(LRFD) is one of the most applicable reliability-based methods. Its advantage is consideration of the uncertainties in strengths and loads separately. In this article, design philosophies and safety factors in different codes are first explained. By comparison of load factors of the LRFD in 8 different codes, it can be concluded that offshore and bridge codes have wider ranges for load factors than building codes. Then, the axial design of piles, in accordance with the API code, Eurocode 7, and Canadian codes, is discussed. API proposes both LRFD and working stress design (WSD) methods for the design of offshore structures. A numerical example for the design of axially loaded pile following API is conducted to compare LRFD (reliability-based) and WSD (deterministic) methods of API. Results show that the required penetration depth computed in the LRFD method is a little higher, however; this conclusion is not generalized to other situations. The Eurocode suggests three approaches for the design of piles. The difference between these approaches is related to the way they use load and resistance factors. A numerical example for design of axially loaded pile, according to three approaches of the Eurocode, indicates that these three approaches give approximately similar answers; however, the third approach is rather more conservative.

Key Words: Axial capacity of piles, pile design codes, IRFD method.

lysts are assisted through defining and providing some effective rules.

Key Words: Construction projects, delay analysis methods, easy plan program, window- based analysis.

A SURVEY OF CONCRETE SLUMP EFFECTS ON THE COMPRESSIVE CAPACITY OF DRILLED SHAFTS (CASE STUDY: SORKHROOD SITE)

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Abstract
Using deep foundations is a solution in regions with surface soil having poor mechanical properties. Indeed this kind of foundation can bear horizontal, gravitational and tensile forces. In this regard, researchers study effective various parameters on pile behavior in the laboratory, such as the effect of pile dimensions, soil properties, methods of installation, types of loading, and some other effective parameters. The bearing capacity of single drilled shafts with the effects of various slumps on poor gradation sandy soil is investigated in this paper, in Sorkhrood. Experiments related to the bearing capacity of a pile using 15 pile samples with 150cm length and 12cm diameter have been undertaken. The concrete used in the piles is considered as 5 discrepant groups, with constant slump of 10, 12, 16, 20 and 24cm and a compressive strength of 210 kg/cm. A strong polymer pipe has been used as a casing, drilled step by step into the ground and then taken from the ground frequently. According to the experimental observations, increasing the amount of concrete slump used in the pile body has a great influence on pile bearing capacity. It is shown that the bearing of compressive piles has been increased in the higher slumps. Increasing the amount of slump, due to the combination of the casing of the pile with the soil around the casing, changes some parameters of the soil, reducing the shaping. The amount of its influence leads to the double difference between the bearing capacity of the pile filled with the lowest slump and the pile filled with the highest slump. It is indicated that the method presented by Janbo & Bousen is an entirely conservative method, while the method presented by Mayerhouf and Bousen is closest to the results of the bearing experiments in calculating the final bearing capacity. Finally, the bearing capacity of piles is investigated and compared with common methods.

Key Words: Drilled shaft, bearing capacity, concrete slump, sandy soil, case study.

COMPARISON OF DIFFERENT CODES FOR DETERMINATION OF THE AXIAL BEARING CAPACITY OF PILES

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Abstract
Despite recent developments in proposing a scientific method in pile design, determination of the capacity of piles is still complicated due to the importance of soil-structure interaction in piles. Different codes have proposed various methods for the axial capacity of piles; however, these methods are based on assumptions that are not applicable in all situations. Traditionally, engineers use safety factors to compensate for the uncertainties and balance between reliability and economy. This traditional method is called deterministic. However, deterministic methods are very subjective and are generally not based on a systematic assessment of reliability. Therefore, these methods may produce structures with some overdesigned components. For elimination of these deficiencies, reliability-based methods have been developed. The load resistance factor design

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Abstract

Among different types of space frame, the dome holds a special position because of its structural stability. Since changes in geometry play a key role in the structural response of space frames, in this paper, the effects of applied pellevation with different geometry on improving the seismic performance of single layer diamatic domes are studied. For this purpose, one group, including simple single layer diamatic domes with different ratios of rise to span, has been created, and then, in another three groups, different types of pellevation are applied to the first group. Each group contains five models, and the defined groups have been generated in such a way that different possible geometries have been covered.

In formex algebra, during the pellevation process, a geometric object is used to deform a part of the given configuration by pushing the object upwards. In this paper, barrel pellevation, which can be easily matched to diamatic domes, is applied via implementing the BAPLE function. The computer program, Formian, is used as a tool to configure the pellevated single layer diamatic domes.

The nonlinear dynamic time history analysis is performed for the defined models, and the structural behaviors of the different systems are compared with each other via frequencies and mode shapes. For non-linear time history dynamic analysis, three scaled ground motion records appropriate to the design hazard levels of the Iranian Seismic Code have been selected.

Checking overall stability shows that dome deflection is the dominant design criteria, and, fortunately, it is possible to decrease the seismic deflection of diamatic domes via a change in geometry by applying proper pellevation. The results show the desirable effects on the weight reduction of pellevated domes. Structural performance has been improved, such as the weight of the dome can be reduced by about 16% via choosing proper pellevation.

Key Words: Space frame, diamatic dome, pellevation, time history analysis, optimum ratio of geometric.

ANALYSING WINDOWS-BASED DELAY ANALYSIS METHODS IN THE EASY PLAN PROGRAM AND OFFERING A FRAMEWORK IN SELECTING THE BEST DELAY ANALYSIS METHOD

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Abstract

Delays in the execution and operation of construction projects are of serious concern. In general, delay is described as any kind of extra time taken beyond previous mutual agreement. This is influenced by a number of internal or external project parameters and often leads to problems and claims between owners, contractors and all parties involved. This issue is even more important in developing countries and is a crucial phenomenon for all involved parties of a contract. The importance of this issue has been compounded by the existence of different delay analysis methods and has made this issue a very challenging controversial area. Mostly, project managers and time scheduling analysts are faced with the problems of delay analysis and solving its induced claims. Furthermore, the system of delay analysis and evaluation is not included in most construction projects and, therefore, both contractor and owner may have differing views on delay analysis and its corresponding responsibilities. Thus, estimation of delay effects and determination of each party's responsibilities are critical. Hence, project managers and analysts must have an effective and efficient systematic approach for analyzing delays and determining responsibilities. In this paper, first, a general comparison on the current available methods for analyzing delays in construction projects is introduced. Then, a windows-based delay analysis, identified as a more accurate method than other effective methods, is presented. The results of each method are discussed and compared through a case study run by the Easy Plan program. Windows-based methods are somewhat similar to each other but still have some differences. Sometimes, their analysis results are different. The results of the present study demonstrate the limitations of each of these analysis methods and helps analysts in their proper selection. In fact, considering project conditions, ana-

linear and nonlinear elastic simulations are included. During unloading and reloading, Plastic deformations can occur and can influence the overall response of the structure. In this study, the Desai equations, which that are simple but can provide satisfactory simulation for the unloading and reloading states of reinforced concretes under cyclic loading are used. The elastic-perfectly plastic behavior of steel reinforcement is assumed. Then, in order to study the capability of the proposed models in the analysis of nonlinear finite elements of reinforced concrete structures under monotonic and cyclic loading, a program was written in FORTRAN language in a framework of the finite element. This program used eight- noded serendipity elements for concrete and two-noded elements for reinforced concrete. In order to study the capability of the proposed model in predicting the behavior of reinforced concrete structures under monotonic and cyclic loading, one beam and one frame have been modeled and the results of the load - displacement were found for them. Comparison between the load-displacement obtained from these structures with laboratory results show good agreement, and shows the capability and potential of the present model in investigating the nonlinear behavior of reinforced concrete structures.

Key Words: Reinforced concrete structures, monotonic loading, cyclic loading, nonlinear finite element analysis, hierarchical single-surface (hiss) plasticity model.

LABORATORY ASSESSMENT OF EFFECTING WATER CONTENT AND FOAM INJECTION RATIO ON SOIL CONDITIONING FOR EPB-TBM TUNNELING

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Abstract

In EPB-TBM tunneling, a positive face control during tunnel excavation is delivered and the tunnel face is supported by pressure from the mass of remolded soil within the cutterhead chamber. EPB TBMs operate more effectively when the soil immediately ahead of the cutterhead and in the chamber forms a plastic plug, which ensures face support. The target properties for extracting soil in an EPB TBM can best be described as a soil matrix exhibiting a soft workable plastic consistency. The behavior of excavated soil from mixing up to extraction depends mainly on the property called workability of conditioned soil. Workability in simple terms can be defined as the ease with which the excavated soil can be mixed with additives, compressed in pressure chamber, flowed freely from the face and finally extracted from screw conveyor. Furthermore, the workability is an indicator for the plasticity of the support media, comparable to the consistency of cohesive grounds and thus a criterion for the applicability of EPB tunneling. The factors which effect the workability of conditioned soil are water content, fine grain, foam injection ratio (FIR). In this study, effecting 10 and 20 percentage of water content and FIR on workability of conditioned soil for EPB-TBM tunneling is assessed with laboratory slump test. The 66 laboratory trials of soil-foam-mixtures were made to investigate the influence of the mentioned parameters on workability of conditioned soil. To analyze the available data using statistical methods, relationships between mentioned parameters and slump test results were investigated. Results of analyzes show that there are a quantitative relation between water content and the workability for the application of EPB shields. The present study clearly showed that the decrease of water content and FIR became stronger with the decrease of the slump of conditioned soil. Finally, in this study, a new empirical chart, for assessment of and workability of conditioned soil is suggested.

Key Words: Epb-tbm, tunnel, soil conditioning, workability, slump.

STUDY OF PELLEVATION GEOMETRY EFFECTS ON IMPROVING SEISMIC PERFORMANCE OF SINGLE LAYER DIAMATIC DOMES

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ROAD USER DELAY ESTIMATION MODEL USING SOFTWARE SIMULATION

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Abstract

Choosing and providing appropriate strategies and proper amenities for road users passing through work zones is an important topic in work zone management. Authorities have always faced issues in this regard, so, there is a need to create a balance between expediting construction projects and the cost to road users, while also keeping the limitations of available resources in mind. The delay caused by work zone activities is an important parameter that disturbs transportation systems. This delay mainly results from queue generation and subsequent speed reduction in the area. Since, in most cases, there is no likelihood of completely removing this delay, using appropriate delay models, it is feasible to get a realistic understanding of the costs imposed on road users, as well as making the best decision to reduce these costs. In order to develop an appropriate delay model, at first, the work zone was modeled using Aimsun microscopic simulation software. Next, the time delay produced by lane closure for different input volumes and work zone lengths was determined. According to the results, the volume-to-length of the work zone parameter is more effective when it comes to work zone delay. Afterwards, taking advantage of SPSS21 and evaluating various kinds of regression model, a multiple nonlinear model was recognized to better explain the work zone delay in freeway two-lane roads. Finally, the costs of work zone activities on the Rasht-Qazvin freeway in 1392 were calculated and the costs associated with each of lane closures were discussed in detail. Based on these results, as expected, the maximum average delays were a result of sudden and un-planned closures. However, for planned maintenance activities, the average delay was greatly reduced due to the ability to choose an appropriate time for the closure. Great care has been taken to produce a usable model based on historic data, which can be used as a tool for estimation of average delay. This model will enable authorities to choose a suitable time and strategy, in order to reduce road user delays.

Key Words: Work zone, delay, microscopic simulation, multiple non-linear model.

NONLINEAR ANALYSIS OF REINFORCED CONCRETE STRUCTURES UNDER MONOTONIC AND REVERSED CYCLIC LOADING USING THE FINITE ELEMENT METHOD

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Abstract

In this study, for predicting the behavior of reinforced concrete structures under monotonic and cyclic loading, a nonlinear finite element analysis has been used. For simulation of the nonlinear behavior of concrete under pressure and tension, the hierarchical single-surface (HISS) plasticity model has been used that can take into account elastic and plastic deformations. It involves a single continuous yield surface, unlike some previous models that include multiple and discontinuous yield surfaces, which can introduce computational difficulties. This model, which allows for isotropic and anisotropic hardening and associated and non-associated plasticity characterizations, can be used to represent material responses based on the continuum plasticity theory. Cyclic and repetitive loading, involving loading, unloading and reloading, occur in many problems, such as dynamics, earthquakes and thermo-mechanical responses. The unloading response is often nonlinear, However as a simplification, it is often treated as linear elastic. Here, both

Abstract

With regard to the benefits and drawbacks of all lateral load resisting systems, using the most appropriate, according to building conditions, can maximize the capacity of the structure. Concentric braced frames (CBF), eccentric braced frames (EBF), intermediate moment frames, and pin connection frames, as well as steel shear walls, are standard systems in designing steel buildings. Seismic behavior and the economy of the design are two fundamental factors for selecting an appropriate lateral load resisting system. In this research, 3-bay frames of 4, 8 and 12-stories, with a braced middle bay, have been designed using Iranian seismic code (standard No. 2800) by the equivalent static approach.

PERFORM 4.0.2 has been used to evaluate the seismic function of structures. Therefore, the frames designed by PERFORM have been modeled and evaluated with nonlinear static analysis. Considering the capacity curve and the target displacement in various limit states of the structures, frames with steel shear walls give the best seismic behavior (in terms of stiffness, ductility and energy efficiency), whereas frames with CBF give the least desirable results (especially with less ductility compared to other systems). Due to the high magnitude welding needed for frames, the frames designed by EBF and steel shear walls are the best and worst economical designs, respectively In view of the economy of the project, as well as its seismic behavior, steel shear walls are the best selection for 12 story buildings. EBF is recommended in 4 and 8 story buildings, while CBF and moment frames are satisfactory in 4 story buildings.

Key Words: Steel shear wall, EBF, CBF, moment frame, seismic behavior, economy of the design, perform.

MODELING OF CYCLIC PERFORMANCE OF STRUCTURES CONSIDERING PINCHING, STIFFNESS DEGRADATION, STRENGTH DETERIORATION, AND SLIDING PHENOMENA

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Abstract

Nonlinear hysteresis behavior is an important inherited property of any structural system. The shape of structural hysteretic behavior is a result of either changing material properties beyond the elastic range or changes in structural geometry (e.g. buckling, cracks) due to the subjected loads. The hysteretic response of a structure depends not only on the immediate deformation of elements, but also on the past history of the deformations, as it represents the energy dissipated by the structure. While, in some cases, such as well-designed hot-rolled structures, the hysteretic loops are quite smooth and stable, in some other cases, like cold-formed steel structures, they exhibit pinching, stiffness degradation, load deterioration, and sliding. Increasing the displacement under strong dynamic forces such as earthquakes, the hysteresis cycles enter from the elastic phase into the plastic phase. Hence, ignoring non-linearity in hysteresis behavior and neglecting degradation effects lead to ignoring much energy loss by dissipated energy mechanisms. Consequently, the designs would be uneconomical. In contrast, improper inclusion of the nonlinear hysteretic performance, such as neglecting sliding and strength deterioration, causes non-conservative structural design. Thus, considering real plastic deformation and proper non-linear behavior are essential and important in the assessment of structural stability. In this paper, an analytical model is introduced to show the hysteresis behavior of the structures, considering degradation phenomena, including pinching, stiffness degradation, strength deterioration and sliding effects. This model is based on a modified Mostaghel model, which is developed considering a single degree of freedom (SDOF) mechanical system; and is characterized using a system of partial differential equations and some specific functions which are mainly derived from the Signum function. The proposed model is developed to a multi-degree of freedom (MDOF) multi-liner model and would be able to capture the key features of the hysteretic cycles of any structure using some measurable system parameters through tests. In order to demonstrate the degrading phenomena of the hysteresis behavior of the structures, several examples are presented to show that the proposed analytical model is capable of providing realistic description of the structural hysteretic performance.

Key Words: Hysteretic behavior, analytical model, pinching, stiffness degradation, strength deterioration, sliding.

have any effect on dye removal. The reducer, however, was able to remove the dye completely. Also, the use of nickel with 3 wt% iron increased dye removal efficiency by 14.65%. According to the survey conducted, optimal conditions were obtained when the tests were performed at temperatures of $25 \pm 2^0 C$ with newly synthesized nanoparticles that have 0.05 gr/L concentration with an initial concentration of dye equal to 200 mg/L and pH of 7.5 and a beginning mixer time of two minutes. These nanoparticles had very high activity, so, removal efficiency after 2, 30 and 240 minutes, was 79.39, 90.52 and 94.42 percent, respectively. Finally, LC-Mass experiments indicated that after 4 hours of reaction, the azo band in the dye was broken.

Key Words: Synthesis of bimetallic nanoparticles fe-ni,performance of bimetallic nanoparticles fe-ni in contaminants removal, dye removal, acid red 14.

USE OF CLOSELY SPACED HEADED BARS IN BEAM-COLUMN JOINTS SUBJECTED TO CYCLIC LOADING

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Abstract
Generally, a conventional 90-degree standard hook is used for the anchorage of reinforcing bars terminating within a beam-column joint. It is well accepted that hooked bars should be bent into the joint with the hook embedded as far as possible from the critical section. This requirement and the specified dimensions of standard hooks in the ACI 318 Code, however, often cause steel congestion in an exterior beam-column joint, thereby, making fabrication and construction difficult. Using headed bars offers a potential solution to this problem and can also ease fabrication, construction and concrete placement.
Relevant provisions and limitations of headed deformed bars have been provided in the ACI 318-11 Code. Over the last two decades, many experimental studies have been carried out to evaluate the provisions of the ACI 318 Code for anchored headed bars. There is still a need for additional data for various design parameters, such as headed-bar clear spacing and the number of layers of beam reinforcing bars. In this regard, the current study investigates the applicability of closely spaced headed bars in the exterior beam-column joints of earthquake resistant structures. Four 2/3-scale exterior beam-column joint specimens were manufactured and tested under cyclic lateral loading. The variables in different specimens include clear spacing and the number of layers of the headed bars of the beam, and also the development length of the headed bars.
The seismic performance of the tested beam-column joints is qualitatively evaluated based on the acceptance criteria in ACI374.1-05 entitled: "Acceptance Criteria for Moment Frames Based on Structural Testing and Commentary". Evaluation of the specimens' load-displacement hysteretic behaviour and comparison of the test results with ACI 374.1-05 criteria, show that beam-column joints with closely spaced headed bars can exhibit satisfactory performance and adequate anchorage capacity. Test results also indicate that headed bars with a development length shorter than that provided by the ACI 318-11 Code can be effectively anchored in exterior beam-column joints under inelastic deformation reversals.

Key Words: Beam-column joint, cyclic load, headed bar, reinforced concrete, seismic design.

A COMPARISON BETWEEN SEISMIC BEHAVIOR AND ECONOMY OF STEEL SHEAR WALLS WITH COMMON LATERAL BEARING SYSTEMS IN STEEL STRUCTURES

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and numerically, the ultimate shear strength of longitudinally stiffened simply supported steel-concrete composite plate girders under shear loading. In this study, a theoretical formula is proposed to estimate the ultimate shear strength of such girders. The proposed method is approximate, simple, does not require any complex mathematical operations and can be applied to composite plate girders at the preliminary stages of design. The proposed analytical method considers the tension field action within the plate girder web panel and the shear failure of the concrete slab. The method incorporates the effects of the concrete slab, composite action, and web shear buckling of the composite girder. The ultimate shear capacity of the composite plate girder may be considered as the combined shear strength resisted by the steel part of the girder and that by the concrete slab. These two components can be computed separately and summed up to obtain the shear strength of the composite girder. The method used to determine the shear strength of the steel part is similar to the Cardiff model, in which the web panels are assumed simply supported along the longitudinal and transverse edges.

On the basis of previous experimental studies and detailed information obtained from finite-element studies, it may be considered that each individual subpanel in the longitudinally stiffened composite plate girder can develop its own tension field independently of adjacent subpanels. Furthermore, the web panels are assumed simply supported along the longitudinal and transverse edges. Three different locations of longitudinal stiffeners are investigated and appropriate analytical methods are proposed for each case. These locations are: close to the compression flange of the steel girder, near to the tension flange of the steel girder and in the middle of the plate girder.

Several validated finite element models of the composite plate girders having different configurations of longitudinal stiffeners are also generated to verify the proposed method and compare the analytical and numerical outcomes. These three-dimensional finite element models are developed to account for the geometric and material nonlinear behavior of composite girders. The models are first verified by experimental values obtained for girders with no longitudinal stiffeners, which have been tested by other researchers, and, afterwards, different configurations of longitudinal stiffeners are added to the models.

The calculated ultimate shear strengths using the proposed method are in good agreement with both numerical and experimental values. This indicates that the proposed analytical equations can be applied to predict the ultimate shear strength of the girders for design office use. In comparison with the un-stiffened girders, it is also observed that longitudinal stiffeners are able to reduce the buckling effects of the web steel plate, increase the elastic shear buckling strength, and, therefore, the ultimate shear capacity of the girders.

Key Words: Composite plate girder, longitudinal stiffeners, shear strength, non-linear finite element analysis, analytical method.

SYNTHESIS OF BIMETALLIC NANOPARTICLES FE-NI AND INVESTIGATION OF THEIR PERFORMANCE IN AR14 DYE REMOVAL FROM AQUEOUS SOLUTIONS

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Abstract

According to studies, nearly 15 percent of synthetic dyes enter wastewater during production and consumption operations annually, which is very dangerous and causes many problems for the environment. Thus, removing these compounds is mandatory. NZVI can be used in detoxification of many environmental pollutants, as a reducing agent and catalyst. In order to develop the technology of NZVI, bimetallic nanoparticles are prepared by deposition of a noble metal, such as nickel, over iron nanoparticles. In this study, as a simple and applicable method in the laboratory, bimetallic nanoparticles, Fe-Ni, were made using the method of chemical deposition of iron chloride ($FeCl_3.6H_2O$) by a strong reducer, sodium bohr hydride (NaBH4), under nitrogen gas. To ensure the size and nature of the nanoparticles, SEM and XRD experiments were performed. Then, the nanoparticles were used in a slurry system to remove the azo dye (ccid red 14). To achieve optimum conditions during the experiments, the parameters of the dye initial concentration, nanoparticle dosage, pH, elapsed time from creation to implementation of the nanoparticles, shaking speed and temperature were investigated. Then, to identify other effective factors, a control experiment was performed under the optimal conditions and it was found that ethanol, nickel, and light do not

on some double layer grids, and a comparison is made with the results of the equations of the code of practice of China. It is shown that the introduced equations in this research make the DLGs safer against strong ground motions.

Key Words: Equivalent static earthquake loading, code of practice of china, double layer grid, a-seismic, space structures.

EFFECT OF BIOGROUTING IN REDUCING THE EROSION RATE OF SAND

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Abstract
The simplest soil improvement processes are compaction and drainage. Other processes include improving the gradation of particle size and adding binders to weak soils. There are various treatment techniques available to improve the condition of poor or unstable ground by altering the nature of the soil in-situ. These methods are used when replacement of the in-situ soil is impractical because of physical limitations, environmental concerns, or is too costly. Biogrout is a new method in geotechnical problems and can induce soil improvement on microbial induced calcium carbonate precipitation (MICP). Biogrout may provide new opportunities for cost-effective and environmentally friendly processes. Bacteria produce the urease enzyme. This enzyme converts urea into ammonium and carbonate; finally producing calcium carbonate. The calcium carbonate forms a bridge between the sand grains, which increases the strength of the soil. In this study, the Sporosarcina pasteurii bacteria were utilized, an aerobic bacterium which exists pervasive in natural soil deposits, in order to control silica sand erosion. An XRD test was performed to evaluate the calcium carbonate precipitation.
Erodibility parameters were obtained by erosion function apparatus (EFA). The test result consists of the erosion rate versus shear stress curve, and the slop of the curve is the erodibility coefficient, which represents the resistance of soil to erosion.
Bacterial optical density (OD600) was $1(8\times10^7$ cell/ml) and cementation included 0.5 M urea and 0.5 M urea and 0.5 M calcium carbonate in all of samples. Bacteria and cementation were separately injected in soil and saturated for 24 hours, then, drained from the soil. The effect of aeration in the bacteria and cementation saturated in soil was investigated and results show that the sample with aeration decreased the erodibility coefficient twice as much as the sample without aeration. A repeat of grouting was investigated too and a reduction of erodibility coefficient was observed up to 95% for sample D (bacteria and cementation were injected twice at an interval of 5 days) Consequently, biogrouting for is shown to have an appropriate performance in the control of sand erosion and can be used in the control of pier, contraction and abutment scour.

Key Words: Biogrouting, sporosarcina pasteurii, erosion function apparatus, calcium carbonate, MICP.

ULTIMATE SHEAR STRENGTH OF STEEL-CONCRETE COMPOSITE PLATE GIRDER WITH LONGITUDINAL STIFFENERS LOADED IN SHEAR

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Abstract
The contribution of longitudinal stiffeners to the shear capacity of composite plate girders has not been studied. This paper aims to investigate, both analytically

Abstracts of Papers in English

ASSESSMENT OF EQUIVALENT STATIC EARTHQUAKE LOADINGS ON DLG AND THEIR VERSATILITY

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Abstract

Reticular space structures are widely selected as cover for large spaces, and are also used as refuge spaces for earthquake hit areas. Space structures are light and highly indeterminate and, for some time, these two properties caused researchers to take them as a-seismic structures. However, the 1995 Kobe earthquake in Japan showed that although space structures are safer than conventional buildings, they are not completely a-seismic.

Double layer grids (DLG) are one of the most frequently used types of space structure. The aim of this research is to introduce some relations for calculating the earthquake induced forces on these structures. The relations comprise of a) assessing the static equivalent vertical base shear of earthquake action on DLGs and b) assessing the distribution pattern of the vertical base shear on the nodes of these structures. These relations make assessment of the earthquake action on the double layer grids very easy and versatile.

In this research, for assessment of the vertical equivalent static earthquake loading on double layer grids, a set of double layer grids are established. These grids have the same configuration but different dimensions. Also, five strong ground motions with high vertical components are selected. The acceleration records of the earthquakes are scaled for a very high seismic area. By numerous linear and nonlinear analyses, a formula for assessing the earthquake vertical base shear on DLGs is produced. Also, a set of equations for distribution of the base shear on the nodes of these structures is developed. In the final stage, the versatility of the equations is examined