Abstracts of Papers in English

NUMERICAL INVESTIGATION OF THE ANISOTROPIC BEHAVIOR OF THE SAND IN DRAINED CONDITION

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DOI:10.24200/J30.2021.57689.2927

Sharif Civil Engineering Journal
Volume 38, Issue 1.1, Page 3-14, Original Article

- Received 27 February 2021; received in revised form 13 November 2021; accepted 6 December 2021.

Abstract

The behavior of natural soils is often anisotropic. In practice, the mechanical behavior of soils is usually assumed to be isotropic. In recent years, various constitutive models have been developed that incorporate the anisotropic behavior of soils. However, most of these constitutive models cannot take into account all aspects of anisotropy. On the other hand, these models are mostly complex and several parameters are needed to be determined to define the model. Therefore, using these models in practical matters is difficult. In this study, a simple method is presented to study the anisotropic behavior of sands in drained conditions. Hollow cylinder torsion tests are modeled using commercial finite element software ABAQUS. The Modified Drucker Prager/,

Cap constitutive model is used to define the soil characteristics. This constitutive model is a practical model that is widely used in numerical analyses of geotechnical problems, assuming that the soil has an isotropic behavior. In order to study the effect of soil anisotropy on the shear strength and stress-strain behavior, USDFLD subroutine is used in ABAQUS software. A new subroutine, called USDANISO, was also developed that links soil mechanical parameters to the major principal stress direction in each element, separately. Therefore, when analyzing the model, soil parameters in different soil elements can change as the major principal stress direction rotates. The hollow cylinder geometry is modeled in ABAQUS software and different combinations of shear and normal stresses are applied to investigate the behavior of modeled samples under the principal stresses with different directions. In the numerical model, stress paths similar to experimental studies (hollow cylinder torsion tests), including different values of intermediate principal stress ratio, are applied to study the anisotropic behavior of soil. The results of numerical modeling are compared with the experimental results of hollow cylinder torsion tests. The obtained results show appropriate agreement with experimental studies. Nevertheless, the method, described in this study, can be an efficient and practical method for considering the effect of major principal stress direction and intermediate principal stress ratio on the mechanical behavior of sand in drained conditions.

Key Words: Anisotropy, principal stresses direction, hollow cylinder torsion test, ABAQUS, USDFLD subroutine.

A SOLUTION TO EXTENDING THE LIFE OF SUSPENSION BRIDGE SUSPENDERS SUBJECTED TO LATERAL LOADS

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Sharif Civil Engineering Journal
Volume 38, Issue 1.1, Page 15-22, Original Article

- Received 11 December 2020; received in revised form 4 September 2021; accepted 16 October 2021.

Abstract

Suspenders are crucial force transmission components in suspension bridges that transmit deck loads to the main cables, and their durability plays an important role in the safety and serviceability of the suspension bridge. However, one of the problems in suspension bridges is that they face the failure of suspenders under applied loads and consequently, exerted displacements. Therefore, the suspenders often have a shorter life time and needed to be replaced. In this paper, the authors aim to find a solution to extend the life of the suspenders; therefore, a new method was proposed to improve the performance and behavior of suspenders. For this purpose, a polyethylene member was added between the socket and the pendant cable. A case study suspender and the proposed model were modeled and analyzed. The results showed that in the proposed model, the stress on the model members was reduced by about 39model. Also, the results showed that unlike the original model, the plastic strain remained zero in the socket and cable.
After proving the effectiveness of the proposed model, two other materials were replaced by the polyethylene member. The results showed that among the proposed materials, Teflon gave the best result.

Key Words: Suspender, suspension bridge, suspender failure, exerted displacement, modifying of suspender.

NUMERICAL STUDY ON PERFORMANCE OF A SIX-STORY HYBRID STRUCTURE WITH STEEL MOMENT FRAME SYSTEM AND USING CLT AS SHEAR WALL AND FLOOR PANEL

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Sharif Civil Engineering Journal
Volume 38, Issue 1.1, Page 23-34, Original Article

- Received 28 February 2021; received in revised form 9 October 2021; accepted 16 October 2021.

Abstract

Recently, researchers have introduced CLT (Cross Laminated Timber), a kind of engineered wood product that

is one of the most suitable construction materials for green building development for the future cities. In the design steel-timber hybrid structure presented in this study, steel is used for the intermediate moment resisting frame of the building and CLT are used as floor panels and shear walls. Therefore, the lateral load-resisting system of the hybrid structure in this study is the dual system of steel intermediate moment resisting frame and CLT shear wall. In order to investigate the structural performance of the above-mentioned system, a sample 6 stories building are considered to be constructed using two types of structural systems were designed using ETABS software; 1- a steel intermediate moment resisting frame with composite concrete-steel floor, and, 2- dual steel intermediate moment resisting frame plus CLT shear walls with timber-steel floor using CLT horizontal panels. Then, FEM model of each of structural frame two types was analyzed using pushover method by ABAQUS software. The behavior of the two type 6-story frame systems were compared. By comparing the weight of Structure with the two types of lateral load-resisting system, it was concluded that the total weight of the building reduced by %22.01 in the structure with a dual system of steel intermediate moment resisting frame and CLT shear wall and composite timber-steel floors, compared to the structure with the steel intermediate moment resisting frame system and composite concrete-steel floors. Comparison of the results concludes that the application of possible substitution of CLT panels instead of steel and concrete common materials of structural members results in light weight structure with acceptable seismic behavior. Furthermore, development of hybrid timber-steel construction can provide buildings with less greenhouse, environmental, and noise pollution for producing materials and building structure, lower energy consumption, less weight, good seismic behavior, fast construction speed, and renewable resource capability.

Key Words: CLT (Cross Laminated Timber), timber-steel hybrid structure, steel intermediate moment resisting frame, CLT shear wall, composite timber-steel floor.

EXPERIMENTAL INVESTIGATION THE MECHANICAL AND STRUCTURAL STRENGTHS OF CONCRETES COMBINED RUBBER WASTES AND FIBERS

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Sharif Civil Engineering Journal
Volume 38, Issue 1.1, Page 35-46, Original Article

- Received 16 January 2021; received in revised form 28 August 2021; accepted 28 November 2021.

Abstract

The current research deals with the use of waste rubber powder with different forms and percentages as a replacement for the fine aggregates in concrete production for the purpose of examining different mechanical and structural properties at an experimental level. The mixed design of common concrete as well as other mixed designs having waste rubber powder were constructed. The amounts of waste rubber were equivalent to 5, 10, and 15% of actual volume of the aggregate. To remove the negative effects on some mechanical properties of the product such as compressive and tensile strength and impact resistance, the synthetic Polyphenylene Sulfide (PPS) fibers known as synthetic complex fibers with 0.75 and 1.5% were added to the concrete having waste rubber powder. The first part of this research examines the effects of the combination of fibers with waste rubber powder on the compressive, tensile, flexural strength, and impact resistance of specimens. Also, in the second part of this research, six concrete slabs were constructed with the structural performance of such concrete in road construction under elastic basement under direct loading. The displacement-load curve of the samples as well as the failure pattern of the samples were observed and analyzed. The result of the experiments on the standard specimen in the first part of this research showed that despite the decrease in compressive strength due to the simultaneous addition of rubber powder compared to the common concrete samples, the tensile, flexural strength, and impact resistance were improved compared to the samples constructed with common concrete. By replacing 15% rubber powder instead of the fine aggregates, the final impact resistance increased up to 48%. Simultaneous addition of 0.75 % fibers and 5% rubber doubled the impact resistance of the concrete. It is worth mentioning that 1.5% addition of fibers to the concrete having 5% rubber power increased final impact resistance up to 5.72 times of that of Ref concrete. The results of the second part of this research showed that the final capacity of fiber-rubber concrete slabs under elastic basement to have favorite flexural behavior as concrete pavement compared to common concrete slab increased up to 50%; meanwhile, the amount of absorbed energy and the strength of combined concrete slabs of rubber

wastes and fibers were 3 times higher than those made by common concrete in the reference sample.

Key Words: Waste rubber powder, tensile strength, concrete slab, toughness, impact resistance.

INVESTIGATING THE INFLUENCE OF PARENT CONCRETE ON MECHANICAL PROPERTIES OF RECYCLED CONCRETE

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Sharif Civil Engineering Journal
Volume 38, Issue 1.1, Page 47-57, Original Article

- Received 3 April 2021; received in revised form 4 September 2021; accepted 16 October 2021.

Abstract

One of the most significant concerns of recent years among scientists has been related to waste management actions and policies. Unfortunately, landfills are filled with various debris and demolition from old building including waste concrete, glass, brick, ceramic, and plastic. Waste concrete seems to occupy a large volume of these landfills; thus, they are potentially among the most appropriate choices for recycling process. However, different papers have focused on the impact of recycled concrete aggregates in concrete and in recent years, no specific model has been recommended to predict the behavior of parent concrete in recycled concrete. In this study, a central composite design along with response surface methodology was employed to prepare experimental designs and model the properties of concrete made of recycled aggregates. Effective factors included compressive strength of parent concrete, substitution rate of parent concrete, and value of cement, while the compressive strength, tensile strength, and water absorption of recycled concrete were introduced as goal responses. Based on the statistical analysis, all recommended models were adequate with acceptable coefficient of determination (0/86-0/92). Response surface and perturbation plots revealed that compressive strength, tensile strength, and water absorption of recycled concretes depended heavily on the compressive strength of parent concrete. Moreover, in order to generate concretes with higher compressive strength than the compressive strength of parent concrete, the value of compressive strength for parent concrete should be above 28 MPa. However, for low-strength parent concretes, substitution rate should be limited in order to reduce undesirable performance. As the compressive strength of recycled concrete aggregates increased from 19 to 36 MPa, the compressive strength of recycled concrete was enhanced by over 40 percent. In this substitution, water absorption reduced over 30 percent. Additionally, when the compressive strength of recycled aggregates was fixed at 28 MPa, by changing substitution rate from 8 % to 92 %, the compressive strength of recycled concrete increased from 26 to 30 MPa. The tensile strength of recycled concrete also was enhanced from 28 to 31 MPa.

Key Words: Recycled concrete, modelling, parent concrete, mechanical properties, waste management.

INVESTIGATION OF DURABILITY OF SELF-COMPACTING CONCRETES MADE OF DIFFERENT AGGREGATES UNDER THE INFLUENCE OF SULFATE ENVIRONMENT USING TWIST-OFF TEST

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Sharif Civil Engineering Journal
Volume 38, Issue 1.1, Page 59-67, Original Article

- Received 15 may 2021; received in revised form 26 October 2021; accepted 8 November 2021.

Abstract

In many parts of Iran, especially in the southern regions of the country where concrete is exposed to seawater, sulfates are the main destructive factors of concrete. The main factors related to the durability of concrete are the type of materials, concrete structure, density, and curing. Inadequate compaction of concrete due to the lack of acceptable vibration in the limited parts between the formwork and rebars is one of the main factors of low structural reliability exposed to sulfates. Due to the lack of information related to the effect of aggregate strength on the performance of self-compacting concrete, in this paper, the effects of type and strength of aggregates on the durability of self-compacting concrete against sodium sulfate is presented. Granite, marble, andesite, rhyolite, travertine, lime, green tuff, crystalline green tuff, and basalt were used to make concrete. "Twist-off" and "Drilled core" tests were employed to measure the compressive strength of rocks. "Twist-off" test is an accurate method with a wide range of applications in determining the strength of materials both in the laboratory and on site and is considered as a fast, accurate and low-cost technique with minor failure in the field of semi-destructive testing. The attractiveness of this method is in accuracy, speed, simplicity, minor breakdown, and low cost of doing it, which makes it more comparable than other on-site tests. This test can be performed in horizontal, vertical, and generally on any smooth surface without the need for prior planning. The tools used in this test are very simple and accessible and performing the test does not require previous skills. The experiments were performed at ages 7, 14, and 28. The results show a direct relationship between the strength of the parent rock and the strength of self-compacting concrete made with of rock. At an early age, there is an increase in compressive strength of samples placed in sodium sulfate compared to samples treated in water. Also, a high correlation coefficient was obtained between the results of the "twist-off" test and the "Drilled core" test, which could be used to measure the compressive strength of rocks with the "twist-off" test with high confidence.

Key Words: Sodium sulfate, "Twist-off", Mother rock, self-compacting concrete, durability.

OPTIMUM LIGHT WEIGHT CONCRETE MIX DESIGN AGAINST HIGH TEMPERATURE

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Sharif Civil Engineering Journal
Volume 38, Issue 1.1, Page 69-78, Original Article

- Received 15 May 2021; received in revised form 22 August 2021; accepted 2 October 2021.

Abstract

The fire phenomenon can cause the loss of structural materials resistance which may end to damage or even structural total collapse. Physical and chemical changes in concrete due to firing also make serious structural defects in concrete structures. Therefore, prevention of reduction of concrete resistance is attended in this research. The primary idea is based on decreasing concrete thermal conductivity to increase chemical and physical resistance. Because of low density and porosity light weight aggregate concrete has low thermal conductivity which can postpone the resistant loss due to high temperature. A set of tests performed to achieve an optimum light weight aggregate concrete mix design in room normal temperature by changing the amount of sensitive mix components and controlling compressive strength and density. In next step some effective additives were implemented to make the optimum mix design against high temperature. For this purpose, 9 different mix designs obtained from the Taguchi method were prepared. For each mix design, 9 test specimens were made. At each, ambient temperature, 400° and 800° ،three samples of each design are tested. The experiments conducted in this research include testing of compressive strength, ultrasonic pulse, and weight loss and heat effect on the appearance of lightweight concrete. It was seen that the effect of temperature above 400° is more significant on concrete compressive strength and in temperatures below400° density loss is more considerable. The results of tests indicate that reducing the water to cement ratio and using super plasticizer has a desirable effect on the physical and mechanical properties of lightweight concrete at higher temperatures. However, test results showed that the presence of silica fume up to 15 percent of weight of cement can't improve the strength of lightweight concrete neither in ambient nor in elevated temperature. Optimum mix design lost about 49 percent of compressive strength in800° . Also it was observed that loss of density and compressive strength due to elevated temperature are in direct relation.

Key Words: Structural lightweight concrete mix design, physical and mechanical properties of lightweight concrete, elevated temperature lightweight concrete resistance, LECA lightweight aggregate, Taguchi method.

AN INTEGRATED FRAMEWORK USING AUGMENTED REALITY (AR) AND BUILDING INFORMATION MODELING (BIM) FOR ENHANCING THE STAKEHOLDERS' INTERACTION IN 4D MODELING OF LINEAR PROJECTS

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Sharif Civil Engineering Journal
Volume 38, Issue 1.1, Page 79-85, Original Article

- Received 22 May 2021; received in revised form 18 September 2021; accepted 6 November 2021.

Abstract

The project schedule is a critical factor in project success in the Architecture, Engineering, and Construction (AEC) industry. An efficient schedule can develop a shared vision (i.e., understanding) among project stakeholders. The traditional construction industry uses paper documents such as Gantt charts to visualize the sequence of construction activities. However, it might be challenging for stakeholders to comprehend the schedule, particularly in large-scale construction projects (e.g.,, pipeline construction projects). The recent development of 4D modeling schedules (i.e., integration of Gantt charts and the 3D digital model) within the Building Information Modeling (BIM) environment has facilitated a better understanding of the project schedule. However, the process of developing 4D scheduled in large-scale linear projects is still demanding. Given that smartphones are becoming increasingly popular and widely available, their potential use in the construction industry is emerging. Nowadays, various smartphone applications are employed in the industry, some are equipped with the fascinating feature of Augmented Reality (AR). AR is an emerging technology being actively developed by major corporations (e.g., Google, Microsoft, and Apple). Several researchers have studied AR and its potential applications in the AEC industry, including visualization, simulation, communication, collaboration, information modeling, access to information and evaluation, progress monitoring, education, safety, and inspection. This study introduces a hybrid BIM and AR framework to monitor construction schedules and demonstrate the linear progress of construction projects. A cloud database (Cloud DB) is used to communicate and share information between BIM and AR. It also provides a more powerful visualized schedule based on the AR technology (comparing to the 4D BIM-based schedule) to facilitate a deeper understanding of the stakeholders (e.g., digest and update the project schedule) and to enhance the project control. Finally, the capabilities of the developed platform are demonstrated successfully by applying it to an actual water pipeline case study. Employing the developed framework by the consultant company demonstrates some advantages of the developed hybrid framework compared to the traditional scheduling approach and 4D BIM schedules.

Key Words: Building Information Modeling (BIM), Augmented Reality (AR), 4D schedule, project control, water pipeline.

INVESTIGATION OF THE EFFECT OF DESCENDING INJECTION ON THE FORMATION OF CALCITE CRYSTALS IN BIO-CEMENTATION OF SANDY SOILS

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Sharif Civil Engineering Journal
Volume 38, Issue 1.1, Page 87-98, Original Article

- Received 19 June 2021; received in revised form 4 September 2021; accepted 8 November 2021.

Abstract

Rapid population growth and wave of immigration to cities are growing needs to expand construction in cities. So, reinforcement of bed soil has a high importance in urban structures. The soil must be stabilized for various applications such as: decrease in erodibility, in-

crease in loading capacity and increase in compressive strength. At the ground level, soil can be stabilized by ecological and compaction methods but in depth, improvement should be done by infusion. Injection of chemical substances is costly, destructive and it causes the destruction of the hydrological ecosystem of the improved area, in addition to, ground water may be deviated from their path. Biological cementation is a modern and environmentally-friendly method to remedy the soil that it has been developed through the linkage of civil, geochemical and microbiological fields. This method of improvement is based on Microbial Induced Calcite Precipitation sedimentation, so sedimentary bacteria is used. To date, many studies have been conducted in which less attention has been paid to the effect of descending injection on the formation of calcite crystals in the biological cementation of sandy soils. Therefore, in the present study, a type of bacterium containing spore called Bacillus pasteurii was used to help the effect of molarity as well as The type of injection (constant and descending) on soil strength and permeability should be investigated. For this purpose, biologically cemented specimens by this method were tested in tri-axial consolidated undrained test, fixed load permeability and scanning electron microscope to investigate this case using the results to be proceeded. The results show that as the concentration increases, more calcite is formed in the soil, therefore the cemented sample with a constant concentration of molar had the best performance and compared to untreated sand, 61.8% an increase of resistance and 41.25% a decrease of permeability was observed.

Key Words: Bio-cementation, descending concentration, constant concentration, tri-axial test, bacillus pasteurii.

AN APPLICATION OF STOCHASTIC USER EQUILIBRIUM ASSIGNMENT IN THE ORIGIN-DESTINATION MATRIX ESTIMATION

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Sharif Civil Engineering Journal

Volume 38, Issue 1.1, Page 99-108, Original Article

- Received 4 July 2021; received in revised form 16 October 2021; accepted 6 November 2021.

Abstract

Estimation (correction) of origin-destination (OD) matrix based on traffic counts data is an inexpensive approach to predicting travel demand in transportation networks. The general formulation of this problem is a bi-level optimization program in which the matrix estimation is solved at the upper level, and the traffic assignment is solved at the lower level. In congested networks, deterministic user equilibrium (UE) assignment is often used at the lower level. Deterministic approaches assume that all users perceive network travel times the same way, which is not the case in reality. In contrast, stochastic methods allow for different user perceptions. This research develops the OD matrix estimation problem (ODMEP) under the stochastic user equilibrium (SUE) constraint. The SUE assignment with the multinomial logit (MNL) route choice model is applied at the lower level. The MNL model is a well-known discrete choice model with a straightforward, closed-form choice probability. Spiess gradient-based approach is used at the upper level, which is efficient in large-scale networks. The Spiess OD estimation models with UE/SUE constraints are implemented on the large-scale Tehran network under different user perception variances represented by the scale parameter (ŏ3b8) in the MNL formula. Two scenarios are adapted to create the initial OD matrix to compare the results of the two models (ODMEP with UE/SUE assignment). Results show that ODMEP with SUE constraint outperforms ODMEP with UE constraint in producing link volumes close to observed traffic counts. Furthermore, the OD matrix resulting from the SUE-based model is better fitted to the real OD matrix than the UE-based model. However, the two methods' results converge when the scale parameter increases (i.e., variance in users' perceptions of network travel times decreases). In the Tehran network, the SUE-based model reduces the ratio of RMSE of the OD matrix to real demand more than 10 percent (more than 20 percent in some cases) compared to the UE-based model when the scale parameter is less than 0.5.

Key Words: Origin-Destination matrix, matrix correction, Stochastic User Equilibrium (SUE), spiess gradient approach, traffic counts.

DEM INVESTIGATION OF THE CRACK EFFECT ON THE BEHAVIOR

OF BRITTLE GRANULAR MATERIALS SUBJECTED TO ONE-DIMENSIONAL COMPRESSION

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Sharif Civil Engineering Journal
Volume 38, Issue 1.1, Page 109-121, Original Article

- Received 17 July 2021; received in revised form 4 December 2021; accepted 12 December 2021.

Abstract

Granular materials have micro cracks in their structure due to changes in temperature, pressure, and weathering. These microcracks, which are distributed within the grains in different lengths, directions, and positions strongly affect the mechanical behavior of grains such as stiffness, strength, and breakage. On the other hand, the discrete element method is a powerful tool for the analysis of granular materials. Ability to model different types of grain shape, loading conditions, and cracking in materials are among the features of this method. Therefore, by modeling cracked grains by discrete element method, the effect of cracking on material behavior can be evaluated. In this paper, cubic and cylindrical cracked and non-cracked grains are modeled and subjected to uniaxial loading with lateral confinement. Using Hertz nonlinear contact model, performing sensitivity analysis to determine the minimum number of balls required to form each clump, controlling the number of contact points, slope and direction of cracking plates in cracked grains to ensure their uniform distribution in different modeling and using the combined criterion of tensile strength and fracture toughness in terms of combination modes of one and two are among the features of this numerical model. Following the validation of the numerical model with similar laboratory results and ensuring the operation of the model, at this stage, to investigate the effect of crack direction on the behavior of materials, cracked grains are regularly placed on top of each other and at each stage of loading, the direction of the cracks changes from zero (parallel to vertical force) to 90 degrees (perpendicular to vertical force). Finally, the combined arrangement of cracked and non-cracked grains at different ratios is modeled and their behavior is evaluated. The results show 16% and 21.5% increases in applied energy and 19% and 6% increases in strain values, respectively, in cracked cubic and cylindrical specimens. Moreover, the breakage factor increases almost 12% in cracked specimens. The effect of crack inclination at a 45-degree angle is maximal so that the fracture stress is 17% smaller than the average fracture stress at different angles. Finally, for any other desired combination of cracked and non-cracked grains, for a given stress, the amount of breakage factor and the corresponding strain in this range can be estimated through numerical modeling.

Key Words: Crack, fracture toughness, stress-strain behavior, breakage factor, discrete element method.

EXPERIMENTAL EVALUATION OF FLOW TURBULENCE IN BOTTOM OUTLET CONTROL GATE OF DAMS BASED ON KOLMOGOROV THEORY

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DOI:10.24200/J30.2021.59129.3030

Sharif Civil Engineering Journal
Volume 38, Issue 1.1, Page 123-134, Original Article

- Received 9 October 2021; received in revised form 27 November 2021; accepted 6 December 2021.

Abstract

In this study the fluctuating loads of the control gate in the experimental model of the bottom outlet of a dam was evaluated. The production, transportation, and dissipation of turbulent flow eddies based on Kolmogorov theory were investigated by image processing of the flow under the control gate, time series of velocity and static pressure fluctuations. According to the results: 1- the flow turbulence at 10% opening of the control gate can be related to large eddies of middle and lower half streamlines of the upstream conduit. 2- The flow turbulence at 30% opening of the control gate can be related to large eddies of lower half streamlines of the upstream conduit. 3- The flow turned turbulent at 50%

and 70% opening of the control gate can be related to large eddies of upper half streamlines of the upstream conduit. It can be concluded that the middle and lower streamlines of the upstream conduit play a major role in eddies production and flow turbulence at smaller openings of the control gate. In contrast, the upper streamlines of the upstream conduit play a major role in eddies production and flow turbulence at larger openings of the control gate. Large eddies are produced by shear layers created by velocity gradient at the guide slots of gate. The large eddies are transported by side guide slots toward the gate create strong secondary flows. After the collision of strong secondary flows with the main flow, the resulting turbulence leads to fluctuating static pressures. These fluctuations lead to the fluctuating loads on the control gate. Wavelet analysis of the time series provides the magnitude and frequency of pressure waves. Then, wavelet analysis and imaging of the gate flow reveal the causes of the turbulent flow formation process. The size and frequency of these large eddies range from 7.5 mm to 25 mm and 0.1 Hz to 2 Hz, respectively.

Key Words: Dam bottom outlet, turbulent flow, eddy, kolmogorov, experimental model.

NUMERICAL INVESTIGATION OF BUCKLING BEHAVIOR OF STEEL PIPELINE AFFECTED BY ECCENTRIC AXIAL COMPRESSION SUBJECTED TO EXTERNAL PRESSURE

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Sharif Civil Engineering Journal
Volume 38, Issue 1.1, Page 135-143, Original Article

- Received 16 October 2021; received in revised form 27 November 2021; accepted 6 December 2021.

Abstract

The pipeline in service may be subjected to complicated loads (including lateral, axial, vertical loads and hydrostatic pressure in addition to internal pressure) when crossing complex geohazard regions. In this study, two kind of loads that cloud be more fundamental are numerically investigated using finite element method. The loads imposed on pipelines depend on the pipe content and the environment that the pipeline is passing through. Axial compression can arise within pipelines from thermal loads arising from hot hydrocarbon passage from offshore oil wells to an onshore station or can arise from anchor forces acting on pipelines and External pressure can arise within pipelines from hydrostatic pressure, sudden valve closures, and pump failures. It is very important to select suitable geometric imperfection form to exact investigation behavior of pipelines and mechanism of failures. In order to verification response of numerical analyses, one of the experimental results is compared with numerical result and concluded that there is a good agreement between results. Meanwhile, the effect of the eccentric axial compression, pipe diameter to wall thickness ratio (D/t) on the buckling external pressure are studied. The interaction between the axial load and external pressure was graphically demonstrated and compared for different geometrical ratios through numerical analysis. During analysis, the eccentric axial compression load in the pipe was primarily induced and maintained constant less than its capacity. Subsequently, the uniform peripheral pressure was gradually increased until failure, and, besides, the response of some specimens was separately investigated under pure external pressure and axial compression load. It was found that the D/t ratio is the decisive parameter to specify the buckling behavior of steel pipelines and type of created failure mode subjected to axial compression. Some significant conclusions were drawn based on extensive parametric studies. The buckling external pressure reduces with the increase of pre-axial compression and diameter to thickness ratio.

Key Words: Steel pipeline, ABAQUS, external pressure, axial compression, imperfection, experimental.

THE STUDY IMPACT OF EFFECTIVE FACTORS IN SEDIMENT TRANSPORT IN UNSTEADY FLOW

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DOI:10.24200/J30.2021.58434.2978

Sharif Civil Engineering Journal
Volume 38, Issue 1.1, Page 145-155, Original Article

- Received 19 June 2021; received in revised form 9 October 2021; accepted 16 October 2021.

Abstract

The role of floods in sediment transport and river morphology has been proven. In this study, the effect of different parameters on the transfer of sediment bed load under flash flood has been investigated.

The input flood hydrograph of the symmetric triangular type with the base time of 90 sec and peak flow rate 30 and 45 lit/s were considered. Sediment particles of quartz type with a moderate diameter of 1.2 and 3 mm and two bed slopes of 0.006 and 0.014 were tested. In this study, changes in water surface profile, rate of bed load in steady and unsteady conditions, and unsteadiness parameter relative to total work done of flow and sediment rate were investigated. By using dimensional analysis, the parameters affecting sediment transport were determined and evaluated in experiments. The results showed that the unsteadiness parameter in unsteady flow had a significant effect on sediment transport. On the other hand, the work done by the flow has a greater impact on sediment transport than the unsteadiness number. In this regard, the effect of channel slope on sediment transport should be considered.

The role of channel slope in the transfer of bed load is very important so that by doubling the bed slope, the total amount of sediment transferred to the downstream increases almost 5 times. Also, with increasing the sediment flow rate, the unsteadiness parameter increases and it plays an effective role in the whole work. In general, in high-value hydrographs, the amount of transfer sediment increases and there is a large relationship between the amount of transfer sediment and the total flow work. Reducing the time of the rising arm of the hydrograph shows the effect of increasing the flow rate, which is effective in these waterways, so that with the faster the flood peak time, the more sediment is transferred and the probability of damage and destruction increases.

Key Words: Bed load, flash flood, triangular hydrograph, base time, unsteadiness parameter, flow work.