International Journal of Earth, Energy and Environmental Sciences
ISSN: 2517-942X
Vol:8, No:8, 2014

Landfill Design for Reclamation of Şırnak Coal Mine Dumps: Shalefill Stability and Risk Assessment

Yıldırım I. Tosun, Halim Cevizci, Hakan Ceylan

Abstract**—**By GEO5 FEM program with four rockfill slope modeling and stability analysis was performed for S1, S2, S3 and S4 slopes where landslides of the shalefills were limited. Effective angle of internal friction (φ'°) 17°-22.5°, the effective cohesion (c') from 0.5 to 1.8 kPa, saturated unit weight 1.78-2.43 g/cm^3, natural unit weight 1.9-2.35 g/cm^3, dry unit weight 1.97-2.40 g/cm^3, the permeability coefficient of 1x10^{-4} - 6.5x10^{-4} cm/s. In cross-sections of the slope, GEO 5 FEM program possible critical surface tension was examined. Rockfill dump design was made to prevent sliding slopes. Bulk material designated geotechnical properties using also GEO5 programs FEM and stability program via a safety factor determined and calculated according to the values S3 and S4 No. slopes are stable S1 and S2 No. slopes were close to stable state that has been found to be risk. GEO5 programs with limestone rock fill dump through FEM program was found to exhibit stability.

Keywords**—**Slope stability, GEO5, rockfills, rock stability.

I. Introduction

BY erosion, climate, weathering parameters such as earthquakes, the shear stress of natural slope increases and the shear failure of the soil material occur. Growing urbanization brought on the slopes; housing, trade, creation of social space and the realization of infrastructural activities are risky [1], [2]. In determining the danger of slipping and possible future dynamics and stability analysis of the estimated total stress its ability to provide accurate results.

Each year, causing heavy loss of life, property damage they create the millions of pounds in the world as you find landslides in Turkey is one of the most important geotechnical hazards [3], [4]. Developing major landslide in the country in recent years, researchers [5], [6] and by the different methods is explored and geotechnical characteristics and formation processes are determined. For areas with similar geotechnical conditions are two main theories of researchers [7], [8]. One landslide dynamics, as in the past the same geological, geomorphologic, hydrological, climatic conditions are formed. One the other hand, slope failure types and features will be similar. Therefore, the mechanism of history and know the characteristics of landslides in the future, as in neighboring areas or similar areas of geotechnical may develop information constitutes an important basis for assessing landslide.

The influence of the ground water, soil and ground cutting exchange dynamics leads to landslide [3], [4], [9].

Yıldırım I. Tosun.is with Şırnak University, Faculty of Engineering, Mining Eng. Dept.73000, Şırnak, Turkey (phone:+90 544-589-6824; fax: +90 486-216-4844; e-mail: yildirimismailtosun@ gmail.com).

H. C. is with Süleyman Demirel University, Faculty of Engineering, Mining Eng. Dept. 32200, Isparta, Turkey (e-mail: halimcevizci@ sdu.edu.tr) .

H. C. is with Süleyman Demirel University, School of Tehnical Education, Const..32200, Isparta, Turkey (e-mail: hakanceylan@ sdu.edu.tr).

Şırnak province and surrounding areas by making geological maps, surface engineering, geotechnical properties of the units have been identified [10]. Determining the engineering properties of the slopes, the future importance in the construction of municipal development plans and geotechnical field is intended to draw attention to critical.

Mass of the examined parameters affecting slope stability, potential unsafe and risky areas are indicated on the map. Shale piles of coal waste will not threaten the environment and will not embarrass the company built in size is recommended. Static characterization of material properties and seismic design of landfills is a difficult task. Due to the heterogeneity of large bulk material must be made of static and dynamic analysis. In this direction, in the province of Şırnak area south of the city and within 7 km from the center of coal mine waste piles (Fig. 1) is evaluated within the city. Working around 3 km^2 area and a map of the area made 1/1.000 scale engineering, also the drillings and laboratory geotechnical engineering properties of materials are determined by experiments. No residential units appropriate, at the bottom of streams and ponds nature will save condition heap slope design and geotechnical properties by examining the stability analyzes with different methods GEO5 programs FEM program was carried out by [11], [12] . Within this project, urban use, which will open workspace and environment covering 3 km^2 area 1/1.000 scale engineering map of field and laboratory studies prepared as a result also the polar coordinate system using a field study with four slopes of the topographic maps have been created.

II. Şırnak Province Earthquake Geology

Southeastern Anatolia Region contains various tectonic structures and stratigraphy, even as geothermal energy reservoir rocks and cap rock features, besides being created in the region fault system and especially tension cracks along the ground to the depths of the waters. The geothermal energy fluid changes the formation. North-south direction across the region with the effect of compression of the earth's crust has been subjected to a stretching east-west direction, and the resulting tension cracks along the asthenosphere have risen from the olivine basaltic magma [10], [11].

Diyarbakır-Şanlıurfa -Mardin Karacadağ in the rest of Gaziantep Yavuzeli region and the Cizre have the great basaltic magma to the surface in the region into several phases under flowing lava. Batman's north, as well as reaching the earth by magma intrusions in several places gave rise to hot areas.

This situation made by the General Directorate of MTA, is evident in the region's geological maps. Lithostratigraphic units in the study area from older to younger Mardin Volcanic (Upper Miocene), Old Alluvium (Quaternary), New Alluvium (Quaternary) and talus (Quaternary) have been recognized as volcanic, tuffs, agglomerates consists of basaltic and andesitic splits made up a large portion of the study area basalt lavas in the study area showed a cropped up. 1st degree eartquake hazardous risk point in the province of Şırnak is in a residential area, but 2 nd degree risk point located in near zones. Due to the land tension cracks, construction defects and deficiencies in the buildings are seen in the province. In this study, reflecting the effects of the earthquake load was taken as 0.2W as safety design parameter. As an example ruins seen in the neighborhood as experienced earthquakes in this region indicates that there is a large risk.

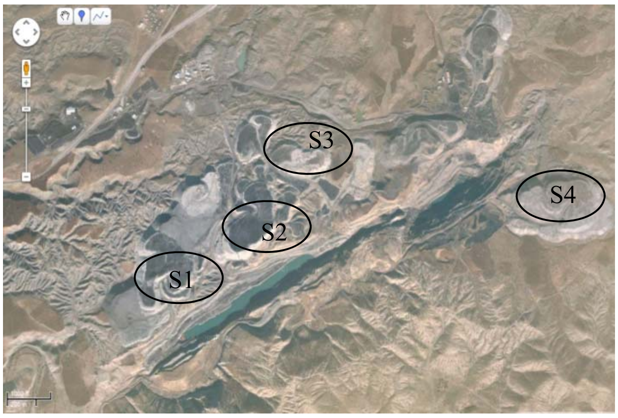


Fig. 1 Satellite Image of Şırnak Coal Mine Dumps 1/5000

III. Soil Geotechnical Properties

A. Field Studies

Şırnak to the south of the city center located on a sloping topography was observed. Field generally formed of claystone and siltstone formations were observed. Germav Şırnak center is known that in the formation. Germav formation, corrosion due weakness quickly eroded; with steep slopes create a topography that is caused to occur locally landslides. Therefore, summarizing the central province of Şırnak, usually because of old landslides sandy, calcareous, clayish, silty resulting from the blending of the units are located on disturbed Germav Formation.

Rubble slope of the creek to the south (Fig. 1) extends to the boundaries of the study area. A Field observation of the Miocene limestones of the talus was determined. Thickness is highly variable. Decrease in the slope of the land where relatively little outcrops.

In January coal waste piles in the study area (Fig. 1) to the south of the observed surface alluvial new menu are gray marl shale. This section is generally covered with alluvial silty soil while some segments are composed of sandy and clayey zones. By the Special Provincial Administration 35 m up in the drilling of new alluvium is determined to continue [12], [13]. Debris slopes in the study area to the south of the creek, is located. Grain size varies from fine clay and coarse sand. Sorting and grading of unseen debris thickness varies between 10 and 35 cm.

B. Geotechnical Properties

Stack outcropping in the area to determine the geotechnical properties of soils in the experiments Turkish Standards (TS 1900) (TSE 8853). , And American Standards (ASTM D3080) is based [14]-[17]. In the area where the drilling of the masses and the presentation of the content is given in Table I. Undisturbed shear tests on samples with the help of the examples belonging to the effective cohesion (c') and effective shear resistance angle (φ°) was found . Cutting box of undisturbed soil samples tested in the TS 1901. Also when carrying out this experiment the bulk density of the material, and the void ratio was determined compression amount. Plastic and liquid limits of the results obtained in experiments for each sample are given in Table I. S1 and S2 No. slope of the masses that occur in the ground is not plastic. S3 and S4 No. evaluate the masses of the same occurred with the ground slope was determined to be less plastic.

TABLE I
The Samples Taken from the Slopes of the Masses on the Results Obtained from the Geotechnical Testing

Sample No	Shalefill	Fine Shalefill	S1	S2	S3	S4
Level(m)	800	850	925	921	933	927
Wopt,%			15.90	13,70	10,80	11,40
c′(kpa)	52	88	0,52	0,59	0,63	0,55
φ′	24,2	22,5	32,50	22,50	21,00	20,00
Lı(%)	11.8 Mpa σ	9.6 Mpa σ	26	15	28	17
Pı(%)	42 RQD	40 RQD	19	11	18	22
Ip (%)	46 RMR	44 RMR	10	9	8	12
γs g/cm^3	2,70	2,70	2,40	2,50	2,40	2,30
Soil	weak	weak	SP	SP	SP	SP
γ_{nat} g/cm^3	1,94	2,14	1,82	1,76	1,90	1,70
γ_{dry} g/cm^3	1,94	2,14	1,65	1,6	1,78	1.60
$\gamma_{sat.}$ g/cm^3	2,0	2,23	2,02	1,84	2,0	1,8

TABLE II
Permeability of the Samples Taken from the Slopes

Specimen no	S11	S21	S31	S41
$\gamma_{s\ max}$ g/cm^3	1,68	1,93	2,05	1,90
w_{opt} %	15,9	19,0	12,3	13,0
Permeability (k) (cm/s)	5,63*10^{-4}	6*10^{-4}	3,0*10^{-4}	5,62*10^{-4}

Soil water content ratio of the clay will be affected significantly. When evaluated according to the percentage of clay in the ground floor of the property shows examples non cohesive or less cohesive.

Which contains the stack of test on samples taken from the one obtained with the bulk density are shown in Table I. For determination of soil types based on grain size, grain size distribution experiments were carried out and the results evaluated in the names and locations of unified soil classification is given in Table I.

Ground in order to determine the permeability constant permeability test instrument is used. Evaluation of the test results to determine the level of soil permeability (Table II). When examined in Table II, S1, S2, S3 and S4 class into The slope is observed that the permeable ground .

Performed on soil samples taken from the stack Proctor test results obtained are given in Table II, γ_s and values W_{opt} . The samples taken from different rock fill slopes, uniaxial and triaxial compressive strength tests were performed. Also a huge waste of shale and limestone rock fill embankment heel parameters are given in Table III below.

TABLE III
PHYSICAL AND MECHANICAL PROPERTIES OF ROCKFILL

Specification of rock fill	Shale fill	Marn fill
Natural unit weight, γ_n (kN/m^3)	16	18
Saturated unit weight, γ_d (kN/m^3)	16	18
Cohesion, c (kN/m^2)	52	88
Intern. Friction Angle, ϕ (°)	30	34

FEM program to assess the risk of slipping GEO5 programs reviewed in this study is advantageous. FEM GEO5 programs Fellenius in the program, either by the Bishop and Janbu calculation are given. Fellenius method in this method the sliding surface is circular. Floating mass at equal intervals as much as possible is cut into slices [18], [19].

Bishop method, as in all the stability problems is the basis of a start offset and slope limit equilibrium is removed as if assuming equilibrium equations. Bishop, with the total stress and effective stress stability analysis operate. This method of Taylor and brought Fellenius of the methods are older [20], [21]. Method Janbu; this method, whether or not circular can be used for any type of sliding surface [22], [23]. Slope stability analysis in the homogeneous excavation and filling that occurring in the landslide, with non-circular more general types of shifts stability analysis for the inter-slice forces, which takes into consideration is a method. Any slope in the floor, too weak rock mass or rust material properties of the slope along very often varies in if circular slip analysis methods applicability is eliminated [24], [25]. This kind of shift conditions, circular or non- circular slope near the top starting deep in areas along the planar surface is developing ongoing. GEO5 programs possible earthquakes and rock stability groundwater data section in the program in Fig. 2, depending on the rock surface or planar wedge type drift is not formed in particular from 30 to 40 m length was determined.

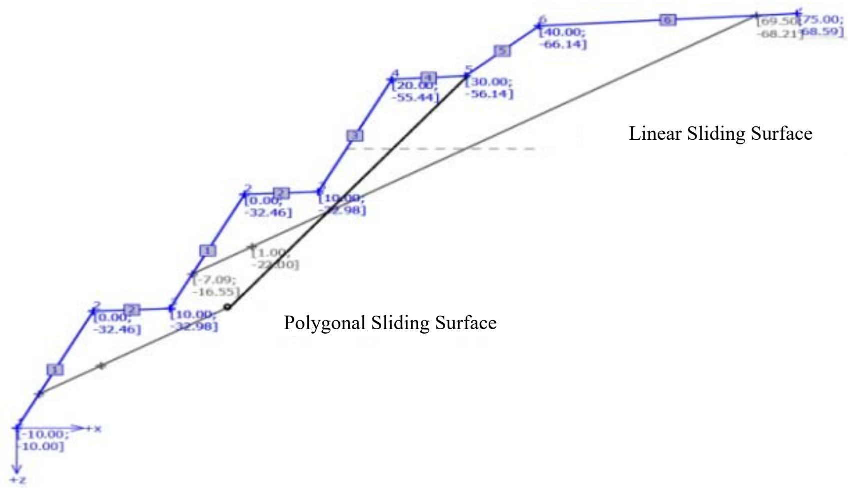


Fig. 2 S1 Cross-section of Rock slope of the Study Area; Rock sliding surfaces, GEO5 program

GEO 5 programs entering the ground surface soil parameters were examined and were found to be circular shifts.

Belonging to the limit equilibrium factor of safety of slopes drawn in accordance with different sliding surfaces for the Bishop, with the circular shift method Janbu and Fellenius, FEM program is used diagrams in GEO5 program. Safety factor in limiting the TS 8853 is based. Safety factor of GEO5 FEM was 1.5. c' and φ ' according to the rock fill parameters have been found effective and maximum resistance. When seen in the field of tension cracks are known to occur in movement. In this case, the intrinsic parameters of the sliding surface will appear smaller than those found in laboratories in other words [26], [27]. It is clear that closer to lasting value. In this respect the limits of the confidence coefficient value was 1.5.

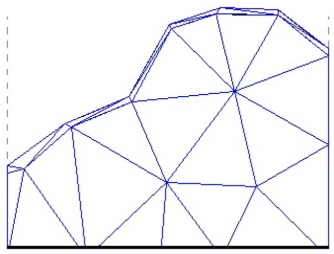
IV. RESULTS AND DISCUSSION

A. Slope Analysis of S2 and S3 Shale Landfills

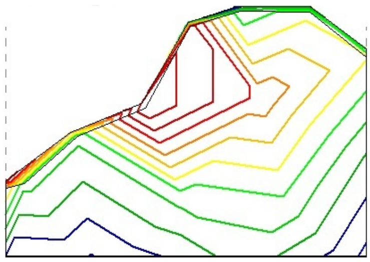
The stack S2 hillside after rains made the small size of the movements that have been identified in field studies. No. S2 to develop pile slope is covered with talus and 10 m mesh FEM GEO5 programs were created with the program (Fig. 3 (a)). S2 The top of the stack and the maximum height difference between the heel point 45 m, the slope of the maximum height of 50 m, the slope of the surface tilt angle is 40 °.

Drilling carried out by the Special Provincial Administration; according to information obtained from the panhandle talus thickness varies from 11 to 20 m. The fill S2 in were the investigation of the slope where the ground water level 35 m was observed at the base S2. The advent of landslides in the slope stability calculations made in c '= 1.9 kpa, φ ' = 22°, $\gamma_{nat.}$ = 1.97 - 2.27 g/cm^3, and are used to γ_{dry}. According to γ_{dry} and γ_{nat} calculated separately on the potential slip surface deformation contour values seen in Fig. 3 (b).

S3 after precipitation in the observations on the slope of a small rupture, leakage occurred was observed. Similarly the slope S3 indicates instability and displacement reached 30mm (Fig. 4).



(a)



(b)

Fig. 3 (a) S2 section of the study area slopes 10 m mesh topology, (b) Deformation FEM stability analysis GEO5 programs, cut red 30mm unstable displacement

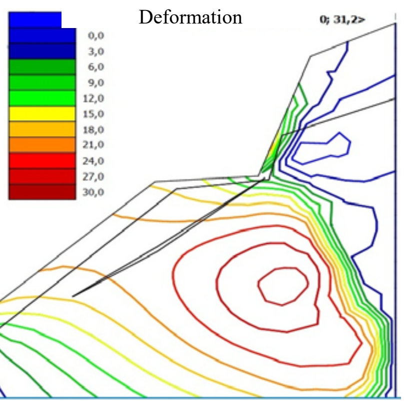


Fig. 4 S3 heel unfilled limestone slopes of the study area section, sensitivity analysis FEM GEO5 programs. Deformation, Red unstable cutting surface

By designing Slope S2 various rubble mound is formed like 2m mesh (Fig. 5) by the GEO 5 FEM program. FEM GEO5 programs groundwater data section in the program depending on the level of the groundwater surface effect and poor stability analysis was conducted by placing in cross section. This 10- m-wide geostationary shale stone fill, depending on the pressure and stress in the critical shear surface prevents slipping. S3 limestone filler 3mlik By designing the slope 3m is formed like mesh (Fig. 6). In addition, thin shale and clayey soils were stabilized with fly ash. This limestone filler geostationary 3 m wide, depending on the pressure and the critical shear stress in the surface region is completely prevents slippage. In addition, 1m wide and 10 m high concrete - rock fill out a safety factor values were above 3 (Fig. 7).

Weak adverse effect with the sliding surface as shown in Fig. 8 (a) and a weak surface tension in the design frequency 2 m mesh weave texture is formed. In this design, even with the heel stone fill that provided stability, security coefficient values exceeded the value of 3.

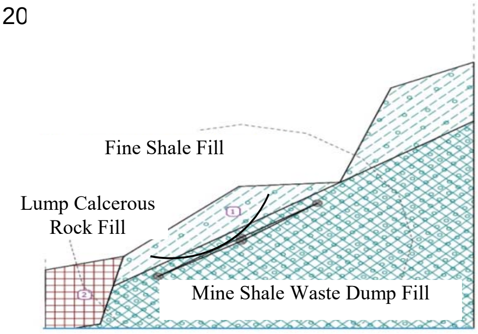


Fig. 5 S2 unstable alluvial slopes in the area of the cross section with heel padding stabilization, stability analysis FEM GEO5 programs

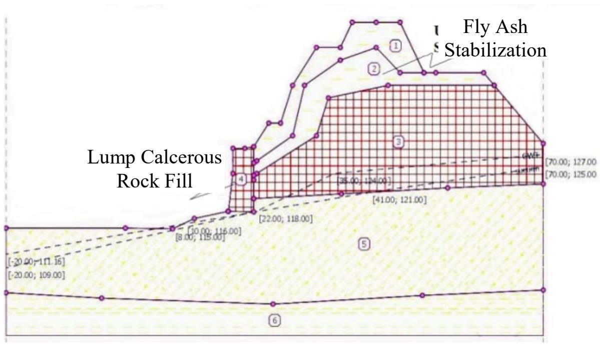


Fig. 6 S2 unstable alluvial slopes in the area of the cross section with heel padding stabilization, stability analysis FEM GEO5 programs

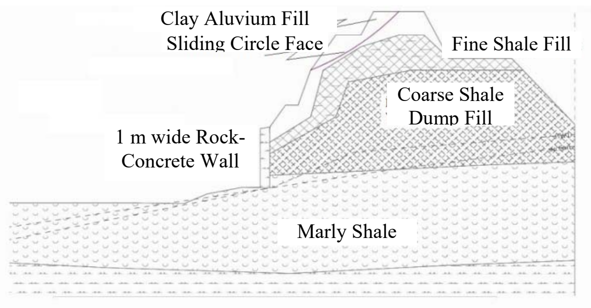
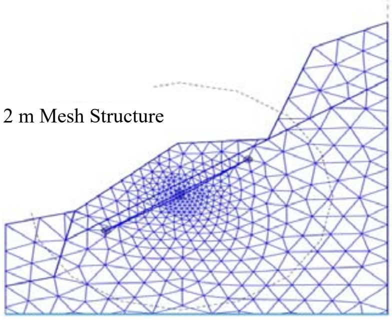


Fig. 7 S2 unstable alluvial slopes in the area of the cross section with heel padding stabilization, stability analysis FEM GEO5 programs

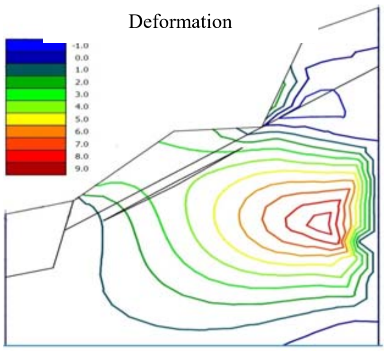
When using a filler to form the slope S3 instabilities deformation displacement are shown in Fig. 8 (b) and displacement m below the maximum possible shift of the substrate 20 has reached 9 mm (Fig. 8 (b)).

S3 slope instabilities will form filler when used in kPa shear stress is shown in Fig. 9 , and ranged from 10 to 16 kPa and 16 kPa reached a possible shift in the base .

GEO5 programs FEM program, the excellent stability of the filler in the cross section shown in Fig. 10 the epsilon (x/z) is calculated as a % of substitution. The critical slip displacement occurs at the base of the possible maximum of 0.77% as seen in Fig. 10. Accordingly, around the sides of the small size of the stack is seen that the risk of slipping.



(a)



(b)

Fig. 8 (a) S3 heel -filled limestone slopes of the study area 2 m mesh topology section (b) geo5 FEM sensitivity analysis, Deformation, Red unstable cutting surface

V. Conclusion

Şırnak located in urban areas close to the border regions of Coal Waste piles. Dumps were separated four units of the slope and slope stability geotechnical properties of soil samples taken from field studies and laboratory experiments have looked at. Risk maps of slope stability and GEO5 FEM programs and stability programs and Rock Slope Stability analysis with high accuracy can be quickly and successfully. Soil- rock contact or mass due to a structural feature such as, in the presence of low levels of planar shear strength is developing planar slip surface in case. This experiment on the ground with the optimum water content and maximum dry unit weight determined and should be used in the calculation of the stability of slopes.

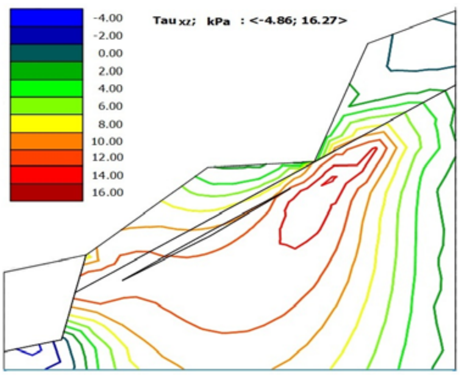


Fig. 9 S3 heel -filled limestone slopes of the study area (1 m mesh) cross-section, sensitivity analysis FEM GEO5 programs. Shear stress, shear Red unstable surface

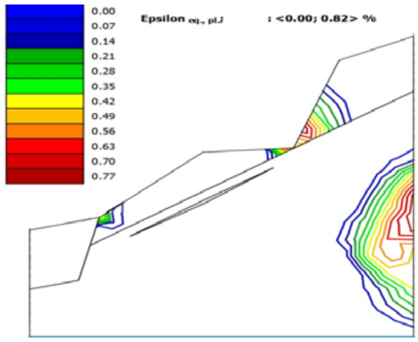


Fig. 10 S3 heel -filled limestone slopes of the study area (1 m mesh) cross-section, sensitivity analysis FEM GEO5 programs. Epsilon %, Red unstable cutting surface

This study just evaluated the various design forms for reclamation on the proposed ground slopes with the optimum water content and maximum dry unit weight determined. A natural slope does not affect the stability with the compression parameters. Because of these parameters of the soil compacted in the desired manner, compression parameters may be used directly in an artificial slope. If there is a danger of landslides on natural slopes, compression will not cancel stability analysis using these parameters and should be compared. The precautions should be taken against the hazard of slipping into the compacted fill and rock fill slope or the slope gradual slope inclination should be done. Also an amount of the natural ground is excavated and compressed according to the compression parameters again. In this case the stability analysis of the parameters used in the compressed ground.

The laboratory tests performed on samples of rocks as a result of the fine and coarse shale fill slopes, respectively, for the value of the cohesion of the 120-180 kN/m^2, the angle of internal friction 30.5-34.4^o were changed between. In the unified soil classification of soils is determined to be plastic. Stability analysis performed in the light of this information , the S4 The slope is stable , S1, S2, and S3nol the slopes are not stable and will be stable with stone fill was concluded .

Şırnak city and surroundings, according to Turkey Earthquake Zone Map is located within the danger zone in the first degree. South East Anatolian Fault Zone in this area was the domain of frequent earthquakes occurred in the region and due to this earthquake consists of some tectonic movements. 0.2 lateral loads in the GEO5 programs passed as this effect and stability is provided in rock fill. However, the application of anchoring the slopes could be made in residential building areas under that of distinct the danger.

Weathering of rocks largely unchanged, the bond between grains leads to weakness and not completely. In the study area weakened by weathering rocks are easily eroded and slope angle of inclination of the slope is changing with height. Dissociation observed in rocks in the study area has a negative impact on the stability problem.

Acknowledgment

The authors would like to thank the Mining Engineering Department Süleyman Demirel University for helps through this work.

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