cyclic loading. In this paper, in order to increase the structural performance of concrete coupled shear walls, a new and simple model of a steel coupling beam with a diagonal web stiffener is proposed, which can be used instead of conventional steel coupling beams with standard or vertical stiffeners, designed based on the Iranian code for steel structure design criteria. For validation of the coupled wall sub-assemblage model in this study, the finite element results were verified with experimental results using Abaqus 6.10.1 software. Then, a numerical study was done and the results were compared with the behavior of steel coupling beams with a standard stiffener. A collection of parametric studies on 30 models, with respect to two dimensionless parameters, under cyclic loading, was carried out. These two parameters were the web compactness ratio, i.e. ratio of height to the web thickness of the beam, and the horizontal diagonal stiffener angle. Analysis results show that a diagonal web stiffener is capable of increasing steel coupling beam performance, in terms of stiffness, strength, energy dissipation and, in some cases, rotation capacity, which lead to a decrease in the depth of the section. Furthermore, to achieve optimum performance, some different geometrical conditions for diagonal stiffeners were investigated and it was concluded that stiffeners should be installed at a 30-degree angle from the horizontal.

Key Words: Steel coupling beam, shear wall, diagonal stiffener; cyclic loading, seismic response.

showed that the larger mesh predicts scour depth better. However, if the mesh becomes very large, because of large errors in the developed flow depth, the scour depth may be predicted wrongly. The maximum scour depth in each three mesh analysis has been overestimated, but, due to the complexity of scour phenomena and the large number of parameter effects, its overestimation is acceptable. It was found that there is good quantitative and qualitative agreement between the experimental results and results of this study.

Key Words: Scour, bridge abutment, CFD.

STUDY OF APPLICATION OF FBP FRICTION DAMPER IN A CHEVRON BRACE FOR STEEL FRAME REHABILITATION

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Abstract
One of the most economical and fast ways in rehabilitation is the use of energy dissipaters in the format of additional dampers. The friction damper is a common damper used in a wide range of applications, due to its dynamic behavior and manner of working. In this paper, we will discuss the effects of the use of a mounted friction damper at the junction of a chevron brace with a floor beam. For this purpose, two frames were designed, a bar frame and an equipped frame, which is of two types: same and story shear ratio distributed. The most important part of friction damper design is determination of optimum slip load. So, frames equipped with a damper in a domain of different slip loads were analyzed using Perform 3D. And the load with the least answer of the structure was chosen as the optimum slip load of the damper. After designing the damper, time history analyzed each of the bar frames and equipped frames. The results of the analyses of the two frames, including absolute displacement, story share, input, strain and dissipated energy, axial force of columns, hinges and inelastic performance levels, were compared.
The results show that the use of a damper in the same distribution could reduce story displacement between 47.28 to 60.71 percent, and story shear ratio could reduce story displacement between 60.7 to 69.29 percent. Furthermore brace shear force in the same distribution reduces 28.7%, while, in shear ratio distribution, reduced 52.3%. All the absorbed energy is reduced and dissipated energy is increased. Altogether, the shares of input and strain energies in the bar frame in comparison with the equipped frame are reduced. Because of the nonlinear behavior transmission of structure members to the dampers, the number of hinges is reduced nearly to zero. In most cases, the equipped frames with safer indices show higher levels of performance.

Key Words: steel frame, friction damper, FBP, chevron brace, optimum slip load, performance levels.

PARAMETRIC INVESTIGATION OF THE BEHAVIOR OF A PROPOSED STEEL COUPLING BEAM IN COUPLED SHEAR WALL STRUCTURES UNDER CYCLIC LOADING

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Abstract
The coupling of individual wall piers via steel coupling beams has shown more lateral stiffness and strength than coupled shear wall systems with concrete beams. In order to obtain the desired behavior of these systems, the coupling beams must be sufficiently strong and stiff, yield before the wall piers, behave in a ductile manner, and exhibit significant energy absorbing characteristics. Therefore, the seismic response of coupled shear wall systems is strongly dependent on the hysteretic characteristics of coupling beams, and the evolution of the behavior of these beams is very important and necessary under

CONSIDERING THE METHOD OF IMPLICIT INTEGRATION FOR THE MANZARI-DAFALIAS PLASTICITY MODEL

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Abstract

This study has introduced, described and compared the performance of two popular integration methods for implementing complicated equations of soil models. Generally speaking, all methods can be classified into two categories of Explicit and Implicit approaches. Two famous methods of the implicit approach, the Closest Point Projection Method (CPPM) and the Cutting Plane Method, (CPM), which are defined under the framework of the Return Mapping algorithm, are considered in this study. Both the Cutting Plane Method and the Closest Point Projection Method are employed in order to implement an advanced critical two-surface model, published by M.T. Manzari and Y.F. Dafalias, in 1997, for sand.

Since the CPPM and CPM methods are implicit, it has a great advantage, as both sizes of steps remain stable. A common weakness of both methods can handle the complexity of numerical integration methods for other types of integration method (explicit) named.

As a result, the current research confirms that, as complicated as the Closest Point Projection Method is, it remains strongly stable in order to integrate equations under conditions of large strain and displacement, such as the liquefaction phenomenon. On the other hand, compared with the Closest Point Projection Method, the Cutting Plane Method is not only more precise and accurate, but also much faster. Additionally, the Cutting Plane Method benefits from an undeniable simplicity against the Closest Point Projection Method. Somewhat importantly, this study aims, by presentation of both the strong and weak points of each method simultaneously, to aid researchers in selecting a reasonable method, with regard to special conditions and the limitations of each problem.

Key Words: closest point projection, cutting plane, explicit integration, implicit integration, plasticity model.

3-D SIMULATION OF SCOUR HOLE AT VERTICAL-WALL BRIDGE ABUTMENT

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Abstract

Scour at bridge abutments is one of the most prevalent causes of bridge failure, which may result in traffic disturbance and even loss of life. Hence, predicting the depth of a scour hole before bridge design and construction to prevent failure is essential. In this paper, using a CFD model, scour at a vertical-wall bridge abutment was simulated. The model has been used to solve a three dimensional, transient, Navier-Stokes equation. A nonlinear RNG turbulence model was used for modeling of the flow field near the abutment, where horseshoe vortices are formed and turbulent flow is more dominant. The sediment scour model uses two concentration fields: suspended sediment and packed sediment. The suspended sediment advects and drifts with the fluid, due to the influence of the local pressure gradient.

The packed sediment represents sediment that is bounded by neighboring sediment particles, and eroded when it becomes suspended sediment. Suspended sediment can become packed sediment if fluid conditions are such that the sediment drifts towards the packed bed more quickly than it is eroded away. According to the results, the horse shoe vortices developed upstream of the abutment, and wake vortices developed downstream of it, and negative velocities have been observed in laboratory results. Mesh sensitivity analysis has been done to find the best mesh for predicting flow and scour depth. The results

and which can be obtained based on probabilistic seismic hazard analysis (PSHA). A common recordselection practice suggests selecting seven records that are compatible with the dominant earthquake scenario in a given site. The selected records are then scaled (if necessary) to match the design level of the uniform hazard spectrum (UHS). Many research results have shown that using the UHS leads to a significant bias in structural response assessment. The conditional mean spectrum (CMS) has been recently proposed as an alternative to the uniform hazard spectrum (UHS) for employment as a target spectrum in ground motion record selection. The CMS provides the expected response spectrum ،conditional to the occurrence of a target spectral acceleration value in the period of interest. The correlation of ε values in different periods is considered in CMS development, but conventional regression analysis has been applied to measure the degree of correlation of ε values in different periods, and the influence of outlier data has not been studied. Outliers are sample values that cause surprises in relation to the majority of samples. The main objective of this paper is to reveal an important drawback in the procedure for calculation of CMS. The authors believe that the developed procedure for CMS leads to a spectral shaped anomaly that is not consistent enough with real ground motion. A robust regression analysis is proposed in this paper to improve the current CMS, which is based on a conventional regression analysis. Robust regression is an important tool for analyzing data that are contaminated with outliers. Robust regression analysis works by assigning a weight to each data point. Weighting is done "automatically and iteratively using a process called" iteratively reweighted least squares.

The results show that the proposed robust CMS significantly differs from the conventional CMS, especially for higher periods of interest. The shape of the robust CMS represents rare ground motion in a more reliable manner, compared with conventional CMS.

Key Words: Conditional mean spectrum, uniform hazard spectrum, robust regression، ground motion, hazard.

DETERMINATION OF CAM-CLAY CONSTITUTIVE PARAMETERS IN NUMERICAL MODELING OF SANDY SOIL BEHAVIOR UNDER TRIAXIAL TESTING

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Abstract

Numerical modeling of soil behavior is known as a new method for predicting soil sample behavior under each test, to reduce test costs used in the laboratory. Triaxial testing is one of the most common soil mechanics tests to determine the shear strength parameters of soil. Due to the excessive use of triaxial test results, numerical modeling is necessary to predict the behavior of soil under triaxial testing.

This paper presents a numerical model to predict the behavior of clayey sands under consolidated-undrained triaxial testing. It is important to predict the relationship between stress and strain to describe soil behavior. The stress-strain curve of clayey sand soils during consolidated-undrained triaxial testing has been simulated using a finite element model, based on the cam-clay constitutive model.

A series of triaxial compression tests was carried out on Firoozkooh sand with a different percentage of clay (0-15 percent) and different relative densities. These tests were carried out under two different confinement pressures (100, 400 kPa); low and high. For the modeling of these tests, a back analysis method is selected. In this method, the results of triaxial tests under high confinement pressures are used as the base data, and, based on simulation results, the strength parameters are determined using back analysis. The cam-clay constitutive model has several parameters to predict soil behavior. These parameters are predicted using the back analysis method and, so, soil behavior is predicted.

After this step, triaxial tests under low confinement pressures are simulated with suggested parameters, and the results are compared with the same experimental results. If there is no good agreement between results, the cycle of modeling is restarted.

Finally, the numerical results are compared with experimental results, which showed good agreement.

Moreover, the effect of clay on the behavior of sand is also investigated and discussed. As a result of modeling, the graphs of q-ε (deviator stress-axial strain), u-ε (pore water pressure-axial strain) and q-p' (stress path) are obtained to predict the clayey sand behavior.

Key Words: Numerical modeling; stress; strain; triaxial test (consolidated-undrained); clayey sand; back analysis.

bargaining process is then done between the client and contractor to share the benefits.
The fuzzy inference system is used to determine the size of the players' discount factor, based on the values of different influencing factors. The size of the discount factor plays an important role in the final results, and in reaching an equitable agreement. The proposed approach models the realistic behavior of contracting parties in the risk allocation negotiation process, which is similar to the players' behavior in a game, and determines a desirable and equitable risk allocation strategy between the client and contractor. To evaluate the performance of the proposed method, it is employed in a pipeline project, and a quantitative risk allocation is performed for the inflation risk, as one of the most important identified risks.

Key Words: Quantitative risk allocation, fuzzy logic, game theory, bargaining game theory.

STABILIZATION OF PROBLEMATIC SILTY SANDS USING MICROSILIS AND LIME TO DECREASE SWELLING POTENTIAL AND INCREASE BEARING CAPACITY

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Abstract
Silty sands contain sulfates, which are the main constituents of the central desert of Iran. Due to the presence of sulfates, a dilative behavior is observed. Also, the unconfined compressive strength of this kind of soil is negligible. These two mentioned reasons make it an unsuitable construction material for roads. In order to make it an applicable material in road construction, it should be effectively stabilized. In this study, to investigate the behavior of stabilized silty sands, two different additives, microsilis and lime, were added to the built samples in different percentages. Then, the unconfined compressive strength (UCS) test, California bearing ratio (CBR) and swelling test were conducted on the stabilized samples. Furthermore, to truly study and interpret the changes in the soil structure as a consequence of stabilization, the SEM technique, scanning electron microscope, was implemented.
The results obtained from the experimental study show that adding microsilica microsilis and lime together to the sulfate silty sand was conducive to causing a considerable rise in the value of the CBR number. Moreover, the swelling potential of the samples was decreased by adding the additives, and actually decreased the swelling of the samples. Nevertheless, adding 1% lime without any amount of microsilis considerably increased their swelling potential. In addition, the results conferred from the scanning electron microscope emphasized that by adding microsilica microsilis to the samples, crystalline textures will be made in the internal structure of the samples. As an important result, the mixture of 1% microsilis-1% lime was shown to be the optimum additive for usage in construction projects, and made the samples show unconfined compressive strength 12 times higher than the intact samples.

Key Words: Silty sand, soil stabilization, microsilis, lime, CBR, unconfined compressive strength, swelling potential.

MODIFICATION OF A CONVENTIONAL APPROACH IN DEVELOPMENT OF A CONDITIONAL MEAN SPECTRUM TO SELECT COMPATIBLE GROUND MOTION RECORDS

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Abstract
The assessment of structural seismic response is often done by selecting ground motion records that conform to the seismic hazard conditions of the objective site,

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Abstract
Shell foundations are structures which derive their strength from geometry rather than mass. This quality enables them to obtain maximum structural integrity with a minimum consumption of construction materials. The use of shells in the field of foundation engineering has drawn considerable interest in different parts of the world. Shell foundations of different shapes have been investigated, on the structural and geotechnical side, at the elastic stage. Because closed-form solutions are extremely complex, especially at ultimate and nonlinear stages, the present investigation has resorted to numerical analysis by the finite element method, using the ABAQUS analysis package. The conical shell is the simplest form of shell that can be employed in foundation engineering, due to its singly curved surface. Reinforced concrete conical shell foundations have been taken up for these studies.
There is close agreement between the analytical and test results, and to show that, the results of the test conducted on the elastic model of a conical shell footing by Kurian (2006) have been represented in this paper and compared with finite element results. The behavior of concrete, soil and bars has been studied in nonlinear form for these kinds of shell foundation. The Mohr-Coulomb plasticity model is used to model soils with the classical Mohr-Coulomb yield criterion. The concrete damaged plasticity model provided in ABAQUS is used for the analysis of concrete. The results presented reveal the general superiority of conical shell foundations. The increasing settlement rate of a shell foundation increases with increasing the load. This is because of the nonlinear behavior of soil and concrete and the decrease in stiffness of these materials. Maximum settlement is shown under the center of the shell foundation, beneath the load. The settlement of the edge of the shell is less than at the center of the shell. But, this difference is not so sensible, because of the high stiffness of shell foundations, and is about 9% for the condition of this investigation. The resistance of the system is increased by increasing the angle of the cone wall.
This increase has an optimum angle, which is about 40 degrees. There is about 90% increase in bearing capacity for the optimum angle of the reinforced concrete cone shell foundation compared to its flat counterpart.

Key Words: Conical shell foundation, finite element method, reinforced concrete, soil structure interaction.

ANALYTICAL MODEL FOR QUANTITATIVE RISK ALLOCATION IN CONSTRUCTION PROJECTS

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Abstract
Risk allocation is commonly defined by the owner through tender documents. The clients commonly transfer the responsibility of most of the risks to contractors. This one-sided attitude regarding risk allocation, however, probably has unfavorable effects on both client and contractor costs.
This research presents a model based on the bargaining game theory, in which the behavior of contracting parties in quantitative risk allocation negotiation processes is modeled. Bargaining is a situation in which players have a common interest to cooperate, but have conflicts on how to cooperate exactly. The most important characteristics of the theory are that the results are determined under perfect information, by rational players, with positive discount rates, having a realistic bargaining protocol, immediate settlement, and a unique equilibrium with no time loss. In order to perform the quantitative risk allocation, the client and contractor costs (payoffs) are determined at different percentages of risk allocation. Having determined the client and contractor payoffs, the common interval between the players' acceptable risk allocation percentage is determined. The

Key Words: Triple friction pendulum, near-field, Genetic Algorithm.

INVESTIGATION INTO THE EFFICACY OF THE CONFIGURATION OF LATERAL BRACES IN 2D STEEL FRAMES ON THE BEHAVIOR OF FRAMES BY SECOND-ORDER INELASTIC ANALYSIS

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Abstract

In this paper, some material and geometrical nonlinear effects, and methods of second order nonlinear advanced analysis are investigated. Numerical methods are used to investigate the effect of replacing concentric braces on steel frame performance. Three, six, ten and twenty story 2D frames with eight different arrays of braces and four loadings are analyzed.

ANSYS finite element software was utilized to perform second order nonlinear analysis and Lateral Load-Displacement curves were drawn. Curves linear regression was calculated to define new lateral stiffness showing the frames performance. The method used in this investigation is plastic region second-order nonlinear analysis and is applied to structural system analysis, based on the modified finite element method.

The plastic-elastic hinge model refers to the simplest analysis. By comparison, the plastic-elastic region model illustrates the most reformations. The plastic region analysis method models plastic development in the whole structure. This method is performed in two ways. The first one is lattice, using finite element, and the second is based on the Beam-Column theory. The second order nonlinear analysis used in this paper enumerated plastic region advanced analysis, and includes nonlinearity in geometry and material, like second order effects (P-$\pounds$ and P-Δ), redistribution of internal loads, because of plastic region formation, lateral stiffness degradation, based on steel yielding, and shear deformations. To apply all the mentioned factors in the analysis, many methods and codes were suggested by other authors. For example, the AISC-LRFD code applies an effective length factor, enhancement factor and interaction design term of the mentioned factors in analysis and design. The reason is because of the low quality of computers when codes were originally established. Second order nonlinear advanced analysis could apply all the mentioned terms in the design procedure directly.

This method assimilates analysis and design, so, designers do not need different codes. It is hoped that these methods will be used as a common structural analysis/design method by developing computers. Each analysis that could determine the strength and stability of structural systems and isolated members in such a way that does not need to control isolated members capacity and the definition of effective length coefficient is enumerated as advanced analysis. This method gives much information to designers about the behavior of structures exposed to external loads and environmental conditions. In this investigation, a BEAM element was utilized to model structures. Results show that applying the method used in ANSYS could determine the frame ultimate loading coefficient of "Vogel Frame" by 3 percent tolerance, compared to the plastic region analysis method and plastic hinge analysis. Performing about eighty analyses denoted that changing bracing arrays could increase or decrease ultimate strength, ultimate displacement and lateral stiffness multiple times. To increase the ultimate strength coefficient, the best option is using an X-brace frame. Furthermore, applying diagonal bracing in off side spans could decline the lateral displacement of the structure. Frames without a bracing system and with Chevron and eccentric bracing systems demonstrate the most nonlinearity.

Key Words: Brace, nonlinear geometric, nonlinear material, second-order effects, inelastic effects, ANSYS.

ANALYSIS OF REINFORCED CONCRETE CONE SHELL FOUNDATIONS WITH DIFFERENT SLOPES

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Abstract

The uncertainty inherited in the behavior of a structure could cause significant differences between the results of the analytical model and the actual behavior of the structure. The probabilistic characteristics of the material, errors in the construction, and the uncertainty of the seismic loads could account for major causes of discrepancy between analytical results and the actual response of the structure. In this regard, inevitable uncertainties in the behavior of the system should be recognized and the probability of the failure of the structure should be calculated for the desired level of performance. The availability of sophisticated computational tools provides the engineering society with the opportunity of estimating the performance of structures by computing the probability of occurrence for a specific state in the structure. Simulation techniques, such as Monte Carlo simulation, are efficient and promising computational methods in the context of reliability analyses to obtain the required knowledge about the probabilistic behavior of structural systems. In this paper, the effect of the tuned mass damper (TMD) on the performance of steel moment-resisting frames has been studied using the Monte Carlo simulation technique. The failure probability for the stories of the structure has been calculated, based on the relative displacement of each story. The capacity and stiffness of the structural elements have been modeled through the probabilistic fiber-discretized sections for each element. Also, the probabilistic effect of seismic loading has been taken into account, by generating records with fully stochastic characteristics in the time and frequency domain. The uncertainty in the damping characteristics and seismic mass of the structure is also considered. The results indicate that for far-field earthquakes with low mean period, TMD could reduce the failure probability of the structure, with different effects on each story. The maximum density of relative displacement has been shifted towards small values, mainly for higher stories, by using the TMD on the roof story of the structure.

Key Words: Failure probability, tuned mass damper, probabilistic model, steel moment-resisting frame.

OPTIMUM SEISMIC DESIGN OF TRIPLE FRICTION PENDULUM BEARING UNDER NEAR-FIELD GROUND MOTIONS

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Abstract

Nowadays, basic isolation is an extensive technology that is applied in many countries, and the construction basics of their different types are well known. It seems that inventors have an inevitable interest in this concept and, so, they propose innovative base isolation systems each year. Many of these systems are not applicable, and may be, in some cases, perilous, but their numbers are vastly growing, year by year. In recent years, the damage to well designed structures, due to ground motion, has attracted the attention of engineers to near-field sources of motion and their effects on building performance. Triple Friction Pendulum Bearings (TFPBs), as an adaptive seismic isolator, with different stiffness and damping properties, can guarantee the seismic performance of an upper structure for long periods and amplitudes of near-field ground motion. TFPBs are made of multiple concave surfaces with different friction coefficients. The magnitude of displacement will cause a transition of sliding on surfaces, and produces appropriate damping and stiffness. Hence, optimization of effective design parameters for an objective performance is critical.

First, the behavior of TFPBs is investigated to identify its dominant design parameters on the response of structures, such as story drift, roof acceleration and displacement of isolated levels. Then, a specific numerical optimization method, based on Genetic Algorithms, has been applied to determine the optimum value of these parameters to achieve the minimum response of the structure. In this process, near-field ground motion with different characteristics, such as a pulse period, at different hazard levels has been used.

As the results of GA analysis shows, it was realized that the optimum design parameters have significantly different optimum intervals for different target responses. So, different response targets were combined linearly, to make a new fitness function. The partnership coefficients of each single objective function can be chosen by the desire of the designer. The superstructure was assumed to have rigid behavior, so, the vibration period of the structure adheres to the TFPB period. Thus, optimum design parameters can be used for different types of superstructure with the same behavior.

the elasticity modulus of the soil was considered to be a linear function of depth.
The results obtained by numerical modeling were compared to the traditional Vesic and Bowel equations. As results, in spite of Terzaghi, Vesic and Bowel methods, it is obtained that the horizontal modulus of sub-grade reaction increases with the pile diameter. Also, a higher heterogeneity factor leads to a higher rate of increase in the value of sub-grade reaction. In the case of larger pile diameters, this increase in the sub-grade reaction value will be more reasonable. In addition, in homogenous clays, axial loads have no significant effect on the value of the sub-grade reaction. Nevertheless, in heterogeneous clays, this modulus increases with the degree of heterogeneity.

Key Words: Single pile, pile's horizontal sub-grade reaction modulus, pile's horizontal sub-grade reaction coefficient, pile diameter, heterogeneity, axial load.

A NEW METHOD TO ESTIMATE IMMEDIATE SETTLEMENT OF A SHALLOW FOUNDATION USING SOIL MAXIMUM STIFFNESS

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Abstract
In the design of shallow foundations, permissible settlement is often the controlling design criterion. Numerous methods have been developed over the years to estimate the elastic settlement of footings over cohesionless soils. The conventional methods utilize correlations between measured settlements and some parameters from reasonably simple field tests. These include, in particular, standard penetration tests (SPT) and cone penetration tests (CPT). Often, the mentioned correlations overpredict settlements.
In-situ direct estimation of the maximum or small-strain stiffness (G_max or E_max) of soil is more effective and reliable than those derived from resistance-based correlation or laboratory testing. In addition to a geophysical refraction seismic survey, there are several other techniques for measuring maximum stiffness at the site, such as the cross-hole, the down-hole, spectral analysis of surface wave (SASW) and the continuous surface wave method (CSW). In these methods, an electromechanical vibrator or impact source is used to generate surface waves. Then, geophones receive ground responses to measure up Rayleigh wave velocity and maximum stiffness.
In this paper, a new method is provided in order to determine the settlement of a shallow foundation based on small-strain stiffness. The suggested relationship in this study will be the modified small-strain stiffness of the soil layer, according to the level of foundation pressure. The elastic settlement is obtained using the relationships of the elasticity theory, based on foundation width, stress field and modified stiffness.
In order to validate the proposed method, the results of the survey of loading tests and seismic geophysical tests at several sites were evaluated and compared. Appropriate coincidence between the results of the loading test and the predicted settlement shows the accuracy of the proposed method in comparison to other methods, which were more accurate than the SPT or CPT based predictions. In general, predictions based on in situ parameters from seismic measurements are closer to the measured settlement under service loads.

Key Words: Immediate settlement, shallow foundation, granular soils, shear wave velocity, maximum stiffness.

EFFECTS OF TUNED MASS DAMPERS ON FAILURE PROBABILITY OF STEEL MOMENT-RESISTING FRAMES

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Abstracts of Papers in English

INVESTIGATION OF PILE DIAMETER EFFECT ON MODULUS AND COEFFICIENT OF HORIZONTAL SUB-GRADE REACTION, CONSIDERING AXIAL LOAD AND SOIL HETEROGENEITY

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Abstract

The modulus of horizontal sub-grade reaction is one of two important stiffness parameters. This modulus defines the relationship between the soil reaction, p, and the pile deflection, y. Thus, knowing the exact amount of horizontal sub-grade reaction will lead to a more accurate pile design.

In the theory of a sub-grade modulus, soil stiffness is defined by a series of independent elastic springs, while, in reality, they are interrelated in a complex fashion. Also, in cases where plastic soil behavior will most likely be initiated at the ground surface, especially for pile heads, the effect of pile diameter on the sub-grade modulus will be more important. Furthermore, in the classical sub-grade problem of Vesic, a flexible beam supported on an elastic half-space, the effect of heterogeneity has not been taken into account.

Thus, in this study, the real behavior of a sub-grade modulus with pile diameter, the effect of heterogeneity and the existence of axial loads on the variation of sub-grade reaction, are investigated using a traditional computer code, namely FLAC (accounted for the Fast Lagrangian Analysis of Continua). The validation of the modeling procedure is carried out using a laterally loaded pile case, in which, the behavior of a driven pile was experimentally studied on over-consolidated clay in Houston. To take the heterogeneity effect into account,