Abstracts of Papers in English

GENERATION OF PERFORMANCE SPECTRA FOR DESIGNING NEGATIVE STIFFNESS DEVICES AND THEIR APPLICATION IN BRIDGES UNDER EARTHQUAKES

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Abstract
In this study, the authors present the performance spectrum (P-Spectra) for an idealized shear SDOF equipped with two types of passive negative stiffness devices. The first device includes a pre-compressed spring, gap springs at the bottom, and a combination of frame elements and plates that hold the parts together. The other device consists of three gears designed to control the movement of the primary gear and affect the response of the structure. Negative stiffening devices are used to reduce the stiffness of the system and increase the displacement of the structure. To prevent displacement increase, a viscous damper with 20% damping is used in parallel to the negative stiffness device. The SDOF structure has a post-yield stiffness of 5% pre-yield stiffness. Using the NLA method, P-Spectra for 0.5 to 2.5 periods are plotted for different mechanical parameters of negative stiffness devices. To construct the performance spectrum, dimensionless parameters of spring stiffness ratio to structural stiffness and yield strength ratio of the device and structure to the structure are used. The performance spectrum is investigated in designing the parameters of the negative stiffness device and its effects on reducing the response of structures. The authors also use a benchmark highway bridge structure in MATLAB software to investigate the effectiveness of systems designed using this method. The obtained target parameters demonstrate the desired results of this method in

designing negative stiffness systems and reducing the responses. The presented findings suggest the potential of using negative stiffness devices as an effective solution to reduce structural response during seismic events.

Key Words: Performance-Based design, negative stiffness device, benchmark structures, passive control.

PREDICTION OF DETERIORATION COMPONENTS IN REINFORCEMENT CONCRETE COLUMNS USING MACHINE LEARNING TECHNIQUES

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Abstract

New performance-based design approaches in earthquake engineering aim to accurately and transparently assess the risk of loss of life and structural damage. Advanced analytical models are used to determine the performance of structures, with one of the key components being the deterioration of structural members under seismic loads. Multilinear backbone curves are commonly used in regulations and software to simplify the behavior of members subjected to seismic loads, including the deterioration components. This paper proposes using machine learning models to predict the deterioration components of reinforced concrete (RC) columns. A dataset of 255 experimental data from 1973 to 2002 is used to predict the deterioration components using different machine learning methods. The RC columns have three failure modes: Bending, shearing, and bending-shearing. The deterioration components predicted by the analytical relationships are compared with the results obtained from machine learning methods. The dataset includes 14 features as model inputs and 3 features as outputs. The paper examines three algorithms for predictions: AdaBoost, artificial neural network (ANN), and random forest (RF). The analysis is conducted using Python software. The results show that the random forest model has an accuracy rate of 91% for the Plastic chord rotations from yield to cap(θ_p), 81% for Post-capping plastic-rotation capacity from the cap to point of zero strength (θ_{pc}), and 88% for normalized energy dissipation capacity (λ) compared to other algorithms.
Also, the results obtained from the predicting models have considerable accuracy compared to analytical relationships. Compared to analytical models, the random forest model has significantly been improved in terms of root mean square error (RMSE), mean absolute error (MAE) and coefficient determination (R^2). These improvement are 79% (θ_p) , 75.3% θ_{pc} and 46.5% (λ) in (R^2), 63.7% θ_p , 48.5% θ_{pc} and 86.7 (λ) in (RMSE), 64% θ_p , 92% θ_{pc} and 89.4% (λ) in (MAE).The results showed that the random forest model has been significantly improved the accuracy of determination of deterioration components compared with analytical models.

Key Words: Deterioration of components, machine learning, artificial intelligence, artificial neural network, random forest.

OPTIMIZATION OF THERMAL CHARACTERISTICS OF INDUSTRIAL STRUCTURES USING ANALYTIC NETWORK PROCESS (ANP)

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Abstract

The ever-increasing energy consumption rate in the construction industry has prompted structural engineers and designers to explore innovative ways to reduce energy consumption throughout the construction-to-demolition cycle. To achieve this, improving the thermal and mechanical characteristics of structural and non-structural elements, along with expanding the application of these materials, is paramount. This approach significantly re-

duces energy consumption and minimizes harmful effects, aligning with the goals of sustainable development. The serviceability characteristics of a structure depend on several parameters that evaluate the thermal behavior of materials. Dynamic heat-transfer analyses of structural components play a critical role in designing energy-efficient new buildings. Thermal conductivity is a key dynamic parameter worth mentioning. However, the thermal conductivity of materials is highly dependent on operating temperatures and moisture content, and little information is available on the performance of insulation materials under actual climatic conditions. Furthermore, temperature profiles in materials are a function of the inside and outside temperatures and thermo-physical properties of the materials. When a heat wave strikes the outer surface of a wall, it travels through the wall and deforms based on the material properties before reaching the inner surface. This phenomenon is referred to as "time lag" and is a critical factor in understanding the thermal behavior of building materials. This study employs an advanced network analysis to determine the most energy-efficient structural panel and steel for constructing the structural components. The selection of the optimal structure is based on key criteria such as thermal conductivity of the panels, time lag, weight of the structure, and cost. By utilizing the Analytic Network Process (ANP) method, the best energy-efficient structure can be chosen. To calculate these parameters, a three-span silo was simulated in the SAP2000V19.2 software.

Key Words: Silos, building panels, energy reduction, thermal conductivity parameters, optimization.

INJECTABILITY OF COLLOIDAL NANO-SILICA IN BUSHEHR CARBONATE SAND WITH DIFFERENT SILT CONTENT

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Abstract

The diverse carbonate materials found in Iran exhibit varied physical, mechanical and chemical behaviors, making their stabilization a subject of great interest. Further research is necessary to investigate their properties. The engineering properties of problematic soils, like carbonate sand, can be enhanced by using suitable chemical soil stabilizers. Colloidal nano-silica solution injection in carbonate soils is highly beneficial, especially in small pores where injecting cement slurry is not feasible. Colloidal nano-silica is a suspension of silica nanoparticles in water, having viscosity similar to water, facilitating injection into such soils. Moreover, it is environmentally and chemically non-toxic. In this study, carbonate soil with varying silt contents (0%, 10%, 20%, 30%, and 40%), different nano-silica concentrations (10%, 20%, and 30%) and an average density of 50% were investigated for injectability along the Persian Gulf coast (Bushehr port). Injection was possible at a pH of about 6.5 with all concentrations, especially at 30%. Unconfined compression tests were carried out at different silt contents, curing periods, and nano-silica concentrations to determine the optimal injection concentration. The results showed that the unconfined compression resistance increased with higher concentrations of nano-silica, with 30% concentration demonstrating the best performance. Injecting colloidal nano-silica in carbonate soils, particularly silty sand, can serve as a stabilizing agent in construction.

Key Words: Bushehr carbonate silty sand, colloidal nano-silica, grouting, stabilization, unconfined compression test.

A DISTURBED STATE CONCEPT-BASED SOLUTION FOR NONLINEAR CONSOLIDATION OF SOILS

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Abstract
This paper proposes a simplified solution for the nonlinear consolidation of soft soils under a wide range of loading using the disturbed state concept. The mechanical properties of soil are stress-dependent, and this affects the soil's compressibility and permeability. However, Terzaghi's conventional theory of consolidation neglects these changes in soil parameters during the consolidation process, which limits its applicability beyond materials with constant parameters. Other sophisticated theories for nonlinear consolidation require advanced calculations that cannot be performed without special programs and codes. The proposed method uses the disturbed state concept to determine the solutions of the nonlinear partial differential equation of consolidation based on the solutions of the linear consolidation partial differential equation in two reference states and a sigmoid form state function for interpolation. The state function is derived using the nonlinear finite difference method. The proposed method accounts for both material nonlinearity arising from changes in the compressibility and permeability of the soil layer and geometrical nonlinearity arising from changes in the thickness of the soil layer. The proposed method adopts the solutions of Terzaghi's theory of consolidation to the solutions of nonlinear consolidation. The results of the proposed method are verified using the results of the nonlinear finite difference method and laboratory data published in the literature. The verification of the results indicates the accuracy of the proposed method.

Key Words: Nonlinear consolidation, disturbed state concept, compressibility, permeability, degree of consolidation.

THE EFFECT OF NOZZLE GEOMETRY ON THE BEHAVIOR OF SALINE EFFLUENT DISCHARGED IN AN INCLINED SUBMERGED FORM WITH AN ANGLE OF 60°

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Abstract
In recent decades, the increase in desalination plant construction along coastlines due to climate change and fresh water resource depletion has been a major concern. The discharge of concentrated wastewater directly into the sea has been shown to cause irreversible damage to the environment. Therefore, the use of appropriate dischargers is crucial in reducing the negative environmental effects of this waste. In this study, ANSYS-FLUENT software was used to simulate the behavior of condensed effluent discharged from circular, triangular, and diamond nozzles. To investigate the effect of nozzle geometry, diamond and triangle nozzles with different dimensions (triangle 1, triangle 2, diamond 1, and diamond 2) were modeled. The effluent was discharged obliquely at a discharge angle of 60 degrees to the horizon in both static and dynamic water environments. The K-ε turbulence model (RNG) was employed for modeling, and the results were validated by comparison with experimental data. The results showed that the height of the maximum jet ascent and the horizontal distance of the point of impact of the effluent with the ground decrease, while the dilution rate of the effluent increases as it leaves the nozzle in a sheet. Moreover, the results indicated that the spreading rate at the inner edge of the jet is lower than that at the outer edge of the jet due to the presence of the bed and the Coanda effect. However, the nozzle geometry was found to have no effect on the reduction of concentration in the center line of the jet. The use of diamond 2 and triangle 2 nozzles for the discharge of concentrated wastewater was found to reduce environmental damage. The findings of this study provide insight into the design of appropriate dischargers for desalination plants and highlight the importance of considering environmental impacts when discharging waste water.

Key Words: Jet, effluent, plume, dilution, desalination.

DAMAGE IDENTIFICATION IN STEEL PLATES USING A DETECTION ALGORITHM BASED ON 1D CONTINUOUS WAVELET TRANSFORM AND 2D VIBRATION MODE SHAPES

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Abstract
In order to examine and monitor the health of structures, it is essential to identify and pinpoint the site of damage in structural elements and connections. After timely detection of various damage situations, it is possible to prevent the spread of damage by repairing the damage or, if necessary, replacing damaged elements, thereby mitigating potential social and economic losses. The construction industry is increasingly employing thin steel wall plates, particularly as steel plate shear walls. Damage to plate members, particularly steel plate shear walls, can be transferred to other elements and cause overall structural damage. Consequently, this article discusses detecting and determining various damage positions in the steel plate element. ABAQUS finite element analysis software was employed to model both the damaged and undamaged states of the steel plate. Subsequently, dynamic modal information was extracted, including natural frequencies and vibration mode shapes. The study observed a difference in frequency values between the primary and secondary states and an asymmetry of the angle matrix between the primary and secondary forms of the vibration modes due to the presence of damage. After that, a detection algorithm based on the use of primary and secondary shapes of two-dimensional vibration modes and continuous wavelet transform with a one-dimensional theoretical background was proposed, and the detection indices DI-L (detection index of longitudinal extension) and DI-W (detection index of transverse extension) were posited and calculated using the MATLAB.R2021a program. The graphical results of the investigations pertaining to the two proposed indices demonstrated the effectiveness and capability of two-dimensional detection of various damage situations, as peaks resulting from the values of detection indicators appeared in the form of irregularities and disturbances in the damage situations. In addition, the identification values achieved using the detection index matrix for the longitudinal extension were more accurate than those obtained using the detection index matrix for the transverse extension.

Key Words: Structural health monitoring, damage identification, 1-D continuous wavelet transform, vibration mode shapes, damage detection index.

IMPROVING THE PERFORMANCE OF A FUZZY LOGIC MODEL IN SEISMIC DAMAGE PREDICTION USING A GUIDED ADAPTIVE SEARCH-BASED PARTICLE SWARM ALGORITHM OPTIMIZATION

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Abstract
This paper proposes a fuzzy logic model to improve the accuracy of seismic damageability simulations for buildings. The Rapid Visual Screening (RVS) method is often used to evaluate seismic damages in buildings due to its speed and simplicity, but it can be subject to human error and other uncertainties. The proposed model uses fuzzy logic to address these uncertainties and build a more robust simulator for estimating the seismic damage state. To fine-tune the hyperparameters of the fuzzy model, the Guided Adaptive Search-based Particle Swarm Optimization (GuASPSO) algorithm is used, which has been shown to be efficient and effective. The model is applied to simulate the damageability of reinforced concrete buildings damaged in the 2017 Sar-Pol-Zahab earthquake in Iran, and the results are compared to those obtained using two popular meta-heuristic optimizers, the PSO and GWO algorithms. The results demonstrate that the GuASPSO algorithm outperforms the other two in terms of performance metrics in the training, validation, and total data sets. The proposed

model is a significant step toward more accurate and practical seismic damageability simulations.

Key Words: Rapid visual screening, seismic damageability, reinforced concrete structures, optimization, GuASPSO, fuzzy logic, self-organizing map.

ESTALISHING A NONLINEAR OPTIMIZATION METHOD FOR STRUCTURAL RELIABILITY ANALYSIS

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Abstract
The Hasofer-Lind and Rackwitz-Fiessler (HLRF) algorithm, which is based on the first-order reliability method (FORM), is widely used to estimate failure probability, reliability index, and design point in structural reliability analysis. However, due to the high nonlinearity of the limit state surface, the HLRF algorithm can be unstable. To address this issue, this paper proposes an optimization method to locate and estimate the design point in the standard normal space and calculate the corresponding failure probability. The reliability problem is solved using sequential least squares programming (SLSQP) to improve accuracy, robustness, and efficiency. SLSQP replaces the quadratic programming problem with a linear least-squares problem, using a stable LDL factorization of the Hessian of the Lagrangian equation. The initial optimization problem is converted into a minimum distance optimization problem with a lower bound constraint. To eliminate linearization errors, the probability expectation method with rotation directions space is employed. The proposed algorithm is demonstrated in several benchmark numerical examples with both explicit and implicit limit state functions. Its fast convergence rate is a notable feature of the proposed algorithm, which enhances its competitiveness in structural reliability analysis.

Key Words: Structural reliability analysis, failure probability, numerical optimization, probability expectation, sequential least squares programming.

OPTIMIZED DESIGN OF BI-ROCKING STEEL BRACED FRAMES VIA CHANGING THE SECOND ROCKING JOINT LOCATION

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Abstract
After an earthquake, plastic deformation of structural elements can render repairing uneconomical, thus necessitating the adoption of low-damage systems that mitigate the residual drift of structures. Among these, self-centering rocking-core systems have been extensively explored. However, due to the geometric nonlinearity of such systems, higher modes dominate their seismic responses, which necessitates the incorporation of secondary rocking joints to minimize their effects. Nevertheless, identifying the optimal location of such joints is challenging, given the redistribution of internal forces between the rocking plates. In this context, a bi-rocking steel braced frame is designed using the modified modal superposition method(MMS), accounting for higher mode effects. Subsequently, the secondary joint is moved floor by floor to determine its optimal location that minimizes shear, overturning moment, peak floor acceleration, and drift. To represent damage to non-structural components, peak floor acceleration and drift are chosen as key parameters. Three sets of seven ground motions, namely Far-Field (FF), Near-Field-Pulse (NF-Pulse), and Near-Field-no-Pulse (NF-No Pulse), are considered for frames

of 12, 18, and 24 stories, modeled using OpenSees software in 2-dimensional frameworks. A total of 1071 nonlinear time-history analyses are carried out, and the results indicate that the conventional practice of placing the secondary joint in the mid-height is inadequate for the 12-story frame under NF-Pulse records, causing a 15.1% deviation from the optimal state of overturning moment. In most cases, placing the joint at 40% height reduces all four demands. To evaluate demand sensitivity, the standard deviation of their percentage difference with the optimal state is computed, with higher values indicating greater unpredictability. Among the sets of records, FF and among demands, overturning moment exhibit the highest sensitivity to the location of the secondary joint, with changes in overturning moment being correlated with shear. Therefore, we suggest selecting overturning moment as an optimization objective function.

Key Words: Bi-rocking system, modified-modal- superposition method, optimizing place of second rocking joint, residual inter-story drift, peak floor-acceleration.

NUMERICAL MODELING OF THE GEOTEXTILE POSITIONING ANGLE IN THE BASE AND SUBBASE LAYER OF THE ROAD PAVEMENT

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Abstract
Geotextile is a useful member of the geosynthetics family, characterized by high tension resistance, good filtration, and flexibility. One of its main applications is as a separator and border creator between base and subbase materials, preventing the entrance of aggregates from other layers and providing good filtering at the border of the base and subbase layer. Designing and constructing embankments on loose subgrades is a critical issue in geotechnics, given the high compressibility and low shear strength of loose soils, leading to long-term deformation and embankment instability, which decreases the useful life of the structure. Various methods, including soil reinforcement, have been proposed to improve embankment stability. This paper aims to improve the reliability coefficient of embankments reinforced by geotextile at different angles and placed on soft soil using the finite element method and the PLAXIS software. The results show that changing the geotextile angle from 0 to 0.95 degrees in sandy soil causes a 53% decrease in the embankment's safety factor, whereas this change had little effect on clay soil, with a 2.9% decrease in the safety factor by increasing the geotextile angle from 0 to 2.01 degrees. Furthermore, increasing the resistance of geotextile by about 2.86 times increases the reliability factor by an average of 14.31% in sandy soil and 2.125% in clay soil. This increase in geotextile resistance also raises the embankment's settlement limit until the moment before rupture by 60.64%.

Key Words: Stability of the embankment, improving the reliability, geotextile, reinforcing soil, PLAXIS software.

VALIDATION OF TURBULENCE MODELS FOR DENSE EFFLUENT DISCHARGED FROM CIRCULAR AND SQUARE NOZZLES WITH A DISCHARGE ANGLE OF 45°

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Abstract
Today, due to the lack of potable water resources in different areas for urban and rural development, serious problems arise in the field of water resources management and supply. One solution to help solve this problem

in coastal areas is the use of water desalination systems. The construction of these projects, in addition to the positive effects they have on water supply, can also lead to environmental problems and change the natural state of the area being used. Therefore, efforts should be made to minimize these negative effects. Given the limitations and high costs of laboratory studies, numerical models are necessary to reduce costs. This research focuses on the validation of the SST $(k-\omega)$, Standard $(k-\varepsilon)$, and RNG $(k-\varepsilon)$ turbulence models using ANSYS-FLUENT software to investigate the behavior of saline effluent discharged from circular nozzles and square nozzles (with a discharge angle of 45 degrees). For this purpose, the results of SST, Standard, and RNG models are compared with the results of different studies. To simulate the behavior of the effluent, the model geometry was first designed in SPACE-CLAIM software, and then meshed using ANSYS-MESHING. Short meshes were used near the discharge site, and the length of the meshes increased as the distance from the discharge site increased. After meshing, the model was entered into the FLUENT software for quantification. The Velocity Inlet boundary condition was used for the nozzle opening, the No Slip boundary condition was used for the bed of the discharge area, and the Symmetry boundary condition was used for the walls around the discharge area. The results of turbulence models are more reliable than the results of integral models due to the consideration of flow turbulence. Based on the results, turbulence models are a suitable tool for predicting the behavior of concentrated wastewater discharged from circular and square nozzles. Standard and RNG models have similar behavior, and their results are more reliable compared to SST model results. The RNG model estimates the dilution value with a smaller difference compared to other models and is recommended as the best model.

Key Words: Nozzle geometry, desalination, dilution, jet, effluent.