Abstracts of Papers in English

ANALYTICAL AND EXPERIMENTAL STUDY ON TWO-TIERED MSE WALLS

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Abstract

A pseudo-static coefficient is required for pseudo-static analysis of mechanically stabilized earth (MSE) walls, but there are no clear criteria for its selection. The current study assessed the horizontal pseudo-static coefficient (k_h) for MSE walls by considering the effects of a tiered configuration and reinforcement type. For this purpose, by selecting two reinforcement types (steel strip and geogrid), six two-tiered MSE walls with three different offset distances and two integrated MSE walls (without tier) were prepared and then were shaken using shaking table tests to determine the geometry of the slip surfaces and the force distribution along the reinforcements at the failure stage. The physical models then were simulated using the limit-equilibrium horizontal slice method to estimate the value of k_h required to establish slip surfaces and reinforcement forces similar to those observed in shaking table tests. Because the equivalent pseudo-static coefficients obtained, were corresponding to the failure stage, they were considered as the upper bound values. The analytical models used a new formulation of the horizontal slice method (HSM) based on the slip surfaces observed in the shaking table tests. This formulation made it possible to determine the distribution of k_h along the wall height as a function of the reinforcement type, offset distance, and PGA. It was found that, as the offset distance increased, the pseudo-static coefficient required for the upper and lower halves of the tiered wall models increased and decreased, respectively. This was observed in both types of reinforcement, but was more prominent in walls reinforced with metal strips. Moreover, the distribution of k_h along the wall height showed that a lower pseudo-static coefficient was required for the upper layers of the integrated walls, but the reverse was true when using a

tiered configuration. This change in the trend of the k_h distribution, which was due to the increase in the dimensions of wedge failure in the lower half and a decrease in dimensions in the upper half of the wall required a larger coefficient in the upper layers of the tiered walls.

Key Words: Pseudo-Static coefficient, two-tiered mechanically stabilized earth wall, shaking table test, horizontal slice method.

DETERMINATION OF STRUCTURAL PROPERTIES USING STRUCTURAL MODAL PROPERTIES AND OPTIMIZATION ALGORITHMS: GENETIC ALGORITHM, PARTICLE SWARM OPTIMIZATION AND TEACHING-LEARNING-BASED OPTIMIZATION

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Abstract

This paper investigates the accuracy and convergence rate of different metaheuristic algorithms in determining the stiffness of structural elements using structural modal parameters and defining a suitable objective function. To achieve this purpose, three different structures, including a three-story one-dimensional frame, a six-story one-dimensional frame and a two-dimensional truss, were investigated. The metaheuristic algorithms, employed in this study, were Genetic Algorithm, Particle Swarm Optimization, and Teaching-learning-based Optimization. The objective function utilized in this study consists of two terms; the first part involves the squared difference between the first frequency of the structure obtained from the responses of the investigated structure and the first frequency obtained from the hypothetical stiffness matrix in each generation of algorithms. The second part measures the norm of the difference between the first mode shape of the structure obtained from the responses of the investigated structure and the first mode shape obtained from the hypothetical stiffness matrix in each generation of algorithms. By minimizing the objective function, the Genetic Algorithm, Particle Swarm Optimization, and Teaching-learning-based Optimization determined the element stiffness of the three-story, six-story and truss structures, thus demonstrating the high efficiency of metaheuristic algorithms in resolving unknown parameters of structures. The average run time for the Genetic Algorithm was 3.38 seconds, 4.47 seconds, and 15.73 seconds for the three respective problems. For Particle Swarm Optimization, the times were 3.76 seconds, 6.47 seconds, and 16.76 seconds. The Teaching-learning-based Optimization achieved times of 1.92 seconds, 4.51 seconds, and 12.76 seconds. The Teaching-learning-based Optimization exhibited the highest convergence rate and the lowest error compared to the Genetic Algorithm and Particle Swarm Optimization. For example, in the two-dimensional truss, the values of the objective function in the last iteration of the Genetic Algorithm, Particle Swarm Optimization, and Teaching-learning-based Optimization were 0.012, 6×10^{-4} and 4×10^{-4} , respectively. The Particle Swarm Optimization demonstrated an acceptable convergence rate and error compared to the Genetic algorithm. The Genetic Algorithm, however, displayed a significant error rate in determining the stiffness of structural elements compared to the other two algorithms.

Key Words: Structural health monitoring, genetic algorithm, particle swarm optimization algorithm, teaching-learning-based optimization algorithm.

EVALUATION OF TEMPERATURE VARIATION EFFECTS ON THE SWELLING CHARACTERISTICS OF FINE-GRADED SOILS IMPROVEMENT WITH SODIUM ALGINATE IN CONSTANT VOLUME CONDITION

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Abstract

In some regions with hot and dry climate conditions, the temperature varies greatly between day and night. Therefore, the materials used in construction projects are exposed to a large number of thermal cycles daily. In this research, the application of sodium alginate polymer as an eco-friendly additive for soil stabilization and improvement of its geotechnical characteristics is studied. The study involves conducting geotechnical tests on both control and stabilized soil samples (with and without sodium alginate polymer) such as standard compaction test, swelling tests, and measuring Atterberg limits, while specimens were subjected to the same temperature variations as those recorded in the Khuzestan province, in the southwest of Iran. In fact, this study aims to investigate the effect of temperature ranges on the changes in the swelling potential of high plasticity clayey soils stabilized with sodium alginate polymer. Consolidation tests were carried out on compacted clay samples - containing different concentrations of sodium alginate polymer with treatment durations of 1 and 14 days - in accordance with method C of ASTM standard. The temperature range considered in this research was 23 to 45° due to the simulation of the temperature in Khuzestan province in the spring and autumn seasons. Observations indicated an increase in the swelling potential up to %13 in a sigmoidal manner with the repetition of temperature ranges and the stabilization of swelling changes, or so-called aging of swelling, which occurs with the repetition of temperature fluctuations. Additionally, the samples were analyzed using X-ray Diffraction (XRD), and X-ray Fluorescence (XRF) techniques to investigate the changes in their compositions. These methods revealed the formation of palygorskite minerals in specimens. This mineral intensifies the soil's swelling potential and is considered one of the contributing factors to the observed increase in swelling in the stabilized soil samples containing sodium alginate polymer.

Key Words: Swelling potential, clay soils, expansive soils, swelling pressure, sodium alginate.

NUMERICAL SOLUTION FOR ONE-DIMENSIONAL PURE-CONVECTION PROBLEMS USING THE HIGH-ORDER TAYLOR-GALERKIN ELEMENT-FREE METHOD

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Abstract

The present study proposes a novel approach for solving one-dimensional pure convection problems, utilizing a high-order Taylor Galerkin element-free method. The standard Galerkin method has limitations in solving such problems due to the predominance of convective terms over diffusion terms, leading to unstable and fluctuating analysis results over time. To address this issue, high-order stabilizing terms can be added to the standard Galerkin method. However, due to the limitations in the derivability of the standard Galerkin shape function, it is not possible to incorporate high-order terms in the equation. In this context, the proposed high-order Taylor Galerkin element-free method enables the inclusion of stabilizing terms with high-order derivatives in the equations, utilizing the moving least-squares (MLS) shape function and exponential weight function, which exhibit the continuity of all their derivatives. This approach provides a promising solution for addressing the limitations of the finite element method and achieving more accurate and stable analysis results for one-dimensional pure convection problems. The accuracy of the numerical simulation was evaluated using two one-dimensional pure convection benchmark problems: the Gaussian wave motion problem and the classical water hammer problem, both analyzed up to the fourth-order. The results of the numerical simulations demonstrated that increasing the number of stabilizing terms led to improved accuracy and decreased fluctuations. Therefore, it can be concluded that the stability terms up to the fourth-order in the equations display acceptable accuracy for these two problems. This development has significant implications for the analysis of fluid mechanics and other related phenomena. By enabling a more comprehensive analysis of fluid dynamics, researchers can investigate complex fluid dynamics with greater precision and detail, yielding valuable insights into a wide range of physical processes. In conclusion, the proposed high-

order Taylor Galerkin element-free method is a noteworthy advancement in numerical analysis, overcoming the limitations of the standard Galerkin method and demonstrating superior accuracy and stability in the solution of pure convection problems. This approach provides an efficient and accurate method for numerical analysis and has the potential to be extended to other areas of research, including computational fluid dynamics, heat transfer, and structural mechanics.

Key Words: Pure convection problem, high-order Taylor-Galerkin element-free method, finite element method, high-order terms.

INVESTIGATION OF NUMERICAL MODELS OF CAVITATION PHENOMENON IN ITS PREDICTION IN NOZZLES

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Abstract

Cavitation is a phenomenon during which, with the movement of the flow and the reduction of the liquid pressure to the saturated vapor pressure of the liquid in susceptible areas, bubbles of air are formed during the flow. The microjet becomes full of energy with the fluid, which when these micro jets collide with the walls, causing vibration and noise and destructive effects such as structural erosion of ship propellers, pump blades, and dams, as well as reducing efficiency, and malfunction of hydraulic devices. This research aims to study different simulation models of the cavitation phenomenon and compare them in the way of cavitation cloud creation and expansion and the effect of this phenomenon on the flow. The present research has been analyzed numerically using ANSYS FLUENT software. In this research, an attempt has been made to study and compare different cavitation models in various geometries. Also, in one example, the results of the numerical model have been compared with the results of the laboratory model. The results showed that the formation of cavitation phenomenon in 10 cm throat compared to 5 cm by 5.88%, in 10 cm throat compared to without throat by 64.71%, and in 5 cm throat compared to without throat by 5.62% has changed.

Key Words: Cavitation, two-phase flow, computational fluid dynamics, saturated vapor pressure.

EXPERIMENTAL STUDY ON DAMAGE DETECTION OF A TRUSS BRIDGE UNDER MOVING LOAD USING ARTIFICIAL NEURAL NETWORK AND EMPIRICAL WAVELET TRANSFORM

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Abstract

Civil structures are always considered one of the most valuable properties of each country. Many factors can lead to local damages in different parts of structures during their operational life. These damages are reflected in the vibration responses of structures. This research aims to detect the existence and determine the location of damage in a truss bridge under a moving load using an artificial neural network and experimental wavelet transform. For this purpose, a two-dimensional truss bridge was built in the laboratory to investigate this research's objectives. Earlier experimental studies in damage detection were subjected to excitations such as impact loads and electrodynamic shakers. Since the appearance of damage effects in the vibration responses of the structure mainly depends on the applied location of the

impact load, a moving load that crosses the entire length of the bridge can be used as input excitation to detect the presence and location of damages for which there is no available data. After measuring the vibration responses of the bridge, 17 time-domain features were extracted from the raw signals, which were used to detect the presence of damage. Although feature extraction is applied to raw signals, the signal processing stage was not eliminated for damage localization. By processing the response signals of the healthy and damaged state of the bridge using experimental wavelet transform, these signals were decomposed into different modes and 5 non-parametric damage-sensitive features such as Shannon and Tsallis entropies, Root Mean Square (RMS), Shape Factor and kurtosis which are all based on statistical parameters in addition to energy, were extracted. Finally, these damage-sensitive features were presented as input to the neural network whereas the state of the bridge (healthy or damaged) was considered as its target. The obtained results showed that the proposed method can effectively detect the presence and the location of the damage in the truss bridge.

Key Words: Structural health monitoring, damage detection, ann, empirical wavelet transform, moving load.

SCENARIO CREATION OF SHARED AUTONOMOUS VEHICLES PENETRATION RATE, A QUANTITATIVE ENVIRONMENTAL ANALYSIS

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Abstract

In 2022, the air pollution levels in Iranian cities increased by an average of 35% compared to 2019, which is concerning considering the growing transportation needs due to population growth. However, alternative travel methods with better environmental performance can help reduce the role of transportation in creating pollution. One potential solution is the use of shared autonomous vehicles, which have the potential to significantly reduce greenhouse gas emissions. However, estimating the exact effects of this travel method on climate change can be challenging due to various factors that come into play. To address this issue, a study was conducted using the SUMO software and random travel demand to quantitatively analysis the environmental impact of shared autonomous vehicles in a specific section of Tehran city. The analysis considered different scenarios related to the penetration rate, fleet size, and sharing policies.

Simulation-based approaches were employed to assess the environmental impact, with a particular focus on greenhouse gas emissions. The results of the study indicated that simultaneous service to two users, compared to other sharing scenarios, can reduce greenhouse gas emissions by up to 10%. This suggests that efficient sharing policies can have a positive impact on the environment.

Moreover, the study found that in scenarios where both autonomous car-sharing and private car modes exist, increasing the fleet size of shared autonomous vehicles can lead to increased congestion, resulting in higher pollutant emissions. Additionally, the penetration rate of these vehicles is crucial, as a penetration rate of 100% tends to result in almost zero greenhouse gas emissions. Regarding the impact of the fleet size of shared autonomous vehicles on fuel consumption, it can be said that increasing the fleet size in scenarios where both modes exist would lead to an increase in fossil fuel consumption and a decrease in electric fuel consumption.

Overall, this study highlights the potential environmental benefits of shared autonomous vehicles in reducing greenhouse gas emissions. By implementing efficient sharing policies, increasing fleet size and density, and aiming for high penetration rates, we can strive towards a greener and more sustainable transportation system.

Key Words: Simulation of Shared Autonomous Vehicles (SAV), ride-sharing, electric cars, environmental pollutants, intelligent transportation.

PROBABILISTIC MODELS FOR PREDICTION OF THE YIELD STRESS OF REBARS AND COMPRESSIVE STRENGTH OF CONCRETE BASED ON BAYESIAN LINEAR REGRESSION

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Abstract

This paper proposes probabilistic models for predicting the yield stress of reinforcing steel bars and the compressive strength of concrete used in Iran's construction industry. The importance of this research stems from the recognition that the strength of construction materials is one of the main parameters in performance-based design, in the calibration of load and resistance factor design (LRFD) provisions, and in risk and resilience analysis of civil infrastructure. Moreover, due to the common practice of on-site casting of the concrete and a large number of rolling mill companies producing reinforcing steel bars, there is a considerable amount of uncertainty in the compressive strength of concrete and the yield stress of steel bars. In this paper, first an extensive database is compiled from concrete and steel laboratory tests. One key field of data for developing the concrete strength model is the nominal design strength of concrete, which was unavailable for a notable portion of the collected data. The database was augmented to account for the missing data using classification algorithms of k-nearest neighbors (KNN) and RBF-Kernel based on machine learning. Next, a probabilistic model is developed using Bayesian linear regression using the Rtx software to predict the compressive strength of concrete as a function of its nominal strength, curing duration, and the quality grade of the concrete manufacturer. The models are subsequently diagnosed for the quality of prediction, heteroskedasticity, and normality of the errors to ensure they are statically sound and well represent the underlying data. Next, a model reduction procedure is implemented to discard the inconclusive predictors from the model and to eliminate high correlations among the model parameters to achieve the final model form. Finally, the yield stress of reinforcing steel of Grades A-III and A-IV are modeled using Bayesian random variables whose distribution parameters are also random and are inferred from the collected data. Bayesian inference enables the quantification of epistemic uncertainties in the model parameters and hence, makes it possible to update the model using Bayesian updating as new data emerge.

Key Words: Bayesian linear regression model, probabilistic modeling, compressive strength of concrete, rebar yield stress, structure reliability.

ASSESSMENT OF UNSATURATED BEHAVIOR OF GORGAN LOESSIAL SOIL UNDER ANISOTROPIC TRIAXIAL COMPRESSION IN MEDIUM SUCTIONS RANGE

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Abstract

Collapsible soils, such as loess, are classified as problematic soils and are usually stable in unsaturated conditions in nature. However, when they are exposed to a moisture increase, especially under an applied load, they undergo a sudden decrease in volume or collapse. Various aspects of the behavior of unsaturated collapsible soils including volume change, soil-water retention, and shear strength have been extensively investigated so far. However, few studies have been carried out on the effect of initial shear stress on the hydromechanical behavior of unsaturated collapsible soils. This study aims to investigate the effect of initial shear stress on the hydromechanical behavior of Gorgan loessial soil under isotropic and anisotropic triaxial compression in the medium suctions including 300 and 400 kPa using a fully automated unsaturated triaxial device. In this study, a set of stress-controlled triaxial tests were performed on reconstituted specimens of Gorgan loessial soil implementing a "suction decrease under constant mean net stress" hydromechanical stress path. The tests were conducted in medium-range suctions under different initial shear stresses. Strain-controlled triaxial shear tests were also conducted at the end of isotropic and anisotropic compression, to evaluate the shear behavior of the tested specimens. Results taken from the wetting stage indicate that the volume reduction of the specimens in-

creases with an increase in initial shear stress under constant mean net stress. The results obtained from shear tests on specimens with constant matric suction and mean net stress in the wetting stage show that the greater the initial shear stress, the lower the shear strength of the specimen. Also, according to the independent stress variables approach, the shear resistance parameters including $c^{'}$, $\phi^{'}$, and ϕ^{b} have been obtained at 4.7 kPa, 32.9°, and 13.6°, respectively. In addition, regression lines through the steady-state data points, used to define the CSL of the reconstituted specimens, had an M-value of 1.19.

Key Words: Loessial soil, hydromechanical behavior, initial shear stress, reconstituted specimen, unsaturated triaxial device.

PROTECTION OF BURIED PIPE USING SOIL BAG

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Abstract

In recent years, geosynthetics have been increasingly used to reinforce soil mass on pipes under static and repetitive loads. Soilbags are also effective for managing floods and various geotechnical applications, such as roadbeds, slope stability, and retaining walls. In this paper, the investigation of the buried pipe's behavior in the unreinforced trench and reinforced trench with soil bag is considered. Therefore, a series of tests were conducted on the unreinforced and reinforced trench (reinforced by one soil bag, two soil bags in columnar arrangement with and without spacing, and three soil bags in two layers of stepped arrangement) containing a pipe with a diameter of 160 mm under static load. The results of the tests show the effect of the soil bag layer on reducing the bed settlement by enclosing the soil inside and preventing the lateral movement of the soil mass above the pipe. Also, the bag, by distributing the stress on a wider surface and significantly reducing it in depth, reduces the transfer stress to the pipe crown and as a result, reduces the deformation of the pipe. Increasing the buried depth of the soil bag results in a reduction in deformation and pressure on the pipe crown and an increase in soil surface settlement. The columnar arrangement of two layers of soil bags with spacing provides better performance in improving pipe behavior compared to those without spacing. Moreover, the use of two layers of soil bag with a stepped arrangement leads to a reduction in surface settlement, pressure on the pipe, and pipe deformation compared to two layers of soil bag with a column arrangement. However, considering the lack of significant difference between the behavior of the stepped and column arrangements (with or without spacing), the use of a column system is recommended, as it saves 33% of the soil bag.

Key Words: Buried pipe, soilbags, reinforcement, settlement.

THE INVESTIGATION OF THE COMBINED EFFECT OF NANO-SILICA, STEEL, AND POLYPROPYLENE MICROFIBERS ON THE MECHANICAL CHARACTERISTICS, PERMEABILITY, AND CHLORIDE ATTACK RESISTANCE OF CEMENT COMPOSITE

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Abstract

The objective of this study was to investigate the combined impact of nano-silica, steel microfibers, and polypropylene microfibers on the mechanical properties, permeability, and resistance to chloride attack of cement composite. To achieve this goal, a 2% weight ratio of nano-silica was used as a cement substitute, while 1.0%

steel and 0.2% polypropylene microfibers, respectively, by volume of the binders were separately and simultaneously employed as additives in the cement composite. Experimental analyses, including compressive, flexural, and tensile strength tests, were conducted to evaluate the mechanical properties. Additionally, the ultrasonic pulse velocity (UPV) and sorptivity tests were employed to assess permeability, and the durability against chloride attack was examined using the Rapid Chloride Migration Test (RCMT). The results demonstrate that the simultaneous incorporation of nano-silica, steel microfibers, and polypropylene microfibers in the cement composite mixture resulted in a significant enhancement in compressive strength, flexural strength, flexural toughness, and tensile strength by 59.3%, 32.3%, 67.2%, and 25.9%, respectively, compared to the control sample after a curing period of 90 days. Moreover, significant decreases were observed in terms of the initial and secondary water absorption rates. Furthermore, the penetration depth of chloride ions was notably reduced from 33.6 mm (in the control composite) to 14.2 mm (in the composite containing the combined effects of nano-silica, steel microfibers, and polypropylene microfibers) after 90 days. The enhancement of mechanical properties, permeability, and durability against chloride attack in cement composite can be attributed to the synergistic mechanisms promoted by the utilization of nano-silica, steel microfibers, and polypropylene microfibers. The filling effect, nucleation sites, and pozzolanic activity of silica nanoparticles significantly contribute to the reduction of porosity and refinement of the cementitious matrix's microstructure. Simultaneously, the inclusion of steel microfibers and polypropylene microfibers reinforces the cement matrix and effectively controls existing microcracks, thereby impeding the propagation of macrocracks and brittle failure in the cement composite. Furthermore, the bridging effect of steel and polypropylene fibers aids in the control of cracks caused by plastic shrinkage during the early stages and secondary or thermal cracks, thereby further improving the properties of cement composite.

Key Words: Nano silica, steel fiber, polypropylene fiber, mechanical characteristics, durability.

MODIFICATION OF SOIL MODELING AND USING IT IN THE FISH-BONE MODEL

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Abstract

The basic design of any structure requires sufficient and detailed modeling of each structural element. It must be taken into consideration that the modeling of each member of the structure and performing nonlinear dynamic analysis due to the presence of multiple degrees of freedom, is time-consuming. Therefore, a wide range of structures cannot be investigated. To resolve this issue, researchers have recommended using simplified equivalent models to study a wide range of structures, provided that the equivalent ones significantly reflect the behavior of the original structure. One of these models is the fishbone model, which is used for modeling moment-resisting steel structures and it also has a suitable accuracy. Additionally, the presence of soil can significantly change the response of the structure. This is despite the fact that accurate modeling of the soil will lead to an increase in degrees of freedom. In this study, the aim is to examine the seismic performance of soil-structure systems to evaluate the accuracy of the models presented in seismic codes, and after modification, provide a simplified model for placement under the fishbone frame. In this regard, first by modeling a number of foundations on distributed Winkler springs considering nonlinear behavior for the soil, the moment-rotation capacity curve of the foundations was drawn, and then the aforementioned graphs were simplified into bilinear curves through an algorithm. The bilinear models that are presented, have greater stiffness and strength compared to the model presented by the seismic code. Two equations were suggested for determining the coefficients of the bilinear model by regression. In the next step, instead of modeling vertical distributed springs beneath the foundation, a rotational spring with modified bilinear behavior was placed under the fishbone model. The analysis of the seismic response of soil-structure systems

under earthquake records shows that using the modified model instead of the model presented in the seismic code leads to responses with appropriate accuracy. In addition, by using the modified model, the time required for the time history analysis is noticeably reduced, which is important in research studies.

Key Words: Moment resisting frame, fishbone model, nonlinear soil-structure interaction, seismic performance, distributed winkler springs.

A NUMERICAL ASSESSMENT OF THE HORIZONTAL SEISMIC COEFFICIENT FOR SOIL-NAILED WALLS

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Abstract

It is the objective of the present study to present a methodology for determining the horizontal seismic coefficient for soil-nailed walls based on numerical non-linear dynamic analysis. As a first step, two verification tests were simulated in order to validate the numerical modeling methodology and assumptions both in static and dynamic modes. The static validation phase involved simulating the soil-nailed wall in the Clouterre project and comparing numerical and measured profiles of horizontal displacement after excavation. The dynamic validation phase included a shaking table test on a soil-nailed wall, followed by a comparison of numerical and experimental profiles of the horizontal displacement of the wall at the end of the seismic loading. Afterwards, an in-depth explanation of the numerical modeling methodology used to calculate the seismic coefficient for soil-nailed walls was provided. Thereafter, an extensive parametric study was conducted to examine the effects of various factors on the horizontal seismic coefficient, including the wall height, soil relative density, soil cohesion, earthquake frequency content, ground surface acceleration, and altering the soil nailing design. In the parametric study, three earthquake acceleration records were used: Kocaeli, Avaj and Chi-Chi. The results of the parametric study showed that the ratio of the maximum horizontal seismic coefficient to the maximum ground surface acceleration (k_{hmax}/PGA) decreased on average with the increase in the wall height, the predominant frequency of earthquake motion and the maximum ground surface acceleration. Furthermore, the results indicated that the k_{hmax}/PGA ratio increased with an increase in soil relative density. Moreover, the ratio increased slightly as soil cohesion increased. Additionally, it was found that modifying the soil nailing design by increasing the diameter, reducing the horizontal spacing, and increasing the length of nails did not significantly alter the k_{hmax}/PGA ratio. The calculated horizontal seismic coefficients ($k_{hdesign}$) resulted from the parametric study ranged from 0.18 to 0.46 of the maximum ground acceleration (PGA), which is less than the commonly used range of 0.33 to 0.5 PGA.

Key Words: Soil-nailed walls, horizontal seismic coefficient, numerical modelling, dynamic analysis and $FLAC^{3D}$.

STATIC ANALYSIS OF THE STRESS-GRADIENT NANOBEAM BY BOTH OF ANALYTICAL AND THE NYSTROM NUMERICAL METHOD

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Abstract

This paper deals with the static analysis of the Euler-Bernoulli nanobeam based on Eringen's nonlocal theory. This theory is used for the nanoscale structures such as

nanobeams which claims that the stress tensor is associated with the strain tensor by a linear integral transformation. The kernel function of the transformation contains an attenuation function. Several candidates have been proposed for the attenuation function. In this paper, the exponential attenuation function is utilized and the corresponding integral equation is solved directly. To do so, two different methods of the Nystrom numerical method and analytical method are employed, respectively. The Nystrom numerical method is one of the numerical solutions that is extensively utilized to solve different integral equations. This method builds up a linear system of equations that is conveniently solved by the computational programs. Next, the function of the answer is predicted and then examined by the analytical method. In fact, the analytical method is the determination of the unknown constants to justify the integral equation by inserting the mentioned probable answer in the integral equation and putting both sides equivalent to each other. At last, the displacement and curvature function of the nanobeam is determined according to the answer of the integral equation so that the mentioned integral equation converts to an equivalent differential equation that is newly proposed. On the other hand, the resultant displacement function is a closed-form function that contains some constants that should be found by utilizing the boundary conditions of the nanobeam. For the sake of verification, the offered function is employed to determine the dimensionless displacement of a specified point of the beam and compare it with the results given in the previously proposed papers. Additionally, the mentioned function is employed to analyze several nanobeams with new boundary conditions and load functions. Then, the displacement function is plotted. Lastly, a contradiction is also determined based on the displacement graphs in the previous section.

Key Words: Stress gradient elasticity theory, nystrom method, fredholm's integral equation, numerical method, equivalent differential equation.