This paper deals with formulating and solving the Multi-Period Network Design Problem (MPNDP). MPNDP is a variation of the Network Design Problem (NDP) which inserts timing into the problem. The model's outputs are the optimum set of projects and the optimal scheduling of the projects simultaneously.
MPNDPs are complex problems, not only due to their large sizes, but also due to interdependency of costs and benefits among projects. In terms of difficulty of solving, they fall within the category of NP-hard problems. In this paper, two heuristic methods, which are based on steepest descent and Tabu search, are offered to solve the problem.
In the solution procedures of both methods, three interdependent matrices track the annual projects progress, the annual projects' budget assignments, and the available projects.
The results of our study show that while the steepest descent method provides more robust solutions than the Tabu based search method for smaller-sized problems, it fails to find solutions to large-sized problems. The Tabu search's relative performance increases as the size of the problem increases; Therefore, it is recommended for solving large networks. The performance of the model and the solution techniques are tested on the Sioux Falls City network which is a mid-sized network.

**Key Words:** Network design, multi-period network design, heuristic methods, tabu search, steepest descent.

## EVALUATION OF RESPONSE MODIFICATION FACTOR AND DEFLECTION AMPLIFICATION FACTOR OF STEEL INTERMEDIATE MOMENT-RESISTING FRAMES

**S. Bagheri**(corresponding author)
s_bagheri@tabrizu.ac.ir
**F. Tayyari**
farshad.tayyari@tabrizu.ac.ir
**Dept. of Civil Engineering**
**University of Tabriz**

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**Abstract**
Response modification and deflection amplification factors are used in the current seismic design codes to account for the inelastic behaviour of structural systems without the need for complicated nonlinear analyses. A deflection amplification factor, cd, is used to compute the expected maximum inelastic displacement from the elastic displacement induced by the design seismic forces. The response modification factor, R, expressed as either a force reduction factor or a behavior factor, is used to reduce the linear elastic design response spectra. It is generally expressed as the product of three factors: overstrength factor, ductility factor, and redundancy factor.

This paper tries to evaluate these factors for steel intermediate moment-resisting frames. For this purpose, two-dimensional steel building models with different number of stories have been designed and analyzed. After obtaining pushover curves of the models, two different approaches have been adopted to calculate the effective parameters of the response modification and deflection amplification factors from pushover curves; the first approach that is suggested by seismic code provisions, like ATC-19, FEMA-356 and Iranian Standard No. 2800, uses the idealized pushover curve to specify the effective parameters, and the other approach that is recommended by FEMA-P695 gets the parameters directly from pushover curves. The obtained results from these two approaches for the above-mentioned factors have then been compared with each other and with the recommended values of these factors in the Iranian Standard No. 2800. In this evaluation, ductility factor of the response modification factor has been calculated based on the relations proposed by Newmark and Hall, Lai and Biggs, and Nassar and Krawinkler.

According to the obtained numerical results, the average response modification factor resulted from the FEMA-P695 approach is 5.26, while this factor was obtained 3.98 based on the Iranian Standard No. 2800 approach. Considering the recommended R factor of the Iranian Standard No. 2800 for the ultimate limit state design of steel intermediate moment-resisting systems equaling 5, it is obvious that the results from the FEMA-P695 approach are more compatible with the code recommendation. In addition, the average overstrength factors, according to the FEMA-P695 and Iranian Standard No. 2800 approaches, are 2.37 and 1.80, respectively, when the recommended value of this factor in the Iranian Standard No. 2800 is 3. The average deflection amplification factor obtained from both approaches is 3.67 that is slightly less than the recommended value of 4 for this factor in the Iranian Standard No. 2800.

**Key Words:** Response modification factor, deflection amplification factor, pushover analysis, steel moment-resisting frame.

# WASTE RUBBER ON THE PHYSICAL AND MECHANICAL PROPERTIES OF KAOLINITE CLAY

**M. Tajdini**(corresponding author)
m.tajdini@tabrizu.ac.ir
**H. Zartaj**
h.zartaj@tabrizu.ac.ir
**Dept. of Civil Engineering**
**University of Tabriz**
**H. Taherkhani**
taherkhani.hasan@znu.ac.ir
**Dept. of Civil Engineering**
**University of Zanjan**

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**Abstract**

Today, several methods are available for improving the physical and mechanical behaviour of the soils unsuitable for construction projects. These methods include compaction, consolidation, preloading, grouting, stabilization by adding chemical materials, etc. Addition of waste crumb rubber to reinforcing the soils is an appropriate method for improvement the strength and bearing capacity of the soils. In addition to the improvement of soil engineering properties, the addition of waste crumb rubber is a measure for the protection of environment. In this study, the shear strength parameters of the kaolinite clay, as the control material, and kaolinite clay reinforced by different percentage of two different types of crumb rubber content have been evaluated. The consolidated drained (CD) and unconsolidated undrained (UU) tri-axial and California Bearing Ratio (C.B.R) tests have been conducted on the control and crumb rubber reinforced soils. Results show that the addition of crumb rubber to the soil results in the improvement of shear strength parameters the ductility f soils. An optimum crumb rubber content is found, which results in the maximum bearing capacity of the soil.

The name kaolin is derived from the kao-ling, a village in Jiangxi province, China. Kaolin is composed of white colour china clay. The mineralogical name of Kaolin is Kaolinite, with chemical formula of Al4 (Si4O10)(OH)8 in triclinic system, and the stiffness of 1-2.5 and melting point of 1785 C. Its colour is white tending toward yellow, sometimes- green or blue, tasting soil and intensely smelling soil in wet condition. This mineral is mostly plastic and solouble in water, diluted cold acid, warm and strong choloridric and sulphuric acid and insoluble hydroxide base. Different types of this clay, including ball clay, Halozite, Dikite, and Nakrite can be found in nature. The reasons for the wide applications of this soil in construction materials, ceramics, etc. are being a good filler and coater, softner of surface, resistant against wear, having low conductivity of electricity and heat and katalizator property. On the other hand, due to the industrialization of societies, generation of waste rubber has been greatly increased in recent years. Decomposition of rubber lasts a very long time, and their deposition without appropriate control leads to many environmental problems associated with the rubber are the leaching of harmful materials of buried wastes, and the generation of heat and poisonous gases due their incineration.

**Key Words:** Base clay soil, reinforced clay, waste crumb rubber, tri-axial test, CBR test.

# PROJECT SELECTION AND SCHEDULING OPTIMIZATION FOR THE MULTI-PERIOD NETWORK DESIGN PROBLEM

**Y. Shafahi**(corresponding author)
shafahi@sharif.ir
**Dept. of Civil Engineering**
**Sharif University of Technology**
**M. Ameri**
ameri@moe.gov.ir
**Institute for management and planning studies**

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**Abstract**

The traditional network design problem tries to increase surplus benefits of users over long-term period or increase the reliability of the system in short-term period. An implied assumption of most these studies is that all projects are selected and implemented in a short period of time and budget limitations are only considered within that short time. This assumption is not a valid assumption for some real transportation projects. It is more appropriate to consider the fluctuations in demand over long-term period. Demand for transportation infrastructures does not only change with time, but is also influenced by variations in supply. Transportation projects usually consist of several components that are continually implemented and operated during the projects' life cycle. The benefits and costs of operation of different parts of the projects at different times should be considered in project evaluation.

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**Abstract**

The settlement of a soil layer beneath structures has an important role in the designing procedure. Consolidation is a major mechanism of settlement in the cohesive soils. In some area, sand lenses may be existed in soil layers which facilitate the dissipation of the excess of the pore water pressure. Since they may possess any arbitrary shapes, the numerical simulation of the phenomena, may face with some difficulties in domain discretization when a conventional mesh based method are used. Meshfree methods are rather new approaches in the numerical solution of the engineering problems which gives a flexible tool in the discretization of domains with complex geometry. In this paper a least squares based and integral free meshless method, named Collocated Discrete Least Squares (CDLS), is used to solve two dimensional consolidation problems in the present of sand lenses with different kinds of shapes and positions in a cohesive soil. In this paper, a bench mark problem is solved to validate the proposed scheme. Then more complicated problems are dealt with to investigate the effect of existence of sand lenses and the location of them into the settlement process of the cohesive soils. Also the results show the proposed approach, can obtain reliable solution for even complicated problems. It is shown that sand lenses have considerable effect in the settlement a soil depending on its shape and orientation. It can be predictable since the excess pore water pressure dissipates from all lateral surfaces of the sand lenses and the external loading will put on the soil aggregate sooner. In type of orientation for the sand lenses, the pore water pressure dissipates more slowly than the lenses with a plane look. The results show that the effect of sand lenses can be more noticeable if they have a plane and horizontal shapes.

**Key Words:** Sand lenses, collocated discrete least squares, consolidation, pore water pressure.

## ESTIMATION OF COEFFICIENTS OF WILLIAMS' SERIES IN LEFM PROBLEMS USING DECOUPLED EQUATIONS METHOD

**M. Yazdani**
mahdi.yazdani@modares.ac.ir
**N. Khaji**(corresponding author)
nkhaji@modares.ac.ir
**Faculty of Civil and Environmental Engineering**
**Tarbiat Modares University**

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**Abstract**

The existence of crack and notch is a significant and critical subject in the analysis and design of solids and structures. As most of cracked domain problems do not have closed-form solutions, numerical methods are the current approaches dealing with fracture mechanics problems. This study presents a novel application of the decoupled equations method (DEM) to model crack issues. Based on linear elastic fracture mechanics (LEFM), the first four coefficients of the Williams' series for the crack tip's asymptotic elastic field are computed using the DEM. In this method, only the boundaries of problems are discretized using specific higher-order sub-parametric elements and higher-order Chebyshev mapping functions. Implementing the weighted residual method and using Clenshaw-Curtis quadrature result in diagonal Euler's differential equations. In the present method, the so-called local coordinate's origin (LCO) is selected at a point, from which the entire domain boundary may be observed. For the bounded domains, the LCO may be chosen on the boundary or inside the domain. Furthermore, only the boundaries which are visible from the LCO need to be discretized, while other remaining boundaries passing through the LCO are not required to be discretized. Consequently, when the local coordinates origin (LCO) is located at the crack tip, the geometry of crack problems is directly implemented without further processing. In fracture mechanics problems, the stress at the crack tip approaches to infinity, and hence the original DEM is not able to represent infinite stress at the crack tip, basically. To overcome this problem, a new form of force function is constructed to represent infinite stress at the crack tip, and the first four coefficients of the Williams' series are then computed. Validity and accuracy of this method is fully demonstrated through two benchmark problems. The results show that stress and displacement fields agree very well with the results of other methods. In addition, the coefficients of the Williams' series show good agreement with the results of existing methods available in the literature.

**Key Words:** Decoupled equations method, linear elastic fracture mechanics (LEFM), williams' series, two-dimensional problems.

## INVESTIGATING THE EFFECTS OF THE ADDITION OF INDUSTRIAL

on the construction of structures in near-fault, structures can survive this destructive feature. In most standards of seismic design of structures, this characteristic was denied; in some other standards, fault avoidance zones have been considered in order to deal with surface rupture, but these zones are not adequate for this purpose due to different reasons.
In this investigation, this characteristic of near-fault earthquake was investigated by studying the effect of foundation stiffness on the surface fault rupture. In order to study the effects of this characteristic on designing structure in near-fault field, 2D models of soil layer with the mat foundation on it were modelled in finite element software ABAQUS considering soil-foundation interaction. The stiffness of foundation was varied with 2 parameters, the thickness of foundation and the length of it.
Results demonstrate that the foundation stiffness has an obvious effect on the surface rupture path and increasing stiffness of the foundation by increasing the thickness of it or decreasing the length of it changes the path of surface fault rupture.

**Key Words:** Near- fault, surface fault rupture, soil-foundation interaction, foundation stiffness, foundation thickness and length.

## EFFECT OF YIELDING SEGMENT ON SEISMIC PERFORMANCE OF BUCKLING RESTRAINED BRACES

**M. Raissi Dehkordi**(corresponding author)
mraissi@iust.ac.ir
**A.M. Foroughi**
a_foroughi1@yahoo.com
**Dept. of Civil Engineering**
**Iran University of Science & Technology**
**M. Eghbali**
eghbali@znu.ac.ir
**Dept. of Civil Engineering**
**University of Zanjan**

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**Abstract**
The use of new lateral load resisting systems to improve the seismic behaviour, optimal management of material utilization and application of modern technologies is indispensable and inevitable. Buckling Restrained Braces (BRBs) as one of these systems have been considered and used in the steel frame buildings. The disadvantage of these systems is their relatively high cost, and the researchers are always looking for methods to optimize the cost requirements to meet the seismic performance levels of structures equipped with these systems. Therefore, in this study, the effect of yielding segment on seismic performance of buckling restrained braces has been investigated. For this purpose, twelve models of steel frames with five and eight stories under seismic loading have been evaluated and the sections of BRB have been reduced up to 25%, 50% and 75% separately and have been studied. The results show that the studied mid-rise buildings have acceptable performance compared with low-rise buildings. Also 50% reduction of BRB section brought about a change in a way that the seismic demand in the studied models increases from Life Safety (LS) to Collapse Presentation (CP). These results will be applicable to the evaluation and design of the building structures for different expected performance levels. Based on these results and importance of structures, seismic risk and the expected performance level can optimize the cost of the application of Buckling Restrained Braces and extension of the BRBs' applications. In addition to, the performance level of BRBs, energy dissipation in the BRBs is the proper criteria to select the optimum of materials; this subject is being investigated in this study. The results of the energy dissipation show that the models with larger spans and the 25% section reduction have the larger dissipation strain energy compared to other models of smaller spans, indicating a greater absorption of energy in these models. Similar results have also been obtained in various studied models about plastic energy dissipation.

**Key Words:** Buckling restrained brace, yielding segment, performance levels.

## INVESTIGATION OF SAND LENSES IN THE CONSOLIDATION SETTLEMENT OF THE SOIL USING A MESHFREE METHOD

**M. Lashkarbolok**
m.lbolok@gu.ac.ir
**A. Tabarsa**(corresponding author)
a.tabarsa@gu.acir
**Faculty of Technology and Engineering**
**Golestan University**

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**Key Words:** Tuned mass damper, optimum stiffness, transient and steady state responses, newmark's method.

## SIMULATION OF MECHANICAL BEHAVIOUR OF THE SAND-RUBBER MIXTURES USING DISCRETE ELEMENT METHOD (DEM)

**D. Rezazadeh Eidgahee**
d.rezazade@gmail.com
**Dept. of Civil Engineering**
**Semnan University**
**E. Seyedi Hosseininia**(corresponding author)
eseyedi@um.ac.ir
**Dept. of Civil Engineering**
**Ferdowsi University of Mashhad**

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**Abstract**

In recent years, application of rubber-soil mixtures has been widened in civil engineering problems. As a consequence, a lot of studies are performed in order to understand the mechanical behaviour of such mixtures. One of the research tools for studying the behavior of such mixtures is the utilization of numerical methods. Among them, Discrete Element Method (DEM), which is specifically denoted to the simulation of granular media, is used in this paper by using DISC code. To this end, several samples, including clean sand as well as sand-rubber mixtures with different portions of rubber (10%, 20%, 30%, and 50%), were considered. The samples were loaded by two stages including isotropic compaction under confining pressures of 50, 100, 200, and 400 kPa as well as deviatoric compression loading. The second stage was performed in such a way that the samples were loaded in vertical direction by displacement-control procedure; at the same time, the lateral stress (in horizontal direction) was kept constant. The simulations were considered in two-dimensional space with circular particles for both sand and rubber. Numerical simulations showed that the increase in rubber content of the samples caused a decrease in the stiffness of the mixtures continuously, while the shear strength raised up to rubber content of 30%, and then it decreased slightly. By comparing the results with those of experiments, it is understood that this occurrence is due to the assumption by which, the geometry of particles was considered as circular. The results show that the increase in the confining stress level causes an increase in the initial tangent stiffness of the samples. However, the increase in rubber content still has decreasing effect on the initial tangent modulus. In the present study, the comparison of simulation results with those of experiments reveals that there is good agreement between the observed trends in the mechanical behaviour in a qualitative manner.

**Key Words:** Sand-rubber mixture, mechanical behavior, discrete element modeling (DEM), numerical simulation.

## INVESTIGATION ON THE EFFECTS OF FOUNDATION STIFFNESS ON SURFACE FAULT RUPTURE IN REVERSE DIP-SLIP FAULTS

**M. Tehranizadeh**(corresponding author)
dtehz@yahoo.com
**M. Moradi Shaghaghi**
mahsa_moradi.sh68@yahoo.com
**Dept. of Environmental and civil Engineering**
**Amirkabir University**

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**Abstract**

The occurrence of large earthquakes in cities placed near active faults is an undeniable fact. Earthquakes which occur in these cities have different characteristics from those occuring in cities placed in far-field. After destructive earthquakes, such as Landers-California(1992), Kobe-Japan(1995), Chi-Chi-Taiwan(1999), Duzce and Kocaeli-Turkey(1999), engineering societies and scientific committees realized that these different characteristics should be considered in analysis and design of structures placed in near fault.

One of these characteristics is surface fault rupture which is a very destructive feature of near-fault earthquakes and has caused great loss of lives and severe damages to lots of structures. But, past earthquakes showed that there were also some structures that survived this surface fault rupture and the rupture path was changed and passed away from the structures instead of passing under the foundation of structure; this fact shows that by studying this characteristic and setting some limitations

Abstract

Failure criterion has long been known and used as a useful criterion for evaluating the strength properties of rocks. Failure criteria development process and increase of their accuracy in predicting the lateral strength of rocks under pressure indicate the high performance and precision of modern standards in evaluating features of rock strength. The development of failure criteria begins with the initial theoretical criteria and leads to empirical criteria based on curve fitting on tri-axial failure data. Accurate theoretical criteria are not reliable in predicting the rock strength regarding most natural stones, and it is proved to be due to their nature.

Although theoretical criteria are critical and necessary for better comprehension of rock behaviour, their application are very limited in practice. Designs' experimental criteria are more frequently used. In recent five decades, in order to simulate tri-axial behaviour of rock specimen, several experimental criteria have been presented which only a few of them have gained popularity. Function forms in these criteria have been different: separate constants are introduced for estimation of the strength of the rock type in every one of them. In this study, the TABU Search (TS) with its considerable features that can help us as a powerful tool in the optimization of difficult problems is used to optimize the mentioned criteria. To use TABU search techniques in this study, the algorithm is written in MATLAB.

In this paper, Hoek—Brown, Fairhurst, Franklin and Bieniawski criteria have been selected as empirical criteria. Verifying the predictions of the four criteria concerning the experimental data of different rock samples will be analyzed; moreover, their advantages will be compared. In this study, constants for each criterion are obtained using two methods; the curve fitting and the optimization with TABU's algorithm. The results achieved in this study indicate that the use of optimization algorithms, compared with the curve fitting (regression), can have considerably better envelope failure prediction for different rocks.

**Key Words:** Curve fitting, optimization, failure criteria, empirical criteria, rock strength.

# DETERMINING CHARACTERISTICS OF OPTIMUM TUNED MASS DAMPER WITH COMBINING TRANSIENT AND STEADY STATE RESPONSES IN DAMPED VIBRATIONS

**J. Alamatian**(corresponding author)
alamatian@mshdiau.ac.ir
**P. Ashrafi**
peyman.ashrafi@gmail.com
**Dept. of Civil Engineering**
**Islamic Azad University, Mashhad Branch**
**S. Vahedi Gerdeh**
sajjad.vahedi@gmail.com
**Dept. of Civil Engineering**
**Islamic Azad University, Zanjan Branch**

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Abstract

This paper deals with studying the specifications of common control system, known as tuned mass damper, i.e., TMD, and evaluating its efficiency for controlling the structural vibrations. For this purpose, a new method is proposed for designing characteristics of tuned mass damper, i.e. TMD. Here, the effects of both the transient and steady state responses of dynamic system are utilized here for determining the specifications of tuned mass damper, i.e. mass, stiffness, and damping factors. The proposed formulation is presented for structures with natural damping. In other words, the tuned mass damper is designed for damped vibrations. This procedure utilizes a new approach in which the mean of absolute values of the lateral structural displacement ratio is minimized. For this purpose, the Newmark time integration is modified so that it is used for minimizing the mean of absolute values of the structural lateral displacement ratio. It should be noted that the minimization process could not be performed analytically. Therefore, a numerical technique, i.e., the modified Newmark time integration, is utilized here to minimize the mean of absolute values of the lateral structural displacement ratio. This procedure leads to new quantities for mass ratio and TMD's frequency, which are obtained numerically. Afterwards, the proposed technique for designing the tuned mass damper is evaluated analytically and numerically. The analytical evaluation of the suggested technique shows that the proposed design method has more efficiency in comparison with other well-known existing approaches, especially for the common mass ratios. In other words, the developed procedure for determining the characteristics of the tuned mass damper has suitable efficiency to use as passive control mechanism. From this point of view, the suggested method has excellent performance in the resonance condition. Moreover, numerical results show that the developed technique reduces the structural vibrations more effectively in comparison with other design schemes.

of the four groups of buildings with base isolators was designed for five periods as: 1, 1.5, 2, 2.5, and 3 seconds. For structural analysis of the supposed models, the OpenSees software was used and P-$\Delta$ effects were considered in the analysis. Each of the structures was analyzed under multi-component non-linear time history of earthquake.
According to the result, the results of the method of equivalent static values and those of time history analysis are different; by increasing the period of structures, the non-uniform distribution of story shear in elevation is deformed to uniform distribution.

**Key Words:** Near field earthquakes; base isolator; multi-component earthquakes; non-linear time history analysis.

## AN EVALUATION OF PERFORMANCE OF ARTIFICIAL BEE COLONY ALGORITHM FOR SOLVING THE COMBINATORIAL OPTIMIZATION PROBLEMS

**A.M. Rahimi**(corresponding author)
amrahimi@znu.ac.ir
**F. Hamidi**
hamidi@znu.ac.ir
**Dept. of Civil Engineering**
**University of Zanjan**

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**Abstract**
Optimization methods are one of the strongest tools for managing time and decreasing unnecessary costs in operational issues. The purpose of optimization, regarding constraints and requirements, is to find an appropriate and acceptable solution to a problem. Since; most of the combinatorial optimization problems, such as Travelling Salesman Problem (TSP) and different types of Vehicle Routing Problem (VRP), are subcategories of NP-Hard class, expert recommendations are toward solving these kinds of problems by metaheuristic algorithms such as Artificial Bee Colony (ABC) algorithm instead of exact solving methodologies.
In this paper, a comprehensive study was conducted on the background of Artificial Bee Colony algorithms and the results of its application on various transportation problems. The formulation of Vehicle Routing Problem and its constraints was also discussed. The results show that the ABC algorithm has a significant power to improve solving various problems. As an intuitive summary, one can refer to Szeto et al. (2010) who proposed an ABC algorithm for solving the Capacitated Vehicle Routing Problem in which the mean percentage improvement of the average results of all test instances was 4.16% and the best percentage improvement was 3.53%. Further, a Hybrid ABC algorithm was designed by Zhang et al. (2014) for one of the latest Vehicle Routing Problems. They implemented the algorithm for Environmental Vehicle Routing Problem which outperforms the original ABC algorithm by 5% on average. Therefore, it can be concluded that the Artificial Bee Colony algorithm is very successful in improving the results of this kind of experiment.
In completion of the above-mentioned, the results of the proposed ABC algorithm by this study for solving Travelling Salesman Problem and Vehicle Routing Problem with Simultaneous Pickup and Delivery confirmed the expressed idea. As a result, the assumed algorithm improved instances of TSP about 1.03% and 8.88% which were named gr120 and gr202, respectively. It also enhanced the CMT1X and CMT3X instances in VRP-SPD about 0.41% and 1.31%, respectively. This certificates the quality, high capacity and preference of the ABC algorithm.

**Key Words:** Optimization, artificial bee colony (ABC), travelling salesman problem (TSP), vehicle routing problem(VRP).

## COMPARISON OF DIFFERENT FAILURE CRITERIA IN ROCK MASSES USING OPTIMIZATION (TS) AND CURVE FITTING

**E. Azar**
eazar111@gmail.com
**M. Naji**
mahmood.naji67@gmail.com
**M. Parvizi**(corresponding author)
parvizi@yu.ac.ir
**Dept. of Civil Engineering**
**Yasouj University**

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# Abstracts of Papers in English

## EVALUATION OF SEISMIC DEMANDS OF STRUCTURES WITH BASE ISOLATION SUBJECTED TO NEAR-FIELD EARTHQUAKES

**M.R. Shiravand**(corresponding author)
m_shiravand@sbu.ac.ir
**M. Bararnia**
m_bararnia@sbu.ac.ir
**R. Rasti**
r_rasti@sbu.ac.ir
**P. Zarparvar**
pouyazarparvar@gmail.com
**Faculty of Civil Engineering**
**Shahid Beheshti University**

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**Abstract**

Nowadays, the uses of seismic isolators as earthquake resistant systems are rapidly increasing. So, in recent years, Iranian researchers have been doing a lot of research on seismic isolators, and results have been published as guidelines for seismic isolated buildings. But, in these regulations, the effects of the near- field earthquake seismic requirements are not mentioned. As earthquake magnitude increases, effects owing to duration, long-period ground motion and near source pulses become more important; in these respects, the current practice may be inadequate. For near-fault locations, the code section on base-isolated buildings requires site-specific analyses, which could produce satisfactory results if the ground-motion consultant makes a realistic recommendation.

Near-field earthquakes due to their severe destructive effect are more important, such that extensive research on the different types of records and their impact on structures are investigated. This paper discusses the seismic requirements of buildings with seismic isolators subjected to multicomponent earthquakes. Parameters, such as the inter-story drift, distribution of earthquake force, and displacement of seismic isolators, have been studied, discussed, and compared the values proposed by the guidelines. In order to evaluate the seismic behavior of buildings with seismic isolation subjected to near-field earthquakes, the study included four groups of structures: three- , five- , seven-, and ten-story; each