Abstracts of Papers in English

ACTIVE LENGTH OF NATURAL GAS PIPELINE SUBJECTED TO LANDSLIDE

S. Hemmati
soheil.hemmati@stu.iiees.ac.ir
A. Vasseghi(corresponding author)
vasseghi@iiees.ac.ir
International Institute of Earthquake Engineering and Seismology (IIEES)
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Abstract
Natural gas transmission pipelines have a vital role in human life and thus, they are classified as lifelines. Long-term disruption in the pipeline operation due to landslides would have substantial direct and indirect consequences. Landslides are generally accompanied by large movements of the ground and result in the deformation of the pipeline and the surrounding soil. In buried pipelines, a significant length of the pipeline moves relative to the soil during a landslide. This movement activates the friction between the soil and the pipeline. The location where the relative movement and the friction diminish to zero is called the virtual anchor point. The clear distance between this point and the landslide where the relative movement occurs is known as the anchor length. Active length of the pipeline is the distance between two virtual anchor points on either side of the landslide and it is the sum of the two anchor lengths and the width of the landslide. During a landslide, the pipe within this length would be highly stressed and it is prone to failure. The active length is considered as the protected length and to reduce the risk of pipe rupture, construction of bents, joints, and equipment should be avoided within this length. Thus, an accurate estimate of this length is an important consideration in the design process.

In this study, finite element analyses are carried out to evaluate the anchor lengths of common gas transmission pipelines in Iran. The analyses are performed using Ansys software platform. The pipe is modeled by nonlinear pipe elements and the pipe-soil interaction is modeled by Winkler springs. Buried pipes with diameters of 12, 20,

30, and 48 inches under internal pressure of zero, 500, 1000 psi in two different soils are analyzed. The results of the analyses indicate that the anchor length increases with increasing pipe diameter. The soil properties also significantly affect the anchor length, but the internal pressure has only marginal effect on the anchor length. The relevant equation of the anchor length provided by the PRCI guidelines is about 35% less than the anchor length obtained from the analyses. A more accurate equation for the anchor length is proposed in this study.

Key Words: Landslide, Gas transmission pipeline, active length, anchor length, failure, finite element analysis.

TURBULENCE STRUCTURES AND SEDIMENT TRANSPORT OF DIFFERENT COUNTERMEASURE ROUGHNESS OF THE SQUIRE BRIDGE PIER

A. Mahmudi Moghadam(corresponding author)
amin.mahmudi@modares.ac.ir
Dept. of Civil Engineering
Shams Institute of Higher Education
S. Salehi
saeedsalehi100@gmail.com
Faculty of Agriculture
Ferdowsi University Mashhad
T. Sadeghifar
tsadeghifar90@gmail.com
Dept. of Civil Engineering
Tarbiat Modares University
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Abstract
Laboratory experiments were carried out to investigate the hydraulics, turbulence structure, and sediment removal capacity of bridge pier with different adjusted roughness. Four experimental models of the roughness were employed to measure the effect of the geometry of the roughness on the scour hole formation and depth. The effects of roughness geometry on the turbulence structure and local erosion through the bridges were studied for one sand sediment size. The three-dimensional velocity profiles and turbulence characteristics of flow downstream and upstream of the bridge pier were measured by Acoustic Doppler velocimetry (ADV) technique due to different adjusted roughnesses. After filtration process by WinADV software, the contour plots of the turbulence kinetic energy were depicted due to triangular roughness. The maximum longitudinal eroded section, which is commonly located by bridge pier corners, was measured through the experiments. The results of the scour hole measurements indicate that due to increasing the length of the roughness, the scour hole depth values decreased; however, increasing the vertical distance has the same effect on the scour hole formation. Furthermore, different geometries of the employed roughness illustrate that the triangular roughness has less scour hole depth than other experimental models with the same hydraulic condition. The detailed information of the magnitude, distribution, and probability of turbulence structures was extracted from time-series data using power spectra. The turbulence data were compared with the topography of upstream erosion. Analysis of the power spectrum density function indicated that the discontinuous adjusted roughness remarkably reduced the downward energy level of vortexes at the upstream of bridge pier, which is supposed that the gap opening through the roughness can increase downward jets impact. It appears that this condition reduces the turbulence kinetic energy near the bed elevation at the upstream face of squire bridge pier.

Key Words: Scour hole, turbulence, reynolds stress, sediment transport, power spectrum.

EVALUATION OF INTERFACE SHEAR STRENGTH PROPERTIES OF GEOSYNTHETIC WITH RECYCLED CONCRETE AND ASPHALT WASTE BY DIRECT SHEAR TEST

H. Heiraty
heiratyhosein.1993@gmail.com
M. Hassanlou Rad(corresponding author)
hassanlou@eng.ikiu.ac.ir
A. Ardakani
a.ardakani@eng.ikiu.ac.ir
Faculty of Technical and Engineering
Imam Khomeini International University
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Abstract

Granular materials are widely used in construction. The cost and environmental impact of supplying natural aggregates force the construction industry to look for alternative materials for engineering applications. The interface shear strength properties of recycled construction materials including concrete and asphalt with geogrid as alternative backfill materials in reinforced structures were investigated by using Large-scale Direct Shear Test (LDST) apparatus. Also, a comparison is made between the recycled materials and a natural material with the same physical characteristics and grain size. Geosynthetics are mainly used to stabilize and reinforce different types of earth structures such as slopes, retaining walls, bridge abutments, and foundations. In these cases, the interaction between soil and geosynthetic has a vital role. Three types of single-stranded geogrids were tested as reinforcements. The results showed that reinforcement increases the shear strength and internal friction angle. The tensile strength of geogrids does not have effect on the interface shear strength as the geogrids do not reach the failure state during shear test. The shear strength coefficient for these materials was greater than one, which indicates a strong interaction between the geogrid and the materials. Recycled materials including concrete and crushed asphalt have good shear strength and can be used as an alternative to natural materials in reinforced soil retaining walls, although their shear behavior is slightly different. In general, due to the involvement of these aggregates with the geogrid, it leads to an increase in the shear strength of the interface of these materials and the geogrid to the materials themselves. The shear behavior of natural materials and concrete changes from a slightly softening behavior to a hardening behavior on the interface, a process that is more severe in the case of asphalt. Also, the volumetric behavior of the interface of natural materials and recycled concrete with geogrid is more extensive than the materials themselves, the opposite is true for asphalt. Recycled asphalt materials have a lower interaction coefficient than natural materials and recycled concrete. This reason could be attributed to bitumen coating on recycled asphalt aggregates. In general, recycled concrete and asphalt materials provide the minimum shear strength parameters when reinforced with geogrids.

Key Words: Geogrid, interface, large direct shear test, recycled material, reinforced soil structures.

3D NUMERICAL MODELING OF GEOTHERMAL TUNNELS AND RECEIVABLE ENERGY

S.R. Sheikhahmadi
sheikhahmadiraef@modares.ac.ir
M.A. Kiani Fordoei
m_kianifordoei@modares.ac.ir
M.Oliaei(corresponding author)
m.olyaei@modares.ac.ir
Faculty of Civil and Environmental Engineering
Tarbiat Modares University

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Abstract

Nowadays, with development of subway tunnels, heating and cooling stations are playing an important role. Shallow geothermal energy as a renewable time-independent energy source helped significantly to reduce energy consumption for supplying ventilation, heating, and cooling of subway stations. The amount of accessible energy from such modern systems is of great importance in their economic assessment. Hence, this research aims to perform and present finite element modeling to evaluate the amount of exploited energy through ground heat exchangers (GHE) in tunnels. After validation of implemented modeling, the effect of various involved parameters in modeling was studied for a short-term operation of heat exchange. Additionally, the effect of lining isolation with respect to the inner environment of the tunnel was investigated. The results show that by increasing water velocity in the pipe, the total extracted power increased in both isolated and non-isolated conditions. The results can be classified into three main categories.

1. By increasing (a) the spacing between the pipe and inner environment of the tunnel in isolated case, (b) the inner temperature of the tunnel in non-isolated case, and (c) thermal conductivity of soil in both isolate and none-isolate cases, the total extracted power could be improved. The pipe diameter has a fascinating effect on the total extracted power. Firstly, it reduces the amount of extracted power. However, in the case of larger diameters, due to the capability of discharging more water, the amount of extracted power is increased.
2. By increasing (a) the spacing between the pipe and inner environment of the tunnel in non-isolated conditions and (b) pipe thickness in both non-isolated and isolated conditions, the total extracted power is reduced.
3. By increasing the specific heat capacity, density, and porosity of the soil, the total extracted power slightly changes. Indeed, these parameters have a negligible effect on extracted power.

Key Words: Subway tunnels, shallow geothermal energy, finite element modelling, ground heat exchangers (GHE), parametric study.

OPTIMIZATION OF CRITICAL SLIP SURFACE IN UNSATURATED SLOPES SUBJECTED TO RAIN INFILTRATION BY CBO ALGORITHM

Sh.S. Naseri
sh.naseri@usc.ac.ir
Dept. of Civil Engineering
Science and Culture University
H. Sadeghi
hsadeghi@sharif.edu
Dept. of Civil Engineering
Sharif University of Technology
A. Akbari Garakani(corresponding author)
aakbari@nri.ac.ir
Power Industry Structures Research Dept.
Niroo Research Institute
DOI:10.24200/J30.2022.59000.3016

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Abstract
Slope stability analysis is one of the most important issues in the safe design of infrastructures. This is mainly due to the historical hazards arising from instability of soil mass, leading to serious consequences including both fatality and financial loss. According to the field observations, rainfall is one of the most important factors stimulating the instability of unsaturated slopes. Nonetheless, most classical solution methods ignore the unsaturated conditions by simply assuming the soil conditions to be dry or completely saturated. In order to cope with this limitation, commercial software has been improved for simulation of two-phase flow under unsaturated conditions such as the GeoStudio software package. However, the scientific challenge as one of the limitations of commercial software is the optimization of critical slip surface under transient precipitation. Therefore, the main objective of this research is to develop a homemade computer code in MATLAB based on the Colliding Bodies Optimization (CBO) algorithm so that it can be used for studying complex two-phase flow problems more efficiently in terms of time. The code can effectively calculate and optimize the factor of safety against stability considering the effects of precipitation applied to the slope boundaries by employing Richards' equation. Calculations of factor of safety are performed by assuming the circular wedge geometry and Bishop's method. According to the algorithm, the centroid of the wedge of slip circles in space is randomly guided and as a result, the coordinates of the circle collision points are obtained within the slope. If the consistency conditions are satisfied, the wedge is divided into parts and the factor of safety is calculated by finite difference method. This process will continue until the optimal factor of safety is obtained. Finally, the results of the code are validated against the output of GeoStudio 2018. The results confirm that the new method is robust in predicting the critical conditions much more rapidly than the software. Although changes in the factor of safety are minor for the simple validation example, the most important feature of the new code is that it reduces the CPU occupancy by 71% on average, independent of the type of CPU.

Key Words: Unsaturated slope stability, rainfall, optimization, colliding bodies optimization algorithm, finite difference method.

BEHAVIOR OF TUBULAR X-JOINTS RETROFITTED WITH EXTERNAL RING SUBJECTED TO COMPRESSIVE LOADING

H. Nassiraei(corresponding author)
h.nassiraei@guilan.ac.ir
Dept. of Civil Engineering
University of Guilan
P. Rezadoost
pooya.rezadoost@gmail.com
Faculty of Civil Engineering
K. N. Toosi University of Technology
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Abstract
Tubular structures are made of hollow steel members with circular cross-sections and connecting them is one of the major challenges in their design. So far, some

techniques to improve the performance of tubular connections have been proposed. Most of these methods (e.g., internal ring, doubler plate) can only be used for structures during the design, but there are only a few techniques (e.g., external ring, FRP) which can be applied during both fabrication and service. This paper investigates the ultimate strength of circular hollow section (CHS) X-connections stiffened with external ring subjected to axially compressive load. The SOLID186 in ANSYS was used to establish the finite element (FE) models. In these models, both geometric and material non-linearity were considered. Moreover, the welds joining the chord and brace members were modeled. The validation of the FE model with several experimental data indicated that the proposed FE model can accurately predict the static behavior of the ring-stiffened X-joints under compression. In the next step, 117 FE models were created and analyzed to evaluate the effect of the connection geometry and external ring size on the static capacity through a parametric study. Results indicated that the external ring can considerably increase the initial stiffness. Moreover, the ultimate strength of the ring-reinforced X-joints under brace compression can be up to 367% to that of the strength of the corresponding unreinforced joint. Despite these significant differences between the ultimate strength of un-stiffened and ring-stiffened X-connections under compressive load, the investigations on this type of stiffened joints have been limited to only three X-joint tests. Also, no design equation is available to determine the ultimate strength of X-connections stiffened with the external ring. Hence, the parametric study was followed by the nonlinear regression analysis to propose a theoretical equation for the static design of X-connection stiffened with the external ring in compressive load.

Key Words: Tubular X-connection; external ring; ultimate compressive capacity; theoretical equation.

EFFECT OF SILT CONTENT ON CYCLIC AND POST-CYCLIC BEHAVIOR OF SATURATED LOOSE SAND

S. Mohammadi(corresponding author)
sa.mohammadi@edu.ikiu.ac.ir
H. Naeini
naeini_h@ikiu.ac.ir
Dept. of Civil Engineering
Imam Khomeini International University
DOI:10.24200/J30.2022.58786.3003

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Abstract
Since most natural deposits are a combination of sand and fine grains and as man-made geotechnical structures like tailing dams have a high percentage of cohesive and cohesionless fine grains, the study of cyclic and post cyclic behavior of these soils is essential. For saturated sands, the effect of non-plastic fine grains (silts) on their monotonic and cyclic behavior has been investigated. A majority of studies are related to monotonic and cyclic loading and post-cyclic loading has received less attention. In this paper, the effects of silt content and different Cyclic Stress Ratios on the cyclic and post-cyclic behavior of saturated loose sand are investigated. The sand used in this study is Firuzkuh silty crushing sand, which is abbreviated to sand 161 . All samples were prepared so that their relative density was about after consolidating. The experiments were performed using the saturated cyclic triaxial apparatus. Suitable preparation of specimens was one of the most important factors in the accurate performance of triaxial tests. The cyclic and post cyclic tests on mixtures made of sand with silt were undertaken following the recommendation of ASTM D4254. Changes in pore pressure coefficient, liquefaction resistance, stress-strain curves, and stress path in clean and silty sand (silt) were recorded. Results show that the tested samples become liquefied in a smaller number of cycles by increasing the CSR until they show softening behavior at larger CSR when effective stress rapidly drops to zero. In lower CSR , the stress-strain curve is collapsible while in larger CSR , loops expand and they indicate more damping of materials.

Key Words: Silty sand, liquefaction resistance, cyclic triaxial test, post cyclic.

COUPLED EFFECT OF LOADING RATE AND NOTCH LENGTH ON TENSILE STRENGTH OF ROCK

P. Asadi
payam_asadi@modares.ac.ir
A. Fakhimi (corresponding author)
a.fakhimi@modares.ac.ir
Dept. of Civil and Environmental Engineering
Tarbiat Modares University

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Abstract

Rock masses naturally contain joints and fractures and the effect of these fractures needs to be carefully investigated to ensure the stability of rock structures. This is particularly the case when dynamic loading effects due to earthquakes or rock blasting are involved. In this study, Brazilian synthetic specimens, made of gypsum with initial notches, were loaded in the mode-I fracture. The specimens were 50 mm in diameter and 10 mm in thickness. The pre-existing notch length in the specimens varied from 10 to 40 mm. The nominal tensile strength of the specimens was numerically evaluated using a bonded particle model (BPM) for the synthetic rock material. The dynamic tests were performed using the Split Hopkinson Pressure Bar (SHPB) system which was numerically simulated by the CA3 computer program. CA3 is a computer program for static and dynamic simulation of geomaterials in which a hybrid bonded particle and finite element system can be employed. The rock specimen was represented by the bonded particle model, while the incident and transmission bars in the Hopkinson Pressure Bar system were simulated by the finite element model. The bonded particle system was calibrated to ensure that the elastic properties, uniaxial compressive strength, tensile strength, and fracture toughness of the rock were replicated by the numerical model. The combined effect of loading rate and initial fracture length on the rock tensile strength was investigated. The results, as expected, suggest that the static nominal tensile strength of the specimens was reduced as the notch length increased. Under dynamic loading, the material response is more complicated; depending on the applied stress rate, the tensile strength can decrease, remain constant, or increase as the initial notch length increases. It is shown that the speed of the crack tip opening is responsible for this interesting observation of tensile strength changes under dynamic loading as the notch length varies.

Key Words: Fracture mechanics, dynamic loading, loading rate effect, notch length effect, crack propagation.

CRACK DETECTION IN MASONRY STRUCTURES USING COMPUTER VISION BASED ON DEEP LEARNING

M. Mousavi
mohammad.mousavi@sharif.edu
A. Bakhshi(corresponding author)
bakhshi@sharif.edu
Dept. of Civil Engineering
Sharif University of Technology

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Abstract

Masonry structures comprise a large proportion of human-made building stocks around the world. In many cases, aged masonry structures have been found to be vulnerable to earthquakes and seismic loads. Due to the historical importance and vulnerable conditions of these structures, an efficient structural health monitoring system is required to detect every sign of degradation. Thus, a suitable restoration scheme could be taken into account. Manual visual inspection is one of the earliest monitoring schemes used to inspect these structures. Due to the limitations and dangers imposed by using human resources, new strategies are required to achieve this purpose. Recent developments in artificial Intelligence and computer vision have helped researchers develop a new generation of autonomous inspection systems. In the present study, we are going to use a deep learning model with an encoder-decoder architecture to automate crack detection in masonry structure images. In the current study, semantic segmentation is proposed as a detailed solution to accurately predict the location and condition of cracks in masonry images. In the development of the main model of the study, we used EfficientNet-B3 as the encoder while the decoder was defined according to U-Net's expansion path in order to predict the accurate segmentation mask for the corresponding input images. For training and evaluation of the proposed model, a dataset composed of 115 images is generated and manually annotated. In the proposed method, transfer learning is used to train the model and the data augmentation techniques are implemented to achieve the optimal results on the present dataset. Furthermore, using the Dice-Coefficient loss function directly optimizes the model for F1-Score, which is the main evaluation parameter in semantic segmentation tasks. Finally, the evaluation demonstrated 81.444% Precision, 71.411% Recall, and 75.366% F1-Score for the never-seen test data. The study shows that the deep learning approach can be accurate and trustworthy for this task. Also, the limited number of training data and the complex background images in the dataset prove the robustness of the proposed model.

Key Words: Structural health monitoring, deep learning, computer vision, convolutional neural network, image segmentation.

CONTINUOUS MEASUREMENT OF MATRIX SUCTION AND DEGREE OF SATURATION OF UNSATURATED SOILS WITH A NEW SOIL-WATER RETENTION CURVE DEVICE

A. Mirzaii(corresponding author)
ali.mirzaii@kashanu.ac.ir
Faculty of Engineering
University of Kashan
M. Mortezaee
mortezaee_m06@yahoo.com
M. Naini
Faculty of Engineering
Imam Khomeini International University
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Abstract

The relationship between matrix suction and degree of saturation within the soil is a fundamental parameter in studying many behavioral aspects of unsaturated soils and is referred to as the soil-water retention curve (SWRC). Due to difficulties associated with negative pore water pressure measurements in unsaturated soils, most SWRC measuring techniques benefit from suction controlling methods such as axis translation or osmosis techniques. These methods provide only a few data points on the matrix suction-degree of saturation relationship and cause a discrete measured soil-water characteristic curve. However, many SWRC elements like drying and wetting curve slopes, air entry, and air expulsion values are fundamental parameters in describing the hydro-mechanical behavior of unsaturated soils. Therefore, a realistic understanding of these parameters requires continuous measurement of the degree of saturation-matrix suction relationship at more points. To this end, this paper examines the performance of a new SWRC device developed for the continuous measurement of the soil-water retention curve of unsaturated deformable soils along drying paths. The new apparatus is equipped with new miniature tensiometers enabling direct measurement of soil suction without the need for an artificial increase in pore air pressure. The variation of the degree of saturation is calculated by contiguous weighing of soil samples along drying paths. The credibility of the new SWRC apparatus is examined to investigate the influence of initial compaction on the soil-water retention response of sandy soil along with drying. This was experimentally achieved by SWRC tests on compacted soil samples with a range of void ratios between maximum and minimum void ratios to examine the influence of compaction on the slope of SWRC along with drying and variation of air entry value. The results are thoroughly discussed and compared against other available data in the literature. Also, the results suggest the fast performance of newly developed tensiometers for direct measurement of soil suction with a minute without the need for the application of elevated pore air pressure, which leads to the continuous SWRC measurement of the soil samples within 3 to 5 days along drying paths. The credibility of the new SWRC device is also examined with additional suction measurement tests using conventional jet-fill tensiometers, showing consistent results.

Key Words: Unsaturated soils, soil-water retention curve, degree of saturation, matrix suction, continuous measurement, miniature tensiometers.

DEVELOPMENT OF THE INTEGRATED MARS-PSO AND ELM-PSO MODELS FOR ESTIMATING THE COMPRESSIVE STRENGTH OF CONCRETE IN CIRCULAR CONCRETE COLUMNS CONFINED WITH FRP POLYMER FIBERS

M. Hanteh
mhenteh@semnan.ac.ir
Dept. of Civil Engineering
Semnan University
H. Malek
H.malek@email.kntu.ac.ir
Faculty of Civil Engineering
K. N. Toosi University of Technology
M. Akbari(corresponding author)
makbari@kashanu.ac.ir
Dept. of Civil Engineering
University of Kashan
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Abstract

Many columns that have been built in the past need to be repaired and strengthened for various reasons such as errors during construction, design errors, changes in the use of the building, changes in regulations, strong beam-weak column conditions and also injuries from accidents. Today, various methods for strengthening and improving structures, especially concrete columns, have become popular. One of the most common methods for reinforcing columns is to confine them using polymer fiber composites. The advantages of this method include increasing the axial and lateral bearing capacity of the column, increasing the compressive and tensile strength of the concrete member and increasing the ductility of the member. The mechanical properties of the concrete confined with FRP polymer fibers may be required for the purpose of design and rehabilitation. Artificial intelligence methods are among the modeling methods that have shown great power to coordinate with engineering problems. The aim of this study is to use multivariate adaptive regression spline (MARS) and extreme learning machine (ELM) artificial intelligence models to estimate the compressive strength of concrete in circular concrete columns confined with FRP polymer fibers. In addition, in order to improve the accuracy of these models, the particle swarm Optimization algorithm (PSO) is used in combination with these models and the accuracy of the models is evaluated to estimate the resistance. The results show that in overall, the used artificial intelligence models estimate the compressive strength of FRP- confined columns more accurately than the existing analytical models. In particular, the integrated MARS-PSO model has better performance compared to other models used, so that this model has a correlation coefficient of 0.9972 in the training stage and 0.9961 in the experimental stage. Also, the combination of PSO algorithm with MARS and ELM models improves their accuracy by 6.13 and 4.68 percent, respectively.

Key Words: Multivariate adaptive regression splines, extreme learning machine, compressive strength of circular concrete columns, artificial intelligence, particle swarm optimization.