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An Analysis on Slide Trenches of the Railway and Stabilization with Slope Change, Retaining Structure and Rock shed Methods and Reducing Destruction of Agricultural Lands and Orchards

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Abstract

Safety in the ways especially in mountain regions is highly important. Ground instability especially in the sloped hillsides can cause many risks. Running of trenches is one of the unpleasant consequences in the instable grounds which usually occur in the marl lands, weathered stones and non- condensing sedimentary layers. These landslides can occur during road making or using and applying the projects. There are several ways for stabilization of steep slopes that usually one or more are used given to the factors causing instability and environmental conditions and geology of the slopes and economic issues and ease of implementation to stabilize instable trenches. Since, the track of railway projects may pass through agricultural lands and orchards and slide of trenches may cause redirection or the variant that this redirection usually causes destruction of the agricultural lands and orchards and leads to irreversible damage in this area then, it is tried in this study to analysis influential factors on regional instability in the country emphasizing railway projects. Data analyzed included factors such as litho logy, the presence of weak surfaces and weak intercalated marlstone layers, gravity and slope changes at the hillsides, loading and total weight of the hillside materials, material and granulation of the material and their thickness, water from rainfall, vegetation, topographic status and alignment of layering slope and topographic slope, hillside direction, land use. Then, methods for stabilization were proposed. Stabilization methods in this study include changing slopes in the trenches, creating maintaining structures such as retaining walls of the trenches and making rock shed or artificial tunnels.

Key words: Agricultural Lands, Railway, Reducing Destruction, Slope change, Stabilization, Trench.

Introduction

In terms of passenger services, the railway can carry a large number of passengers. Although the railway is the most reliable way of transportation, at most safety in its design and implementation should be observed (Mohammadi et al., 2021). Railway is sensitive to the up and down and many excavation, earth filling, bridge and tunnels are required. During making railway projects, they may pass through mountainous and sloped regions that it is one of the most difficult stages in the implementation of a project in a geographical region or in the country. Iran is a mountainous country and has specific geomorphological and geological features in the slopes and mountains foot. The remaining of thick and detached sediments from the last glacial period is its main features, which are prone to motion of the hillsides and specially land slide (Khosro Tehrani, 1998). In general, landslides are more predictable and manageable than other natural disasters in such a way that by understanding potential of the land slide an appropriate strategy can be provided to encounter or coexistence with it (Darvishzade, 1991). Land slide blocks the way, decreases the quality of project implementation and creating risks of life and huge costs to maintain and reconstruction that if occurs during the implementation of the project, causes delaying the due time of project exploitation and lengthening the implementation time as well. Therefore it is needed in implementation of the railway projects in mountainous regions with instable trenches that safety are considered and geological studies is conducted thoroughly and the best engineering method is applied. One of the strategies to decrease damage resulting from slope motion is to identify regions that have potential of instability (Mirzai, 2002). Understanding instable regions can be effective in selecting the best method in stabilization. Meanwhile, various parameters such as the type of land slide, magnitude of land slide, operational limitations, and economic issues play role in selecting stability method. The most important factor in not changing the path and designing a new variant is longitude slopes and horizontal curves for railway lines given to present standards (Farmanian, 1992). Then, one another purpose of this article is to study other methods other than path variant. The most important factor to avoid redirecting and designing a new variant, is first to limit longitudinal slopes and horizontal curves for the railway tracks given to available standards and second, which is one of the purposes of writing this article is to prevent the destruction of the agricultural lands and orchards that will be generated if the project redirects. Then, one another purpose of this article is to study methods other than route variant.

Literature Review

Land slide includes the movement of the mass stones, debris or the land downside a slope (Motie, 1993). Slope rapture is considered as one of the major factors in geometric deformation of reliefs in railways. It includes transition of materials results from stripping, from upstream lands and mountains (trenches) to downstream and the path (projects line). Occurrence of mass movement of the materials in slopes such as slide and slope raptures are responsible for above mentioned operation and cause the transformation of a great volume of material in to the path (Hashemi Tabatabi & Mohamadi, 2011). Meanwhile, drift and slip at the routs besides the agricultural lands and orchards causes masses, soils and rocks to move towards the agricultural lands and leads to the destruction of these lands and huge costs will be needed for its compensation. Therefore, such paths, especially along discussed trenches are now changing under the effect of slide process and slope rapture. To understand slide factors initially geological studies and folding of land and hydrological studies of the region where railway project is to conducted should take in to account that we will discuss about these studies further (Danesh, 1995).

General geology and structural units of Iran

From Proterozoic up to now, all plate tectonic stages related to Wilson cycle has occurred in Iran and currently these stages are evolving too from continental rift (such as Dahshir fault) to subduction region (subduction of Neo-Tethys remaining under the Makran) and continental-continental collision areas (collision of Arabian plate with an Iranian plate along with Zagros). In each of these tectonic stages special structural, magmatic, metamorphic and sedimentary environments are generated and certain deposits are created in each of these environments (Jeager, 2018).

Iran's major sedimentary- structural plane:

Iran's metallogenic analysis is related directly to geological features and Iran's structural geology then we describes briefly Iran's most major and important tectonic units as fallow and then we discus about Iran's geodynamics evolution. Total categorization of structural units of Iran includes:

Zagros

A. Khuzestan plain

This plain includes the vast part of wide Mesopotamia plain and it is considered as a part of Arabian platform from structural point of view. It is relatively simple from structural perspective and just very gentle folds with north-south trend that fallows general Arabian platform's fold axis can be seen in it. Oil wells are mainly located in this plain and geophysical studies indicated that Paleozoic formations exist in this area.

B- Folded Zagros

This area which includes Zagros Mountains is located at the south west of Iran and is restricted by Minab fault from the east. Its geological construction is simple and gentle and includes a set of close and compact anticlines with usually vertical axial surface and northwest-southeast trend and from stratigraphy perspective, folded sediments of this region alternately are made up of limestone and dolomite accompanied with marl and calcareous marls that are characterized by more or less delicate stratification.

C- Zagros over thrust (elevated Zagros): In this region, Mesozoic rocks are driven to the south west and are placed on upper sections of Mesozoic and Cenozoic rocks with scaly structures. Over thrusting of Zagros with straightforward and north west- south east alignment is an indicative of very deep and old fracture which specifies the border between Arabian and Iran platform and the best elevated Paleozoic outcrops from strtigraphy can be found in Gahkon mountain, Feraghon, Zard Kuh and Dena mountain. Silurian with dark facies shales are characterized in Gohkom and north of Feraghon and other Paleozoic stratigraphy units (Barout, Zagon. Laloun and Mila) and Ordovician rocks are expanded to Dena Zard Kuh from Permian period onwards sedimentary conditions are similar to Zagros folded region.

Sirjan- Sanandaj: this zone is located at the south and southwest of central Iran and north east of Zagros zone. It is separated by depressions such as Urmia lake, Tozlogol, Gavkhouni and faults such as Shar-e Babak fault and Abade fault from central Iran and in south west by the Zagros main thrust from Zagros. One of the main features of this zone is the existence of big volume of magmatic and metamorphic rocks from Paleozoic and specially Mesozoic ages. Regarding stratigraphy of this region, old rocks of this zone includes metamorphic rocks with amphibolite, Gneiss, cyanite, amphibolite schist and marble facies with Perkemberin old. But it is possible that the upper part of these facies continues to the early Paleozoic. Sediments after Permian in this region are more and less similar to Iran's sediments but shale rocks are more in Permian and volcanic rocks are made with them too.

Central Iran: Central Iran is rectangular which is restricted to Lut block from the east, to Alborz range from the north and to Sirjan- Sanandaj region from the south. Azerbaijan is located in the north east of central Iran. This tectonic unit creates the main and intermediate body of the Iran plateau and while it is considered as a major structural unit, includes a few structural subset from tecnotic and metallogenic perspective and in stratigraphy discussion at all time of Paleozoic period this region has the same condition to other parts of Iran in such a way that a platform status is dominated on it and the great desert and central Iran depression probably is formed a shallow vast basin. After sedimentation of the middle Permian a long erosion period had dominated on Iran which resulted in deposition of the red detrital sediments at the time of lower Triassic (Sorkh Shale formation) and central Iran has been an active region from tectonic point of view in the Mesozoic and Cenozoic period in such a way that several quite specified unconformity magmatic activity in the form of volcanic rocks and granite, intrusion are seen in it too(Mahmoud et al., 2021).

Alborz- Talesh: the east of Iran and Makran range

A very big tectonic- metallogenic unit has created a vast zone at the east of Iran which is restricted to the Lut block from the west (Central Iran's eastern subset) and to the Hilmand block from the east. The eastern part of this tectonic unit is adjacent with Afghanistan and Pakistan borders with a north- south trend and Oman sea with a east-west trend and stratigraphically, in Makran and Iran's east sedimentary domain not any formation has been found older than Cretaceous except in the vicinity of Lut block. In the vicinity of Lut block and east of Iran the upper Cretaceous sediments have deep marine facie. These sediments have mingled with submarine andesite and basaltic volcanic materials with ultramafic igneous rocks and can be seen in the form of colored mélange that sometimes metamorphic can be found among them.

Koppeh Dagh: Another tectonic unit which has different structural features compare to other parts of Iran is located at the north-east end part of Iran. Geologically, there is a significant difference between this zone and Alborze and stratigraphically there had been a shallow sea from Lias period up to the early Oligocene in this part of Iran. The thickness of continuous marine sediments in this domain reaches to 6000 m and Jurassic to Oligocene sediments are stacked homoclinal on top of each other. Marine sediments had continued until the late Upper Cretaceous, only mild epeirogenic movement has occurred in the late Jurassic and early Cretaceous.

Lut block: Lut block is a stretched land with a north- south trend which continues from the Jaz Murian depression in the south to Gonabad at the north with more than 800 km length and average width of 200-250 km. The eastern border of Lut region constitutes Nehbandan fault and its western border constitutes Nayband fault. Stratigraphically, in the main Lut block just Permian limestone outcrops at some regions from Paleozoic period and sedimentary rocks related to shallow siliciclastic sediments from Mesozoic period (Shirgasht, Padha, Sardar, Jamal, Shotori formations and so on) are found in small amounts in this block and its surface is covered with Neogene-Quaternary dry sediments. But at its west, at the Tabas block, Triassic to Cretaceous sedimentary area has been made which the thickness of its sediments reaches to 6000 m. At the east of Shotori Mountains

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Mesozoic sediments are not very thick while the thickness of Cenozoic volcanic sediments reaches to more than 2000 to 3000 m (Zussman, 2016).

Folding

Generally when an initial surface curves due to metamorphosis a structure called fold is formed. The process of forming a fold is a secondary process and the factor that causes folding is tension.

2.3 Hydrology

Hydrology as a basic science is considered as a category of water engineering sciences. In understanding hydrology of basin studies, factors such as relative humidity and annual and monthly precipitation as well as the climate of the region from dry, semi-arid, moderate and cold, mountainous, hot and dry point of view are reviewed. Iran is a flat plateau which is located at the latitude of 25 to 40 degree in the northern hemisphere and in a warm region. Desert and semi desert climate occupied more than half the surface of the country. Nearly one third of Iran is mountainous and small part of Iran (including the plains south of the Caspian Sea and Khuzestan plain) constitutes of fertile plains. Iran has highly diverse climate. From the north to the south of the country, we are gradually facing with different climatic regions. Iran is considered as arid and semi arid region from precipitation point of view. Annual precipitation is varied in different parts of the country and in different seasons of the year.

After understanding the tectonic and folding and hydrology studies if the given region for the implementation of the railway project has instable trenches, stabilization methods are to be considered. In this article three methods for stabilization as slope change, retaining structure and rock shed have been proposed.

Stabilization methods

Changing trench slope: Geometry revision of the slope to decrease driving forces or increasing the resistant forces is a method which is applied commonly to increase stability factor of the slopes and stabilization of landslides.

Retaining structures: in order to supplying stability for trenches and preventing from the destruction results from the possible falls and slips of the rocks below methods are conducted in the regions with fall and slide of the trenches which are indicated in the (Figure 1).

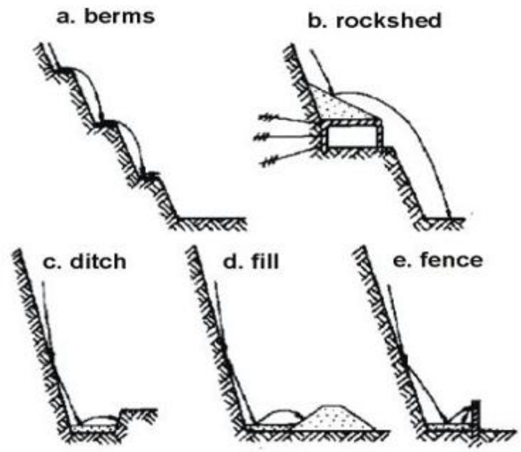

Figure 1. Methods for reducing destruction results from stone falls

Retaining walls or retaining structures act as a supporting structure to stabilize another structure and prevent surface falls, restrain soil as well as pressures results from the current situations due to the earth filling, excavation or natural factors.

Rock shed: Rock shed or artificial tunnel means here creating concrete structures in open trenches. The difference of rock shed and tunnel is that in tunnel excavation usually is done under the mountain. Then primary and secondary consolidation operation including lining is conducted. But in artificial tunnel or rock shed there isn't any excavation operation and concrete structures or lining are constructed with the same cross section and tunnel lining frames in open trenches and for overload of the artificial tunnel earth filling is done on it after construction rock shed (Safari Kamal Abadi, 2020).

Materials and Methods

Instability analysis

In order to analyze instable trenches regional seismicity, general geology, statistical studies of the joints and structural and numerical analysis using specialized software have been considered.

Seismicity study in Iran: Below table indicates frequency percentage of the earthquakes in Iran

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Table 1. Frequency percentage of Iran's earthquakes

Structural state	Percentage of earthquakes
Zagros zone	50.83
Central Iran	13.94
Lut	11.93
Alborz	10.43
Koppeh Dagh	4.85
Sanandaj- Sirjan zone	4.28
Makran- easr of Iran	3.74

General geology: Geology analysis of the regions which railway construction project is to conducted in it should be study carefully by experts in the same field. Iran's geology and regional zone study have been provided in literature review section.

Joint Study: joint study is conducted to determine joint sets and fracture systems exist in the rocks as well as determining the main trend of the direction and slope of the joints. For this purpose, usually specifications of the joints are taken along and around trenches and processed and analyzed using "Dips" software.

With drawing contour diagram, dominant direction along the fractures (joints) has been studied. In this method joints plates are specified then the coordinates of points with the highest pole densities are determined and from this special coordinates the plates which have average coordinates of fracture surfaces with dominant direction can be specified.

In slide trenches under studied two coordinates of 80/235 and 62/115 are the pole of the plates which have the position of the dominant fractures. Meanwhile, the extension and coordinates of the rock unit layering at the trench site is 50/042 and trench extension is N80W (Figure 2).

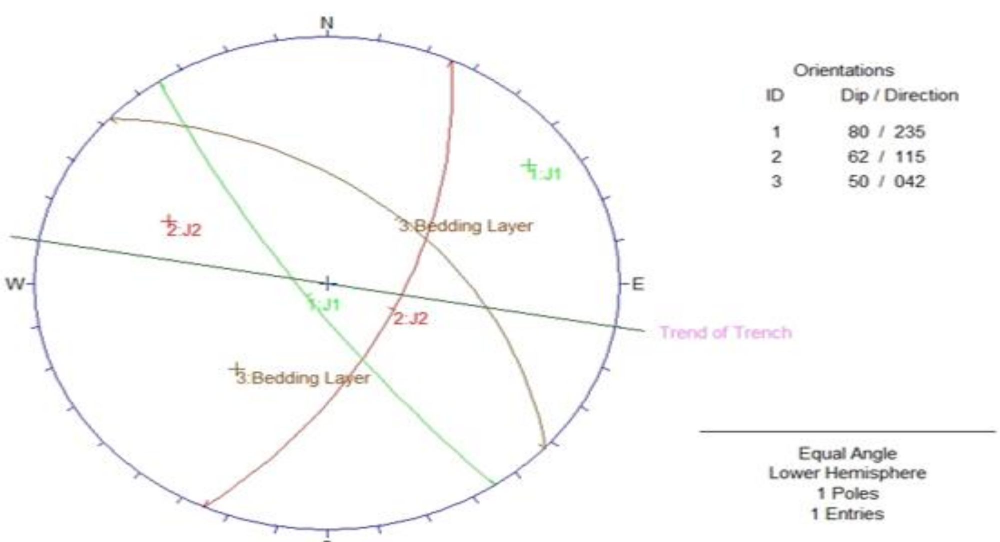

Figure 2. Diagram of dominant joints and stratification along with slide trenches under studied

Structural analysis:

(Figure 3) indicates four main instability mechanisms in trenches (a) plane failure (b) block failure (c) overturning failure (d) circular failure.

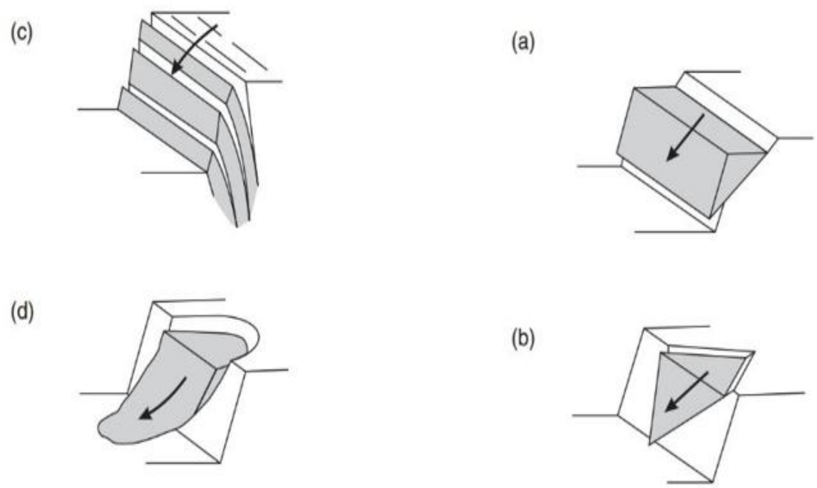

Figure 3. The main failure mechanism in trenches

To structural analysis of the present trenches first we determined the rapture potentials. This potential is studied using stereography methods. Determining the rapture potentials using with Dips5.103 software have been conducted by studying spatial condition of each trenches wall compare to the condition of the main joint sets and current stratification. Three main factors are considered for this purpose.

Slope angle of the stone wall (ψ_s)

The friction angle of the discontinuity surface (φ)

Slope angle of the joint surface in plane failure or plunge of influence line of the collision of two joint sets in wedge failure (ψ_I)

Instability occurs when

$$\psi_S \succ \psi_I \succ \phi$$

To study structure of the understudied trenches, friction angle of the joints and geotechnical features of the given trench according to the geology report has been conducted (Figure 4).

Trench orientation: N80W

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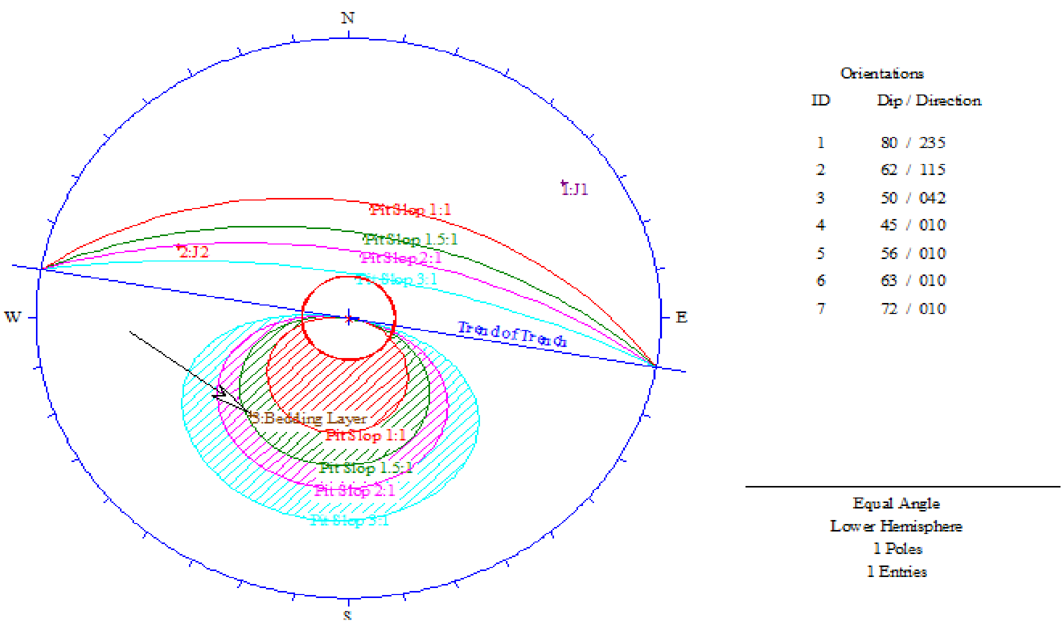

Figure 4. studying the possibility of the plate sliding in understudied trench

Numerical analysis:

Modelling is conducted based on the most critical available cross sections in Phase2. Modelling and stability analysis of the given slopes are conducted according to the available cross section and at the most critical state of the ground line relative to available profile and presented in tables and will be commented.

Stabilization

Three methods have been provided in stabilization discussion and in each method implementation, advantages and disadvantages and application if each kind of instable trench has been stated.

Methods of geometric revision of the slopes

One of the significant advantages of these methods that make them more applicable compare to other methods is their cost effectiveness and ease of implementation. Meanwhile these methods make it possible to use lands after implementation and create appropriate landscape. Different parameters play the role in selecting the method for geometric revision of the slopes including:

A- Type of land slide

In using methods for geometric revision of the slopes identifying the type of landslide (fall, slide, flow) curviness or straightness of the slide surface are important. Meanwhile, having information about how rapture starts and expands, that the slip starts from the toe and spreads upwards or simultaneously raptures throughout the slip is crucial. Using unloading method at the top of big translation slide (infinite slope) may lead to instability at the upper parts of the slope. Generally, using unloading methods at the top of slide and earth filling at the toe about deep rotational slides in which slide surface has steep slope at the top and is raising at the toe are most effective.

B- Landslide magnitude

Landslide magnitude plays role in selecting the appropriate method. Complete removing of instable materials is applicable just for small slides. Of course defining a border as small is relative which depends on the method for decreasing slope is applicable for shallow movements which are unique to superficial soil layers near the ground surface.

c- Operational limitations

One of the operational limitations in adopting methods of geometric revision is the issue of waste establishment and existence of enough space to work. In the large slides, issue of material results from unloading especially in the places that there is not enough space at the vicinity of slide location for establishment the waste materials can cause restriction in selecting unloading method. Meanwhile, existence of enough space for operation should be taken in to account. For instance, in the slides occurred at artificial slopes alongside mountainous roads, usually there is not enough space for establishment of toe fill or placement of the top of slide near the structures is considered as an obstacle for selecting the unloading method. Another issue in operational limitations is that in most slides unloading should be started from the top and continues towards the bottom that if road does not exist it will have high cost.

d- Economic issues

Economic issues should be considered both in compare methods of geometric revision with other methods and among different kinds of geometric revision methods. For example the method of unloading at the top is economical for the slides with the volume available equipment and machines. General of 2000 to 2000000 yards (nearly 15000 to 1500000 m3). But for greater slides it may not have economic justification and by using terrace method instead it may arrive to the amount of ground stability. Meanwhile, lack of Borrow pits near the slide location can make earth filling options in the toe uneconomical or lead to replacement of instable materials.

Unloading

Different methods of unloading are applied for stabilization at the soil slopes which are described at below:

Local unloading at top:

This method is used in occurred slides and it is an excellent method for the slopes that do not need removing high volume and slide surface is rotational too as significant driving gravity force acts at the top of these slides. This method is not recommended for the flows and slides having direct rapture surface (infinite slope) meanwhile in potential slides rarely enough information is available for designing this method. Estimating appropriate volume for removing is not a simple task but theories of the soil mechanic and stability analysis can be applied to determine this volume. Generally in occurred slides causing from trenches or toe erosion the amount of unloading volume is removed one or two times of the initial removed volume from the top (Figure 5).

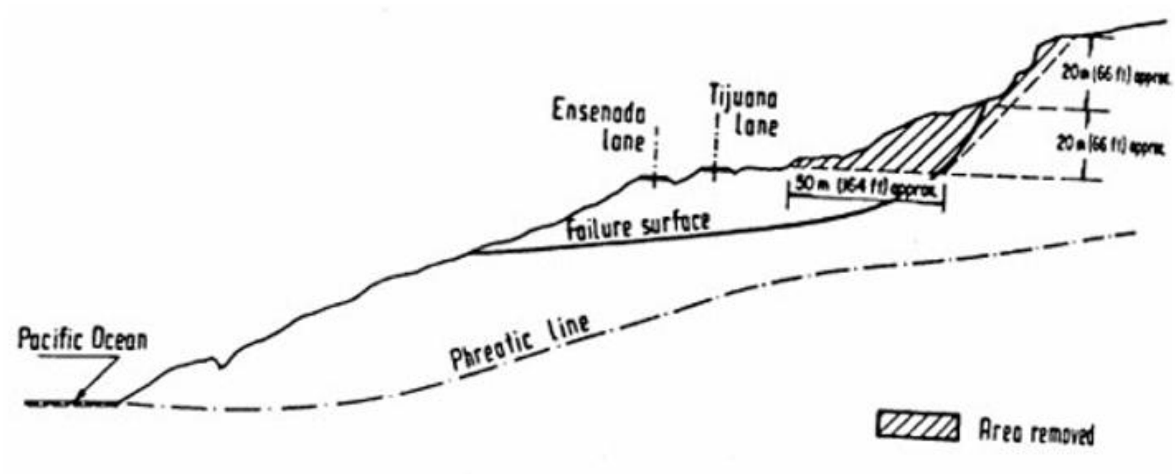

Figure 5. Stabilization of slide by unloading at top

Operational method of geometric revision of the slop in order to stabilization and revision of the trench at the first stage is removal and scaling that given to weak status of the lime layers due to the existence of clay and marl bands tensile fractures and cracks have been expanded. In this method first materials and debris are removed through changing the slope to the horizontal mode then steps are stabilized and widen and cracks and fractures profiled where layers and floors and rocky slopes reach their maximum stability and debris and stone and soil mixture are collected and removed. Therefore, decreasing slope angle, stepping and widening steps and soil drainage and using light material in earth filling are among the operational methods to decrease the weight of slide mass and as the result reducing ground driving forces (Figure 6).

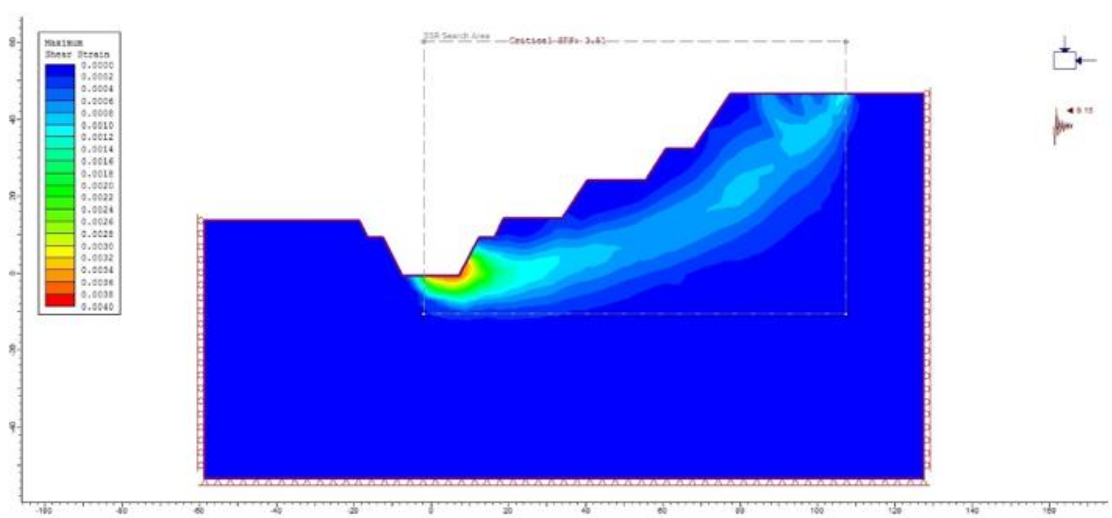

Figure 6. Slide stabilization through unloading at top using geometric slope revision method

Operational method of retaining structure:

One of the most important factors in designing and calculating these retaining walls or supporting structures is the identification and estimation of the lateral compressive force of the soil to it, control of resistance against overturning, slip and allowable bearing capacity under the foundation. To supply stability of the slopes and prevent surface falls to the road area, retaining walls with different height are conducted to increase safety factor with reinforced concrete type. Total input loads from the soil to the retaining well at the seismic mode is analyzed and calculated considering coulomb – Mononobe Okabe Method and intervention of internal friction angle between the soil and the wall. To analyze stability of the wall it is required that the safety factor against overturning, slope as well as loading capacity of the wall foundation is controlled in equivalent static and dynamic states (quasi-static) within the allowable range. The amount of safety factor is offered according to the AASHTO-LRFD regulation. Applied load on the wall including lateral and gravity loads and earthquake are the load results from the wall weight, load results from vertical pressure and lateral pressure and load results from earthquake force on the soil and the wall (Figure 7) & (Figure 8).

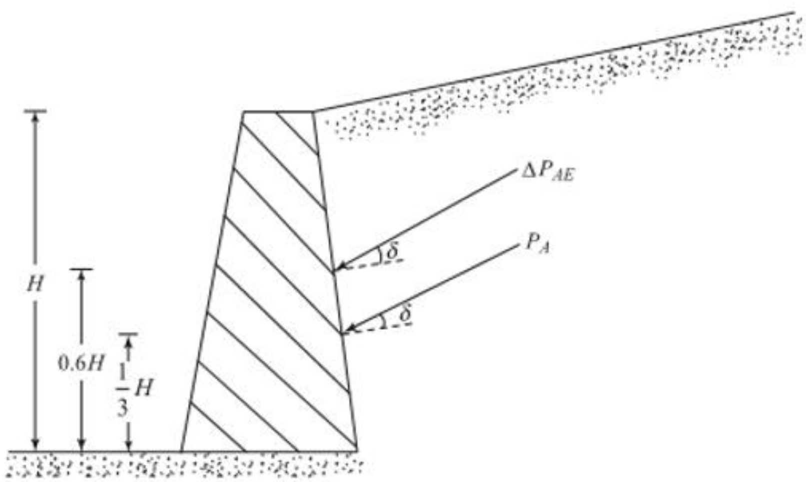

Figure 7. The place of effect for coulomb soil stimulus pressure (at Mononobe Okabe seismic state)

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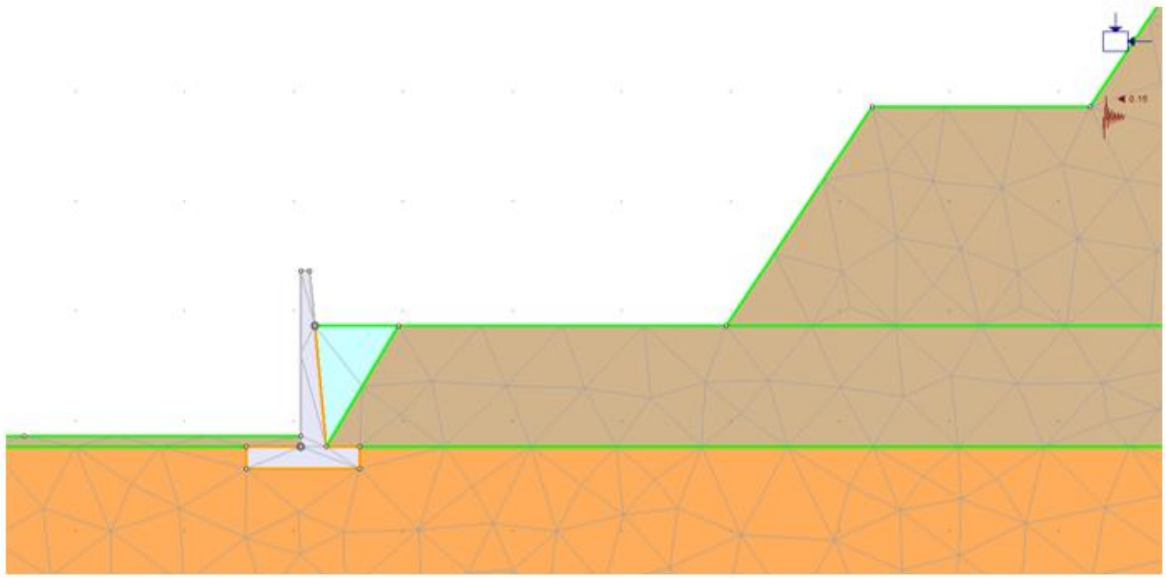

Figure 9. modeling slide trench accompanied with a 8m retaining wall at phase 2 software

Rock shed operational method

Rock shed is a kind of concrete structure with the cross section the same as tunnel which is buried
with soil after completion. Rock shed or concrete artificial tunnel is a constructional engineering structure which is used at mountainous regions in which falls and slides cause the roads to be closed. An artificial tunnel is constructed at the top of the path which is located along falling slope. These structure are used at the same manner to protect railway which are designed as a heavy reinforced concrete on the path which protects surface of the road and the vehicles and train against damages result from stone fallings at a sloped surface in order to remove slippery material from the track and they are usually constructed to reduce the danger of stone falling from the regions that have lime stone joints.

For rock shed calculations all input loads are done through soil overburden. Upper part of the soil overburden is covered after conducting rock shed cross section. Meanwhile, soil specifications and consumed concrete and rebar at the time of designing. Applied load on the rock shed includes lateral and gravity loads patterns including load results from the rock shed weight, load results from soil overburden, load results from soil lateral pressure, load results from earthquake force on the rock shed. There are several methods for modelling and analyzing rock shed's cross section that selecting each of them depends on the desired accuracy of the designing and current understanding from the ground conditions and their interaction of the soil and structure. In the applied method given loads are imposed on the concrete cross section and analyzed. Usually modelling and analyzing concrete covering is done in SAP2000 v.18.1.1 software (Figure 9).

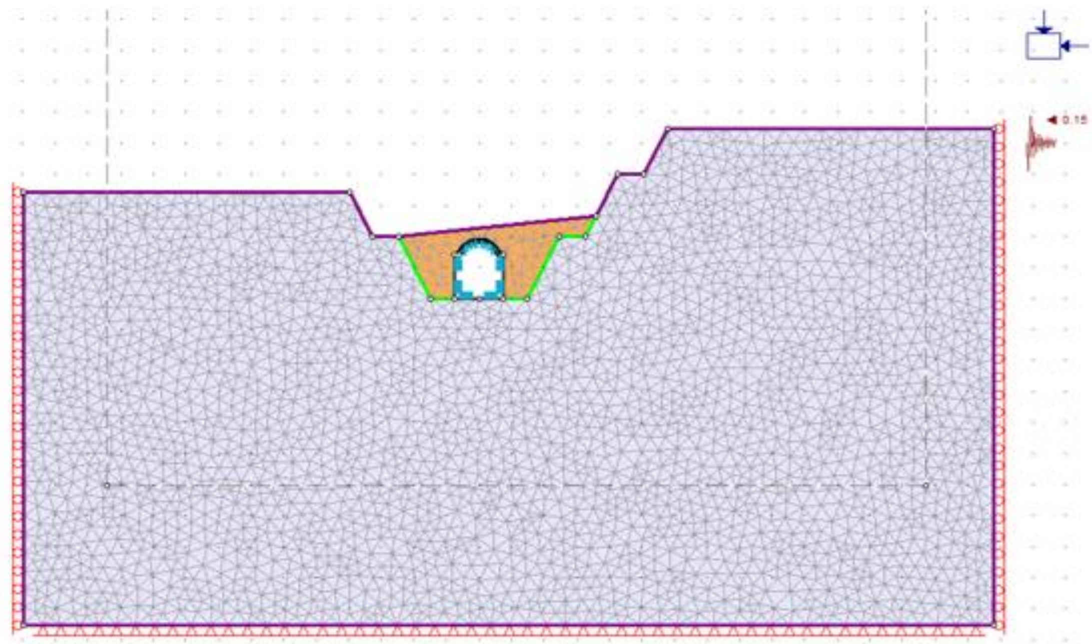

Figure 9. Modelling slide trench accompanied with rock shed using SAP2000 v.18.1.1 software

Results

In engineering analysis of trenches slide lithology factors and the status of the stone layers and categories of mass movements are studied. lithology factors and the status of the stone layers includes the region that the given trench is located on from geology perspective and the thickness of the constituent layers. Meanwhile, degrees of weathering of rocks and karst development due to the existence of marl and clay and traces of being washed by rainfall and surface flows in the lime are studied. Type of constitute layers and their resistance are calculated.

Classifying factor of the mass movements describes the movement of the materials and stones. One of the common replacements and mass movements of the material is the phenomenon of soil and gravel slide or on the other word, landslide. Theoretically two factors cause difference between different kinds of mass movements. These two factors include humidity and speed. Triangular diagram (Figure 10), indicates the process of changing different kinds of slope movements based on these two factors.

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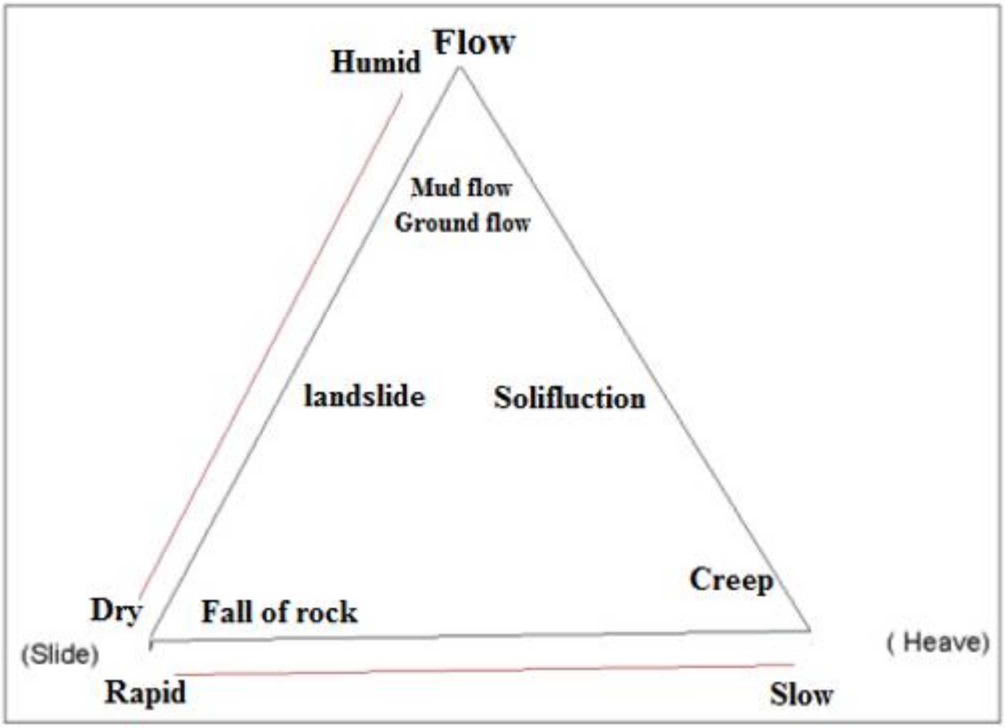

Figure 10. Classification of slope movements based on humidity and speed

As it can be seen, flows result from high humidity and slides results from dryness while heaves are generated at desirable conditions. Heave processes are always slow while both process of flow and slide movement is rapid. In this diagram only general kinds of slope movements are shown but the most complete classification owned by (Salehi et al., 2017). This classification is based on two principles: kind of movement and kind of material.

The main reasons for trenches slide of the railway:

1- The effect of rainfall on the instability of the slopes depends on the climatic conditions of the region, topography, geological structures and the permeability of the constituents of the slopes. Rainfall can be one of the important factors causing ruptures and landslides in the region (Hook, 1997). Penetration of rainwater into the pores of the soil mass and discontinuities of the slope materials reduces cementation and the cohesion coefficient of materials. On the other hand, this has led to an increase in the weight of the slope constituents (loading in the upper slope) and consequently increases shear tension. Surface flows and climatic precipitation have not been able to penetrate areas with hard rocks and all runoff from rainfall and surface flows has penetrated into quaternary deposits and marl and clay interlayer's and saturates them. This state in steep slopes will lead to slide. Given to above mentioned it can be said that the amount of rainfall is considered as one of the most important factors in increasing potential and rapture and slide phenomenon in the slopes having materials with high permeability (marl, clay and silt). Execution operations and construction of railways, excavation and drilling, have provided conditions for morph dynamic imbalance in the slopes and causes that inactive phenomena including slope movements resume their activity proportional to the severity of the imbalance and threaten communication ways. One of the important and primary factors that can be related to the slipping and movement of floors with high volume and width and the destruction of stairs is the periodic presence of marl layer , clay and silt sediments with high permeability and very low adhesion and resistance and relatively poor material and gradation which are formed as thin layers between the layers of some trenches and have a direct effect on the rupture of layers.

2- Slope angle is one of the main factors in the readiness of rupturing slopes and slides and changes in both natural and artificial ways (Hock & Brown, 1980).

3- Among other factors that make primary and secondary cracks is the existence of joint systems and tensile fractures perpendicular to surface of the layers in some under studied trenches which are often formed at the plunge of the layers at the sides of the trenches lead to syncline. These fractures are intensified after excavation operation and generation of trenches and have caused secondary openings. Litho logy has effective role on the scattering landslide and rupturing of the slopes.

Discussion

Application of trenches stabilization methods given to the type of the slide trench

Application of slope revision method:

This method is appropriate in the trenches with surface structures and relatively highly steep slopes, and alignment of slope steep (topography) with layering in addition to relatively heavy rainfall and material of surface formations as well as in weak marl and clay interlayers which leads to the replacements and mass movements of the slope sediments. Given to the height of some of these trenches and high volume of possible slide, retaining structure does not seem very applicable then in order to increase safety factor, with increasing the weight of toe through earth filling which is usually done by creating soil platforms prevent lateral pressures and initial movements at the toe of the trench. In this method determination of correct place of earth filling and appropriate drainage are very important too. In application of this method first trench analysis has been done using phase 2 software and then modelling has been conducted.

In this method fallowing stages are conducted to design and modelling:

- Selection of the appropriate range based on the finite element method
- Creation of a suitable network of the rock mass of the construction site based on cross sections
- Application of rock mass parameters based on the considered rupture criterion
- Application of boundary conditions and determination of in situ stress conditions in the trench under study
- Studding the mass rock behaviour and assessment of Strength Reduction Factor at each stage
- Designing of maintenance system based on resistance reduction parameter by quasi-static analysis method (equivalent dynamics)

Application of retaining structure construction method:

Retaining walls are used for mountain roads with weak foundations or unstable slopes. It is used in trenches where the volume of possible landslides is small and usually the altitude of the trenches is short. In slopes where slides have large faults and huge rocks, applying wall is not very suitable.

Application of rock shed construction:

Rock shed construction method is used in the regions with instable slope and in those that with using slope revision and retaining structures cannot reach to the suitable stability. Rock shed construction is usually built on slopes with high altitude and steep slopes where there is a possibility of heavy landslides. Maybe it can be said that rock shed is the last stage at stabilization of the current trench which is usually accompanied with huge costs and needs spending time.

Conclusion

In this study and in the discussion of understanding instability factors and brief introduction of key factors for slide of railway trenches it can be concluded that factors such as the effect of rainfall in recapturing layers and penetration of rainwater in to the pores, existence of weak and low resistance marl and clay interlayers periodically, alignment of layering slope with topographic slope of the regions, removing natural support due to the construction of trenches and generation of the situation for morphodynamics instability, weak adherence between the marl and clay layers and increase of shear tension, existence of joint system and tensile fractures perpendicular to the surface's layers and their intensification after construction of the trench. lithology and existence of weak under surface layers and instability of the upper layers are the most important reasons. In the discussion of instability of railway trenches and final conclusion based on the type of trench and geology studies three methods of stabilization as slope revision, retraining structure and rock shed as the retaining structure have been provided. For financial estimation of each option should refer to the assessments and opinions of the consulting engineers of each project and contractors based on the projects contracts. However, safety in the construction of railways in mountainous areas with steep slopes and unstable slopes requires study, calculations and engineering methods of implementation.

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