismic resistance of the structure was calculated in the ANSYS program.*

Keywords

Probability, Seismic, SSI, Tool building, ANSYS.

1. Introduction

During the structural design process, an engineers must consider problems of the safety, reliability, and durability of a single structural element as well as the entire structure from the point of view of its planned life cycle. Randomness in the loading and the environmental effects, the variability of the material and geometric characteristics of structures, subsoil and many other "uncertainties" affecting errors in the computing model led to a situation where the actual behaviour of a structure is different from the modelled one. Recent advances and the general accessibility of information technologies and computing techniques give rise to assumptions concerning the wider use of the probabilistic assessment of the reliability of structures using simulation methods.

The use of simulation methods (RSM and LHS) in the ANSYS program will be presented on the example of a high-rise building installed in complicated foundation conditions to analyse the impact of uncertainties in the calculation model of the structure and subsoil on the building reliability and safety under seismic loading.

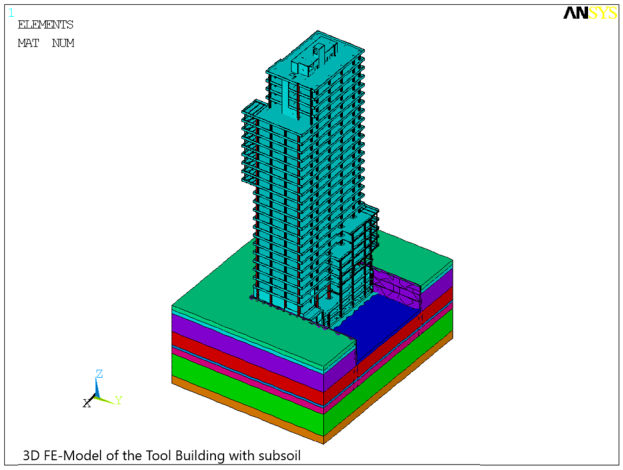

Fig. 1: 3D FE-Model of the asymmetric high-rise building with subsoil.

The building is designed from a combined system consisting of two reinforced concrete monolithic cores and a system of columns. In the lower part of the building, the reinforced concrete walls are designed around the perimeter from three sides of the building. The building is based on a monolithic foundation slab. The subsoil was improved by a reinforced concrete tub created by Keller-type and micropyle's. The high-rise building has floor plan dimensions of 40x22 m and a height of 98.3 m. The building has 3 underground floors with a foundation joint at the level of -11.1 m.

The results of the probabilistic seismic analysis of the asymmetric high-rise building considering the uncertainties of the structure-soil interaction and the random distribution of mass eccentricity on the building slab are presented in this paper.

Acknowledgements

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ABOUT SOME POSSIBILITIES OF NUMERICAL MODELLING

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Keywords

Vehicle, roadway, stochastic, numerical modelling.

1. Introduction

The presented article tries to numerically model the response of a truck when driving on the road in the time and frequency domain and to verify the quality and usability of the numerically obtained results by means of an experiment.

2. Road Profile

Two longitudinal profiles 500 m long with a distance of 2 m from each other were laid out. Road irregularities were mapped in two ways: accurate levelling and spatial scanning. The values thus obtained were used in the numerical simulation.

3. Vehicle Model

The subject of numerical modelling is a Tatra truck. A space multi-body computational model with 15 degrees of freedom was created for the vehicle, Tangible degrees of freedom (in number 9) correspond to movements of the mass points of the model and intangible degrees of freedom (in number 6) correspond to movements of the contact points with the road.

Due to the used method of solution, the equations of motion are given in the form

$$[\mathbf{m}]\{\ddot{\mathbf{r}}(t)\} = \{\mathbf{F_R}(t)\}\,, \tag{5}$$

where **[m]** is mass matrix of the model and vector of resulting forces

$$\{\mathbf{F_R}(t)\} = \{\mathbf{F_{DF}}(t)\}+\{\mathbf{F_G}\}+\{\mathbf{F_{RS}}(t)\}\,. \tag{6}$$

$$\{\mathbf{F_{DF}}(t)\} = \mathbf{[A]}\ \{\mathbf{F_{JE}}(t)\}, \tag{7}$$

4. Experimental Test

The experiment was performed with the vehicle Tatra T815. During the test, vertical accelerations were monitored at three points on the right side of the vehicle. At the centre of gravity (CG) of the vehicle's sprung mass - sensor A1. On the right front axle (FA) - sensor A2. On the right rear axle (RA) - sensor A3. Acceleration sensors Brüel & Kjær type BK4508B were used to monitor the response. The measuring string is composed of these components: sensor, amplifier with a band-pass filter, analog-digital interface, computer. The signal from the sensor was routed through a coaxial cable. The measuring string was located in the vehicle. The sampling frequency was 2000 Hz.

5. Experiment Versus Numerical Solution

From the records of vehicle response obtained by the experiment and by numerical simulation, sections corresponding to the vehicle movement along the selected section of road in the length of 100 m were selected. These selected sections were subject to mutual comparison. Runs at the lowest speed $V = 15.18$ km/h and at the highest speed $V = 52.95$ km/h were chosen for comparison. As an example, this article presents the response records (values of the vertical accelerations) at the centre of gravity of the vehicle (CG), sensor A1 and the comparison of distribution functions for this case.

In the 2nd step, the PSDs were compared with each other using the FFT.

Acknowledgements

This work was supported by Grant National Agency VEGA of the Slovak Republic. Project number G1/0006/20.

POSSIBILITIES OF LONG-TERM MEASUREMENT OF CLIMATE DATA ON NEW AND EXISTING BRIDGE STRUCTURES

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Abstract. *This paper presents the importance of obtaining continuous and long-term climate data directly from bridge structures. The collected data can be subsequently used for the assessment of the durability of reinforced concrete bridges with respect to aggressive environments. General and commercially used methods are briefly presented as well. However, these methods are expensive and not suitable for every structure. The paper describes the possibilities of using a development kit based on the M5Stack platform, which is a robust yet cost-effective alternative to other instruments. Finally, the possibilities of deploying the M5Stack kit on several bridge structures in the Czech and Slovak Republics and comparing the obtained climatic data with data from meteorological stations are discussed.*

Keywords

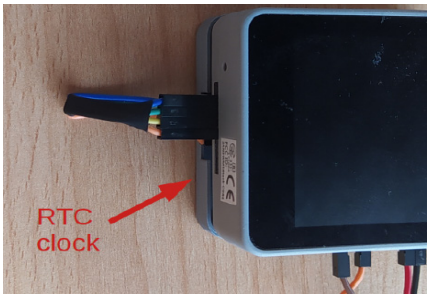
In-situ measurements, bridge, humidity, temperature, long-term, durability.

1. Monitoring Systems

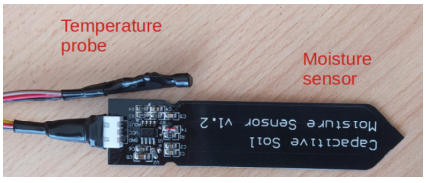
In general, the monitoring of reinforced concrete bridges is mainly applied for the evaluation of crack initiation, excessive deformation etc. This monitoring includes long-term and short-term data collection related to, for example, load tests. However, obtaining data directly from the bridge for the purpose of life estimation is a relatively young initiative.

2. Modular Development Kit

The aim of the research was to assess whether it is possible to prepare a user-friendly device which can be placed anywhere near the selected bridge and obtain continuous temperature and humidity data. The cost of the whole designed device is about €60 (not including the assembly work, only the material). It is a basic unit (computer) M5Stack ESP32 which was complemented with several components and a power supply. The device consists of the main control unit with an LCD screen, a real-time clock (RTC) concealed behind the back panel, and two sensors (see Fig.1 (a)). The two sensors are a moisture detector measuring in a range of 0% to 100% and a digital temperature probe with a range between -55 °C to 125 °C (see Fig. 1 (b)).



(a)



(b)

Fig. 1: LCD screen and RTC clock (a), moisture detector and digital temperature probe (b).

Acknowledgements

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FRACTURE PARAMETERS OF A PERPENDICULAR CRACK WITH ITS TIP CLOSE TO A CORROSION PIT

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In this paper, an effect of a corrosion pit on the propagation of a perpendicular near crack is investigated via linear elastic fracture mechanics principles. The analysis presented is performed via finite element method and the influence of the mutual distance of the pit and the crack on the stress intensity factors is investigated, see the scheme of the model in Fig. 1.

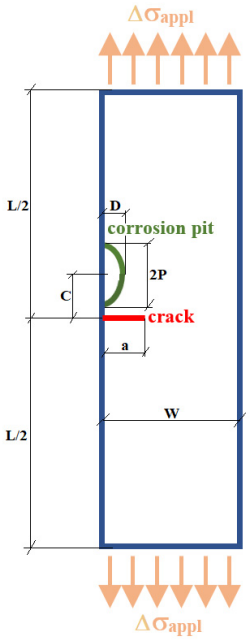

Fig. 1: Scheme and dimensions of the cracked bar with a corrosion pit subjected to remote tensile loading.

The following values have been used: the specimen length $L = 100$ mm, the specimen width $W = 10$ mm, length of the corrosion pit $2P = 0.4$ mm, depth of the corrosion pit $D = 0.15$ mm, applied tension $\Delta\sigma_{appl} = 300$ MPa. The last two parameters varied in the defined range: crack length a between 0.05 and 0.7 mm and the distance of the middle of the corrosion dip from the crack C between 0.25 and 0.5 mm. A simplified 2D numerical model was created. Material properties of the specimen were defined by the Poisson's ratio of 0.3 and by the Young's modulus of 210 GPa, as are typical for lots of steel grades. In total, 154 various configurations have been simulated and the corresponding fracture parameters calculated.

The stress intensity factors ranges and T-stress/biaxiality factor (B) were investigated in dependence on the (relative) crack length for various mutual distances of the crack and the corrosion pit in a rectangular specimen under pure tension. As an example, the results for ΔK_{II} can be seen in Fig. 2.

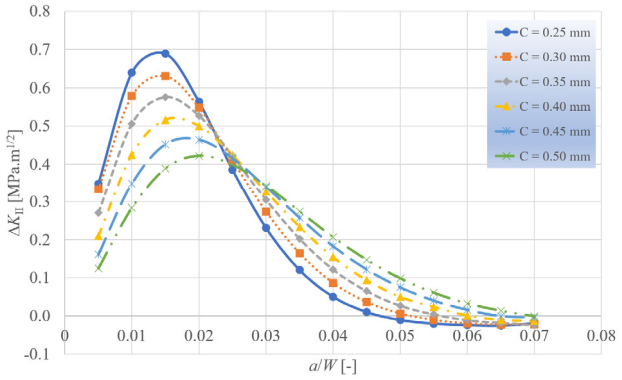

Fig. 2: Mode II stress intensity factor range as a function of the relative crack length for various distances of the crack and the pit.

It has been found out that the corrosion dip influences the crack behaviour only for very short cracks. Such a configuration leads to development of I+II mixed-mode conditions of the crack propagation and can cause deflection of the perpendicular crack from its original direction and consequently its stopping at the corrosion pit.

Acknowledgements

Financial support from the Czech Science Foundation (project No. 21-14886S) and from the Faculty of Civil Engineering, Brno University of Technology (project No. FAST-S-22-7881) is gratefully acknowledged.

NUMERICAL STUDY OF FLOW AROUND A HOT CYLINDER

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1. Introduction

The flow around a heated circular cylinder and the wake behind it were studied by numerical simulation. The Reynolds numbers ranged from 2000 to 20 000 and the cylinder wall temperatures varied between 27 °C and 177 °C. Some of the results were compared with results from experimental research [1]. The results have shown relatively significant influence of surface temperature on flow structure and wake length in the case of the lowest free stream velocity, whereas a very small influence of heating at a higher free stream velocity was observed.

The numerical study was carried out on two cases of flow around a cylinder. The flow around the unheated cylinder was modelled as isothermal flow, whereas in the case of the heated cylinder, it was modelled as incompressible non-isothermal flow. In both cases, the calculations were performed for two velocities, $v_1 = 0.35$ m/s ($Re = 2204$) and $v_4 = 2.95$ m/s ($Re = 18580$), as in the experiments. Mean x velocity in the wake at the cylinder centreline for $Re < 5000$ is visible in Figure 1.

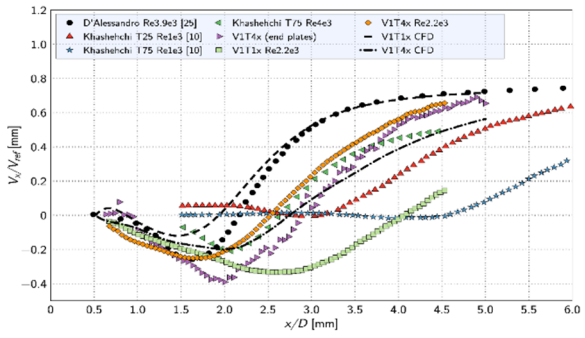

Fig. 1: Mean streamwise velocity components v_x in the wake at the cylinder centreline for $Re < 5000$ [1].

The tasks were solved in Ansys Fluent software using the Large Eddy Simulation (LES) method. The LES method is based on the filtration of the flow field to vortex structures containing macro and micro scales. Macro scale vortex structures were directly simulated. Micro scale turbulent structures, being isotropic in general, were expressed in so-called subgrid-scale models. These small vortices contributed little to heat and momentum transport, so they were expressed as parametric schemes that were included in the large eddy equations, which use the filtration of continuity, momentum and energy. The parameters entered in the numerical solution in the case of heated cylinder are: air temperature T [K], thermal conductivity λ [W/(m·K)] and sensible enthalpy h_s [J/m^3], which is dependent on the specific heat capacity of the air c_p [J/(kg·K)]. The present work was solved using the Smagorinsky-Lilly subgrid model, where the so-called subgrid turbulent viscosity is dependent on the length scale of small vortices.

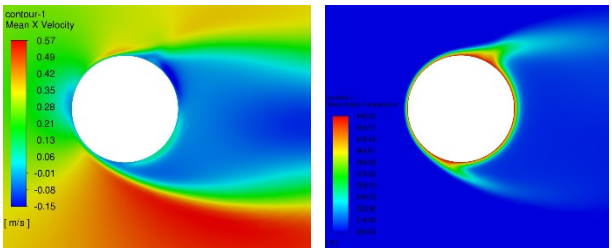

Fig. 2: Mean streamwise velocity v_{1x} (left) and mean static temperature (right) around the hot cylinder.

The dimensions of the computational area are (length × width × height) 7.0×1.8×0.1 m, which can be expressed in the cylinder diameter as 70 D×18 D×1 D. The height of 1.8 m corresponds to the wind tunnel height. The boundary layer of the cylinder surface is created with hexahedral elements in 20 layers and continues with tetrahedral elements. The transition from hexahedral to tetrahedral elements is smooth to ensure the necessary conditions for near wall modelling $y+ \leq 1$, which is a non-dimensional quantity dependent on the flow type and many other parameters. In order to ensure that $y+ \leq 1$, there is an indirect proportion between the first cell at the wall and the flow velocity. Thus, different meshes with different BLs have to be created for each Reynolds number. The initial cell size corresponding to the velocity v_1 at the wall is $d = 2 \cdot 10^{-4}$ m, while the cell dimension for v_4 is $d = 5 \cdot 10^{-5}$m.

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PILOT NUMERICAL ANALYSIS OF RESISTANCE OF STEEL BEAMS UNDER COMBINED SHEAR AND PATCH LOADING

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1. Introduction

The last decade revealed a growing interest in the use of computer models for the analysis of structural resistance. While some studies showed a good correspondence between experiments and FE models, missing widely accepted principles for creating FE models presents an obstacle for their practical applications. As a consequence, it is of interest to analyze the behaviour of steel beams based on computer modelling and compare the results with experiments. The application of FE models involves three basic steps: (i) development and unification of principles and parameters for FE models – the main focus of this study; (ii) evaluation of the accuracy of results based on comparison with experimental data – discussed briefly; (iii) determination of reliability parameters such as partial and sensitivity factors.

The article presents an overview of the principles and main parameters for constructing FE models such as FE mesh size or material model, as well as analysis of their influence on resistance estimates, based on which recommendations for setting and parameter values of FE models for thin-web steel structures are provided.

2. Results

The creation and study of the accuracy of the application of FE models for ultimate resistance of thin-web welded beams is based on the results of experimental studies. Developed numerical models are compared with experimental results. The presented principles for constructing FE models (mesh size, material model, etc.) are recommended to follow when analysing the resistance and behaviour of beams with a thin web. Sensitivity analysis of the FE model with respect to the input parameters revealed the most important parameters (yield strength of steel and web thickness), the uncertainties of which needs to be taken into account. Some results of the experimental and the FE models are presented in Fig. 1. The models showed close numerical convergence with the experimental results.

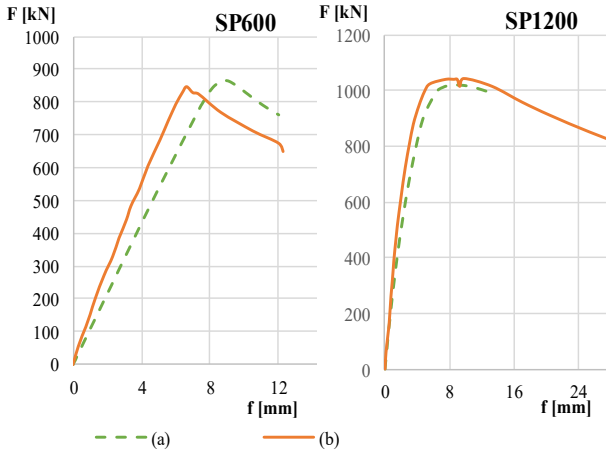

Fig. 1: The load-displacement (a) FE model, (b) Experimental data.

3. Conclusions

The main parameters affecting the result of modelling a thin-walled element include a selection of the deformation diagram and values of material properties, type and size of the final element, and size and shape of initial imperfections. The models of materials are analyzed, based on which it is proposed to use a 4-line relationship with the yielding and with the self-hardening stage. The analysis of the mesh size showed that the most optimal size is about five web thicknesses. As the use of solid elements provides insignificant increase in the accuracy, it is recommended to use shell elements. The imperfections are recommended to be based on the first eigenforms.

The analysis of the sensitivity of the FE model to the input variables showed that the greatest sensitivity is associated with the variability of the thickness of the web and the strength of the yield.

4. Acknowledgements

This study has been supported by the Ministry of Education, Youth and Sports of the Czech Republic under Grants LTT18003 and CZ.02.2.69/0.0/0.0/18_053/0016980.

ANALYSIS OF THE USE OF TENSEGRITY AS DISPLAY POSTUMENTS IN MUSEUMS

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Abstract. *Tensegrity structures, due to their high stiffness and lightness, have been interesting for designers and architects for decades. The key stage of each design is the selection of the optimal structural system, the task of which is to ensure the load-bearing capacity and meet the visual expectations of modern museums and traditional exhibitions. The article analyzes the use of the tensegrity structure as display pedestals in museums due to its stability and load-bearing capacity. Numerical calculations of the analyzed structural systems of museum pedestals were performed using the finite element method in RFEM.*

Keywords

Tensegrity structure, museum pedestal, RFEM.

1. Introduction

Exhibition pedestals in museums fulfill the role not only of displaying the items on display, but also of an appropriate interior arrangement. Tensegrity structures are the subject of reflection among scientists and engineers from such disciplines as architecture, civil engineering, aviation, biology and robotics, which results in more and more interesting projects using this concept [1]. The tensegrity system is a spatial structure consisting of ropes and struts. The stability of the structure is ensured by the integrity between the compressed struts and the stretched ropes. Due to the presence of many tensile cables in the structure, it provides a high strength-to-weight ratio while maintaining high stiffness [2].

The word *tensegrity* comes from a combination of words *tensile* and *integrity*. The definition of a tensegrity system is: "*A tensegrity is a system in stable self-equilibrated state comprising a discontinuous set of compressed components inside a continuum of tensioned components"*. There are many methods of selecting the geometry of the tensegrity structure, but they are looking for more and more effective ones. Tensegrity is a spatial lattice in which the infinitesimal mechanism is balanced by a self-equivalent system of forces [3].

The article presents an analysis of the use of tensegrity as museum pedestals. Based on numerical calculations for various structural systems, the stability and load capacity in relation to the adopted system were analyzed. Figure 1 shows the analyzed numerical models. Numerical calculations were performed in Dlubal RFEM.

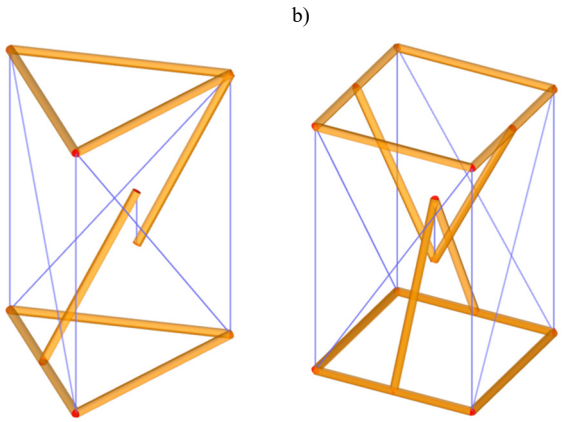

Fig. 1: Analyzed numerical models of display pedestals; a) layout with a triangle-shaped base, b) layout with a square-shaped base

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COMPARISON OF SELECTED PROPERTIES FROM VARIOUS STRUCTURAL ELEMENTS MADE FROM AISI 304

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The use of stainless steel for civil engineering structures is relatively recent, 20 to 25 years. In addition to the traditional use as architectural features, guardrails and handrails, stainless steels, especially AISI304, are increasingly being used for structural components of decks or in suspension systems, as well as in anchorage components. Significant advances in the use of stainless steel in construction are described, for example, in [1].

In this contribution, the basic AISI 304 properties from various structural elements are compared and evaluated by advance probabilistic methods.

Methods and Results

Vickers hardness of Metallic materials [2]: The test consists of a small pyramid shaped diamond indenter with an apical angle of 136°, which is pressed into the test sample at a predetermined load. The resulting indentation is then measured in both axis from tip to tip. The average of the two axis measurements is then converted into a Vickers Hardness number by the use of a formula:

$$HV=0.1891F/d^2 \qquad (1)$$

Table 1. HV - AISI 304 beam with cross section: 10 mm×60 mm, 20 mm×60 mm production from Europe and Asia.

AISI 304	E10	E20	A10	A20
HV	233.1	308.0	253.5	236.7
Standard deviation	17.9	11.6	8.7	4.5

Tensile test of Metallic materials [3]: Properties that are directly measured via a tensile test are ultimate tensile strength, breaking strength, maximum elongation and reduction in area. From these measurements, the following properties can also be determined: Young's modulus, yield strength, and ultimate strength, see Tab. 2.

A *S-N Curve* is a plot of the magnitude of an alternating stress versus the number of cycles to failure for a given material. Typically, both the stress and number of cycles are displayed on logarithmic scales, see

Table 2. Selected mechanical properties - AISI 304 beam with cross section: 10 mm×60 mm, 20 mm×60 mm production from Europe and Asia.

AISI 304	E10	E20	A10	A20
R_m [MPa]	740.0	756.9	707.4	698.2
R_e [MPa]	353.7	626.2	473.0	450.2
A_g [%]	47.0	24.6	34.2	38.7

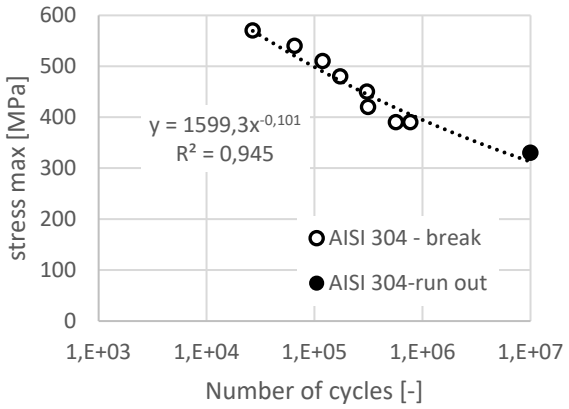

Fig. 1. Fatigue behaviour of AISI 304 from beam with cross section 100 mm×100 mm.

Acknowledgements

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Semi-probabilistic Nonlinear Analysis of Post-tensioned Concrete Bridge Made of KT-24 Girders

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Abstract

This paper deals with the assessment of the design resistance of an existing railway bridge made of KT-24 precast post-tensioned concrete girders. The load-bearing capacity of the structure is determined using probabilistic nonlinear analysis by the finite element method (FEM).

The FEM computational model was created in ATENA 3D software. The symmetrical half of the girder was modelled. The girder was loaded with self-weight, secondary dead loads, and a partial continuous load corresponding to the LM71 load model to induce the maximum bending moment (Fig.1).

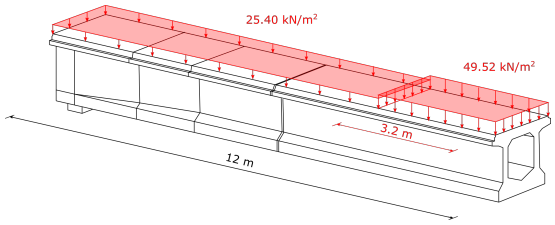

Fig. 1: LM71 load model on the symmetrical half of the girder.

This paper compares the effect of the details of the stochastic model and the safety format method used for assessing the load-bearing capacity of an existing bridge made of KT-24 precast prestressed concrete girders.

The load-bearing capacity is determined for the ultimate limit state (ULS) and few serviceability limit states (SLS). A fully probabilistic approach (FP) is compared with selected semi-probabilistic methods recommended by codes, which are able to significantly reduce the number of non-linear calculations required to estimate the design resistance. The studied semi-probability methods include the ECoV method according to fib Model Code 2010, the method according to EN 1992-2, the partial safety factor method (PSF) (EN 1990) and new Eigen ECoV method, which is based on Taylor series expansion. The results are compared and discussed in terms of accuracy and required computational time.

The design values of the moment resistance were determined for five limit states and their corresponding reliability levels using methods mentioned above. Figure 2 shows results for ULS obtained for two different stochastic models, the simplified model (red) and the full model (blue). The results show that the FP method provides the least conservative design resistance, but at the cost of increased computational time.

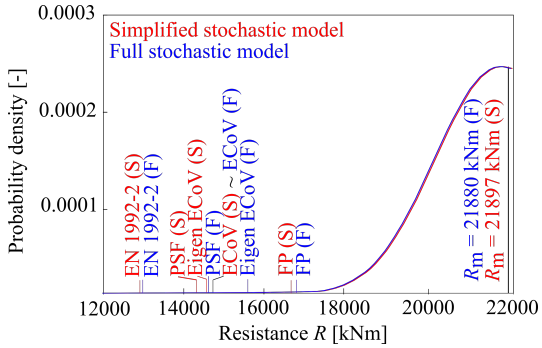

Fig. 2: Comparison of design moment resistance values for ULS.

Acknowledgment

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EXPERIMENTÁLNÍ MĚŘENÍ ENVIRONMENTÁLNÍCH ZATÍŽENÍ V ZÁŘEZU SILNIČNÍ KOMUNIKACE

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Abstract. *Structures in the vicinity of exposed roadways are affected by specific microclimatic conditions that can affect their long-term reliable operation. Among the most significant environmental loads are chlorides, the primary source of which is from de-icing salts used in winter road maintenance. Road traffic generates dust and/or aerosol to which chloride ions are bonded. The environment around roads, including construction sites, is subsequently affected by atmospheric deposition of chlorides. The amount of chloride deposited is significantly influenced by the location and design of the structures in the vicinity of the road, as well as the topography of the surrounding terrain. In this paper, the influence of road cut on the deposition rate of chloride ions is mainly discussed. The results of experimental measurements carried out in 2021 at selected locations on the I/11 road in Ostrava are presented and evaluated.*

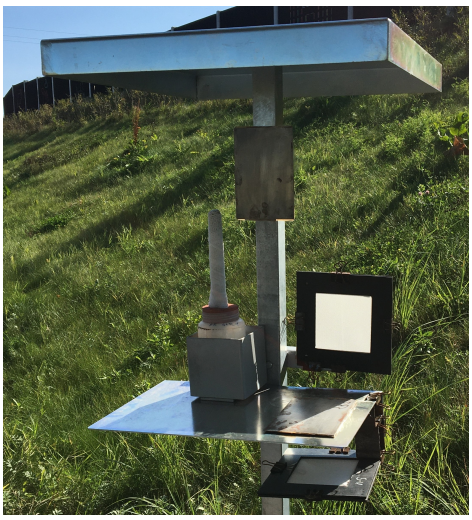
Keywords

Environmentální zatížení, depozice chloridů, experimentální měření, životnost.

1. Úvod

Životnost stavebních objektů situovaných v okolí silničních komunikací může být významně negativně ovlivněna usazováním chloridů. K usazování chloridů na površích stavebních objektů dochází buď přímým zatékáním, například z netěsného systému odvodnění mostních konstrukcí, nebo vzdušnou cestou, kdy jsou prachové nečistoty a/nebo aerosol emitovány silničními vozidly z povrchu vozovky. Chloridy usazené na povrchu nosných konstrukcí mohou významně urychlit degradační procesy, především pak korozní poškození konstrukční oceli či betonářské výztuže. Depoziční rychlost chloridů v okolí silniční komunikace závisí na mnoha faktorech a jejich vzájemné kombinaci.

Experimentální ověření vlivů souvisejících s topografií okolního terénu a umístěním či konstrukčním řešením stavebních objektů v okolí silnic je vhodné provádět za předpokladu, že další vlivy (intenzita dopravy, množství použitých posypových solí, klimatické podmínky v době měření) nejsou významně odlišné. Je proto vhodné provádět jednotlivá porovnávací měření na vhodně zvoleném úseku silniční komunikace, optimálně v úseku mezi dvěma křižovatkami.



Obr. 1: Zkušební stojan experimentálního měření in situ - vlevo metoda mokré svíce, vpravo metoda vertikální suché desky, dole metoda horizontální suché desky

3D SCANNING AS AN EFFECTIVE TOOL FOR CONTROLLING THE DIMENSIONS OF TEST SPECIMENS

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Abstract. *3D laser scanning is a powerfull tool that digitally captures the shape of physical objects using a laser light crosses. In this work, the 3D laser scanning technology is used for the 3D shape capture of specially designed specimens. These specimens previously made of fine-grained cement-based composite of the nominal dimensions* $40 \times 40 \times 160$ *mm with inclusion in the shape of prisms with nominal dimensions of* $8 \times 8 \times 40$ *mm were provided with an initial central edge notch and tested in the threee-point bending configuration, see Fig. 1.*

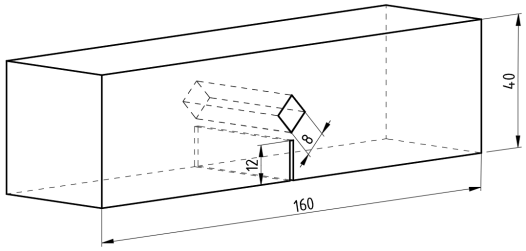

Fig. 1: Specimen geometry.

The aim of this paper is to study the macrostructure of fracture surfaces via 3D scanning technology, verify the designed notch depth and evaluate the fracture toughness based on the measured notch depth and specimen height. The 3D scanning technology has been widely used mainly in the mechanical engineering industry to control the accuracy and quality of products. The principle of the 3D laser scanning technology is based on the projection of a laser beam by laser emitter onto the surface of scanned object and simultaneous scanning of these projected beams by two (or more) high speed cameras located in the 3D scanner. The position of the scanned objects is determined by position targets. The result is a 3D coordinates of all visible points at the laser projection point which generates polygonal mesh after scanning – see Fig. 2.

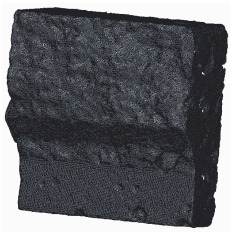

Fig. 2: Polygonal mesh.

From the actual notch depth and specimen height obtained by 3D scanner, the fracture toughness was calculated and compared with the fracture toughness for designed notch depth. The differences between fracture toughnesses are approximately 10 %. In addition, the fracture toughness for designed notch depth is overestimated. Macrostructures of fracture surfaces correspond to the results (values of fracture toughness). The most porous area of ligament and disruption of horizontal alignement of inclusion was found in the case of specimen with amphibolite inclusion, which corresponds to the lowest value of fracture toughness. On the contrary, the most compact areas of ligament were found in the case of specimens with marble and basalt inclusion.

Keywords

3D scanning, fracture test, fracture toughness.

Acknowledgment

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Computational Intelligence in the Analysis of Local Climate and Its Predictions

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Abstract. *One of the important aspects of the structural analysis and building physics is knowledge about local climate in the certain area. Climatic loads in the mechanics of structures are a statistical problem. This paper shows that such data can be obtained and analyzed with the aid of Computational Intelligence built in Wolfram Mathematica and Wolfram|Alpha.As a place of interest, the city of Ostrava is analyzed. Several types of characteristics of climate attributes have been taken into account: air pressure, humidity, air temperature, wind speed, and its direction. Some simulations have also been shown to show the prediction of local climate warming in the future. The designer of a structure and the contractor must have that knowledge for strategic planning of the activity and maintenance of the structure.*

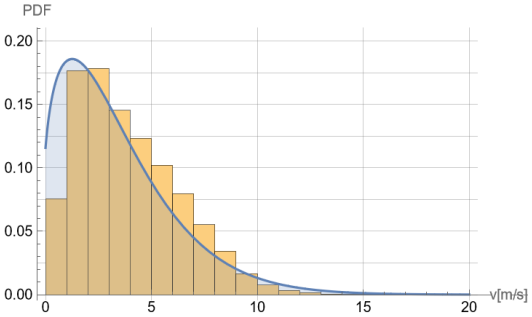

Fig. 1: Histogram wind speed in Ostrava 1951–2022 estimated by Weibull Distribution with $\alpha = 1.3475$, $\beta = 3.95005$ and $\mu = -0.184607$

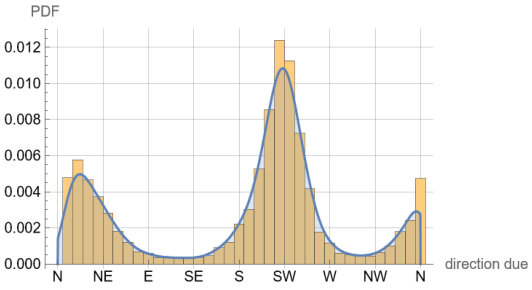

Fig. 2: Histogram of wind direction in Ostrava 1951–2022.

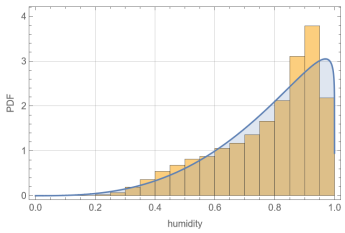

Fig. 3: Histogram of humidity in Ostrava 1951–2022 estimated by Noncentral Beta distribution with $\alpha = 3.80157$, $\beta = 1.0881$, $\gamma = 3.59188 * 10^{-9}$

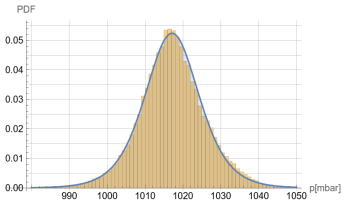

Fig. 4: Histogram of probability density function of air pressure in Ostrava 1.1.1951–3.5.2022 estimated with logistic distribution $\mu = 1017.13$, $\beta = 4.76889$.

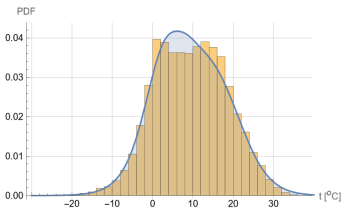

Fig. 5: Histogram of probability density function of air temperature in Ostrava 1.1.1952–3.5.2022 estimated with mixture distribution.

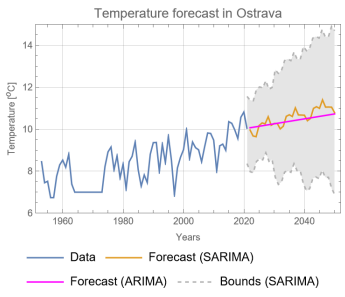

Fig. 6: Warming forecast in Ostrava.

Ponding Effect: Nonlinear Loading on Tensile Surface Structures

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Abstract. *This paper deals with a potentially dangerous phenomenon known as the ponding effect that may occur on tensile surface structures. This phenomenon may cause a local disorder that might lead to fatal damage and collapse of the structure. The aim is to create and verify a searching algorithm in order to localize a possible ponding effect occurrence. Its main purpose is to scan the membrane surface deformed under snow load and locate regions prone to accumulation of melted snow. Thereafter the area of water pond is calculated and the region is burdened with an additional load. A verification is made on the conical structure considering a variety of height to length ratios.*

Keywords

Algorithm, ponding effect, snow load, tensile surface structure.

1. Introduction

Contemporary structures require proper modern solutions. It is inevitable that structure design requirements are on the rise in order to ensure proper utilisation of building materials. This effort leads to the construction of much lighter tensile surface structures. In case of an inappropriate design the structure may deform in an unfavorable way. Hence, the risk of ponding effect is increased in certain areas on a membrane surface with lower inclination such as in Figure 1.

2. Conclusion

Tensile surface structures may provide an excellent service only in case of a proper and thorough design. Hence, different combinations of geometry, prestress and material of conical membrane structure have been calculated and compared.

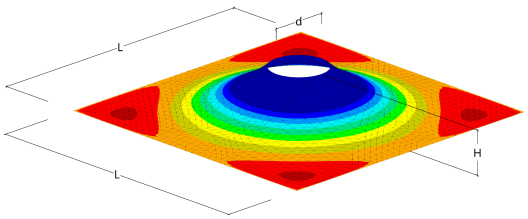

Fig. 1: Dimensions of deformed computational model with ponding water in highlighted corner areas.

The possibilities of shape choice are limitless, but as it has been proved, it is necessary to take into an account every unfavorable phenomena in order to provide a proper solution. The choice of covering material is equally important as are other aspects of the structure.

Acknowledgment

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FRF FUNCTION INFORMATION USEFULNESS IN BRICKS DEGRADATION

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Abstract. *In this article authors shows chosen problems of technical state diagnosis with the use of identification and technical diagnostics methods such as experimental modal analysis. Relations between methods of dynamic state evaluation and methods of technical state evaluation were indicated. Example modal analysis results illustrate the complexity of projecting dynamic state research into diagnostic research of state evaluation.*

Keywords

Technical diagnostics, identification, modelling, modal analysis.

Destruction processes of technical systems force the need to supervise changes of their technical state. It is possible with the use of technical diagnostics methods.

The bases of identification, modelling and concluding fully convince towards the dominating role of vibrations in machine state identification [6.7.8.9]. Properly planned and realized experiment is the base to obtain diagnostically sensitive signals which processed will determine state diagnosis procedures. The process of diagnostic identification includes modelling (symptom or structural), identification experiment (simulation and/or real), estimation of diagnostic parameters (state features or symptoms), diagnostic concluding. The specificity of diagnostic identification tasks is different from general identification in the way that it includes several additional elements enhancing this process.

The dynamic state of the object can be, in the easiest case, described with a model of 1 degree of freedom – Fig.1. A conventional description of this model is known relations indicating that vibrations well reflect the state of the machine. A description of this model can be achieved within m, k, c categories, or through a, v, x research.

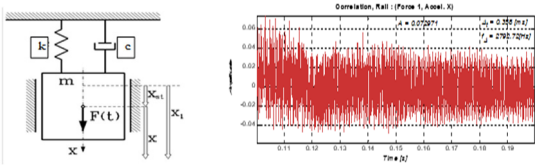

Fig. 1: System model of 1 degree of freedom and vibration signal of real system.

Determining the value (5) requires realizing identification experiment from which the frequency f or frequency ω can be determined. Here is useful the simple identification or modal analysis directly giving the values of own frequencies ω from the stabilization diagram – Fig. 2.

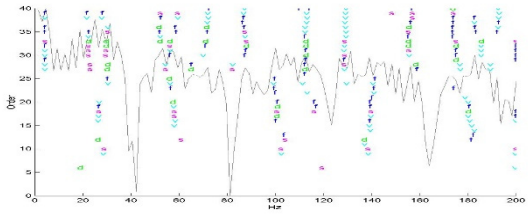

Fig. 2: Stabilization diagram for ω determination.

In the study, it was decided to check is it possible to see a difference in destruction state in bricks, with use of only FRF function. For this purpose, were use 2 types of the samples. There was a full brick tested, and for comparison a cracked full brick was also measured. For a better visualization of the results of the investigation, the results are shown.

FRF – (Frequency Response Function) can be described as a quotient of the Fourier transform vibration exciting force F(ω), the Fourier transform of the response signal A(ω).

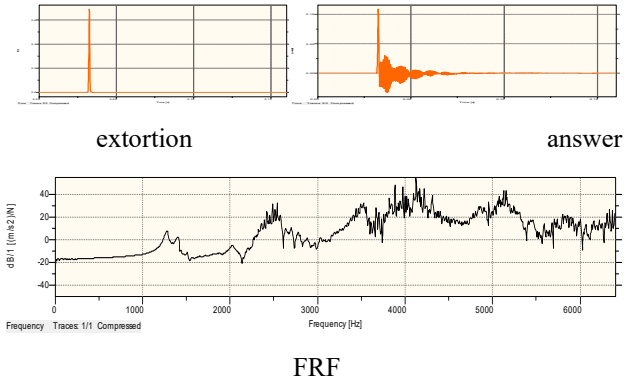

Fig. 3: Composition of results of measurements (the temporary course of extortion, temporary course of answer, function the FRF) the full brick in axis X.

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