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Abstract

Generally, the Earth is under the force of actual stress, and any disturbance such as tunnel excavation disarranges the stress condition and surface displacements. If these displacements are not in a standard range, it can cause some problems to the surface and lower level of structures.

At the time of tunnel excavation, some parameters such as cohesion, friction angle, elasticity modulus, tunnel diameter, and tunnel space affect the surface settlements and inner forces of tunnel lining. Therefore, the prediction of these displacements and forces plays a vital role in tunnel design. In this research, at first, three base models in the Plaxis software are modeled; then, the effects of the mentioned parameters on surface settlements tunnel lining forces are assessed. In these models, geometry range is rectangular such that two lateral sides are allowed to have vertical displacement. In addition, nether side in vertical and horizontal direction has closed. Closed nether side shows a stone bed. The model is considered to be plane strain, and tunnel shape is considered as a horseshoe-shaped section. Ordinarily, soil environment has different properties and behavior varieties. There are several behavior models for soils from which Moher-Columb model is selected and used in this research. According to the analysis, an increase in cohesion and elasticity modulus causes a decrease in the surface settlement; however, increasing the friction angle or tunnel diameter causes surface settlement enhancement. In the following, attempt has been made to forecast the surface settlement and inner forces of tunnel lining by using artificial neural network (ANN). Obtained results of software have been modeled by artificial neural network (ANN). For this purpose, at first, the network is expanded; then, the mentioned parameters are analyzed to evaluate the results. In this paper, considering different parameters, sensitivity analysis for displacement and inner forces of lining is conducted. Results indicate that these parameters have significant effect on surface settlement and forces of lining.

Key Words: Tunnel, surface settlement, inner forces, artificial neural network.

toughness modes I and II are two important parameters of materials in fracture mechanics, which can be determined by the method provided in ASTM E399.
In this study, through 3-point and 4-point bending tests, the tensile strength, mode I and mode II fracture toughness of core's soil at different moisture contents are evaluated. Due to the low tensile strength of the soil, the direction of load is perpendicular to that of weight to reduce the influence of the weight. The ability to perform experiments is provided by making some changes in direct shear apparatus.
Moisture content is the most important factor affecting the tensile strength and fracture toughness of soil. Experiments have been conducted with different moisture contents to evaluate the effect of this parameter. The results show that based on the moisture content, soils can be divided into three categories: 1. Brittle, 2. Semi-brittle, and 3. Elastic-Plastic. Increasing the moisture content reduces tensile strength and increases flexibility. In general, fracture toughness of mode 1 is obtained to be more than that of mode 2. Therefore, the probability of crack expansion with tensile mechanism is less than shear mechanism. At the end, based on the results of laboratory tests, mode I and II interaction diagram has been plotted as a fracture criterion at different moisture contents.

Key Words: Earth rock fill DAM, tensile strength, fracture toughness, moisture content, clayey soil.

SANDY SOIL STABILIZATION WITH COPPER SLAG- BASED GEOPOLYMER AND COPPER SLAG AND SILICA FUME BLEND GEOPOLYMER

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Abstract
Nowadays, cement is one of the most used materials in civil engineering. However, a large amount of energy is used in the cement manufacturing industry and produces greenhouse gases, which are the main contributor to environmental issues. Therefore, researchers and engineers look for alternative materials that can satisfy the physical and the mechanical properties of cement with relatively small adverse effects on the environment. The purpose of this research is to stabilize the sandy soil using copper slag-based geopolymer instead of cement to increase the compressive strength of soil and to decrease the environmental effects. Two types of alkali solution (Solutions A and B) were used to activate Geopolymer raw material composed of slag. Solution A, contained sodium hydroxide, silica fume and water. Solution B, contained sodium hydroxide and water. In this study, two types of coarse and fine-grained copper slag were used to determine the effect of particle size on the mechanical properties of soil. In addition, the effect of adding silica fume as part of the geopolymer raw material was investigated for evaluation of the compressive strength of soil. The results showed that adding finer particle size copper slag and silica fume, as part of the geopolymer raw material, increased the compressive strength. The results of compressive strength tests were compared between copper slag-based geopolymer stabilizer and Sandy soil stabilized with cement. XRD analysis was used to study the crystalline phase of geopolymer raw material and Sandy soil. furthermore, the reason for cracks occurring in stabilized specimens was studied. Hydrate lime was used to improve the mechanical properties of the stabilized soil with geopolymer by preventing transverse and longitudinal cracks. SEM Photos were taken to analyze and compare infrastructure of the stabilized specimens with high and low compressive strength. SEM images showed that specimens with high-strength have denser particles and more highly uniform structure. The results of this study indicated that waste and sub-products of the industry including copper slag and silica fume can be used instead of cement for soil stabilization.

Key Words: Soil stabilization, unconfined compressive strength, geopolymer, copper slag, silica fume, alkali activation solution.

PREDICTION OF SURFACE SETTLEMENT AND INNER FORCES OF LINING OF HORSESHOE-SHAPED TUNNELS BY USING ARTIFICIAL NEURAL NETWORKS

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Abstract

The retrofitting of concrete columns by using FRP fiber for strength and ductility is taken into consideration. Recent studies have shown that confined concrete with FRP shows different behavior comparing when confined with steel; therefore, the need for research on concrete columns reinforced with FRP is clear. In this study, finite element analysis and modeling by using finite element software are used to investigate the behavior of columns reinforced with GFRP fibers. Model verification is performed by using the results of laboratory study, and the good agreement between test results and finite element modeling is observed. The next step is to examine the parameters of compressive strength of concrete and column shapes in behavior of reinforced column with FRP. The results in terms of vertical displacement-force Graphs and buckling, are extracted and compared.

The deterioration of the nation's infrastructure has been well documented and publicized FRP composites have emerged as a potential solution to the problems associated with the infrastructure. An economic application of FRP materials is in the form of composite construction with concrete, such that FRP can act as a load-carrying partner and protective measure for the structural members. One such application has been demonstrated in fiber jacketing technique, which is now considered as an effective retrofitting tool for the existing columns. By using the principles of fiber-wrapping and steel-jacketing practice, classic steel-concrete composite columns, FRP pressure vessels, and steel-encased plastic piles, a novel type of composite column is proposed that consists of a reinforced concrete core confined in a FRP tubular jacket. The main advantage of FRP-concrete composite construction is the optimal use of materials based on their mechanical properties and resistance to corrosive composite members with pseudo ductile characteristics and high stiffness and strength properties.

The composite shell may be a multi-layer FRP tube that consists of at least two plies: an inner ply of longitudinal fibers and an outer ply of circumferential fibers. The longitudinal fibers are inhibited from outward buckling by the outer circumferentially oriented fiber ply and from inward buckling by the concrete core. Similar tubes have been made with a center ply of longitudinal fibers sandwiched between two plies of circumferential fibers.

Key Words: Reinforced concrete column, GFRP, Finite element method, confinement, ductility, axial displacement.

THE EFFECT OF MOISTURE CONTENT ON THE TENSILE STRENGTH AND FRACTURE TOUGHNESS OF CLAY CORE EARTH DAMS

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Abstract

According to statistics, internal erosion and piping have been known as the main causes of the destruction of earth and rock-fill dam. In earth dams, hydraulic fracturing and internal erosion are two interdependent phenomena. Hydraulic fracturing causes expansion of the cracks. The flow of water in cracks causes the leaching of soil, materials and internal erosion occurs.

The Bidwaz dam is an earth and rock-fill dam. About seven and a half years after the start of the first impounding, a subsidence appeared on the upstream face of the dam body. This dam is located in a narrow valley; therefore, hydraulic fracturing and internal erosion are proposed as one of the main causes of subsidence.

Using the concepts of fracture mechanics is one of the prediction methods in hydraulic fracturing. Fracture mechanics is the field of mechanics concerned with the study of the crack propagation in materials. Fracture

In this study, the effect of adding Crumb Tire to the Calcareous Sands of Qeshm Island was evaluated. By doing several tests, effect of adding Crumb Tire on the shear strength of Calcareous Sand and its crushability was evaluated. In this regard, Consolidated-drained triaxial tests on the crumb tire-sand mixtures were conducted under the confining pressures of 100, 350, and 600 kPa using two different relative densities of 30% and 60%. By volume percentage of 0, 10, 15, 20 and 30%, Sand and sand-crumb tire mixtures were examined, and the optimum crumb tire content was found to be 10 percent for the considered type soil.
Finally, the results showed that by adding 10% Crumb Tire to the Calcareous Sand, the internal-friction angle of loose specimens increased by approximately 8.9% compared to pure sand specimens. Furthermore, the particle breakage factor decreased by adding specific percentage of Crumb Tire to the soil. Hence, this issue could be considered as a noteworthy achievement because of Crumb Tire improving effects on the mechanical characteristics of a problematic soil in nature.

Key Words: Crumb tire, calcareous sand, shear strength, particle breakage, environment.

TIME-DEPENDENT BEHAVIOR OF CANTILEVER LIGHT WEIGHT CONCRETE BRIDGE BASED ON TENDON AND LIGHT WEIGHT CONCRETE TYPES

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Abstract
The balanced cantilever construction of pre-stressed concrete box-girder bridges has been recognized as one of the most efficient methods of bridge construction. This method has great advantages over other methods, especially in urban areas where traffic may be interrupted, or over deep valleys or waterways where formwork could be expensive and hazardous. Time-dependent deformation of materials has adverse effects on balanced cantilever bridges. The time-dependent concrete creep and shrinkage effects on segmental bridges are more critical than other types of concrete bridges. An increase in time-dependent deformation of concrete leads to the reduction of pre-stressing force of cables and affecting the service ability of the balanced cantilever bridges. The combined effects of creep and shrinkage of concrete and relaxation of pre-stressing tendons cause gradual changes in the internal forces and deflections of span. Despite a wide range of applications of balanced cantilever light-weight concrete bridges with longer spans, there is no sufficient knowledge about the time-dependent behavior of light-weight concrete. In this study, time-dependent analyses of balanced cantilever light-weight concrete bridges are carried out by considering the creep and shrinkage of light-weight concrete and relaxation of pre-stressing cables. Stolma bridge field experimental results are used to verify the analysis method. ABAQUS software capabilities are utilized to consider the step-by-step construction procedure, so the suitable simulation of the bridge lifetime is achieved. The numerical study is performed for one, three, five and thirty years after the completion of construction procedure. A parametric study is conducted based on three types of concrete LC60, LC40, and LC25 as well as two types of behavior of steel, normal relaxation and low (TRB) relaxation. The results demonstrate that time-dependent deformations have considerable effect on lifetime behavior of light-weight concrete bridge. Most of the time-dependent deformation happened in early years after the completion of construction procedure of the bridge. The parametric study showed the identical results of contribution of creep, shrinkage and relaxation effects on the deflection of the middle span for different types of concrete. The effect of relaxation on the deflection of the middle span is negligible for relaxation cables.

Key Words: Bridge, balanced cantilever method, light-weight concrete, time-dependent behavior, creep, shrinkage, relaxation of pre-stressing cables and redistributed of force.

INVESTIGATING THE AXIAL BEHAVIOR OF CONCRETE COLUMN CONFINEMENT WITH INNER AND OUTER GFRP

FRAMES USING ARTIFICIAL NEURAL NETWORKS

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Abstract

Materials such as steel, that are commonly used in high volumes in the construction industry have a considerable role in the total cost of projects. On the other hand, financial resources are one of the main factors in the construction and will affect the design process. By predicting the weight of structures before starting the design process with a reasonable way based on the characteristics of the structures, a designer is able to estimate the approximate required steel materials and strives to optimize its value. In this study, the artificial neural network (ANN) method is used to predict the amount of steel material used in the steel structures with a moment-resisting system. The effects of four basic parameters including span length, story height, shape of column sections, and number of floors are investigated. A variety of steel structure models with a moment-resisting system are designed based on changes in the aforementioned parameters. These models are delivered to the artificial neural network and the network is trained and verified by means of controlling errors. Database includes more than 1100 structural models. A variety of samples including models with span length vary from 3 to 6 meters, and the number of floors varying from 3 to 14 stories and also story height varying from 3 to 4 meters have been studied. In all models, beam section is selected from IPE family, and two types of highly used cross-section, including H-shape and Box-shape sections, are used in the design process of the column elements.

Results show that, the structural weight can be estimated with appropriate accuracy by the suggested ANN method depending on structural principal parameters; in this way the effect of building height on the weight of structures is explained. Using cross-section of BOX-shape instead of H-shape in the structures with a moment-resisting system leads to about a 10% decrease in the consumption of steel. Increasing the ratio of span length to story height (L/H) from 1 to 1.5 leads to 5% increase in the weight of the structure and, thus, in the consumption of steel material. Increasing this ratio from 1 to 2 leads to 20% increase in the weight of the structure and, thus, in the consumption of steel material.

Key Words: Steel structures, artificial neural network (ANN), weight of steel structures, moment resisting frames.

EVALUATION OF SHEAR STRENGTH AND PARTICLE BREAKAGE OF CRUMB TIRE-CALCAREOUS SAND MIXTURE

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Abstract

One of the main problematic soils in nature with which we are dealing is carbonate or calcareous sand. Carbonate sediments are located in temperate and tropical areas and cover approximately 40% of the ocean surface. Theses soils are made up of the rest of the body of marine creatures, particularly tiny cowries or have physical or chemical origins.

In Iran, Northern Shores of the Persian Gulf and islands of Qeshm and Hormoz contain Calcareous Sands. The most significant characteristic of this soil is particle breakage under shear stress that decreases the shear strength, which also affects its Stress-Strain behavior. On the other hand, due to the large increase of transportation in these regions, the accumulation of scrap tires leads to environmental problems. Therefore, in order to use these materials much better as they are, they can be reused in geotechnical engineering for providing geo-materials with better quality and helping to have a cleaner environment.

studies were performed to achieve an optimum connection. The parameters include using bolts in columns and beams, thickness of plate connections, using the angle profiles in the corner columns and size of angle profiles connected to steel infill plates.

Based on the modeling results, a comparison of the values of the ductility, elastic stiffness, energy dissipation capacity, and load-carrying capacities of specimens with different connections, indicated a significant increase in the values of initial RCF. Increasing the thickness of the plates connected to beams and columns and the growing use of the angle profiles in the corner columns improve the performance of the connections; however, do not lead to a considerable increase in resistance and non-economic causes of the connection. By comparing the performances of different connections, an appropriate connection was proposed. Based on the results of all specimens, response modification coefficient and over strength factor of special RCF with thin SPSW were estimated at 8.37 and 2, respectively, as compared with the values of the proposed the ASCE 7-10, for dual system of special steel frame with SPSW.

Key Words: Thin steel plate shear wall, reinforced concrete frame, rehabilitation, connections, response modification coefficient.

PROPOSAL FOR AN EQUIVALENT LINEARIZATION METHOD FOR CONTROLLED-ROCKING SELF-CENTERING SYSTEMS

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Abstract

Modern rocking self-centering frame is known as one of the most efficient seismic lateral resisting systems. Previous studies indicate that the analysis of this modern system is possible through nonlinear time history analysis (NTHA); however, its modeling and analysis are costly and time-consuming. To overcome this disadvantage, approximate analysis methods, including linearization analysis (ELA) method, are developed. For EAL method, the maximum inelastic displacement demand of a system is determined using elastic analysis of the equivalent single degree of freedom (SDOF) model. The method accuracy in estimating seismic demands depends on predefined parameters of equivalent damping ratio and secant stiffness for the equivalent system. This paper presents a new model for equivalent linear analysis of rocking self-centering systems under far-field ground motions. To this end, a set of rocking self-centering models with flag-shaped hysteretic behavior is simulated by OpenSees software. Exact and approximate estimations of inelastic displacement of the models are obtained using NTHA and ELA, respectively. Equivalent SDOF systems are first modeled with secant stiffness parameter and Jacobson's damping models. By using statistical analysis, the effect of the earthquake and modeling parameters on the analysis results is discussed based on various aspects. Findings indicated that the modeling parameters had the considerable effect on the equivalent linear model, while the seismic parameters had no significant effect. Moreover, it is shown that the Jacobson's damping parameter is not appropriate for ELA of rocking self-centering systems and leads to underestimating the maximum nonlinear displacement. In order to increase the accuracy of the proposed model, a new formula is proposed for optimal damping ratio by minimizing the error between the exact and approximate displacement demands obtained by NTHA and ELA, respectively. The assessment of efficiency for the proposed model showed that suggested formula could be used to estimate inelastic displacement of rocking self-centering systems.

Key Words: Rocking self-centering frame, equivalent linearization method, Jacobsen's damping, secant stiffness.

INVESTIGATION OF THE EFFECTS OF NUMBER AND HEIGHT OF THE FLOORS ON THE WEIGHT OF THE STRUCTURES WITH MOMENT-RESISTING STEEL

THE EFFECTS OF SOIL REINFORCEMENT WITH GEOGRID AND GRID-ANCHOR SYSTEMS ON UPLIFT CAPACITY OF BURIED PIPELINES

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Abstract

Reinforcing soils with geosynthetics is an effective method for improving the uplift capacity of buried pipelines. The pullout resistance of the reinforcing elements is one of the most notable factors in increasing the uplift capacity. In this paper, a new reinforcing element including the anchors attached to the ordinary geogrid, namely grid-anchors, was used for increasing the pullout resistance of the geogrid. An experimental study was performed to investigate the uplift resistance of the pipelines buried in sand reinforced with this system. Then, 37 experimental models and 33 numerical models were conducted to investigate the effect of pipe diameter, soil moisture content, soil type, pipe burial depth, the location of reinforcement layers installation, as well as the number of reinforcement layers and the width of reinforcement layers on the uplift resistance of granular soils. The PIV method reveals that due to a developed longer failure surface, inclusion of grid-anchor system in a soil deposit significantly increases the uplift capacity. Therefore the grid-anchor system of reinforcing can increase the uplift capacity 2.5 times greater than that for an ordinary geogrid and 4 times greater than that for non-reinforced sand. Compared to the multilayer reinforcement, the single layer reinforcement was more effective in enhancing the uplift capacity. Besides, the efficiency of reinforcement layer inclusion for uplift resistance in lower embedment ratios is higher. In addition, by increasing the pipe diameter, the efficiency of the reinforcement layer inclusion will be lower. There appears the efficiency of reinforcement layer inclusion for uplift resistance in the single layer reinforcement with higher width and installed in the pipe bottom; lower embedment ratios and lower pipe diameter are higher. To verify the experimental results and completion of research, the finite deference software FLAC-3D was used. It was found that experimental and numerical results were in good agreement.

Key Words: Uplift resistance, buried pipelines, experimental study, numerical modeling, PIV, grid-anchor.

REHABILITATION ASSESSMENT OF REINFORCED CONCRETE FRAME WITH STEEL PLATE SHEAR WALLS DUE TO DIFFERENT CONNECTION METHODS

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Abstract

In recent years, the use of thin Steel Plate Shear Walls (SPSWs), for rehabilitation of existing reinforced concrete (RC) structures has increased due to their significant resistance, stiffness, ductility, and energy dissipation capacity. The main issue in the rehabilitation of RC structures with SPSWs, is the necessity of the existence of a suitable connection between SPSW and the RC frame (RCF), so that the tension field of SPSWs can well be transferred to the RCF and steel infill plate capacity can well be used. In this study, different proposed connections between SPSW and RCF are studied.
After the verification of the experimental specimen, one-span three-story special RCF with SPSW with one-third scale, specimens were modeled by the proposed connections. Four types of connection were investigated for connecting the steel infill plate to RCF. All specimens were analyzed by non-linear static analysis. Parametric

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Abstract

Sudden impacts may afflict wide damages on structures. Therefore, it is required to investigate these incidents when designing structures. In this paper, different failure types in steel column are investigated and, for each type, numerical results are compared with the experimental ones for the sake of validation. Initiation and development of structural failure due to truck collision with one of the corner columns was modeled dynamically and was investigated. For this purpose, the three dimensional moment frame steel for a 4-story building with medium ductility using ETABS software under dead, live, and seismic load was designed; then, was loaded with the ABAQUS software under impact load. For validation of the molding process, the experimental results in the field of vehicle collisions with steel columns were used. The nonlinear dynamic analysis was used for simulation of impact caused by the collision of trucks having different masses and speeds. Using the appropriate plasticity and shear failure model, the stresses and internal forces in the structure, especially in the damaged column, were extracted. To study the effects of various parameters on structural response, a parametric study was conducted, and the results were compared with each other. The results showed that mass and speed play an important role in building damage. When the collision occurs, the entire structure, including columns, is affected by the dynamic load. As a result, the current method of elimination of only one column and applying static loading to the structure cannot show progressive collapse accurately.

Key Words: Progressive collapse, steel, impact, collision, column removal scenario, ABAQUS.

COMPARISON OF STATIC AND MODAL ANALYSIS IN DAMAGE DETECTION OF CONCRETE GRAVITY DAMS VIA WAVELET TRANSFORM

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Abstract

Natural occurrences, such as earthquake and wind, cause damages to structures (e.g., buildings and bridges) through enforcing extreme loads. Consequently, they might result in catastrophic structural collapse and failures. Most importantly, this brings the necessity of safety assessment of the structures, especially of the large concrete dams affecting the lives of many on the downstream of a dam. Hence, it is required to develop a damage detection system able to recognize the cracks or discontinuity on the dam before they start to propagate. To this end, the Structural Health Mentoring (SHM) process should be adopted to control and keep the structures safe. This safety system will provide with the possibility to detect the damages quickly so that the engineers will be more capable of doing safety operation in terms of maintenance and repairing of structures. Wavelet transform was introduced as an efficient SHM process to achieve the objective of damage detection. This approach can extract hidden information from the obtained results of structural analysis. In this research, using wavelet transform, the static and model analysis of the Koyna gravity dam was done, and the supposed cracks were identified. The obtained results showed that during the damage detection process based on the static data, factors such as vicinity of the crack to the location of sample points were found to be affecting the wavelet coefficients. On the contrary, the modal analysis indicated that the aforementioned relation would not be revealed, and the damage could be properly detected over the regions with high expectation of failures. It was observed that the height of the dam reservoir in the static analysis was not affected to accurately identify damages by the wavelet transform. In addition, the results including the effect of damages under higher modes and multiple cracks during the damage detection process were thoroughly explained and clarified.

Key Words: Damage detection, concrete gravity dams, wavelet transform, modal analysis, static analysis.

In order to deploy 2QACM benefits in nonlinear applications, complete lagrange formulation 3Q4HY is used, numerical examples in geometric nonlinear problems have shown presented formulation's ability to prevent loss of precision in highly distorted meshing for 4-node hyper elastic elements. To show effectiveness of presented elements two numerical examples are presented. Q4HY elements efficiency in nonlinear analysis of planar elements made of hyper elastic materials is significantly obvious.

The program is written in matlab environment for nonlinear analysis of hyper elastic problems. Two formulations are proposed and results have been compared with references results. Examples of rubber like problems have shown these formulations ability to analyze large strain structures.

Numerical examples express four node element has less sensitivity to distortion in meshing in nonlinear analysis and can be used with good precision when element is diagonal, while calculated responses using 4 node isoparametric element may be inappropriate.

4 noded elements effect on developing a simple, applicable and valid nonlinear geometric analysis is significantly observed. Furthermore, a complete lagrangian formulation with a particular formulation by applying integration techniques to effectively establish stiffness matrix is presented. According to presented examples, the investigated elements have great potential in solving Hyper elastic problems.

Key Words: Hyper elastic, total lagrangian, nonlinear analysis, geometric nonlinear.

STUDY OF SOFT CLAY LAYER EFFECTS ON STEEL SHEET PILE WALLS BEHAVIORS USING CONVENTIONAL AND NUMERICAL METHODS

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Abstract

Conventional methods used for the design of sheet pile walls as a retaining system are based on the lateral force equilibrium and proposed equations. Soil is not uniform in depth, sometimes, soft soil layer may exist in various depth and situations. This issue can cause different effects on forces and moments acting on sheet pile and struts during the excavation procedure, compared with status such that soil is uniform in depth. In this study, a deep excavation using the finite element method is analyzed. Excavation's depth is divided into three clayey layers. One of the three layers is soft clay layer whose position ns are modelled in three different situations, top, middle, and bottom. The obtained results are compared with those of the conventional design method. According to the comparative obtained results, it can be concluded that:

1. In relatively uniform soil deposits, conventional methods cannot correctly estimate sheet piles maximum bending moment locations.
2. In status in which a soft clay layer exists between two stiff clay layers whose thicknesses of all three layers are the same, bending moment location acting on sheet pile is different from other status and is very close to the conventional method value.
3. By increasing the depth of soft clay layer, bending moments acting on sheet piles are increased, especially in the final stages of excavation. This issue is not considered in the conventional method.
4. When the soft clay layer is a surface layer whose thickness does not exceed the one-third the depth of the excavation, using the conventional method for design practices is conservative.
5. It appears that the conventional method underestimates the forces of struts near excavation depth so that, in the current study, forces of these struts are increased by about 15-70 % in finite element method in comparison with conventional method.

Using equivalent cohesion and specific gravity in layered soils cannot consider location effects of different soil layers.

Key Words: Sheet piles, retaining system, strut, finite element method.

NON-LINEAR FEM DYNAMIC ANALYSIS OF 3D STEEL FRAME WITH INTERMEDIATE DUCTILITY UNDER CRASH LOADING

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Abstracts of Papers in English

LAGRANGE METHOD FOR NONLINEAR SOLUTION OF HYPER ELASTIC MATERIAL BY ISOPARAMETERIC ELEMENT

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Abstract

In this article complete numerical formulation for nonlinear analysis of planar structures made of hyper elastic materials with application in civil engineering is presented. Structural problems can be solved by finite element method using complete lagrange formulation.

The presented formulation is for large strain problems and is applicable for a wide range of hyper elastic nonlinear materials. Generally in nonlinear finite element analysis large deformation and disordered mesh (distorted) is seen. As using disordered elements, isoparametric elements would have low precision. Hyper elastic materials like rubber are one of the most effective materials in engineering application.

The high axial strength and large deformation capacity of these materials make them suitable for many applications. Theory of hyper elastic materials is proposed by references [13,14].

These theories explain hyper elasticity behavior in complicated formulations. Therefore we are interested in studying planar hyper elastic elements with large deformation like rubber, leather etc.

Eventually planar nonlinear elements formulation with hyper elastic behavior is presented for structures having large deformations and complete lagrange formulation is used to analyze the structure. This formulation has been developed to analyze quadrilateral finite element models, which comparing to isoparametric 4-node elements is less sensitive to distorted meshing and doesn't have shear locking problem generated by geometrically distorted meshing.