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Rock Sliding Risk of Şırnak Asphaltite Coal Quarry - Study on Cemented Cracks of Shale, Marly Claystone for Upper Slope's Stability by Sawing Disc Tests

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Anahtar Kelimeler

Şırnak Asphaltite Coal Quarry,
Cracks of Shale,
Upper Slope's Stability,
Sawing Disc Tests

Abstract: There is a relationship among the type of crack formations and shear properties of different rocks depending on the dynamic loads in the shale formations of the Şırnak Asphaltite Coal Quarries No 1,2 and 3 and other critical asphaltite coal pits. The crack density and formation on the Stereonet records of Şırnak asphaltite quarries and sawing test results of the face stones are becoming so critical for safety of slope stability. The possibility of safety factors of rock sliding and critical rock falling in the quarry No. 1 was investigated locally by comparing the crack factors caused by crack propagations over determining the impact loads on the site blocks shale, marly shale slope faces in advance. The safety factor calculations showed possible rock fallings with the aim of determining the impacts or pressure loads before excavation without overloading the composed highly cracked shale and shattered shale and marly shale stone formations on the upper slopes.

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1.Introduction

Open pit mining excavation of asphaltite has become a general method for asphaltite coal production in the region (1-5). Utility of a hauling system of the lorries at 25 tons capacity and excavators of 2 yd3 bucket capacity were mechanized in the about 20 mining asphaltite quarries. The asphaltite production capacities did not much increased in different hard conditions getting deeper excavated pits in the area. About total of 500,000 tons per annum asphaltite excavation has caused an overburden load capability of 1,5 millions tons limestone and claystone dumping every year by Asphaltite open pit mining excavation with about 20 separate pits waste output continued to increase rapidly in Şırnak Province. The deeper open quarries need safety demands due to vertical inclined asphaltite coal seams required trimming bottom level at 3-20 m seam wide orientation during asphaltite excavation. This is a hard competent in excavating in the asphaltite quarries avoiding the management of the various safety precautions taken in asphaltite mining. Haulage road was one of them to take a low sensitive safety precautions required for high capacity of asphaltite production to provide high efficiency hauling. Secondly the management the dumping sequences in safety way and to control the mechanism of dumping ability.(6,7) The most important other safety precaution is the, modeling slopes for controlling the intensive stability of excavation area and slopes of the haulage road at each bends and inclinations taken rapidly foreseeing to mining development and the other safety measurements and observations needed (8-10).

The values of cracking risk and slope stability risks in explosions and excavation showing high degree rock falling risk (11-15). The studies considered to take precautions for steep slopes avoid those as below:

• steep slope structures over 60°;

• earthquake resistant hollow-type structures;

• high slope type pits, excavating without basement control in real sense; and

• slope models designed without paying attention to hydrologic conditions and ground conditions did not escape attention (16-20).

The rock toppling or fall parameters were investigated with relationships between critical upper slopes rock layers of the coal quarries in Şırnak. The porous limestones of Mardin, Urfa Birecik and Batman Hasankeyf and porous basalt stones of Anatolia are used for decorative purposes. The cutting speed of the sawing disc, the cutting shear speed, the wear and shatter strength test results were determined as an awareness of crack propagation in the coal quarries in Şırnak. For this purpose, uniaxial Compressive Strength, Point Load Strength, Impact Strength, Sawing Disc Shear, Indentation Tests and Los Angeles, Micum drum tests were performed and correlated with rock parameters of RQD and RMR.

The rock blocks were studied for high shear sawing tests. High shear occurring formations need the reinforcement for the upper slopes signed. The resulted strength patterns of the wet substrate rocks in Şırnak Asphaltite Quarry, the critical limits for crack propagation and creep strengths for slopes and cracked rock formation were determined and discussed.

Figure 1: North face of Avgamasya No. 1 pit Şırnak asphaltite coal mine site similar to study area.

1.1. Stereonet Study and Crack Properties

Ground movements that may occur on a regional and/or 5–10 m basis have been observed in many irregular shale facing, high crack risk areas as seen in Figure 2.

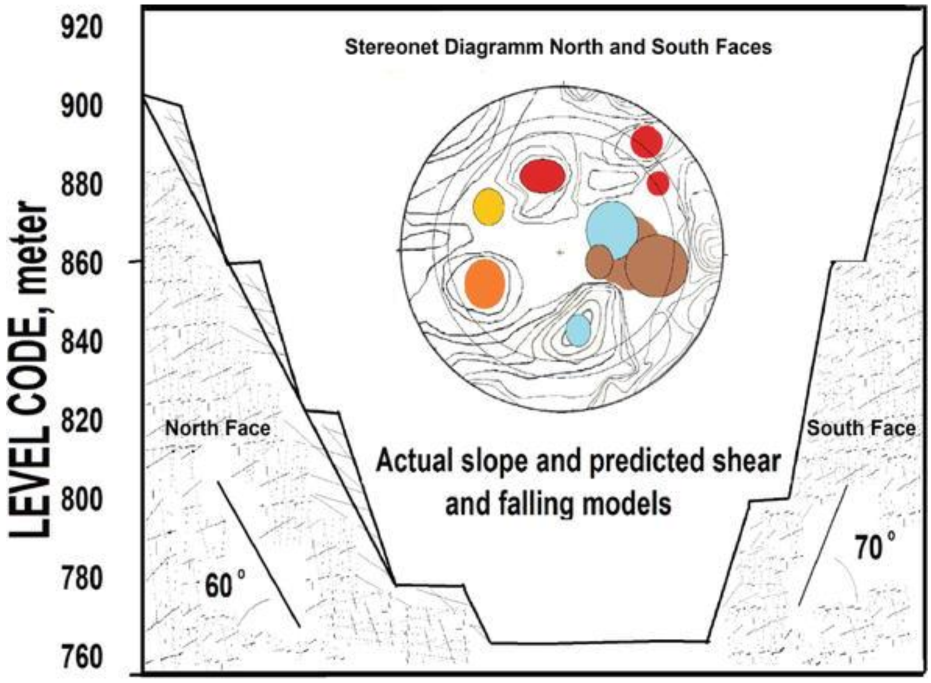

Figure 2: North and south steep slope faces of Avgamasya No. 1 pit of Şırnak asphaltite coal mine site and survey area.

2. Method and Materıals

In the potential slopes carrying landslide risk and rock qualities were determined regarding ASTM standards, and modified sawing disc tests of the rocks of the region taken from the study area were tested over the undisturbed formations. The lump rock samples were taken from the ground parts of the investigating quarry upper slope faces. In sawing experiments 18 mm diameter an 1,5 m thick sawing disc and manual power sawing were performed over 100 mm diameter rock pieces in order to determine sawing area as mm2/s at sawing about a minute sawing duration. The patterns are determines as shown in the extrapolated upper functional regressed lines shown in Figure 3 and 4. The slope unit having clay stones sowed much cracks and lower stability manner regarding this figure patterns and safety consistency limits were obtained.

The cracking manner of rock formations in the quarry was determined by stereonet investigations taken from the pictures by drone observations and processing the pictures and cracks and counting the cracks at upper and other slope areas in the Avgamasya asphaltite coal quarry no1 and 2. The critical cracks for sliding are seen as the cracks having dips 55-65^o as seen from Figure 3 and 4.

3. Results and Discussion

In this study, the open pit slope surfaces on the newly opened critical southern side of Avgamasya No1 quarry were examined with drone photographs, and fracture densities and pole points were determined as shown in Figures 3 and 4. One of the biggest advantages of this Stereonet survey is the rapid determination of the main possible slip planes over the traditional stereonet and the ability to scan the very large data that can be obtained by compass measurements with terrestrial methods.

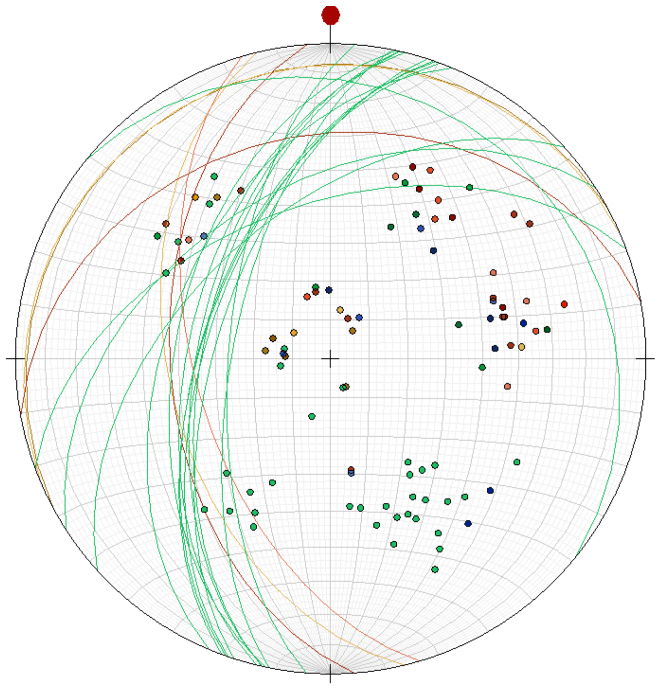

Figure 3: Stereonet for South side Upper Slopes in Asphaltite Coal Quarry

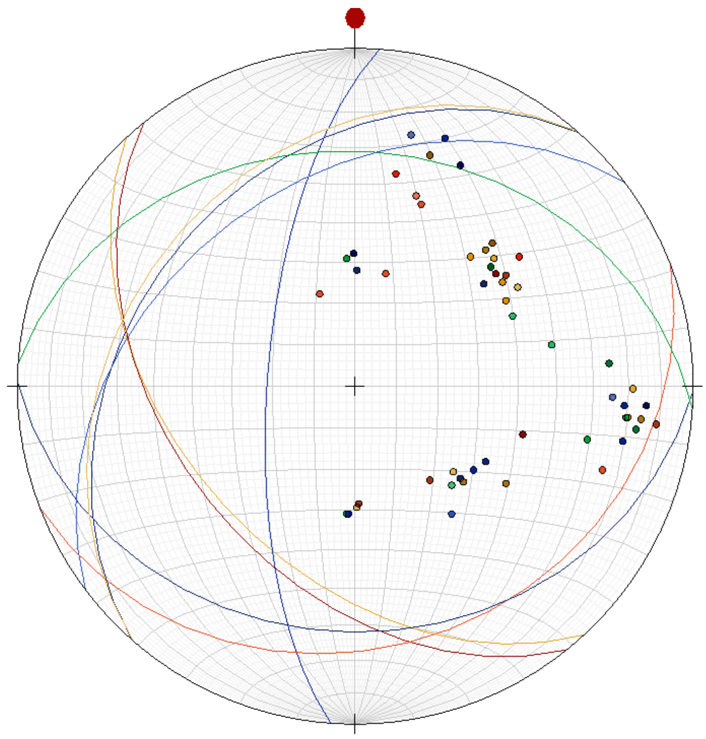

Figure 4: Stereonet for South side Lower Slopes in Asphaltite Coal Quarry.

Larger areas in the stereonet are quickly processed as fracture records. Then, critical slope, bottom mode and pole mode can be switched. As seen in Figure 3, the upper slopes in the south direction represent mirrors with more fractures and shear planes. Various pole points have been shown to be critical for wedge-type or planar rock slides with an angular inclination of 60 and 50 degrees. The ratio showing the frequency of broken points provides three specific regions on the stereonet and the average density of 24 and 38% of values of a set of planes. Moreover, with the average set, the slip plane of the fractures with graphical average density values above 20% is expected to fracture from the slip planes with 30% density. In this way, it is understood whether there is a problem with the risk of falling rocks. These estimated slip probabilities were easily determined in stereo net. Meanwhile, critical large fracture clusters could be easily identified through analytical analysis. The water content on the ground will be significantly affected by the claystone and mudstone contents. As looked to the percentage of claystone in the slope face, the face rock samples showed a non-cohesion or low cohesion feature. The regional rock types and rock quality change are experimented for shear ability. It has been carried out over the rock specimens, classified as given in Table 1.

In order to determine the safety factor of the compressed upper slope ground, a fixed level sawing test instrument was used. The degree of the sawing rate ability of the slope face rock was determined by evaluating the sawing rate results of the shear experimentation (Table 2and 3). Regarding sawing ability of the quarry rock samples, it is seen that the slopes S1, S2, and S3 fall under the high sawing ability of slopes rock faces on upper class.

3.1. Sawing Disc Tests for Rocks in Asphaltite Coal Quarry

Manually operated sawing discs of stone diamond at 13cm diameter was used by BOSCH marked spiral cutter machine over 20 different samples representative rock blocks taken on the site of Avgamasya asphaltite coal quarry No 1 and neighborhood rock formations in Şırnak Province. The Los Angeles and RQD tests were also correlated by point load Is and unaxial compressive strength tests carried out in the laboratory.

The sawing tests results were taken as sawed area in the rock blocks taken from quarry and slopes with shattered rocks blocks which had lower critical values during rock failure or sliding. The sawing test results measured as sawed area as mm^2 per second were shown in Figure 5 and 6. The shale samples and asphaltite coal samples shattered form were resulted lower compressive strength values of 5-6 MPa and 4-5 MPa. The point load tests were much suitable for determining failure during slope stability and the values were dropped to 455 kPa for shale and 345 kPa for coal samples.

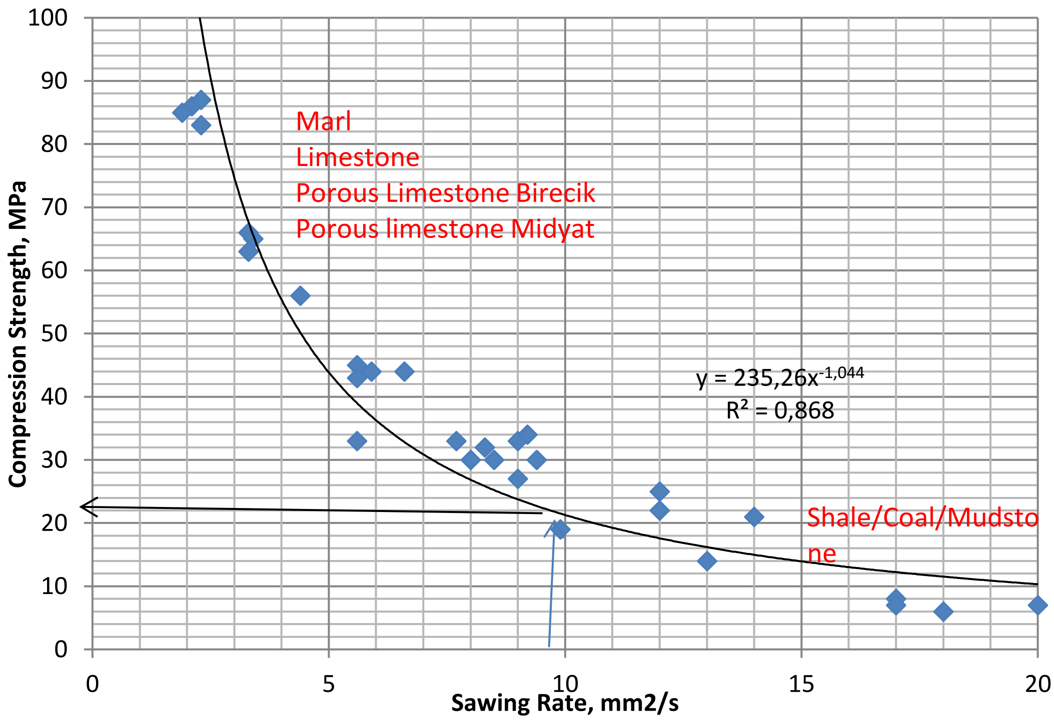

Figure 5: Sawing rate pattern for determining rock strength on slope rock face

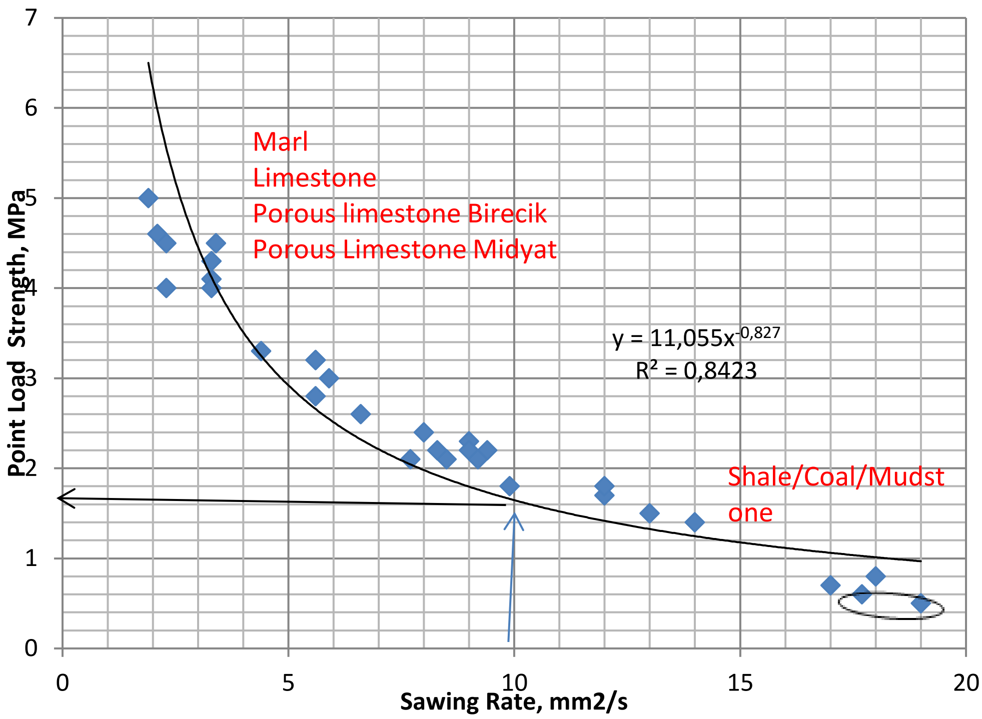

Figure 6: Sawing rate pattern for Point load correlated determining crack propagation on slope rock face

3.2. Rock Sliding and Cracking

RMR and RQD and other mechanical charactheristics were determined by standard tests and the results were given in Table 1 and 2.

Table 1: North and south steep slope faces of Avgamasya No. 1 pit of Şırnak asphaltite coal mine site and survey area rock quality values

Rock Type	RMR	RQD	U_{Cs} Compression Strength,MPa	I_{50}, Point Load Strength,MPa
Browny Marl	43	40	87	3,5
Gray Limestone	36	38	67	3,3
Limestone	33	31	65	3,2
Porous Limestone Birecik	20	22	26	1,6
Porous Limestone Midyat	20	22	26	1,8
Marly Şırnak Claystone	14	17	9,8	0,9
Şırnak Claystone	13	15	8,9	0,8
Şırnak Shale	11	12	5,5	0,5

Table 2: North and south steep slope faces of Avgamasya No. 1 pit of Şırnak asphaltite coal mine site and survey area rock quality values

Rock Type	Density, gr/cm3	Shatter Value, % -10mm	LosAngeles, +35mm	Micum Drum,-10mm	Bit Indentation ,mm/s	Sawing Rate, mm²/s
Browny Marl	2.68	5,6	85,3	3,4	2	2
Gray Limestone	2.67	5,5	82,3	5,1	3,5	2,1
Limestone	2.62	7,5	72,3	8,1	3,7	3,2
Porous Limestone Birecik	2.41	13,5	51,3	21,6	5,2	5,2

Porous Limestone Midyat	2.38	15,5	42,3	22,6	5,6	5,8
Marly Şırnak Claystone	2.55	22,4	38,3	27,5	8,9	19,3
Şırnak Claystone	2,44	28,4	33,5	38,5	9,7	21
Şırnak Asphaltite	1,72	26,4	34,6	37,5	9,8	23

3.3. Stability Analysis

The slope model construction plan is shown in Figure 5. The anchorage improved stability safety factors for steep sliding slopes in 20 m height excessive to 30 m. Wire mesh hanged top of slopes were avoiding rock falling of highly cracked shale block stones at 3–5 m size. The pile anchorage was designed and practiced for hauling road slopes control and stability at the constructed near deep of slopes bottom line as shown in Figure 6.

North and south steep slope faces of Avgamasya No. 1 pit of Şırnak asphaltite coal mine site and survey area with anchorage pile pattern.

The uniaxial compressive test point load tests, RQD values, and Mohr-Coulomb criteria diagrammed were determined regarding ASTM standards; effective cohesion (c‘) and effective shear resistance friction angle (ϕ°)’ of the rock samples were given in Table 3 on the sample rock lumps regarding ASTM standards, taken rock samples of about 100 mm diameter and cubic forms with the compression loads of ELE press equipment.

Table 3: Safety values for Rock falling on North and south upper slope faces of Avgamasya No. 1 pit of Şırnak asphaltite coal mine site and survey area rock quality values

Rock formations	Thickness (m)	RQD (%)	c′ (kPa)	ϕ′	Pı (MPa)	Iı (MPa; 50 mm)	Shear strength (mm2/s)	γsat n (g/cm^3)	γdry (g/cm^3)
South1	15	25.9	370	19	12.0	0.4	22	2.62	2.58
South 2	24	32.9	330	18	15.0	0.8	13	2.62	2.57
South 3	15	30.8	230	22	26.0	1.2	14	2.7	2.62
North1	27	25.9	270	22	38.0	1.0	25	2.62	2.61
North 2	25	25.4	470	27	35.0	1.3	12	2.7	2.68
North 3	26	33.9	410	24	36.0	1.2	12	2.7	2.68

The water content on the ground will be significantly affected by the claystone and mudstone contents. As looked to the percentage of claystone in the slope face, the face rock samples showed a non-cohesion or low cohesion feature.

The regional rock types and rock quality change are experimented for shear ability. It has been carried out over the rock specimens, classified as given in Table 1.

In order to determine the safety factor of the compressed upper slope ground, a fixed level sawing test instrument was used. The degree of the sawing rate ability of the slope face rock was determined by evaluating the sawing rate results of the shear experimentation (Table 2and 3). Regarding sawing ability of the quarry rock samples, it is seen that the slopes S1, S2, and S3 fall under the high sawing ability of rock faces on upper slope and mid levels.

Rock face data regarding rock parameters are given in Table 2. With this experiment, optimum water content on the ground and maximum dry unit volume weight are determined and used for stability calculations of the slopes. Compaction parameters do not affect the stability of a natural slope, because these parameters are the parameters of the ground compacted in the desired way. In artificial slopes, compression parameters are used directly. If there is a rock fall danger in a natural slope, in case of compression, the stabilization analyses are compared using these parameters. In the precautions to be taken against landslide danger, compacted filling can be made in front of the slope or bench slope can be made in the slope. At the same time, the natural ground is dug up and compacted according to the recompression parameters. In this case, parameters of the compacted soil can be used in stability analysis.

In order to determine the slip resistance parameters of samples taken from different points of four separate slopes, a cutting box experiment was carried out. After the experiments, c′ and ϕ′ values were found. The stability analyses were carried out by the model constructed and practiced in the field as shown in Figures 7 and 8 and the safety factors are given in Table 4.

The toppling failure and sliding failure were compared between each other in the stability analysis for upper slopes and mid slopes of Şırnak Avgamasya asphaltite coal quarry. The critical failures showed as toppling 2 m 3 m blocks regarding stereonet investigations. The rock sliding analysis showed that the unsafe values for upper slopes and even made the rational higher values. The safety undertaken during mining excavations and rock blast vibrations was greatly developing on upper slopes excavations. Further water bursting threat may become critical for dangerous rock sliding or toppling failures during excavations on the south hill side of the quarry.

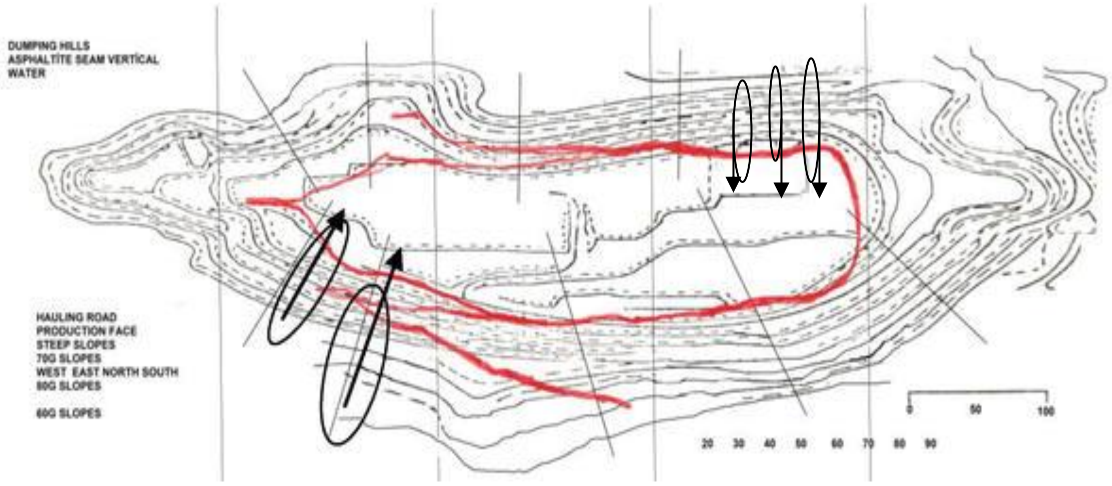

Figure 7: Sliding shale areas contour topography of Şırnak Avgamasya open pit No.1 mining area and survey area 1/5000.

The observed crack propagation for a month was reduced in summer time period. However, the number of cracks was reaching over 50 as compressed cracks parallel to each other at 3 cm distance. A detailed research is carried over rock falling possibility risks data required for those compressed cracks numbering and rock quality as seen Figure 7.

The manual weight chart method was so efficient and useful in slide pattern analysis in the area as shown in Figure 8. The sliding surface is circular half cylindrical. The sliding mass is divided into slices as equally as possible. (Table 4).

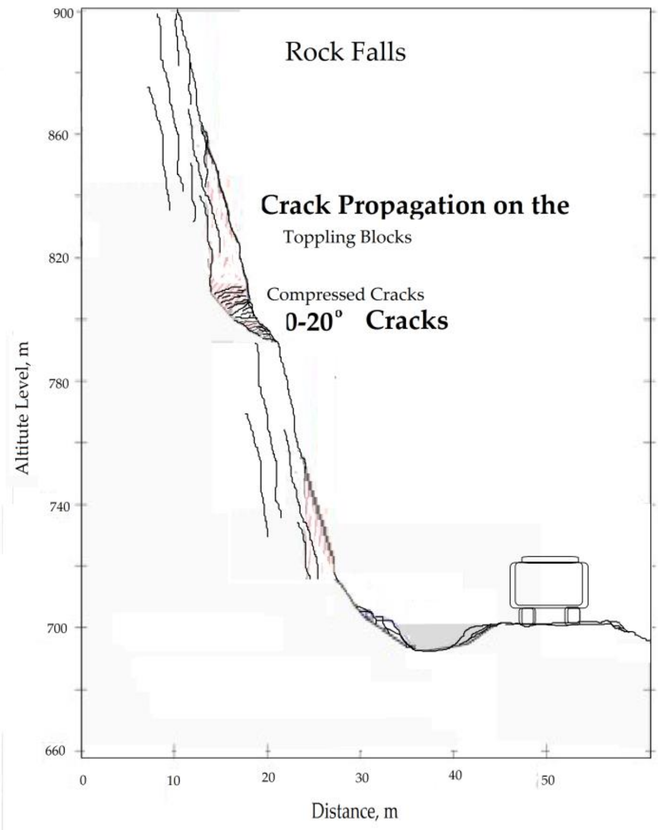

Figure 8: Toppling failure as rock falls over shale slope areas cross section of Şırnak Avgamasya Quarry No.1 south area and survey area 1/5000.

Table 4. Safety Parameters for Toppling Failure/Rock Falls on Upper South Slopes1,2,3 at 10 m rock water level.

Rock formations	Moment Height (m)	Toppling F (tons)	c′ (kPa)	ϕ′	No Jı/m (+10: 5)	NoJı/m (+3:5)	Resistive Force (tons)	Safety Factor
South1	15	45.9	50	19	12	42	42	0.92
South 2	24	52.9	30	18	15	48	53	0.62
South 3	15	50.8	60	22	16	52	44	0.81

Toppling failure can be commenced by water effect over the horizontal cracks filling, so rock falling impended over the lowering the weight of the vertical independent wedge for fall down at the cracks over the cracks inclined 20 below. The water level is decreasing half of the wedge part due to water discharge during the falling. The main falling parameter is just toppling moment arm length decisive over the safety factor for rock fall. Even rock sliding at upper 2-3 m blocks may create high sliding threat for shattered shale and marly shale formations.

4. Conclusions

The crack propagation and the number of cracks are observed by month time and a year crack development tables and graphs pattern were studied recently. The data showed that point load strength and sawing disc tests were so beneficial for evaluating the crack propagation in the new excavated pit quarries of Avgamasya asphaltite seam near No1 Avgamasya Quarry. During excavation period, the risky upper slopes as shown in Figure 8 were observed by topographic measurements, which is carried out every week period was effective to criticize the risky area in the quarries over showing 10 mm inclination.

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