Група показатели В: хабилитационен труд – научни публикации в издания, които са реферирани и индексирани в световноизвестни бази данни с научна информация.
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В-1
Автор(и): **Zhelyazov, T.** (2020)
Modeling of the behavior of a friction pendulum seismic isolator on the macroscopic scale.
In Modeling of the Soil-Structure Interaction: Selected Topics; Zhelyazov, T., Ed.; Nova Science Publisher, Inc.: Hauppauge, NY, USA, 2020; pp. 49–85. ISBN: 978-1-53617-683-4
Резюме: The contribution focuses on the modeling and simulation of the mechanical response of friction pendulum systems for passive seismic isolation of buildings and structures. The first part of the chapter introduces testing protocols designed to model a seismic event. The contribution also addresses the formulation of a single-degree-of-freedom (SDOF) model of the isolator. The SDOF model is generalized to a model aimed at the simulation of the 3-D response of the isolator to various excitations, including strong ground motions. The equations of motion, employed in the generalized model, are derived by using the Lagrange formalism. The accurate modeling of the response of the friction pendulum isolator requires the explicit formulation of the constitutive relation for the sliding interface. Therefore, constitutive relations capable of reproducing the interface response are also within the research topics discussed in the contribution.

В-2
Автор(и): **Zhelyazov, T.** (2025)
Numerical analysis of the dynamic response of a structure equipped with friction pendulum bearings.
Uchenye Zapiski Kazanskogo Universiteta. Seriya Fiziko-Matematicheskie Nauki, 167(4), 675-688. (Q3 за 2025) https://doi.org/10.26907/2541-7746.2025.4.675-688
Резюме: This article focuses on the implementation of a lightweight model of a friction pendulum bearing in the finite-element model of a base-isolated structure. The proposed approach appears as an alternative to a high-fidelity finite-element model. The model considers the slider moving on the sliding surface as a material point with three degrees of freedom. The equations of motion for the slider are derived by leveraging the Lagrangian formalism. The three-degrees-of-freedom model is compared with other available analytical approaches that can be employed to define the response of friction pendulum bearings, mainly unidirectional formulations. From the

numerical experiments, the dynamic response of a structure with and without base isolation is obtained using a finite-element analysis. Acceleration time series, recorded during an earthquake, are employed as an input. The numerical results, in terms of displacement and acceleration evolutions, demonstrate the positive effect of seismic isolation on mitigating the risk of failure in the structure.

B-3

Автор(и): **Zhelyazov, T.**

(2024)

Modeling the Response of Friction Pendulum Systems.

In Hydraulic and Civil Engineering Technology IX: Proceedings of the 9th International Technical Conference on Frontiers of HCET, Sanya, China, 25-27 September 2024 (pp. 1021-1027). 1 Oliver's Yard, 55 City Road, London, EC1Y 1SP: SAGE Publications. (Q4 за 2024)

https://doi.org/10.3233/ATDE241093

Резюме:
The contribution focuses on the response simulation of friction pendulum seismic isolators during a strong ground motion. The device is considered an isolated structural element. Its action is effectively described as the motion of a particle (i.e., the slider) on a spherical surface (i.e., the sliding surface). The bearing is inherently a system with three degrees of freedom and a Lagrangian formalism is employed to derive its equations of motion. Taking into account that the slider is constrained to move only on the spherical sliding surface, one of the degrees of freedom remains constant when the bearing is activated. Two second-order ordinary differential equations can be consequently derived for the remaining degrees of freedom. The response of the isolator depends strongly on the friction coefficient. The latter doesn't remain constant; it is assumed to vary with the sliding velocity, the normal pressure acting on the interface, and the rise in temperature during sliding. The input for the analyses is provided in terms of acceleration time series recorded during a real earthquake. Numerical simulations are performed, and results obtained in terms of the slider's trajectories are presented.

B-4

Автор(и): **Zhelyazov, T.**, Debray, K.

(2018, June)

Mechanical Response of a Frictional Seismic Isolator.

In 2018 International Conference on High Technology for Sustainable Development (HiTech). IEEE.

https://doi.org/10.1109/HiTech.2018.8566562

https://www.scopus.com/pages/publications/85060641332?origin=resultslist

Резюме:

Seismic isolation is an attractive option to dissipate the energy transmitted to structures during a strong ground motion and thus mitigate the damage to structural and non-structural elements and to displacement-sensitive and acceleration-sensitive equipment. The dynamic response of a double pendulum is discussed in this paper in the framework of an approximation of the mechanical response of seismic isolation. The contribution is focused on the formulation of a constitutive relation capable of reproducing the behaviour of hardware for seismic isolation on the macro-scale. The macro-model of the seismic isolation is to be implemented in a finite element model of an isolated structure.

B-5

Автор(и): **Zhelyazov, T.**, Debray, K.

(2020, October)

Prediction of the thermo-mechanical behavior of a sliding isolator based on finite element and analytical analysis.

In 2020 III International Conference on High Technology for Sustainable Development (HiTech) (pp. 1-6). IEEE.

https://doi.org/10.1109/HiTech51434.2020.9363973

https://www.scopus.com/pages/publications/85102763043?origin=resultslist

Резюме:
This contribution focuses on the analytical and finite element modelling of the thermo-mechanical behaviour of a friction-pendulum bearing device for passive seismic isolation. The influences of some crucial factors, such as the magnitude and the rate of change of the sliding velocity, the weight of the superstructure, and the rise in temperature on the force-displacement relationship characterizing the isolator, are studied. Numerical results obtained for a realistic testing protocol (plausible values of the applied normal force and sliding velocity) are presented.

B-6

Автор(и): **Zhelyazov, T.**

(2025)

Modeling the Behavior of the Interface in Friction Pendulum Bearings.

In Hydraulic and Civil Engineering Technology X: Proceedings of the 10th International Technical Conference (HCET 2025), Xiamen, China, 26-28 September 2025 (pp. 792-797). 1 Oliver's Yard, 55 City Road, London, EC1Y 1SP: SAGE Publications. (Q4 за 2025)

https://doi.org/10.3233/ATDE251305

Резюме:
Accurate modeling of the interface behavior of friction pendulum bearings is crucial for accurately predicting their dynamic behavior and, consequently, the optimal response of a base-isolated structure during a strong ground motion. The interface constitutive relationship,

typically defined on the macroscopic scale through the friction coefficient, requires consideration of various factors: sliding velocity, normal pressure acting on the interface, and temperature. This contribution presents examples of the numerical implementation of some approaches that predict the dynamic response of the interface. Models defining the interface response are reviewed and illustrated by numerical simulations. Specifically, these are models that reproduce the dynamic hysteresis response of an interface subjected to normal pressure, for bidirectional loading, and account for factors that lead to degradation of the friction coefficient. The latter is commonly assumed to depend on the sliding velocity, the normal interface pressure, and the temperature increase. A characterization test is numerically simulated using an approach in which the complex motion of the slider on the sliding surface is approximated by two coupled single-degree-of-freedom systems that define the response in two principal directions. The focus is on the modeling of the thermo-mechanical response of the interface through a degradable friction coefficient.

B-7

Автор(и): **Zhelyazov, T.**

(2023)

Modeling the response of a lead core rubber bearing for seismic isolation.

In Hydraulic and Civil Engineering Technology VIII: Proceedings of the 8th International Technical Conference on Frontiers of HCET 2023 (pp. 11-17). 1 Oliver's Yard, 55 City Road, London, EC1Y 1SP: SAGE Publications.

https://doi.org/10.3233/ATDE230696

https://www.scopus.com/pages/publications/85181172142?origin=resultslist

Резюме:
Lead core rubber bearings are among the commonly used devices for seismic isolation of buildings and structures. They are a part of the so-called base isolation meant to decouple the superstructure from the ground, thus modifying the structure’s fundamental period and mitigating damage to structural and non-structural elements. Many insightful models have contributed to a better understanding of the lead core rubber bearings' response, considered as a separate unit or components of a seismically protected structure. However, the available models can still be enhanced. Furthermore, prediction of the dynamic structural response always offers, in most cases, unique problems; the incorporated models of the devices for seismic isolation play a crucial role in such a context. The article discusses an approach to predict the lead core rubber bearing response considered as a separate unit. To this end, the needed constitutive relations are defined on the material scale. The behavior of the isolator is then studied by transient finite element analysis. Both ready-to-use material models and original procedures (being developed) are considered. Additionally, some features of a data-driven algorithm designed to predict the response of a lead core rubber bearing are outlined.

B-8

Автор(и): **Zhelyazov, T.**

(2019)

Single-Degree-of-Freedom Analytical Predictive Models for Seismic Isolators.

In: Rupakhety, R., Olafsson, S., Bessason, B. (eds) Proceedings of the International Conference on Earthquake Engineering and Structural Dynamics. ICESD 2017. Geotechnical, Geological and Earthquake Engineering, vol 47. Springer, Cham.

https://doi.org/10.1007/978-3-319-78187-7_14

https://www.scopus.com/pages/publications/85049502395?origin=resultslist

Резюме:
Single-degree-of-freedom constitutive relations aimed at modeling the mechanical response of seismic isolators, specifically lead-core bearing devices and elastomeric bearings, are discussed in this contribution. Two constitutive models are considered. For the lead-core bearings, a model that defines the relation between the shear displacement and the generated shear force is postulated. This model involves a hysteresis parameter, the evolution of which is separately defined. The mechanical behavior of the elastomeric bearings is modeled assuming a constitutive law that takes into account several interacting mechanisms, including mechanical damage accumulation. Numerical procedures are developed for both constitutive relations. These numerical procedures are to be implemented in detailed finite element models and accurate finite element analysis of base-isolated structures.

B-9

Автор(и): **Zhelyazov, T.**, Rupakhety, R., Ólafsson, S.

(2017)

Calibration of constitutive macro model for a lead-core bearing device: Identification based on results obtained by finite element analysis.

In 6th International Conference on Computational Methods in Structural Dynamics and Earthquake Engineering, COMPDYN 2017 (pp. 4306-4314). National Technical University of Athens.

https://doi.org/10.7712/120117.5725.17017

https://www.scopus.com/pages/publications/85042299442?origin=resultslist

Резюме:
An identification procedure based on a genetic algorithm is discussed in this paper. The procedure is aimed at calibrating a single-degree-of-freedom (SDOF) model capable of simulating the mechanical response of a lead-core bearing device for passive seismic isolation. The identification is based on data obtained by finite element simulation. An accurate finite element model is built. All components of the bearing device: lead-core, rubber layers, and steel shims are discretely modeled. The lead-core bearing device is seen as a multiple-component system. Constitutive laws are defined on the meso-scale for all materials: lead core, rubber, steel. Furthermore, a typical identification test is simulated to obtain the shear stress-shear strain

relationship that characterizes the response of the lead-core bearing device. In the SDOF model describing the response of the bearing device on the macro-scale, a damage variable is introduced to account for mechanical damage accumulated in the lead-core.

B-10

Автор(и): **Zhelyazov, T.**, Ólafsson, S., Rupakhety, R.

(2024)

Assessment of the efficiency of the base-isolation for a bridge structure.

In Bridge Maintenance, Safety, Management, Digitalization and Sustainability (pp. 270-277). CRC Press.

ISBN: 978-1-032-77040-6

https://doi.org/10.1201/9781003483755-28

https://www.scopus.com/pages/publications/85200341724?origin=resultslist

Резюме:
Various types of models of a lead core rubber bearing are discussed in this contribution. This includes an analytical model defining the overall behavior of the isolator and a finite element model in which constitutive relations are formulated for the constituencies (rubber, lead, and steel). The models are being developed for implementation in the finite element model of a seismically protected structure. The presented ongoing study aims to simulate the dynamic response of a base-isolated bridge during a strong ground motion. On the one hand, the focus is on the LRB model, and the bridge structure is described with relatively few details. On the other hand, both the analytical and the finite element models are to be implemented in the finite element model of the bridge. Comparison of the dynamic response of the bridge obtained with the LRB models will enable the assessment of the analytical model validity domain.

B-11

Автор(и): **Zhelyazov, T.**

(2025, June)

Application of machine learning algorithms in the investigation of the dynamic response of moment-resisting frames.

In COMPDYN Proceedings (pp. 445–451). National Technical University of Athens.

https://doi.org/10.7712/120125.12421.25364

https://www.scopus.com/pages/publications/105033531575?origin=resultslist

Резюме:
The contribution discusses some aspects of the design and simulation of a reinforced concrete frame structure’s response to a strong ground motion. A machine learning (ML) algorithm is implemented to design some vertical structural elements. To create the database needed to train

and validate the ML algorithm, results obtained by response spectrum analysis are employed. After that, the structural response is again investigated using time-history finite-element analysis. Additionally, algorithms reproducing the action of seismic isolators are integrated into the model of the reinforced concrete structure. Results for the structure with and without isolation are compared in terms of displacements and accelerations monitored at a specific location.

B-12

Автор(и): **Zhelyazov, T.**

(June 2023).

Surrogate modeling of the response of a bearing device for passive seismic isolation.

In COMPDYN Proceedings (pp. 11–17). National Technical University of Athens.

https://doi.org/10.7712/120123.10466.20481

https://www.scopus.com/pages/publications/85203736722?origin=resultslist

Резюме:

The contribution discusses the application of a multilayer perceptron network in the assessment of the behavior of bearing devices for passive seismic isolation. One of the essential characteristics of a bearing device is the relationship between the applied displacement and

the restoring force. Besides the relationship between the applied displacement and the generated restoring force, an extra equation characterizing the evolution of the hysteresis variable is commonly provided. A neural network comprising an input layer, several hidden layers, and an output layer is built to reproduce the nonlinear constitutive relationship for the sliding isolator. The neural network is to be trained to reproduce the response of the bearing device considered separately, i.e., the device response in a characterization test. An accent in the study is on the use of synthetic data for the perceptron's training as an alternative to using data sets using results obtained by finite element analysis or experimental studies.

B-13

Автор(и): **Zhelyazov, T.**, Ólafsson, S., Rupakhety, R.

(2023)

Prediction of the response of a lead-core rubber bearing using machine learning.

In Life-Cycle of Structures and Infrastructure Systems (pp. 1443-1449). CRC Press.

ISBN 978-1-003-32302-0

https://doi.org/10.1201/9781003323020-177

https://www.scopus.com/pages/publications/85186674083?origin=resultslist

Резюме:

Lead-core rubber bearing is a widely used device for seismic isolation. It remains a preferred option for important structures such as bridges, nuclear power plants, hospitals, etc., mainly due to its considerable energy dissipation capability. Accurate predictive models are a prerequisite for a safe and efficient design and thus prolong the life cycle of buildings and structures. A detailed finite element model generally provides insight into the complex behavior of the lead-core rubber bearing. However, being demanding computational resources, its implementation in the base-isolated structure analysis might not be appropriate. The contribution focuses on a more efficient model from a computational point of view –a neural network. Although the neural network doesn't use the physical model, the latter is employed to produce the target data. Some technological aspects of the multilayer perceptron are discussed, such as architecture, choice of the activation function, and training strategies.

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Г-1

Автор(и): **Zhelyazov, T.**

(2024)

Models analyzing the response of the adhesive joint between FRP and concrete: a comparative analysis.

Discover Mechanical Engineering, 3(1), 23. (Q2 за 2024)

https://doi.org/10.1007/s44245-024-00060-9

Резюме:
Fiber-reinforced polymers (FRP) for structural elements' strengthening and rehabilitation are increasingly gaining popularity because of their proven efficiency and ease of application. The response of the adhesive joint formed between the FRP and concrete is a crucial factor influencing the overall behavior of FRP structures. The analysis of interface crack propagation is a complex task involving the consideration of multiple interacting mechanisms. This work aims to provide a background for a recently proposed model that analyzes the behavior of the adhesive joint formed at the interface between the FRP and concrete by creating its counterpart. The study presented herein discusses a model based on fracture mechanics to obtain a reference point needed to assess the output provided by an algorithm utilizing a damage-based model for concrete and an empirical-based procedure for the loss of bond action. Typically, model validation is performed via a comparison against experimental data. However, additional insights into the interacting phenomena can be provided by comparing the results of various applicable models.

Г-2

Автор(и): **Zhelyazov, T.**, Thorhallsson, E.

(2023)

Numerical Simulation of the Behavior of the Adhesive Joint Between FRP and Concrete.

In: Ilki, A., Çavunt, D., Çavunt, Y.S. (eds) Building for the Future: Durable, Sustainable, Resilient. fib Symposium 2023. Lecture Notes in Civil Engineering, vol 350. Springer, Cham. (Q4 за 2023)

https://doi.org/10.1007/978-3-031-32511-3_45

Резюме:
The reported study aims to model the FRP-concrete interface degradation. More precisely, it focuses on the response of the adhesive joint formed between an FRP plate and a concrete element. The performed numerical analyses simulate the progressive local bond failure. The developed numerical procedure incorporates failure criteria associated with various potential failure modes to ensure applicability for different geometries and loading cases. The algorithm is implemented in a general-purpose finite element code. The finite element analyses employ customized constitutive relationships and failure criteria defined for all the constituents of the adhesive joint. The constitutive law for concrete employs the damage mechanics fundamentals. By assumption, the unidirectional FRP material is transversely isotropic and exhibits linear and elastic behavior until failure. A subroutine estimates the state (coupled or uncoupled) of the initially coincident nodes on the FRP/concrete interface and their relative displacements produced by the interfacial shear stress. The numerical procedure does not explicitly model the adhesive layer. Hence, it doesn't incorporate a failure criterion for the adhesive layer. The finite element analysis employs a benchmark example: an 'angled-peeling test' is simulated.

Г-3

Автор(и): **Zhelyazov, T.**, Thorhallsson, E.

(2022)

Loss of Bond Action in FRP-Strengthened Structural Elements: Modeling.

In: Ilki, A., Ispir, M., Inci, P. (eds) 10th International Conference on FRP Composites in Civil Engineering. CICE 2021. Lecture Notes in Civil Engineering, vol 198. Springer, Cham. (Q4 за 2022)

https://doi.org/10.1007/978-3-030-88166-5_22

Резюме:
The contribution focuses on the modeling of the interface between Fiber-Reinforced Polymer (FRP) and concrete. The customized procedure designed for this purpose is to be integrated into the finite element models: taking into account the possible loss of bond action will possibly lead to more accurate predictive results. Within the numerical algorithm, the relative position of the initially coincident nodes on the interface is updated. Before any loading is applied, the degrees of freedom of the coincident nodes are coupled to model a perfect bond. In the loading history, the relative slip between initially coincident nodes occurs in conformity with a predefined slip – stress relationship. The numerical procedure is tested by modeling the progressive loss of bond

action in a single-lap shear test specimen. The utilized empirical data are found in literature sources.

Г-4

Автор(и): **Zhelyazov, T.**

(2018)

Basalt fiber for strengthening of compressed structural elements in concrete and reinforced concrete: finite element modeling.

In Life Cycle Analysis and Assessment in Civil Engineering: Towards an Integrated Vision (pp. 2707-2712). CRC Press.

https://www.taylorfrancis.com/chapters/edit/10.1201/9781315228914-348/basalt-fiber-strengthening-compressed-structural-elements-concrete-reinforced-concrete-finite-element-modeling-zhelyazov

https://www.scopus.com/pages/publications/85063961491?origin=resultslist

Резюме:
The contribution is focused on the numerical simulation of the mechanical response of concrete structural elements loaded in compression and strengthened externally by composite material, specifically Basalt Fiber Reinforced Polymer (BFRP). The constitutive laws defined on the mesoscale for concrete and for the external reinforcement in basalt fiber are discussed. Some details of the numerical solution, including the organization of the computational process and the finite element model built, are reported. Results obtained by finite element analysis are presented: a macro-characteristic of the BFRP-strengthened concrete structural element (i.e., the commonly used stress-strain relationship as well as visualization of the damage initiation and propagation in the concrete.

Г-5

Автор(и): **Zhelyazov, T.**, Donchev, T.

(2019)

Finite element modelling of FRP–strengthened structural elements.

IABSE Symposium, Guimaraes 2019: Towards a Resilient Built Environment Risk and Asset Management - Report (pp. 752–758).

https://www.scopus.com/pages/publications/85065250811?origin=resultslist

Резюме:
Numerical aspects of the analysis of structural elements strengthened with FRP reinforcement are discussed in this contribution. Constitutive laws are defined on the meso–scale for the materials involved (steel, concrete, FRP). The evolution of experimentally observable parameters of FRP-strengthened concrete elements loaded in flexure is obtained by finite element analysis. Numerical results are compared to experimental data. The employed

numerical strategy consists in defining a damage-based constitutive law for concrete. A beneficial outcome of the implementation of such constitutive relation is the possibility to monitor the damage evolution for a given period of exploitation. Since the remaining structural life can be assessed in this way, monitoring of damage accumulation appears to be a prerequisite for an accurate and efficient design of the reinforcement.

Г-6

Автор(и): **Zhelyazov, T.**, Thorhallsson, E.

(2022)

Analytical and Numerical Approaches for the Design of Concrete Structural Elements with Internal BFRP Reinforcement.

Materials, 15(4), 1497. (Q2 за 2022)

https://doi.org/10.3390/ma15041497

Резюме:
Although basalt fiber-reinforced polymers (BFRPs) have been known for a few decades, new trends such as sustainability and environmental care have provoked intensified research on their structural applications. In construction, BFRPs, as internal reinforcement, have to compete with traditional steel reinforcement products. Because of their high resistance to aggressive environments, BFRPs have emerged as an attractive solution for infrastructure in coastal zones. In this article, we discuss some aspects of BFRP applications such as flexural reinforcement of concrete beams. The mechanical performance of a BFRP-reinforced beam is illustrated by using a widely accepted model based on the classical beam theory. The elastic modulus of the BFRP reinforcement is lower than that of structural steel. Therefore, to meet serviceability requirements (e.g., in terms of limitation on the mid-span deflection of a beam), BFRP could be pre-tensioned. The positive effect of pre-tensioning is outlined by finite element analysis. An original numerical procedure involves a constitutive relation for concrete based on damage mechanics. Experimental results previously reported in the literature provide the background for the numerical model procedures. The numerical procedure predicts the mechanical response of the concrete beam with BFRP reinforcement subjected to four-point bending in terms of the load-deflection relationship and the dominant failure mode.

Г-7

Автор(и): **Zhelyazov, T.**

(2026)

Finite-Element Analysis of the Quasi-Static Response of Concrete Specimens Containing Polymeric Self-Healing Microcapsules.

Polymers, 18(11), 1289. (Q1 за 2025)

https://doi.org/10.3390/polym18111289

Резюме:
Healing agent encapsulated in polymeric microcapsules has proven its ability to seal surface and internal cracks. Focused on mitigating the negative impact of capsules on the properties of fresh cement paste and hardened cementitious matrix, uncertainties in self-healing triggering, and poor control of the released quantity, researchers report technological improvements in predominantly experimental studies. However, practical applications will necessitate lightweight models that capture all the characteristics of practical importance. Analysis of the scientific literature reveals the lack of such models adapted for cementitious composites. In this paper, a model rooted in continuum damage mechanics, tuned based on empirical data, is used in the finite element analysis of concrete specimens containing polymer self-healing microcapsules to quantify self-healing efficiency and local damage-healing behavior. The predicted increase in the self-healing rate is more pronounced for specimens subjected to compression compared to that for elements subjected to four-point bending. Thus, for a 20% increase in healing efficiency, strength recovery in compression increases from 18.5% to 32% for C25 and C30, respectively, whereas the corresponding values for tension in the tension-by-flexure setup are 3.5% and 5.3%.

Г-8

Автор(и): **Zhelyazov, T.**, Nedjar, B.

(2025)

Numerical analysis of the autonomous self-healing in concrete structural elements.

In Life-Cycle Performance of Structures and Infrastructure Systems in Diverse Environments (pp. 1703-1710). CRC Press.

https://doi.org/10.1201/9781003595120-206

Резюме:
The contribution presents numerical results obtained by modeling the mechanical response of elements in plain concrete with self-healing capabilities. The capabilities of two approaches are investigated: a model assuming a coupling between elasticity and isotropic damage with isotropic healing, and a model accounting for the damage-induced anisotropy combined with isotropic healing. The model employing isotropic damage and healing is implemented in the finite-element analysis of the damage-healing response of cylindrical specimens loaded in compression and prismatic specimens loaded in tension by flexure. The model accounting for the damage-induced anisotropy reproduces, by finite-element simulations, the damage-healing response of a cylindrical concrete specimen loaded in compression. Additionally, the induced anisotropy is illustrated using a numerical procedure developed in Python. The finite-element procedures quantitatively assess the regain in strength resulting from the activation of autonomous self-healing after a specified period of exploitation.

Г-9

Автор(и): **Zhelyazov, T.**

(2025, August)

Modeling the anisotropic damage in cementitious composites.

In AIP Conference Proceedings (Vol. 3177, No. 1, p. 070007). AIP Publishing LLC. (SJR(2025)=0.146)

https://doi.org/10.1063/5.0296718

Резюме:
Smeared crack models rooted in continuum damage mechanics are one of the available options for modeling material degradation. This contribution focuses on damage accumulation in concrete and, more generally, cementitious composites with self-healing capabilities. In previous publications of the author, it has been demonstrated via comparison with experimental results (in a broader context) that procedures implementing isotropic damage models provide

satisfactory accuracy. However, damage modeling should account for the anisotropy. Since the applied load that generates mechanical damage is generally characterized by a specific direction, the amount of damage in different material directions is expected to vary. Hence, damage might induce anisotropy in an initially isotropic material. A material characterization test that effectively reproduces a uniaxial stress state is simulated using both isotropic and anisotropic damage models. Some case-specific model features within the context of modeling self-healing materials are also considered.

Г-10

Автор(и): **Zhelyazov, T.**

(2022)

Numerical simulation of the response of concrete structural elements containing a self-healing agent.

Materials, 15(3), 1233. (Q2 за 2022)

https://doi.org/10.3390/ma15031233

Резюме:
Self-healing of a crack is a relatively novel technique allowing for the partial recovery of the initial mechanical characteristics of a structural element after some period of exploitation. By a widely accepted convention, self-healing is either autogenous or autonomous. The former is a mechanism inherent to cementitious composites (in particular—concrete), while the latter is an engineered process. Both autogenous and engineered healing have recently been the object of numerous studies. Despite the large amount of research work being carried out, the potential of this technique has not yet been fully realized. The article focuses on the modeling and the finite element simulation of the recovery of the initial material properties resulting from the sealing of cracks. The employed numerical procedure uses a constitutive relation for concrete based on continuum damage mechanics. It captures both the strain-softening and the inverse process-crack healing. Finite element simulations of benchmark cases illustrate the effect of self-healing. The numerically obtained constitutive relations for specimens with and without a healing agent are compared.

Г-11
Автор(и): **Zhelyazov, T.**, Ivanov, R. (2020, December)
Numerical investigation of the mechanical behaviour of a structural element containing a self-healing agent.
In IOP Conference Series: Materials Science and Engineering (Vol. 1002, No. 1, p. 012015). IOP Publishing. https://doi.org/10.1088/1757-899X/1002/1/012015
Резюме: This paper presents a virtual experiment on the behaviour of a self-healing material from the family of cement-based composites that contains a healing agent. A numerical model of a specimen made of a cement-based material and containing a healing agent is subjected to the loading configuration of the four-point bending test, whereby the forces are applied in a quasi-static way. The response of the healed specimen is compared to the response of a specimen that doesn't contain a healing agent. For the specimen that contains a healing agent, homogenization techniques are used to determine the characteristics of the equivalent material (cement-based composite/healing agent) in zones where damage and macro-cracking have occurred, i.e., zones in which the healing agent has been activated. The main result of this contribution is the formulation and validation of a numerical simulation approach suitable for modelling the mechanical behaviour of self-healing cement-based composites.

Г-12
Автор(и): **Zhelyazov, T.**, Ivanov, R. (2020)
Numerical simulation of cracking in concrete using damage mechanics.
Resilient Technologies for Sustainable Infrastructure, Proceedings of the IABSE Congress, Christchurch. https://www.scopus.com/pages/publications/85104792662?origin=resultslist
Резюме: Damage Mechanics is employed to simulate crack initiation and propagation in concrete structural elements. To this end, the stress-strain relationship for concrete is modified by introducing a damage variable that affects the elasticity tensor. The damage-based constitutive relationship defined for concrete is integrated into a general-purpose finite element code. The damage accumulated in each finite element is quantified throughout the loading history. Finite elements in which a critical value of the damage variable is reached are deactivated. The volume of cracks can also be approximately evaluated. The relative amount of cracks is considered by the authors to be an important characteristic of the material in the context of smart, self-healing

concrete. It provides valuable information for the design of a smart structural element, namely in optimizing the amount and pattern of placement of the healing agent.

Г-13

Автор(и): **Zhelyazov, T**., Pshenichnov, S.

(2023)

Simulation of the Mechanical Wave Propagation in a Viscoelastic Media With and Without Stiff Inclusions.

In: Georgiev, I., Datcheva, M., Georgiev, K., Nikolov, G. (eds) Numerical Methods and Applications. NMA 2022. Lecture Notes in Computer Science, vol 13858. Springer, Cham. (Q2 за 2023)

https://doi.org/10.1007/978-3-031-32412-3_30

Резюме:

The contribution focuses on numerically simulating wave propagation in an array of regularly distributed solid inclusions within a viscoelastic matrix. Waves are provoked by a transient load. The study aims to compare wave propagation in the viscoelastic continuum with and without the presence of solid inclusions. To this end, stress and displacement evolutions (in the time domain) are monitored at specified locations at the boundaries of the defined continuum. The case study contributes to a better understanding of the phenomena related to the reflection and diffraction of the mechanical waves by the solid inclusions. The modeled setup, often referred to in the literature as a phononic crystal, will possibly shed light on numerous practical applications. Among others, these are high sound absorption and strategies for the detection of defect locations.

Г-14

Автор(и): **Zhelyazov, T**., Pshenichnov, S.

(2023, December)

Modeling the viscoplastic transient dynamic process.

In Journal of Physics: Conference Series (Vol. 2675, No. 1, p. 012017). IOP Publishing. (SJR(2023)=0.18)

https://doi.org/10.1088/1742-6596/2675/1/012017

Резюме:

A hollow viscoelastic right circular cylinder subjected to a time-dependent load is considered. The cylinder has finite dimensions. A transient load acts upon the inner surface of the cylinder, whereas no loads are applied to the outer surfaces. The end surfaces of the cylinder are restrained to move along the cylinder axis. The viscoelastic behaviour of the material is modelled using Boltzmann – Volterra equations. A yield criterion is implemented in the numerical analyses. By assumption, upon reaching the yield surface, the linear viscoelastic model switches to a plastic

constitutive relation. The transient dynamic behaviour of the material is simulated for different intensities of the applied load and model parameters.

Г-15

Автор(и): **Zhelyazov, T**., Pshenichnov, S.

(2023, November)

Modeling of wave propagation in a viscoelastic medium.

Proceedings (Vol. 2953, No. 1, p. 060001). AIP Publishing LLC. (SJR(2023)=0.152)

https://doi.org/10.1063/5.0177686

Резюме:
The contribution presents a study of the propagation of waves in a hollow finite cylinder provoked by a transient load. The viscous behavior is superimposed on linear elasticity in terms of the linear Boltzmann-Volterra model. The proposed semi-analytical algorithm includes Laplace transform with respect to time applied to the wave equation with an account for the specified stress-strain relationship, boundary, and initial conditions. The solution is found in the space of images and is then `projected back' into the space of originals. Alternatively, the wave propagation is investigated by monitoring the stress and the displacement evolution in a specified location within a transient, finite element analysis. Viscoelasticity is modeled by modifying the material parameters according to a predefined time-dependent constitutive relation. Both analyses employ the same geometry and comparable boundary conditions, assuming isotropic viscoelasticity and constant Poisson’s ratio.

Г-16

Автор(и): Pshenichnov, S., **Zhelyazov, T**.

(2022, October)

Dynamic problems for linear-viscoelastic bodies.

In AIP Conference Proceedings (Vol. 2637, No. 1, p. 030006). AIP Publishing LLC. (SJR(2022)=0.164)

https://doi.org/10.1063/5.0118702

Резюме:
A non-stationary dynamic problem of linear viscoelasticity is considered under the condition of a limited perturbation propagation domain. The connection of such a problem with the problem of free oscillations of the body under consideration is established. The structure of the set of eigenvalues of the spectral problem of free oscillations is investigated. The cases when the Poisson's ratio of the material is constant, as well as the case when it depends on time, are considered. A method for finding eigenvalues in the vicinity of the limit points of the spectral set is proposed. It is assumed that relaxation kernels are represented as a finite sum of exponents. For the case when the Poisson's ratio depends on time, as an example, the solution of the problem of the propagation of unsteady waves in the cross section of a linear viscoelastic cylinder is

constructed. The resulting solution is valid over the entire time range and is convenient for numerical implementation. An example of calculations performed on the basis of the constructed solution with specific source data is given.

Г-17

Автор(и): **Zhelyazov, T.**

(2022, September)

Numerical investigation of waves propagation in a viscoelastic material.

In AIP Conference Proceedings (Vol. 2505, No. 1, p. 080015). AIP Publishing LLC. (SJR(2022)=0.164)

https://doi.org/10.1063/5.0101114

Резюме:
The contribution reports some results from a numerical study of the wave propagation process in a viscoelastic medium. Specifically, evolutions of stress and displacements provoked by a transient load are monitored at a predefined location. A material constitutive relation that defines the viscoelastic response based on the generalized Hooke's law is discussed. A numerical procedure designed to modify the material properties as a function of the assumed viscoelastic constitutive relation is integrated into a transient, finite element analysis.

Г-18

Автор(и): **Zhelyazov, T.**

(2022, April)

Analytical investigation of wave propagation in a deformable viscoelastic media provoked by a transient load.

In AIP Conference Proceedings (Vol. 2459, No. 1, p. 030041). AIP Publishing LLC. (SJR(2022)=0.164)

https://doi.org/10.1063/5.0084690

Резюме:
Wave propagation in a viscoelastic material is studied in this contribution. After postulating the wave equation and the stress-strain relationship, boundary, and initial conditions, the problem is approached using the Laplace transform with respect to time. Viscosity is superimposed on linear elasticity through the linear Boltzmann-Volterra model. Analytical solution of the wave propagation in a deformable body generated by a transient load is discussed. The deformable body is treated as a single-degree-of-freedom system. The contribution aims to shed light on the mathematical insight of the solution to the wave equation obtained based on the Laplace transform.

Г-19

Автор(и): Korovaytseva, E., Pshenichnov, S., Bazhlekova, E., **Zhelyazov, T.**

(2022)

Non-stationary waves in a linear-viscoelastic cylinder with rigid inclusion.

Problems of Strength and Plasticity, 84(1), 5-14. (Q4 за 2022)

https://doi.org/10.32326/1814-9146-2022-84-1-5-14

https://www.scopus.com/pages/publications/85130830316?origin=resultslist

Резюме:
We have constructed a solution to a non-stationary dynamic problem for a linear-viscoelastic homogeneous infinitely long cylinder with a rigid axial inclusion exposed to an axisymmetric radial load uniformly distributed along the element of the cylinder. On the contact surface with a rigid inclusion, the displacements are equal to zero. The hereditary properties of the material of the cylinder are taken into account using the Boltzmann–Volterra linear integral relation, and the Poisson's ratio of the material is considered time-independent. The integral Laplace transform in time is applied to the initial problem, and the analysis of the solution in images is carried out. In the case when the hereditary kernel is an exponential two-parameter, the originals of the displacement and stresses are constructed in the form of series. Asymptotic formulas for the stresses behind the front that first came from the loaded boundary are obtained. The constructed solution to the non-stationary problem is valid over the entire time range and does not require that the viscosity be small. With the help of the constructed solution for the case of an exponential relaxation kernel, investigations of the wave process in a cylinder cross-section with various initial parameters are carried out. It is established that in the case of a compressive external load, significant tensile stresses occur at certain moments at the contact boundary with a rigid inclusion. They decrease with the growth of the parameter characterizing the viscosity of the material. With a stepwise change in time of the external load, the dependence of the maximum tensile stresses at the boundary with a rigid inclusion on the inclusion relative radius and the viscosity parameter of the material is investigated.

Г-20

Автор(и): Hovorukha, V., **Zhelyazov, T.**

(2020)

Assessment of the stability and loading indicators of two-axle mine cars and rail tracks.

In E3S Web of Conferences (Vol. 168, p. 00044). (SJR(2020)=0.203)

Резюме:
The paper presents the research results on the stability and loading of the two-axle mine cars and rail tracks with various design schemes for the construction of transport systems of underground rail haulage. The dependence of changes in loading, stability, and operation safety of rolling stock on the parameters of irregularities, curvature radii of the rail track, and the movement speed of rolling stock at various technical solutions of the transport system has been studied. The research results of the interaction between the two-axle mine cars and rail track with the gauge of 750 mm for underground rail haulage are presented. The parameters of the rail track irregularities in the horizontal and vertical planes have been determined, which cause the highest values of vertical and horizontal loads acting on the rail track and the two-axle rolling stock. The recommendations are proposed for improving the study of rail vehicles and regulatory document development for the construction and operation of the track structure. The results can be applied to underground rail haulage when creating new vehicles for mines.

Г-21

Автор(и): Kiriia, R., Smirnov, A., Zhyhula, T., **Zhelyazov, T.**

(2020)

Determination of the limiting angle of inclination of tubular belt conveyor.

In E3S Web of Conferences (Vol. 168, p. 00047). (SJR(2020)=0.203)

https://doi.org/10.1051/e3sconf/202016800047

Резюме:
Currently, the widespread use of tubular belt conveyors is constrained by insufficient justification of the conveyor parameters. In this work, on the basis of the theory of the limiting equilibrium state of bulk load, equations of equilibrium of load on the belt of an inclined tubular conveyor are obtained. It is assumed that the belt is a rigid cylinder filled with bulk material in extreme equilibrium. Based on the obtained equilibrium equation, the analytical dependences of the limiting angle of inclination of the belt conveyor with a tubular belt on the degree of unfilling with the bulk load of the belt and the properties of the bulk load are found. From the analysis of these dependencies, it follows that the limiting angle of inclination of the tubular belt conveyor depends on the angle of internal friction of the transported load, the angle of friction of the load on the conveyor belt, and the angle of unfilling of the belt with load, and does not depend on the radius of the conveyor belt.