were observed for the Fe_3O_4-APTES membrane. The values of total, reversible and irreversible fouling for the bare PES were 54.0, 12.6, and 41.4% respectively. Whereas these values for the Fe_3O_4-0.50 were 31.9, 12.8, and 19.1% respectively, and 26.8, 10.3, and 16.5% for the Fe_3O_4-APTES, showed higher fouling resistance of the Fe_3O_4 and Fe_3O_4-APTES modified membranes due to the more hydrophilic surface. Flux recovery ratio (FRR) was measured as the most important fouling factor. The value of FRR was increased from 58.6% for the bare PES to 80.9 and 83.5% for the Fe_3O_4-0.50 and Fe_3O_4-APTES, respectively. Dye rejection performance for all prepared membranes was near total removal (more than 95%). The maximum and the minimum removal efficiency were observed for Fe_3O_4-APTES (99.5%) and bare PES (95.4%), respectively. the results introduced Fe_3O_4 and Fe_3O_4-APTES nanoparticles as an excellent membrane modifier for wastewater treatment objectives.

Key Words: Nanofiltration, Fe_3O_4 nanoparticles, APTES, polyethersulfone, dye removal.

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Abstract

Owing to the fact that the world's population and their need for water are becoming increasingly larger, the construction of structures like dams and levees to profit from water sources and, also, the prevention of possible disasters, are inevitable. Moreover, embankments are more economical and have been immensely under consideration by the expert communities. Internal erosion plays a major role in the failure of embankments. Due to internal erosion of an earth dam water that seeps through the dam, soil particles are carried away from the embankment, foundation, or abutments of the dam. Internal erosion may be a result of inadequate compaction during construction, differential settlement, desiccation, earthquakes, burrowing animals, and/or vegetation roots. The erodibility of the material in the internal erosion flow path and hydraulic stresses are the most important factors in determining the degree of erosion. The challenge in predicting failure due to internal erosion characterizes the material properties relevant to the rate of failure. To prohibit this natural phenomenon, the addion of chemical additives and grouting is highly suggested. In the present study nanoclay devoid of any environmental detrimental effects was utilized. Erodibility of samples contained naoclay with 0, 1 and 1.5 weight percent of dry soil and curing time of 0, 7, 14, 28 days went under investigation through image processing. Furthermore, to make a contrast between the modern and typical additives, another sample containing bentonite clay with 5 weight percent of dry soil was used. The results illustrated that the specimen containing 1 weight percent of nanoclay with a curing time of 14 days possessed the strongest resistance. Curing time of 14 days diminished erodibility in all the specimens; however, the allocation of more curing time had no beneficial effect. In addition, the sample containing 5 wt. % bentonite clay could decrease erodibility to a 10-fold extent, compared to the sample containing 1wt. % nanoclay.

Key Words: Curing time, image processing, internal erosion, nanoclay.

SYNTHESIS OF PES MEMBRANE USING AMINO-FUNCTIONALIZED MAGNETIC FE_3O_4 NANOPARTICLES FOR NANOFILTARTION OF RG19 DYE WASTEWATER

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Abstract

In the present study, a mixed matrix nanofiltration membrane was prepared by blending magnetic Fe_3O_4 and amino-functionalized Fe_3O_4 (Fe_3O_4-APTES) nanoparticles into polyethersulfone (PES) matrix. To achieve this purpose, Fe_3O_4 and Fe_3O_4-APTES nanoparticles were introduced into PES matrix using phase inversion technique. Scanning electron microscopy (SEM), water contact angle and overall porosity technique were used to investigate the effect of Fe_3O_4 and Fe_3O_4-APTES nanoparticles on membrane morphology and hydrophilicity. The effect of Fe_3O_4 and Fe_3O_4-APTES nanoparticles on membrane performance was studied in terms of pure water flux, antifouling properties. Nanofiltration performance of the membranes was examined using reactive green 19 (RG19) separation. The Fe_3O_4 and Fe_3O_4-APTES modified membranes showed an increased hydrophilicity, porosity, permeability, and dye rejection efficiency and also improved antifouling properties, compared to the bare PES. Water contact angle result demonstrated a decreasing trend with addition of Fe_3O_4 and Fe_3O_4-APTES content, showed the effect of hydrophilic nanoparticles on membrane surface hydrophilicity. Membrane porosity was increased from 63.3% for the bare PES to 73.3% and 78.0% for the Fe_3O_4-0.50 and Fe_3O_4-APTES respectively, due to the presence of nanoparticles. Pure water flux was increased from 36.1 to 80.4 (L/m^2 h) by increasing the Fe_3O_4 nanoparticle content from 0.00 to 0.50 wt.% and then increased to 92.9 (L/m^2 h) by addition of the Fe_3O_4-APTES nanoparticle. Fouling resistance of the prepared membranes was investigated with filtration of a 250 mg/L bovine serum albumin (BSA) solution. All modified membranes showed improved antifouling properties compared to the bare PES. The best antifouling properties

study of the behavior of the lateral resisting systems under blast loading conditions is essential. In order to achieve the aforementioned goal, 20 seismically designed steel frames with a number of stories of 3, 6, 9, 12, and 15 and different widths were modeled and analyzed under four explosive scenarios in OpenSees software (nonlinear dynamic analysis). The response of stories drift and acceleration, as well as the ductility ratio of the steel plate shear wall, were studied. The results of the study showed that tall buildings with steel plate shear wall system had behaviors far better than short buildings. The dominant behavioral modes of tall, medium height, and short buildings are flexural, combined shear and flexure, and shear modes, respectively. It is also observed that, in medium- and high-rise structures, the maximum horizontal acceleration of roof occurs in free vibration, while, in low-rise structures, this amount is experienced during loading. In addition, for all structures, the maximum horizontal displacement of the roof occurs in free vibration so that, with the increasing number of stories, this amount occurs later. In the other part of the study, it was shown that, in the same way, as we know for SDOF systems, in MDOF structures, the usual damping in systems with no control device is not significantly affected by the structure response to the explosion.

Key Words: Steel plate shear wall, blast loading, nonlinear analysis, finite element method.

EXPERIMENTAL STUDY OF THE PERFORMANCE OF FLOATING STONE COLUMNS FILLED WITH RECYCLED MATERIALS

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Abstract

In this study, the behavior of the floating stone column in clay bed was evaluated using a scale small-axial loading tests and the replacement of recycled materials with natural materials in the construction of the stone column. Since the construction of stone columns requires huge amounts of natural aggregates and limits on the supply of aggregate environmental aspects such as transportation-induced pollution, and the management of construction and demolition wastes through waste reuse and recycling would bring the use of recycled materials in stone columns to consider. According to this study's findings, the use of a combination of recycled aggregates might lead to the achievement of the goals; however, future research studies are needed to investigate other available and similar materials. For this purpose, the individual stone columns were made of three different materials such as the crushed brick, the crushed concrete, and the gravel aggregate. The material index tests, such as aggregate crushing value and aggregate impact value, were used to assess the quality of recycled materials. Due to the fact that the surcharge pressure is greater in the depth of the soil, the passive pressure of the soil is mobilized and creates more confinement. Therefore, the stiffness of materials in the floating stone column alone is not an effective factor in increasing the bearing capacity, and the bulge of the column at lower depths plays an important role in the bearing capacity of the columns. The results show that the recycled materials provide poor performance compared to natural aggregates. However, the bearing capacity of the clay bed reinforced using the floating column with crushed materials is approximately 5 times the capacity of soft bed without stone columns. Moreover, the results of the loading test show that the made floating stone columns provide suitable performance compared with the made columns using the combination of several types of recycled materials.

Key Words: Stone column, recycled material, crushed brick and concrete, ground improvement.

EFFECT OF NANO-CLAY ADDITIVES ON INTERNAL EROSION IN EMBANKMENT DAM BY IMAGE PROCESSING

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0.7g, the response swing (mean plus minus two standard deviations) for a failure time of 145 minutes have been calculated.The highest swing for the reinforcement yield stress, concrete cover and concrete strength was calculated 60, 53 and 40 minutes, respectively.

Key Words: Post-Earthquake fire, sensitivity analysis, RC frame, random variable.

EXPERIMENTAL AND ANALYTICAL STUDY OF STEEL YIELD DAMPER WITH THE AIM OF IMPROVING ITS SEISMIC PERFORMANCE

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Abstract

Dampers are a suitable choice to improve structural performance and protect structures against lateral loads, including seismic excitements. A steel slit damper (SSD) is a damper that can be replaced after major earthquakes. After reviewing literature on the metallic yielding dampers, this paper tried to identify the behaviors of such dampers in order to find approaches that are suitable for improvement and/or optimization of such dampers by increasing the number of blade rows and introducing a new geometric pattern. This study designed, fabricated, and examined a total of seven laboratory samples, including a solid damper without slit or blade as the reference, three slit dampers with a single blade row, as well as three slit dampers with two blade rows, which were subjected to static cyclic loading in laboratory. Results showed that a shift from bending towards shear behaviors can increase energy dissipation by the damper. In addition to the behavioral shift, the displacement capacity of damper partially reduces. To prevent the reduction of displacement capacity and achieve higher level of performance, dampers should be designed with two or more blade rows. The experimental observations showed that the stiffness of dampers with two blade rows is approximately twice the dampers with a single blade row; in addition, their effective damping was nearly 1.25 times higher. In addition to experimental results, different parameters, such as force capacity, effective stiffness, and dissipated energy, were calculated and compared. Results showed that the force capacity, effective stiffness, and absorbed energy were significantly better in dampers with two blade rows. In that, the difference between these two dampers in terms of the force capacity was 61.6%. Regarding the superiority of dampers with two blade rows and observation results, the optimal ratio of blade length to width (h/b) to prevent buckling in the samples was estimated at 1.58.

Key Words: Yield damper, cyclic loading, bending behavior, shear behavior, dissipated energy.

STUDY OF THE BLAST RESISTANCE OF SEISMICALLY DESIGNED STEEL PLATE SHEAR WALL FRAMES

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Abstract

During recent years, the occurrence of terrorist attacks and explosive events has increased the need to investigate the response of structures under blast loading. Due to the nature of blast loading, a lateral resisting system must damp energy to behave properly against blast loading. Steel plate shear wall system, which features a high level of stiffness, flexibility, and energy absorption, can be used as a means of the lateral resisting system against blast loading. In order to gain a better understanding of responses of the buildings and lateral resisting systems with different characteristics, the

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Abstract

Land subsidence due to groundwater over-exploitation is a man-made hazard, and identifying those areas vulnerable to subsidence is of undeniable significance. The present study applies the ALPRIFT method to assess the vulnerability of land subsidence in the Marand plain located in East Azerbaijan province in Iran, which has been at the risk of subsidence in recent years. In the framework of this method that has been developed recently, seven incorporated data layers comprise aquifer media, land use, groundwater pumping, net recharge, aquifer thickness, distance from fault, and water table decline. The data layers were prepared by GIS processing, and the prescribed rates were assigned to the data layers. Then, the data layers were prioritized based on the recommended weights, and the vulnerability map of the region was delineated. In this paper, with respect to the significance of water table decline, two strategies were used in the process of preparing this data layer. In the first strategy, the difference in water levels was used in the first and the last months of a specific year. Based on this strategy, the decline of water table was prepared during 2011-2018. In the second strategy, the trend or slope of water table decline during the same period was used to prepare this data layer. The goodness-of-fit for the vulnerability map and InSAR processing were evaluated by ROC curve. The comparison of the results showed that the estimation of subsidence vulnerability by the first strategy varied for different years; however, the second strategy provided the vulnerability to subsidence regardless of seasonal and temporal fluctuations. Moreover, the result revealed that the southeast and southwest parts of the plain, the Marand city and the Yamchi and Kushksaray residential areas were located in the vulnerable area to subsidence. Moreover, the average subsidence in this plain is 2 cm based on the results of InSAR processing during 2017-2018. The results of this research can be utilized in the planning and management of groundwater abstraction to control subsidence.

Key Words: Land subsidence, vulnerability, InSAR, water table decline, marand plain.

SENSITIVITY ANALYSIS OF RC FRAME FAILURE TIME UNDER POST-EARTHQUAKE FIRE TOWARD DESIGN AND LOADING PARAMETER

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Abstract

Several loads over the lifetime of buildings threaten the safety of structures. Earthquake, fire, explosion and ... hazards that jeopardize the safety of the structure.Post-earthquake fire (PEF) is one of the rare occurrences with high consequences.Resistance time of structures against fire in damaged structures caused by earthquake can be different from intact structures.In this research, the importance of designing and loading parameters on the resisting of reinforced concrete frames under post-earthquake fire loads has been investigated.For this purpose, the sensitivity of the parameters was investigated using the FOSM sensitivity analysis method based on random variables.The time of the first failure in the reinforced concrete frame is considered as the reinforcement frame resisting against the PEF load.The thermal load provided by ISO 834 is considered to thermal loading.The results show that, among the design parameters, the reinforcement yielding stresses are the most important parameter in the resistance of the reinforced concrete frame.Concreteresistance and dead load is also one of the most sensitive random variables.The modulus of the elasticity of the armature and the length of the span (if the armature cover is ignored) will produce the least sensitivity for the failure time.In the further analysis of PEF for ten earthquake records, the sensitivity of the failure time to seismic loads is investigated.The results show that seismic load in concrete frames (unlike steel frame) is the most sensitive to failure time.Among the loading parameters, the intensity of seismic load is most important in the resistance of reinforced concrete frames in post-earthquake fires loading.For example, in Sa =

skeleton void ratio, the microscopic changes of particles are discussed. Skeleton void ratios are used to describe the idealized packing conditions of the dominant particle fraction. For soils with distinct coarse and fine particles, the skeleton void ratio is defined as the volumetric ratio between the voids formed by the soil skeleton and the volume of particles that make up the skeleton. Using the $G/G_o - \gamma$ curve, variations of threshold shear strain, γ_{th} are also investigated. The results show that decreasing relative density and mean effective stress increase the stiffness degradation and damping ratio in the granular soil. The amount of γ_{th} has also increased with increasing mean effective stress and relative density in all subgroups of the soil. In addition, the results presented on the basis of the skeleton void ratio indicate that the dynamic properties of the mixed granular soil can be evaluated using the skeleton void ratio. The dynamic properties of gravelly soils depend on the gravel skeleton void ratio (e_{gk}), which is a more representative parameter for the soil packing condition than the global void ratio and the dynamic behaviour of sand-like gravelly soils can be estimated from the sand skeleton void ratio (e_{sk}).

Key Words: Dynamic properties, shear modulus, damping, skeletal void ratio, sand.

INVESTIGATION OF COMPACTION EFFORT ON OVERTOPPING EROSION IN EMBANKMENT DAM BY IMAGE PROCESSING

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Abstract

By 2070, approximately 140 million of the world's population will have resided in coastal areas and in the vicinity of rivers and, thus, economist forecast that around 30000 million euro of assets could be dependent on flood protection. A large part of these flood protection systems is old and need replacement and / or adjusted to match safety standards. It requires a significant investment in addition to an increase in population pressure in coastal areas. Eembankment structures are built of erodible (earthen) and/or non-erodible (Concrete) material by humans or formed naturally. These are used as in the flood protection system and water storage for drinking and irrigation, energy production, and recreation purposes. Due to various reasons, such as overtopping, seepage, internal erosion and piping, and slope instability earthen embankments may fail. However, more than 34% dam, 35% earth dams throughout the world, and 30% dam failure in USA during the last 80 years are consider due to overtopping. More than 60% of human casualties resulted from the failure of dams due to the failure of the three large dams (Vajont dam (Italy), John Storm dam (USA) and Mucho dam (India) due to overtopping flow. Heavy rainfall and consequent dramatic increase in water level, or wave attack caused by hurricane and earthquake are regarded as the primary factors in creating overtopping flow. Inadequate free height, limited capacity of weirs, and inaccurate prediction of the most likely flood are among the most well-known human factors. Laboratory experiments are carried on overtopping of embankments consisting of silty sand constructed with different levels of compaction. Digital image processing was employed to investigate the surface variation in embankment due to overtopping erosion with time. The results show that a direct relationship exists between the relative density of soil and erosion duration. It is also an inverse relationship between density and rate of erosion. On other hand, relative compaction has a key role in headcut erosion and is clearly evident that in the rate of erosion.

Key Words: Overtopping, compaction, image processing, headcut erosion.

VULNERABILITY ANALYSIS TO AQUIFER SUBSIDENCE BY ALPRIFT METHOD DUE TO OVER-EXPLOITATION FROM GROUNDWATER RESOURCES

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Abstract

In this research, the seismic performance of a linked column system is evaluated as a secondary lateral resisting system. The linked column is a new idea of the lateral resisting system that can be used in seismic rehabilitation of existing buildings and increases the lateral load-carrying capacity of buildings against the earthquake load. Moreover, this research used the linked column system for the seismic rehabilitation of existing buildings, which do not have adequate lateral load resisting capacity. For this purpose, several models are designed in 3, 6 and 9 stories with 40, 60, and 80 percents of the required lateral load resisting capacity in a special concentrically braced frame and special moment-resisting frame systems. Then, the linked column as a secondary lateral resisting system was added to the first models for supplying the required lateral load-carrying capacity. After the evaluation of rehabilitated models with nonlinear static pushover analysis, the results show that the increased capacity of models using the linked column system is possible, and rehabilitated models have adequate capacity for lateral loads. In the next part, the capacity of structural stability and collapse mechanism of rehabilitated models have been evaluated by using nonlinear dynamic time history analysis under the 14 ground motion records that scaled to the base design earthquake. The coming results are indicated based on the maximum inter-story drift of models. Based on these results, the mean value of maximum inter-story drift for all models is below 2 percent, and rehabilitated models have the capability of structural stability against the earthquake records. The plastic hinges spreading and beginning (collapse mechanism) in nonlinear analysis show that the secondary linked column system has a good interaction with the first system of models. Based on these results, linked column system has the capability to provide an increase in the lateral load-carrying capacity of buildings in an optimum design with high energy absorption and dissipation, while low space occupancy is considered and also without requirement of changing or retrofitting structural members. Thus, the linked column system is presented as a convenient choice for the existing buildings seismic rehabilitation.

Key Words: Linked column, fast and simple rehabilitation of existing buildings, lateral resisting systems, shear links.

DYNAMIC BEHAVIOR OF GRANULAR SOILS FROM THE POINT OF VIEW OF EQUIVALENT SKELETON VOID RATIO

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Abstract

The shear modulus (G_o), the shear modulus versus shear strain ($G/G_o-\gamma$) and damping ratio versus shear strain ($D-\gamma$), are important parameters for the design of structures subjected to dynamic loading and can be obtained by in situ and laboratory measurements. Advanced laboratory testing techniques such as bender element (BE), resonant column (RC) and cyclic triaxial (CT) testing have been developed to study the dynamic properties of soil. Despite extensive studies on the dynamic properties of granular soil, previous research has lacked a quantitative study of the effects of mean effective stress, relative density and gravel content on the dynamic properties from the point of view of equivalent skeleton void ratio. The results from a laboratory experimental study on granular soil are presented. In the current study, $G/G_o-\gamma$ and $D-\gamma$ curves of sand-gravel mixtures have been evaluated using a triaxial cyclic apparatus along with local axial strain measurement and also a resonant column apparatus. The effects of mean effective stress, relative density and gravel content on $G/G_o-\gamma$ and $D-\gamma$ curves have been investigated. Also, using the soil

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Abstract

The growth and maturity of project-oriented organizations depends on the success of the projects, and the success of the projects depends on the resource productivity. Productivity is a dynamic variable and varies in accordance with project conditions and management decisions throughout the project. This paper examines the factors affecting productivity at the project level. Factors affecting productivity and complex relationships were identified with field studies and library research and, then, modeled using dynamic systems. After creating the model structure, the factors affecting productivity at the project level were grouped and analyzed in five general categories including project management productivity, work safety policies, human resources management policies, motivational policies, and quality policies. The evaluation of the results showed that project management had the greatest role in increasing productivity in project-oriented organizations.

Key Words: Productivity, dynamic system, human resources, project-oriented organizations, construction projects.

A COMPARATIVE INVESTIGATION ON STIFFNESS MATRIX CONDITIONS FOR FEA, XFEA, AND IGA IN FRACTURE PROBLEM

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Abstract

Fracture mechanics is a vast and growing open research field of sciences which concerned with the study of crack propagation. Stiffness matrix is an inherent feature of a numerical method. Its condition has a great influence on numerical calculation and the stability of the solution. Since the application of numerical methods such as the standard finite element method, the extended finite element method and the isogeometric analysis approach in the problems of fracture mechanics has been approved, in this contribution, a theoretical comparison between stiffness matrices is conducted. For this purpose, three computer codes are prepared to make a comparison on the stiffness matrix geometry and mathematical properties such as matrix sparsity, stiffness index, bandwidth, number of independent rows and columns, zero and non-zero elements, symmetric/ nonsymmetric and hermitian/ nonhermitian. The 8-node singular element is used in the framework of the finite element method. And in the case of extended finite element, the principles of enrichment of the interpolation functions of finite element and the application of the partition of unity method is considered. Also in the isogeometric analysis approach repetition of two different control points between two patches can create a discontinuity and also demonstrates a singularity in the stiffness matrix. In addition, the NURBS of order 3 are utilized as the basis functions to approximate the geometry and the solution. By comparing the stress distribution, the accuracy of the calculations and the smoothness of the results are investigated. It is found that, stiffness matrix obtained from the isogeometric analysis method is non-diagonal in the fracture problems. Extended finite element stiffness matrix in comparison with the other methods possess a better numerical conditions.

Key Words: Stiffness matrix, finite element method, extended finite element method, isogeometric analysis, partition of unity.

SEISMIC REHABILITATION OF EXISTING BUILDINGS BY LINKED COLUMN SYSTEM

result of that, the slenderness effect may prevent the column to achieve its maximum load-carrying capacity. In this study, six concrete specimens in the height of 900 mm under eccentric loading with 60 mm eccentricity were tested. Half of the specimens were with a circular cross-section and half with a square cross-section. All the specimens are retrofitted with FRP composites in the longitudinal direction using externally bonded reinforcement (EBR) and externally bonded reinforcement on grooves (EBROG) method. Results show that for the columns strengthened via the EBROG method, the load-carrying capacity is more than that of reference and EBR columns. Furthermore, the EBROG method decreases secondary effects and increases ductility in slender columns compared with reference and EBR columns.

Key Words: Circular RC column, square RC column, slenderness, retrofitting, FRP composites, secondary effects, grooving method (GM).

INVESTIGATION OF THE MOST IMPORTANT FACTORS AFFECTING COST OVERRUNS IN CONSTRUCTION PROJECTS USING HYBRID SYSTEM DYNAMIC AND DEMATEL METHOD

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Abstract

One of the main goals of any construction is to provide a project within the budget range. However, most of the construction projects cost more than predicted. Cost overrun is a worldwide problem, but it has become a major challenge in developing countries. The purpose of this research is to identify the most important structures related to cost overrun in construction projects in Iran using the hybrid method of Systems Dynamic and DEMATEL. For this purpose, 55 factors affecting cost overruns in construction projects were identified through a literature review and classified into 6 groups. From the 55 identified factors, more important factors were selected based on the frequency and experts' opinion. Then, using the System Dynamic method, the Causal Loop Diagram of factors affecting the cost overrun and the interrelations of these factors are built in the project work process in the form of four subsystems including labors, materials, equipment, and overhead. The resulting causal loop diagram obtained from SD were used subsequently for identifying the most significant factors influencing and influenced by cost overrun through the Decision Making Trial and Evaluation Laboratory (DEMATEL) method. The ranking of the factors was determined by the amount of affecting degrees. Factors and subsystems were also divided into cause and effect groups. The results of this study indicate that lack of cash flow, lack of technical and specialized personnel, and the reworks are the most affecting factors on the cost overrun in construction projects. Also, the duration of the project, cash flow, and efficiency of the employees, respectively, are the most affected factors by the cost overrun in construction projects. Also, according to the model presented in this study, the factors in the labor subsystem with 36.3%, overhead with 24.4%, materials with 21.7%, and the equipment with 17.6%, respectively, have the most effect on the cost overrun. Finally, the most important loops related to cost overrun has been identified.

Key Words: System dynamics, causal loop diagram, DEMATEL, cost overrun, cost management.

ANALYSIS OF FACTORS AFFECTING HUMAN RESOURCES PRODUCTIVITY IN PROJECT-ORIENTED ORGANIZATIONS WITH DYNAMIC SYSTEMS APPROACH

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Abstracts of Papers in English

EXPERIMENTAL STUDY OF SLENDERNESS EFFECTS ON BEHAVIOR OF CIRCULAR AND SQUARE RC COLUMN STRENGTHENED WITH FRP SHEETS BY GROOVING METHOD UNDER ECCENTRIC LOADING

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Abstract

The application of FRP composites is one of the most prevalent methods for retrofitting concrete structures. Strengthening of columns as a major member of structures undergoing concentric or eccentric loads is of considerable importance. The column under eccentric loading experiences lateral deflection at any particular column height, which is defined as an eccentricity for the axial load at both ends of the column. The lateral deflection would lead to the secondary moment, whose combination with the primary moment will produce more significant effects. Although concrete columns are mostly under eccentric loading in practical use and are vulnerable to instability caused by the slenderness effect, limited experimental studies have been conducted on the behavior of slender concrete columns strengthened with FRP composites in comparison with strengthened short columns. Previous studies state that the strength of columns increases with retrofitting with FRP; however, the strengthening effect of FRP on the column under axial-bending (P-M) loading would be reduced with an increase in slenderness. In other words, the capacity of FRP is not achieved completely since the column is vulnerable to instability and buckling. As a