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Foam concrete landfill use in landslide hazardous area in West Şırnak Road

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Abstract. There are steeper slopes, sliding large land masses or rocks in Şırnak City and the surrounding areas. Underground water and harsh climatic conditions contain high risk hazard areas in urban living site with higher population density. In order to eliminate landslides and related events, significant precautions should be taken. The mapping of landslide risk may ease to take precautions. Even the application of landfill rock may reduce water content of soil. In this research, fly ash and Mine Waste shale stone were used with low density foam concrete. Waste mixture at certain proportions decreased cement use. Shale stone as fine aggregate instead of fly ash in specific proportions improved mechanical strength and porosity. Hence landslide hazardous area could be safer for urban living.

Keywords. Foam concrete, lightweight concrete, foam mortar, fly ash, clay stone

Introduction

Slope stability and landslide problem dealing with the ground have been closely worked for many years by geotechnical engineers. For this reason, the deep disorder of land masses and slope instability are known as natural disasters such as flood, hurricanes, similar to leading to serious loss of life and property [1-10]. The civil engineers are much interested in the foundation issues regarding the earth soil, surface created by the nature, the slope geometry and design of the structures built on land [11-13]. The technological development parallel to the housing needs the high embankment, dams, large and deep excavations along with stability problems. Each year, few flood and landslide damages may cause to heavy loss of life. They also cause to loss of the millions of pounds in the world. The landslide in Turkey is one of the most important geotechnical hazards [11-13].

In this study, Şırnak city and the surrounding area were studied by geological mapping at 1/1000 scale and the soil units. The properties of every unit soil were determined. Landslide hazardous area provisionally was concerned in the first region's landslide area. The soil properties worked promotes the construction distributions in the future in Şırnak City, promoting winter tourism, one of the popular south eastern Anatolian lands. The importance of civil constructions under the threat of landslide intended to draw attention to the urbanization of the area.In order to minimize the landslide hazard, geological and geotechnical analysis of the land slopes were needed to be studied.

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In this study, in the area of south Şırnak City (Figure 1) 2 km circled from the center of the slopes S2 was investigated as much critical hazardous area due to some mass sliding occurred in the district. Geotechnical properties soils of four different locations were determined for examining the stability analysis. This project was carried out for urban use, which will open workspace and environment covering the engineering geological mapping of the field of 4 km^2 area at 1/10.000 scale. The laboratory studies followed by the polar coordinate system using a field study with the topographic maps and cross-sections of four slopes were prepared.

1. Method

Alluvium soil, muddy shale occurs in wide urban living area of Şırnak City at the south, which field as seen in Figure 1 extends to the study area. In field observations, the Miocene aged limestone and dissociated limestone were determined. Thickness of this formation is highly variable among 2-30m. Decrease in the slope of the land shows that a relatively small outcrop occurs.

The study area to the north of the city contains fundamentally higher land slopes in the urban location. The observations of sorting and grading of unseen alluvial fill show a thickness varies between 10-35 m. The high slope massive fills are concerned as active and potential hazardous landslide areas and are requiring for various examinations.

The representative contents of drilling logs were taken from the rectangular fields as seen from Figure 1.The representative samples of soil were taken from each different location over the slopes. The experiments conducted to determine the geotechnical characteristics regarding the American Standards (ASTM 3080) [13-15]. The mechanical properties of soils are given in Table 1.

In the study area of fine-grained portions of alluvium samples were taken from slopes as undisturbed and disturbed sample logs. The results of the experiments conducted on the samples of disturbed soil grain distribution curve, unit weight and consistency limit grain sizes are given in Table 1 [16-18]. With the help of Shear box tests on undisturbed samples, the effective cohesion (c') and effective shear resistance angle (ϕ°) belonging to the representative logs was found.

Table 1. Properties soil formation in Şırnak City.

Slope Specimen No	S1	S2	S3	S4
Level (m)	1225	1221	1233	1227
Wopt,%	15.9	13,7	10,8	11,4
c′(kPa)	1,2	4,7	5,3	2,5
ϕ′	12,5	22,5	21	20
Lı(%)	26	15	28	17
Pı(%)	19	11	18	22
Ip (%)	10	9	8	12
γ_{sat} g/cm^3	2,4	2,5	2,4	2,3
γ_{ap} g/cm^3	1,65	1,6	1,78	1.6
γ_{dry} g/cm^3	1,82	1,76	1,9	1,7
γ_s g/cm^3	2,02	1,84	2,0	1,8
w_{opt} %	15,9	15,8	12,3	13,0
Permeability (k) (mD)	0.56	0.38	0.31	0.56

Figure 1. Satellite image of the study area and the slopes in Şırnak City.

2. Results and discussion

According to the classification of the soils in S1 and S2 landslide hazardous areas, the soils were determined as less plastic and non plastic group, even the soils of S3 and S4 in the landslide hazardous area were determined as less plastic.

Fly ash and Mine Waste Shale stone thrown as waste in Şırnak City of Turkey were used with foam concrete. Waste mixture at certain proportions of fly ash and shale stone were decreasing the use of cement. Fine shale aggregate in specific proportions were decreasing the use of fly ash. Certain proportion of fly ash and fine shale aggregate mixture used improved mechanical strength and porosity. Fine aggregate was reducing porosity rather than fly ash. Three different methods are performed in foam concrete production. Firstly, only foam concrete was used as binder of mixture fill. Secondly, foam concrete included fly ash. Thirdly, foam concrete included fly ash and fine shale stone. Effects of foam concrete on mechanical properties of fly ash and fine shale stone aggregate were studied intensively.The results contributed the widely efficient use of high amount of shale stone and fly ash, better workability of the foam concrete and the improved curing time. For this purpose, in the mixture of foam concrete fine shale aggregate was added 5 %, 10%, 20% and 30% weight rates, fly ash was added 5%, 10%, 20% and 30% weight rates, respectively. Water / cement ratio were kept constant 3/1-4/1 volume rate. The prepared laboratory 10x10x10 cm cubic blocks was tested as the foam concrete mixture blocks. In conclusion, depending on the amount of the fly ash in foam concrete mixture, workability significantly improved and even significant the pressure increase was observed.

Compression strength values depending on the increasing amount of fly ash and foam concrete reduced. Increase in fly ash amount used in the foam concrete mixture by curing time was found to reduce the porosity.

The representative rock fill samples were taken from the construction foundation and strengths with the bulk density are shown in Table 2. For determination of rock types based on logging were carried out and the results showed poor and good rock classification as given in Table 2.

Evaluation of the test results to determine the level of soil permeability regarding Table 1, for S1, S2, S3 and S4 slopes may be critically hazardous on land constructions. It is observed that low permeable ground under construction as seen in Figure 2 caused sliding tension cracks and soil land slide.

Landfill of foam concrete performed was compared with the soil samples taken from the test results as given in Table 2. The pore pressure parameters foam concrete landfill at the optimum water content and maximum dry unit weight were determined and used in the calculation of the stability of slopes. A natural slope does not affect the stability of the compression parameters. These parameters of the soil were improved by compacted landfill in the desired manner. Artificial compression parameters used directly on the slopes [19-21]. If there is a risk of landslide hazard in a natural layer, compression case using these parameters are used in stability analysis. The use of anchorage or pile applications should be taken in consideration against to the any possible hazard of landslide in the front slope or the slope should be gradually compacted [22-25]. In this study, an amount of the natural ground is excavated and compressed and foundation was filled by certain foam concrete and rock fill. The pore parameters were improved against to the hazard. In this case, the stability analysis of these improved parameters was used in the stability analysis of compressed ground [22-25].

c' and ϕ' values are taken as given in Table 1. In addition, the safety coefficient values were used as 1.3-1.5 in GEO5 program. The probable circular sliding surfaces were determined using the methods such as landslide, according to Fellenius, Bishop and Janbu calculations [22-25].

Table 2. The resulting strength of foam concrete landfill.

Mixture in Foam Concrete	σ, Strength MPa	Water Discharge (%)	γ_{ap} Unit Weight, g/cm^3
Claystone,5%	8.9-9.9	88.2	1.540
10%	12.4-13.9	85.5	1.620
20%	14.5-17.5	82.4	1.790
30%	19.1-20.3	77.7	1.850
Fly Ash,5%	9.6-9.9	64.3	1.250
10%	11.5-12.5	62.7	1.380
20%	13.4-13.9	61.2	1.420
30%	14.3-14.9	60.3	1.580

Figure 2. Sliding land soil and foam co ncrete landfill study area.

This kind of soil conditions in this study provide a circular or non- circular sliding close quarters to the top of the slope begin as a deep developing and ongoing planar surfaces. In this type of instabilities developed along the sliding surface in order to investigate the stability of the slope the Bishop method is commonly used [26-28].

At the construction site foundation the foam concrete wells in 2 m diameters were excavated at elevation 1210 m to 10 m depth to sliding face. At creeping slopes hazard of mass slide may be prevented by rock fill. Even 1 meter depth foam concrete landfill horizontal columns constructed as seen in Figure 3.

With performed the foam concrete landfill application as constructed in Figure 3, hydraulic works at high rate water discharge through the foam concrete structure of landfill, even separately improved compression strength obtained by waste shale stone and fly ash use. Shale stone in the foam concrete mixture provided higher water discharges. According to landfill construction seen from the Figure 4, the landfill length varies from 3 to 10 m horizontal length. Shale stone and fly ash concrete covered foam concrete tunnels and wells could easily provide the sliding face dry.

The landslide S2 maximum elevation difference between the top and the heel point 35 m, 30 m maximum height of the slope divided three faces by excavation, surface slope angle is 43 °. Any slope in the floor was too weak, rock fill mass covered weak material properties of the slope along so that circular 10m mass sliding was avoided. However water drainage was almost varied. At that point, the floor - rock interface with a certain water holding structural feature needed the foam concrete application so that in the mass, reaching low shear strength planar levels were auger bored and tunneled and foam concrete -rock fill were applied as seen in Figure 3.

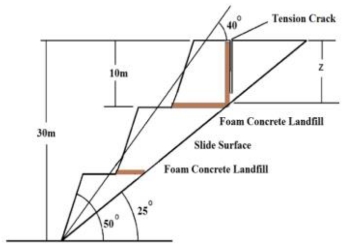

Figure 3. Foam concrete landfill application cross-section.

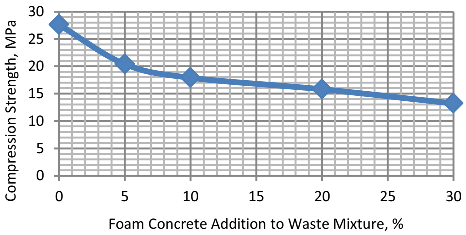

Figure 4. Compression strength of foam concrete landfill.

In this study, the compression strength of the foam concrete applied landfills for the slopes in the area is illustrated in Figure 4. The stability analysis for S2 slope in terms of active and potential hazardous areas of landfill was carried out. The applied foam concrete on the soil surface improved the strength and eliminated hazard of sliding. According to studies of the stability without landfill, the land mass slope area there was relative movement designated as the active landslide area. Relative movements are determined by making use of tension cracks on the surface. From this point of view, the foam concrete landfill of horizontal column improved water level under sliding surfaces and the safety factor values reached over 1.5 and 1.8.

3. Conclusions

The studied area of potential landslide hazard around the active site of stress, cracking displacement of relative motion could be observed, but changed regarding the field.

Soil samples performed on the laboratory test results in the slope material permeable that the cohesion value of 1.2 - 4.7 kPa, angle of internal friction of the 17.5 - 22.4^{o} varied between unified soil classifications. Stability analysis performed in the light of this information, S1, S2 and S3 were unstable hillsides. By use foam concrete application the hazardous slopes were concluded that the stable condition.

Landfill porosity thus reduces the retaining force which stabilizes the slopes. For this reason, the vegetation of landslide hazardous areas is preventive enrichment an important parameter in the region. However, up to 30 m depth to the sliding surfaces of vegetation stability effect will be minimal. Weathering of rocks varies greatly in to undergo, to the weakening of the bond between grains and leads to total extinction. 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 also offers a negative contribution to stability problems.

As a result of this work performing of the geotechnical analysis, hazardous conditions would not be expected of a very large landslide. However, the urban living areas and the urban development areas at certain land slopes for the possibility of landslide hazard should need further technological improvements.

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