Intercontinental Geoinformation Days

igd.mersin.edu.tr

Mapping of local soil conditions in GIS environment: A case study in Çukurkeşlik village

Aydın Alptekin*[1], Murat Yakar[2]

[1]Mersin University, Engineering Faculty, Geological Engineering Department, Mersin, Turkey
[2]Mersin University, Engineering Faculty, Geomatics Engineering Department, Mersin, Turkey

Keywords
GIS
MASW
Borehole
Microzonation

ABSTRACT

Turkey has frequently exposed to natural disasters due to its geomorphological structure. Urbanization should be well planned in order to survive disasters with the least damage. Local ground conditions need to be determined in order to create healthy cities. Soil parameters need to be mapped in order to design the earthquake-resistant building and predict the liquefaction potential of the land. In this study, it is aimed to map soil geo-engineering parameters for Mersin Province Çukurkeşlik District. Engineering geological maps were created from the data obtained from drilling and seismic studies in the region using Geographic Information System (GIS). Ground dominant vibration period, the average shear wave velocity of the top 30 m of the soil, soil amplification and Atterberg Limits were modeled in GIS. In this study, the landslide area was mapped with a small data set and a base was created for future microzonation studies.

1. INTRODUCTION

New settlement areas are needed parallel to the population growth. It is essential for the city planners to know the local soil conditions of the area before starting construction works in a region. Planning of settlement areas is useful in determining possible problems that may be encountered later.

Turkey, located on active fault zones and is exposed to frequent natural disasters. Earthquake is one of the leading disasters that result in death. Seismic microzonation studies should be carried out in the Geographical Information System (GIS) environment using geological, geophysical and geotechnical studies in order to minimize the loss of life and property in earthquakes (Sarı and Turk, 2020). The importance of microzonation studies comes to the fore in Turkey where it is located in the active earthquake zone. The map obtained as a result of the microzonation study will reduce the damages that may be caused by the earthquake and provide correct land use.

Microzonation studies are of great importance for modern urbanization. GIS is of great importance in urban planning. Microzonation can be done by different disciplines working together. Creating microzonation maps depends on the detailed study of the region's geology and the comprehensive geotechnical ground survey and seismic studies. The soil class can be determined after these studies are performed. In addition, these maps are guides in the master development plan.

Mapping of local soil properties is very important in selecting new settlements and planning existing settlements. Generally, attention is not paid to the engineering properties of soils in underdeveloped countries. This situation causes natural disasters to result in loss of life and property.

GIS is frequently used in the mapping of soil parameters. GIS provides the analysis and visualization of the information about the earth surface in computer environment. GIS offers great advantages in terms of cost, time and ease of operation. A database was created from the results of field and laboratory tests.

Compression and swelling index mapping study obtained from the consolidation test for the vicinity of Mersin Port was conducted by (Alptekin and Taga 2017).

* **Corresponding Author**

*(aydinalptekin@mersin.edu.tr) ORCID ID 0000 – 0002 – 5605 – 0758
(myakar@mersin.edu.tr) ORCID ID 0000 – 0002 – 2664 – 6251

Cite this study

Alptekin A & Yakar M (2021). Mapping of local soil conditions in GIS environment: A case study in Çukurkeşlik village. 2nd Intercontinental Geoinformation Days (IGD), 64-67, Mersin, Turkey

Özyazıcıoğlu et al. 2019, produced a microzonation map by evaluating the ground amplification effects.

2. STUDY AREA

Çukurkeşlik village, is located in Mersin city, is characterized by typical Mediterrenean climate. In parallel with the rapid increase in the population of the city, uncontrolled construction occurs in the city. The region is located in left-lateral Ecemiş Fault Zone. A landslide event has been observed in the study area (Alptekin and Yakar 2020).

3. METHOD

The physical properties of the environment where earthquake waves spread affect the degree of damage in buildings (Uyanık 2015). Therefore, it is vital to know the engineering properties of soils.

In the study area, the Geological-Geotechnical Survey Report was prepared by Yenişehir Municipality in 2017 as a basis for the development plan. We used the engineering properties of soils obtained from drilling and seismic investigation results. A data set containing geotechnical and geophysical properties has been created.

3.1. Borehole

The purpose of drilling is to monitor the change of geological units with depth, to define the engineering properties of rocks and soils, and to obtain data with groundwater.

In Çukurkeşlik district, six boreholes, each 10 m deep, were drilled. Groundwater was not found in these drillings. Disturbed and undisturbed samples were taken from the boreholes. Atterberg Limits Tests were performed on the disturbed samples.

The soil may appear in four states such as solid, semi-solid, plastic and liquid. The water content at which soil changes from one state to other is known as Atterberg limits. Atterberg limits, which are Liquid limit (LL) and Plastic limit (PL) outlined in ASTM D4318.

LL is the water content that soil changes from the liquid state to plastic state. PL is the water content that soil changes from plastic to semi-solid state. Plasticity index (PI) is the difference of LL and PL (Eq.1).

$$PI = LL - PL \qquad (1)$$

In this study, we mapped the Atterberg limits, which were taken 1.5m depth. The results are shown in Table 1. It was determined that the soil samples are in the clay with intermediate plasticity (CI) group in the Unified Soil Classification System (USCS) soil classification.

Table 1. Atterberg limit tests results

Borehole	Depth (m)	LL (%)	PL (%)	PI (%)
1	1.5-3	41.2	23.58	17.62
2	2.0-3.5	41.3	22.96	18.34
3	1.5-2.5	44.8	25.20	19.60
4	1.5-3	42.0	23.15	18.85
5	2.0-3.0	43.2	23.00	20.20
6	1.5-3.0	43.8	22.79	21.01

3.2. Multichannel Analysis of Surface Waves (MASW)

MASW data was obtained by 4.5 Hz geophone and 12-channel seismogram, which can obtain V_P and V_S accurately. A sledgehammer was used to obtain data. Ground dominant vibration period (T_0), soil amplification. The results are shown in Table 2.

Soil was classified according to Desing of Structures for Earthquake Resistance (Eurocode 8), National Earthquake Hazards Reduction Program (NEHRP) and average shear wave velocity in the upper 30 metres (Vs30). The results are shown in Table 3.

Table 2. MASW results

Seismic	T_0 (sn)	V_s30 (m/s)	Soil amplification
1	0.35	543	1.55
2	0.30	645	1.40
3	0.39	501	1.63
4	0.56	343	2.04
5	0.44	437	1.77

Table 3. Soil classes

Seismic	EUROCODE	NEHRP	Vs30
1	B	C	C
2	B	C	C
3	B	C	C
4	C	D	C
5	B	C	C

4. RESULTS

GIS is a platform that performs the storage, processing, management and querying of data. It has been frequently used in engineering projects since 1990s. It is not possible to obtain data from every point in the study area. Interpolation allows us to predict missing points.

The obtained engineering properties were mapped in ArcGIS software by using spatial analysis module. Inverse Distance weighted (IDW) interpolation method was used. Atterberg limits distribution maps, LL (Figure 1) and PL (Figure 2) were prepared. Vs30, T0 and soil amplification values were determined with MASW analyses. The distribution maps (Figure 3-5) were prepared.

The Vs30 values of the near surface soils varies from 343 m/s to 645 m/s. T_0 values vary between 0.30 s and 0.56 s. Soil amplification varies between 1.40 and 2.07.

Many researchers (Maheswari et al. 2010; Rahman et al. 2016; Bajaj and Anbazhagan 2019) prepared Vs30 distribution map.

Atterberg Limits Test results show that all of the samples are in CI group. While B and C classes are seen in the study area according to the EUROCODE classification, C and D classes are seen according to the NEHRP classification (Table 3).

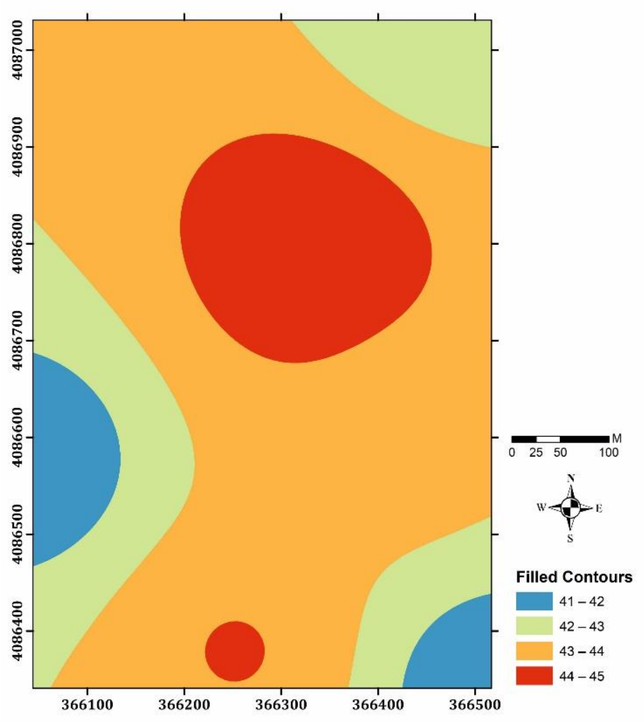

Figure 1. LL distribution

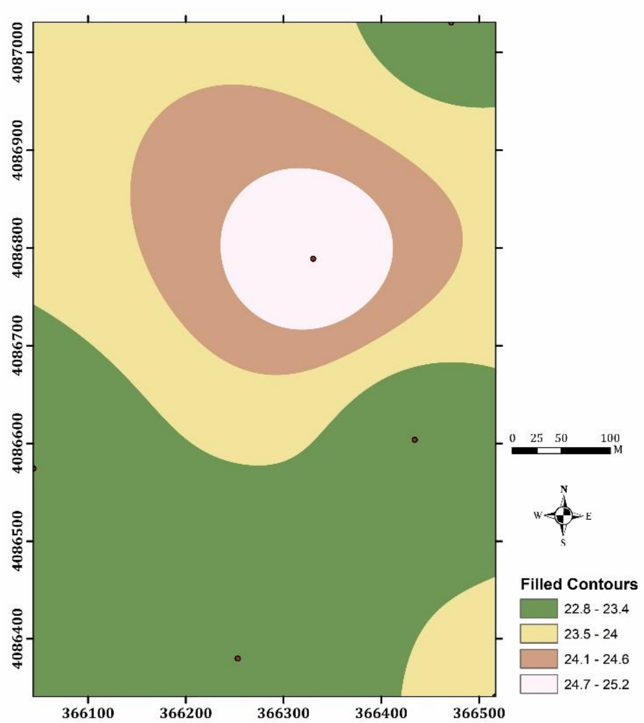

Figure 2. PL distribution

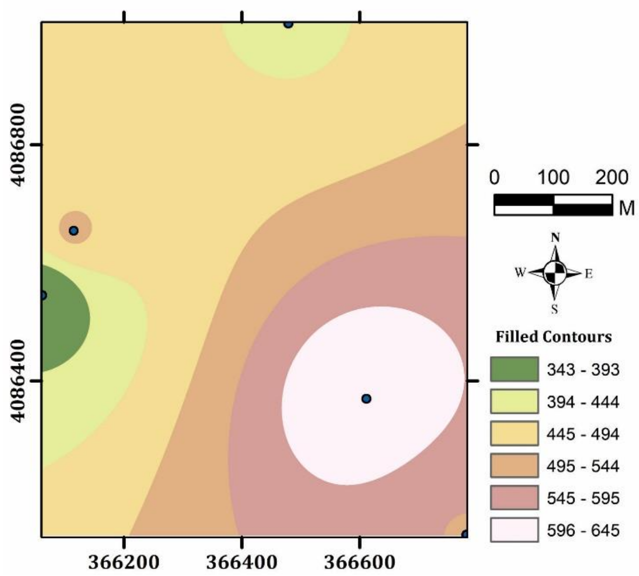

Figure 3. Vs30 distribution

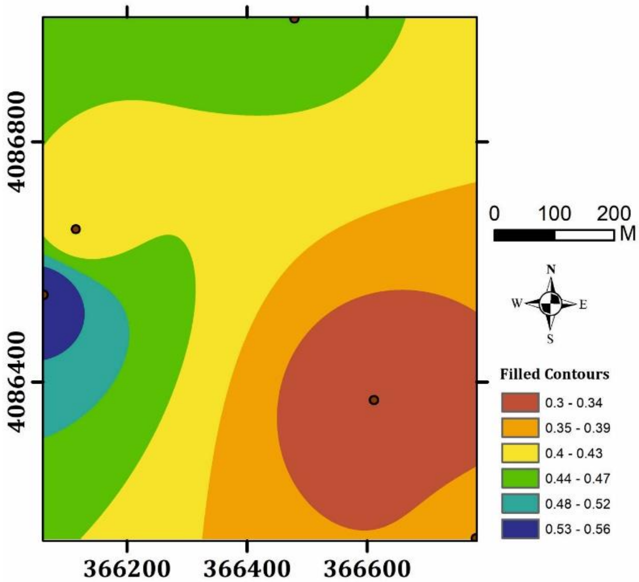

Figure 4. T_0 distribution

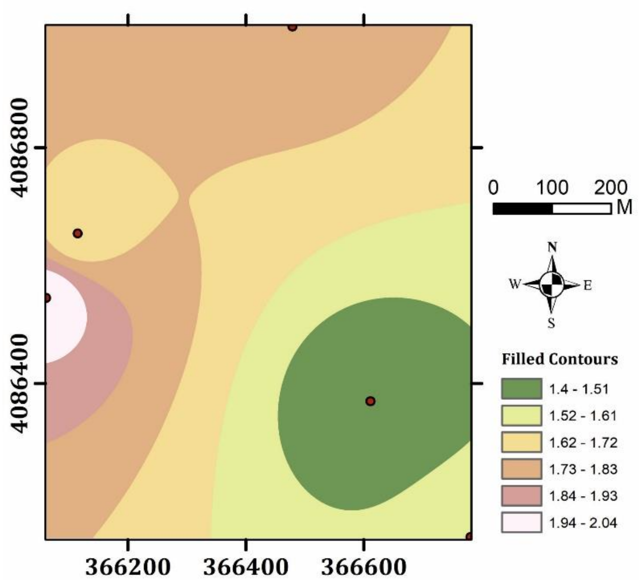

Figure 5. Soil amplification distribution

5. DISCUSSION

Microzonation determines all disaster risks in a region on maps. Microzonation studies should be carried out to determine the suitability of a region for settlement, urban planning, and zoning and land use planning. Urban planning without sufficient research on the geological environment and soil conditions causes natural disasters to come out with more damage. In this study, we prepared a preliminary study for microzonation.

6. CONCLUSION

Engineering properties of soils effects the damage caused by natural disasters. In this study, we mapped the engineering properties of a landslide area. We prepared the basic maps in ArcGIS for microzonation study.

ACKNOWLEDGEMENT

We would like to thank Mersin Yenişehir Municipality for contributing to our data acquisition.

REFERENCES

Alptekin A & Taga H (2017). Mersin Limanı'ndaki zeminlerin indeks ve konsolidasyon özelliklerinin değerlendirilmesi. Ulusal Mühendislik Jeolojisi ve Jeoteknik Sempozyumu, Adana, 200-207.

Alptekin A & Yakar M (2020). Heyelan Bölgesinin İHA Kullanarak Modellenmesi. Türkiye İnsansız Hava Araçları Dergisi, 2(1), 17-21.

ASTM 4318, (2014). Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils (p. 16). ASTM, West Conshohocken United States

Bajaj K & Anbazhagan P (2019) Seismic site classification and correlation between VS and SPT-N for deep soil sites in Indo-Gangetic Basin. Journal of Applied Geophysics, 163, 55–72

Maheswari R U, Boominathan A & Dodagoudar G R (2010). Seismic site classification and site period mapping of Chennai City using geophysical and geotechnical data. Journal of Applied Geophysics, 72, 152–168.

Özyazıcıoğlu M, Dönmezçelik K, Orhan S N & Özkan M Y (2019). Erzincan İli Zemin Büyütme Etkilerine Dayalı Mikrobölgeleme Çalışması. Doğal Afetler ve Çevre Dergisi, 5(2), 247-256.

Rahman M Z, SiddiquaS & Kamal A S M M (2016) Shear wave velocity estimation of the near-surface materials of Chittagong City, Bangladesh for seismic site characterization. Journal of Applied Geophysics, 134, 210–225

Sarı s & Turk t (2020). Depremde Meydana Gelebilecek Bina Hasarlarının Coğrafi Bilgi Sistemleri ile İncelenmesi. Türkiye Coğrafi Bilgi Sistemleri Dergisi, 2(1), 17-25.

Uyanık O (2015). Deprem Ağır Hasar Alanlarının Önceden Belirlenmesi ve Şehir Planlaması için Makro ve Mikro Bölgelendirmelerin Önemi. Süleyman Demirel Üniversitesi Fen Bilimleri Enstitüsü Dergisi, 19(2), 24-38.