Abstracts of Papers in English

EVALUATION OF THE WIDELY-USED EQUATIONS OF HYDRAULIC LOSS CALCULATION AND CALIBRATION OF THE HAZEN-WILLIAMS EQUATION IN DRIP IRRIGATION LATERALS

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Abstract

Hazen-William's equation is usually used to determine the hydraulic head loss when designing drip irrigation systems. The mentioned equation is suggested for pipes with diameters greater than 75 mm and flow rates above 2.3 l/s. However, lateral pipes with 16 to 32 mm diameters are generally used for trickle irrigation. In this case, the calculated hydraulic head loss is lower than the actual hydraulic head loss, and subsequently, the hydraulic pressure at the desired point will be lower than the required value. In other words, the output flow from

the droppers will be reduced, and the water distribution uniformity will be less than expected. Herein, using laboratory models and polyethylene pipes with a diameter of 16, 20, 25, and 32 mm, the amount of hydraulic loss was measured for different flow rates and according to the permissible velocity limits. Hydraulic pressures were measured using a data logger, with one record for each second, and the discharge was adjusted volumetrically. A bypass pipe was installed on the physical model to control the discharge and the hydraulic pressure. The amount of hydraulic head loss was measured for different flow rates in the permissible flow velocity range (1-2 m/s). Then, by analyzing the recorded data, a new relationship was obtained that calculates the amount of hydraulic head loss in 16 to 32-mm pipes as a flow rate and pipe diameter function. The Hazen-Williams equation was compared with the results of Moody, Churchill, and Colebrook methods and the actual measured values. According to the results, the most significant error between the measured and the calculated head loss was for the Colebrook & White equation for the 25 mm pipe, and the smallest error was for the same equation for the 32 mm pipe. The obtained relationship is recommended for polyethylene pipes with a diameter of 16 to 32 mm and a Reynolds number above 2000 with high confidence. One of the advantages of the obtained relationship is its independence from the Hazen-Williams roughness coefficient and its remarkable accuracy.

Key Words: Drip irrigation, hydraulic loss, laboratory model, Hazen-Williams.

ASSESSMENT OF THE MOMENTUM BALANCE METHOD FOR DETERMINATION OF SHEAR STRESS IN COMPOUND MEANDERING CHANNELS

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Abstract

Shear stress is one of the most essential factors in the flow dynamics of open channels. The hydraulics of sediment transport in channels are affected by how and the amount of this factor. Considering the three-dimensional and complex nature of the flow in meandering compound channels, and based on the effective role of secondary flows and momentum transfer, especially in curves, calculating this parameter using the methods provided for straight channels is challenging. The Momentum Balance Method, introduced as one of the shear stress determination methods in straight channels, can be used to determine the shear stress in meandering channels. In this research, using the 3-D flow velocity component data measured by ADV, the distribution of shear stress along the flow path in a meandering compound channel was investigated. The transverse distribution of streamwise velocity was investigated in a physical model, including a rectangular concrete channel, a meandering main channel, and two floodplains. Then, the transverse distribution of shear stress in five sections along the flow was calculated using the momentum balance method, and the results were compared using the logarithmic distribution method of velocity and Reynolds shear stress in these sections. Also, the amount of shear stress at four depths of the main channel is illustrated. Since the determination of maximum shear stress areas can be effective in flow and sediment studies, and issues related to river maintenance, such as bed erosion, especially in arches, the maximum values of relative shear stress in MBM, RSM, and LLM methods were determined as 5.43 and 7.24 in the fourth section and 6.05 in the first section, respectively. The minimum amounts of shear stress were observed in section 5 in both RSM and MBM methods. According to the reviewed results, the MBM method can be introduced as a practical method for evaluating shear stress values in meandering rivers.

Key Words: Momentum exchange, reynolds shear stress, RSM, MBM, meandering compound channels.

NUMERICAL MODELING OF LAND SUBSIDENCE INDUCED BY GROUNDWATER EXTRACTION CONSIDERING UNSATURATED EFFECTS AND USING ELEMENT-FREE GALERKIN (EFG) METHOD

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Abstract

This study aims to provide a coupled flow-deformation model for simulating land subsidence associated with groundwater extraction in aquifers. For this simulation, we have adopted the element-free Galerkin (EFG) method and considered the unsaturated effects in the aquifers based on the aquifer's hydrologic and geotechnical characteristics. This model gives us a better understanding of the aquifer's hydrogeological characteristics, enabling us to forecast changes in the hydraulic head and land subsidence. To ensure the credibility of our model and to verify the code, we modeled unsaturated hydromechanical benchmark problems. Then, using the EFG method as a numerical tool, we modeled an isotropic aquifer to investigate the effects of groundwater pumping on land subsidence and hydraulic changes in the aquifer. To ascertain the reliability of the modeling, we compared the results obtained from the EFG method with those from the Finite Element Method (FEM). The comparative analysis of EFG and FEM models demonstrates discrepancies of 5.51% in land subsidence and 13.35% in hydraulic head reduction, which are satisfying. The land subsidence and hydraulic head profiles demonstrate that the EFG method is capable of land subsidence simulation caused by water pumping. Furthermore, our findings highlight the nonlinear correlation between groundwater extraction and the subsequent decrease in hydraulic head and land subsidence augmentation. Finally, we conducted a parametric study to better understand the effect of various characteristics of aquifers and observe the effect of the aquifer's parameters, such as hydraulic conductivity, elastic modulus, and Poisson's ratio. We investigated the effect of each parameter on land subsidence increase and hydraulic head decline. The results show that elastic modulus and Poisson's ratio have the most significant effect on land subsidence. Although hydraulic conductivity controls the hydraulic decrement and land subsidence increase time, it slightly affects the ultimate hydraulic head and land subsidence at the steady-state stage. These results highlight the importance of in-situ measurement of elastic modulus and Poisson's ratio parameters with acceptable accuracy for groundwater extraction projects, as these parameters play a significant role in the feasibility studies.

Key Words: Land subsidence, groundwater extraction, numerical modeling, coupled hydromechanical analysis, Element-free Galerkin (EFG), unsaturated effects.

DETERMINATION OF SURFACE POTENTIAL OF KAOLINITE FOR SELECTION OF OPTIMAL ENHANCEMENT PATTERN FOR REMOVAL OF HEAVY METAL CONTAMINANT IN ELECTROKINETICS REMEDIATION

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Abstract

Buffering capacity measurement is one of the standard methods to evaluate contaminant retention by soil or the selection of enhancement methods for contaminant removal. However, due to the limitations of this experiment, the quantitative use of the results of this experiment involves noticeable errors. The main objective of this paper is to present theoretical and practical insights into zeta potential theory to optimize the removal of heavy metal contaminants from clayey soils. This is achieved by aligning the direction of electro-osmosis flow with the ion migration phenomenon. Based on the results of this paper, with the determination of variation of the surface potential of clay at different geo-environmental conditions, the curve of zeta potential can be divided into three zones, which are called retention,

stable, and desorption sections. Based on these three different areas, with a selection of optimum enhancement patterns, one can align the direction of electro-osmosis flow with the ion migration phenomenon. Consequently, more uniform removal of heavy metals will be achieved, and the efficiency of the electrokinetics method will increase. Finally, it is shown that using a fundamental aspect of the surface potential of clays with the concept of different retention phases of a contaminant in the soil is an applicable and theoretical method for optimized contaminant removal from clayey soils.

Key Words: Heavy metal contaminant, zeta potential, clay, contaminant removal, electrokinetics.

A NEW STRONG GROUND MOTION MODEL FOR PREDICTING PEAK GROUND ACCELERATION (PGA), PSEUDO-ACCELERATION SPECTRA AND DISPLACEMENT SPECTRA IN IRAN

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Abstract

Due to the inelasticity of the ground and geometric expansion, seismic waves are reduced by moving away from the center of wave propagation, which is called the attenuation of seismic waves. Therefore, the ground motions that occur at the site of the structures are different from the ground motions that are emitted from the source. The upcoming study investigates the attenuation of seismic waves in the geographical area of Iran based on the accelerogram data of Iran.

In this study, a new ground motion model (GMM) for Iran is developed to estimate peak ground acceleration (PGA), pseudo-acceleration spectral values (PSA) in 2, 5, and 10 percent damping, and displacement spectral values (Sd) at 21 oscillator periods ranging from 0.04 s to 4 s. The displacement spectra considered in this research are those with a constant resistance-to-weight ratio, which includes both elastic and inelastic displacement types. Also, the considered resistance-to-weight ratios include five ratios from 0.05 to 0.3. The database of this study consists of 659 records of 115 shallow crustal mainshocks that occurred in Iran from 1976 to 2022 with a magnitude range of $5 \leq Mw \leq 7.4$ and an epicentral distance range of 0 to 200 km. Random-effect coefficients were defined in the mixed-effect regression model for regional differences among the five regions of the Iranian plateau, and no statistical differences were detected among these regions. The effects of the site soil's nonlinear response are considered in the developed GMM using the V_S30 parameter (average shear wave velocity in the upper 30 meters of the soil profile). The residuals of the proposed GMM are decomposed into three between-event, site-to-site, and event-site-corrected components, and their distributions are examined against the predictor variables. The distribution of residuals obtained showed no significant bias for the developed GMM. The output of this research is a GMM for Iran, which can be used to estimate the spectrum of pseudo-elastic acceleration and the spectrum of elastic and inelastic displacement.

Key Words: Strong ground motion model, ground motion prediction equations, pseudo-acceleration spectrum, elastic displacement spectrum, inelastic displacement spectrum, iran earthquake catalog.

INVESTIGATING THE EFFECT OF DRIVEN LENGTH AND DIAMETER OF MONOPILE ON SEISMIC PERFORMANCE OF OFFSHORE WIND TURBINES THROUGH PHYSICAL MODELING

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Abstract

Global warming and its following environmental problems have led to increased attention to the use of renewable energy sources in most countries worldwide, and wind energy has emerged as a significant contributor. The use of wind energy through offshore wind turbines is one of the clean energy harvesting methods that initially began in Europe. Due to their larger size and higher wind speeds, offshore wind turbines have gained popularity worldwide, including seismic areas such as the United States and Southeast Asia, especially China. These turbines are located in marine environments and are subject to cyclic loads caused by wind, waves, and ocean currents. Monopiles, cylindrical hollow piles with diameters ranging from 2 to 8 meters and lengths of approximately 60 meters, are widely used to install offshore wind turbines. The design regulations for these turbines often overlook influential factors such as soil-structure interaction and refer to seismic design guidelines for onshore turbines. In this research, the seismic performance of monopiles has been investigated by conducting six experiments using a shaking table in a 1g condition. The effects of driven length and monopile diameter were analyzed, along with the impact of the installation medium being either saturated or dry. Various parameters, including ground motion acceleration, displacement, and induced excess pore water pressure, were scrutinized in this study. The results indicate that the saturated environment weakens their seismic performance. Therefore, the seismic design considerations for monopiles, based on the existing guidelines for dry structures, are inadequate. Furthermore, increasing the monopile diameter by 57% causes a 24% increase in the acceleration of the superstructure, a 40% increase in the cumulative displacement, and a 30% decrease in the average maximum displacement of the cycles during loading. It was also observed that by increasing or decreasing the driven length by about 15% compared to the driven length of the base monopile, the acceleration value of the superstructure increases by more than 20%, and the cumulative displacement value decreases by about 60%. The average maximum displacement of the cycles decreases by 30%, with an increase of 33% in the driven length.

Key Words: Monopile, offshore wind turbine, physical modeling, seismic performance.

HEALTH MONITORING OF STRUCTURAL ELEMENTS USING CT-XRAY

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Abstract

Structural health monitoring is becoming more reliable as technology advances. Many structures are in use throughout cities and environments that require constant attention due to fatigue of corrosion and environmental effects such as floods, earthquakes, or strong winds. This means that with the advent of new damage detection techniques, authorities can make sure that these vital structural elements, such as road signs or traffic lights and so on, are safe.

The important key to these techniques is that they must be simple and relatively inexpensive. Therefore, an attempt was made to use techniques in medical practice and adapt those to structural members.

In this article, the effectiveness of X-ray computed tomography in the inspection of urban structures and building structures is discussed. X-ray tomography is a non-destructive method based on X-ray absorption, widely used in the medical field. By using this method, it is possible to study and examine the internal structure of old structures to fix defects and maintain the safety of residents, as well as to maintain them as best as possible. For example, urban structures such as electric poles and traffic signs cause financial losses or even deaths due to natural hazards or wear and tear every year. One of the features of this method is its high accuracy and speed in checking the member. Considering the capabilities of this method, in this research, a baggage inspection device at the MehrAbad airport was used to examine a number of concrete and wooden samples to identify defects such as cracks, holes, or knots in wooden samples. The investigation results are directly related to the device's power and the duration of radiation used on the sample. According to the results, defects such as cracks in concrete or knots in wood can be observed.

Key Words: Non-destructive, X-ray, computed tomography, earthquake, destructive, structure, structural defects.

AN INVESTIGATION ON THE EFFECTIVE PARAMETERS OF LOOSE SANDS LIQUEFACTION POTENTIAL USING IMPROVED HYPERCUBE SAMPLING METHOD

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Abstract

The occurrence of the liquefaction phenomenon in saturated loose sandy soils under seismic loads causes the soil particles to tend to decrease in volume. So, if drainage is not possible, the pore water pressure inside the soil increases, and in constant stress conditions, the effective stress between particles approaches zero. In this case, the soil particles have no shear resistance, and liquefaction occurs. Liquefaction is one of the important issues of concern in seismic geotechnical engineering, which involves many uncertainties in soil and earthquake parameters. The most common method to evaluate the potential of liquefaction is a deterministic method, which cannot consider the pertinent uncertainties. Soil properties are uncertain due to various sources of variability of soil deposit formation. Currently, there is a less reliable procedure to account for all pertinent uncertainties in predicting the occurrence of soil liquefaction phenomena when subjected to strong ground motion. In this research, liquefaction reliability analysis was performed by considering the soil and earthquake loading uncertainties using the latest modifications provided by Idris and Boulanger (2014) for the simplified method and using the improved hypercube sampling (IHS) method. Comparing the results of the IHS method with Monte Carlo simulation showed that the proposed method is reliable for liquefaction analysis. The analyses have been performed on well-documented historical cases. The Monte Carlo method has been accepted as the benchmark method in most studies based on liquefaction reliability analysis. Comparison of the Monte Carlo (MC) method and IHS results indicate that the IHS method is more accurate, reliable, and capable than MC for analyzing the reliability of liquefaction and can be used as a benchmark approach in future studies. The results show that the proposed approach is a favorable and useful tool for the reliability analysis of liquefaction potential estimations. Sensitivity analysis based on the coefficient of variation on a wide range of liquefaction and non-liquefaction case histories illustrates that the variability of soil parameters and earthquake loading can affect the probability of liquefaction. It is worth noting that different parameters may have the most effect on the probability of liquefaction depending on soil conditions.

Key Words: Liquefaction, uncertainty, loose sandy soil, reliability analysis, improved hypercube sampling.

THREE-STAGE AUTOMATIC OPERATIONAL MODAL ANALYSIS USING MATHEMATICAL MODE ELIMINATION BY DENSITY-BASED CLUSTERING METHOD

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Abstract

Estimating a structure's modal parameters is essential for various applications, including health monitoring, damage detection, design verification, and model updating. Modal parameters are a structure's natural frequencies, mode shapes, and damping ratios. They can be used to understand the structure's dynamic behavior and to identify any changes that may occur over time. Operational modal analysis (OMA) is a technique that uses the response of a structure to environmental

loads to estimate modal parameters. OMA is a non-destructive testing method that can be used on structures in their operating environment. This makes it a valuable tool for health monitoring and damage detection of buildings, bridges, wind turbines, and stadiums. One of the challenges of OMA is that its methods rely on the user's judgment to separate physical modes from spurious modes and to distinguish between real modes of the structure. Spurious modes are not caused by the actual structure but by noise or other environmental factors. Real modes are caused by the structure itself. In recent years, there has been extensive research on automating OMA methods for modal parameter estimation. Most of these studies have attempted to minimize the need for user intervention in modal parameter calculation by using machine learning techniques. Machine learning techniques can be used to identify physical modes automatically and to distinguish between real modes of the structure. This research uses the Stochastic Subspace Identification (SSI) method for OMA. The DBSCAN clustering method is used to separate physical modes from spurious modes. Finally, the hierarchical clustering method is used to distinguish between real modes of the structure. The proposed algorithm was implemented on a 6-degree-of-freedom structure and a real bridge. The results show that the proposed method has a higher power to separate physical modes from spurious modes than previous methods.

Key Words: Automatic operational modal analysis, machine learning, clustering, structural health monitoring.

NUMERICAL MODELING OF SWASH ZONE MORPHOLOGICAL PROCESSES IN COARSE-GRAINED BEACHES WITH XBEACH OPEN-SOURCE MODEL

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Abstract

The swash zone and its processes are significant in a beach system due to their considerable effects on beach hydrodynamics, morphodynamics, and ecosystems, including beach flows, aquifers, and sediment transport. Developing efficient numerical models to evaluate hydrodynamic-morphodynamic processes is essential, particularly in the swash zone. XBeach is a numerical model for beach simulations. In this regard, research gaps in this field have been considered in assessing the performance of the XBeach model based on the SB and NH modules, comparing the results of morphological process simulations, and sensitivity analysis of the results under different coastal conditions. Based on this, this research is dedicated to modeling three different laboratory models with varying hydrodynamic- morphodynamic conditions to evaluate the XBeach model's performance in simulating coarse-grained beaches' morphological processes. After calibrating and sensitivity testing the models, the results are extracted and compared with laboratory models in the numerical modeling process. The results of this research indicate that the XBeach model has an acceptable performance in modeling hydrodynamic and morphodynamic processes in the Swash region, and simulation with the NH module performs better compared to the SB module (with a reduction in modeling error of over in various models). Additionally, the results show that phase errors during water infiltration/percolation into the aquifer in XBeach lead to the expansion of numerical modeling errors in calculating changes in the seabed profile and aquifer water level.

Key Words: Swash zone, numerical modeling, beach hydrodynamics, XBeach model, gravel beaches.

EXPERIMENTAL INVESTIGATION OF THE BEHAVIOR OF COLUMN BASE CONNECTIONS WITH CONCENTRICALLY WELDED ANCHOR RODS USING DIGITAL IMAGE CORRELATION METHOD

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Abstract

Base plate connections are one of the most important connections in steel structures. Besides the moment capacity of the connection, the rotational stiffness is an equally critical property that is frequently used in design. Because of the low rotational stiffness of the column base-plate, column base-plate connections do not have enough rigidity to create perfect plastic hinges. Therefore, concentrically-welded anchor rods were used under the column base plate to transfer loads properly. In this paper, four different weld types were used to connect the anchor rods to the bottom of the base plate. In this new connection, the eccentricity between anchor rods and the steel column is removed to improve the strength and stiffness of the base plate connections. The aim of this paper is to design four different weld types according to the specifications of welding standards. Five laboratory samples with different anchor rod strengths were tested to evaluate strength and ductility of each weld type under tensile loading. Anchor rods were the weakest member in transferring tensile load in each sample and expected to fail at the end of the test. Digital Image Correlation (DIC) method was used to provide force-displacement diagram and full field strain information of each laboratory sample. DIC is a non-contact and non-destructive technique in which digital images of the point of interest (POI) of a test specimen are captured continuously using a high-resolution camera all through the test. Fortunately, experimental results were similar to DIC results. Brittle failure was observed in the samples with high strength anchor rods at the softened heat affected zone (HAZ) in the anchor rods. As a result, all the anchor rods in each laboratory sample fractured at a tensile strength higher than yield strength of the anchor rod. Therefore, to prevent the failure of anchor rods in softened HAZ area, it is recommended to design the anchor rods of the column base connections to remain elastic under cyclic loads. It was also concluded that the fillet weld had a better performance in terms of executive and economy compared to the other welds.

Key Words: Base plate connection, T-shape connection, component method, groove weld, fillet weld, anchor rod, DIC.

INFLUENCE OF BEAM HEIGHT-COLUMN WIDTH RATIO ON SEISMIC BEHAVIOR OF RC MOMENT RESISTING FRAMES

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Abstract

Most reputable international design codes have included provisions for achieving ductile behavior and avoiding brittle and hazardous behavior in reinforced concrete frames. These provisions aim to achieve the concept of the weak beam-strong column, where plastic hinges during an earthquake occur first in the beams. Analysis of frequent and repetitive failures in strong earthquakes in recent decades of reinforced concrete structures shows that the strong beam-weak column failure mode typically leads to severe damage in these structures. The frequent occurrence of this failure mode can be attributed to two main factors. Firstly, stiffer beams are often used against more flexible columns due to the absence of seismic provisions that limit the relation between beam height and column width, which results in column severe damage to the columns and, finally, collapse of them. Secondly, the effect of the cast-in-situ slab in increasing the negative flexural strength of the beam is often underestimated or ignored, leading to the flexural strength of the columns being less than that of the beams. A series of computational models were created and analyzed in a parametric study to assess the impact of the ratio of beam height to column width on the seismic performance of MRFs. Before that, the FEA performance was validated by comparing its results with experimental data. The findings emphasize the urgent need for a new seismic provision that limits the beam height to column width ratio to a maximum of 1.25. Also, it is indicated that the values of effective slab width obtained from the provisions of ACI and EC8 are insufficient to ensure the implementation of the weak beam-strong column design methodology. Findings demonstrate that the value of effective slab width is minimally impacted by the beam height when the ra-

tio of longitudinal beam height to column width h_{lb}/C is less than 1.5.

Key Words: Finite element analysis, strong beam-weak column failure mode, beam height to column width.

ASSESSING LONG-TERM (3-YEAR) MECHANICAL PROPERTIES OF RECYCLED AGGREGATE CONCRETE CONTAINING ZEOLITE AND SILICA FUME

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Abstract
Using recycled concrete aggregate as a sustainable solution has been the subject of much research in recent years. The use of recycled aggregate has led to a reduction in the quality of concrete, according to various studies. A promising approach to enhance the concrete properties of recycled aggregate concrete involves the use of pozzolans as supplementary cementitious materials. In this study, cement was replaced by silica fume in 8% of the specimens, while in other specimens, cement was replaced by zeolite in 15%. Natural aggregate was substituted with recycled concrete aggregate in varying proportions of 30%, 50%, and 100%. Subsequently, various mechanical and durability tests were conducted to evaluate the properties of each specimen. Compressive and tensile tests were carried out to assess the mechanical properties of the specimens. The tests revealed that specimens containing recycled aggregate exhibited inferior properties compared to natural aggregate concrete. Over the long term (3 years), the specimens containing recycled aggregate also displayed lower compressive strength. Specimens containing silica fume demonstrated higher compressive strength in the short term when used with natural aggregate concrete but showed similar performance over the 3-year period. In specimens containing recycled aggregate, silica fume had a more pronounced effect, leading to higher compressive strength in the short term but similar or reduced strength over the 3-year period. A similar trend to that observed in compressive strength was found in splitting tensile strength. As the percentage of recycled aggregate replacement increased, tensile strength decreased. The use of silica fume increased splitting tensile strength, even over the 3-year period. On the other hand, using zeolite did not result in a significant change, and specimens exhibited similar or reduced compressive strength over the 3-year period. In general, it can be inferred that the use of supplementary cementitious materials can enhance mechanical properties in the short term. However, durability tests, including water penetration depth and water absorption percentage, demonstrated almost the opposite trend. This suggests that the use of supplementary cementitious materials generally has a negative impact on concrete properties in the long term.

Key Words: Recycled concrete aggregate, zeolite, silica fume, recycled aggregate concrete, long-term properties.

DETERMINING THE LOCATION AND OPTIMAL NUMBER OF BUILDING LIFTS IN HIGH-RISE CONSTRUCTION PROJECTS USING A LINEAR INTEGER MATHEMATICAL MODEL

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Abstract

Vertical transportation technology is essential for constructing tall and medium-rise buildings. Although lifts are a functional component of buildings, their vital nature depends on the continuous and uninterrupted use of lifts in each tall building. Therefore, using lifts for vertical transportation of materials and human resources has gained greater importance. Extensive research has been conducted on reducing lift travel time between floors, optimizing lift systems design, optimizing lift movement paths, determining the sequence of floor travel, managing lift energy consumption, and floor zoning. However, the optimization of lift installation locations and quantities has not been examined so far. The use of lifts in construction projects incurs multiple costs, including rental or purchase costs, energy consumption during vertical transportation of materials, and operator salaries. One of the main solutions to reduce these costs is to minimize the duration of lift usage, which, by delivering the required materials on time, can also reduce the project's execution time. The installation costs of lifts may also vary at different candidate points due to factors such as weight and dimensional capacity, electricity consumption, the number of visits for monthly or annual maintenance and repair, and lift operator salaries. Additionally, some candidate points may have advantages over other points in terms of the amount of horizontal movement of materials on building floors. These distinctive features present challenges in selecting the optimal installation point. In this article, an integer linear programming model has been proposed to determine the optimal number and location of lift installations. The number of lifts used can affect the number of project working days, and as a result, the optimization is performed simultaneously for the number of working days and the number of lifts. The goal of this optimization model is to minimize the duration of lift usage and the associated costs. Additionally, using this model, the number of project working days is obtained with a balanced distribution of lift activities. The effectiveness of the proposed model was tested in a case study to evaluate its effectiveness. The case study involved a 20-story building located in the city of Mashhad, which requires determining the number and location of lifts during the workshop preparation phase. Using this model can lead to cost reduction and a decrease in the number of project working days.

Key Words: Construction lift, high-rise construction, optimization, linear programming, positioning.