International Journal of the Physical Sciences Vol. 6(22), pp. 5243-5252, 2 October, 2011
Available online at http://www.academicjournals.org/IJPS
DOI: 10.5897/IJPS11.576
ISSN 1992 - 1950 ©2011 Academic Journals

Full Length Research Paper

The effect of geological and geotechnical factors on the project design of coastal structures (Alanya Marina case study)

Devrim ALKAYA[1]*, İbrahim Çobanoğlu[2] and Burak YEŞİL[1]

[1]Department of Civil Engineering, Faculty of Engineering, Pamukkale University, Denizli, Turkey.
[2]Department of Geological Engineering, Faculty of Engineering, Pamukkale University, Denizli /Turkey.

Accepted 22 August, 2011

Coastal areas of Turkey are scientifically, culturally and economically very important places because of values in geomorphological, geological, biological, archeological and tourism properties. In this study, coastal structures are classified; and design phases of shore structures and required geological and geotechnical studies before design are explained. As an example, geological and geotechnical studies carried out during Alanya Yacht Harbor site investigations are evaluated. The effect of geological and geotechnical data obtained as a result of GDCRSA (General Directorate for the Construction of Railways, Seaports and Airports) studies was evaluated and geotechnical conditions which effect the project were determined.

Key words: Coastal structure, geology, geotechnical, marina.

INTRODUCTION

Geological and geotechnical applications take a significant place in designing and constructing the coastal structures. Geological factors bear significance as regards to the soil and construction material. This condition strongly effects the selection of structural type and structural cost. It is important, in the sense of safety and economics, that geological, geotechnical, and construction material investigations should be conducted by a team of experts on the specifications of coastal structures. In this study, geological and geotechnical surveys conducted before designing the Alanya Marina Project were examined; the design parameters were evaluated; and the effect of the geotechnical conditions on the project were revealed. In the preliminary project of Alanya Marina, landing deck was projected as a piled deck; and the soil investigation was structured according to the preliminary project with piled decks. Following the soil survey, it was determined that the soil had sufficient durability and there was no need for building piles. With

*Corresponding author. E-mail: devrimalkaya@hotmail.com. Tel: +90 258 2963354. Fax: +90 258 2963382.

Basic principles in designing the coastal structures

The decision of not building any piles, the structural cost decreased. The implementations in this field, termed as coast, harbor, and sea structures, can be defined as:

1. Design and construction of harbor facilities,
2. Building of open sea drilling platforms, resting facilities, industrial centers, radio detecting towers, and military services over the sea,
3. Enabling the stability of undersea bevels,
4. Preventing the erosion and carrying of coastal sand, the siltation and sanding of harbors, piping around the undersea foundations, and deepening of the sea transport channels,
5. Laying of pipe and cable under the sea, and
6. Formation of artificial islands.

Designing the projects of coastal structures is a wide working field that includes various factors aiming to reach the optimum solution in the end.

The problem in any coastal study should be approached from various points of view:

1. As regards to the hydraulics, the investigations regarding the wave, current, and wind data should be implemented;
2. As regards to the sanding, the movements of sand and the change in coast line should be considered;
3. Environmental factors should be examined, and the negativities of these effects should be reduced to minimum;
4. Necessary geological and geotechnical factors should be considered in designing the construction methods and foundation structures;
5. While examining the structural material and determining the material quality, geological and geotechnical characteristics of natural material should be taken into account;
6. Commercial, touristic, and transportation requirements should be determined by conducting coastal and harbor surveys;
7. The coastal structures should be designed by considering all the data;
8. As regards to the economics, the most appropriate solution according to the monetary potential should be found out.

When all of these factors are totally taken into account, it is clearly revealed that the design of a coastal structure is not just limited to the shape, location, and dimensions of the structure; and the static stability alone is not sufficient. Moreover, a coastal structure should function in the most economical way. Additionally, the environmental effects of the structure should be minor; and, at the same time, its effects in the adjacent regions should be considered. When viewed from this aspect, the structure should be aesthetic, barely affect the currents, and not change the ecological balance (Kapdaşlı, 1992).

DETERMINATION OF SUB-SEA GEOLOGY AND GEOTECHNICAL SPECIFICATIONS

Under the subject field of undersea geology, formations that start from the river mouths, extending inside the bays and continental shelves, descending towards deep sea ocean floors, and rising again in the open seas, by showing morphological features such as mountain ranges, hills, and islands, are examined. The sea beds are almost as much rugged as the earth's surface. Long mountain ranges, volcanic cones, wide planes, large steps, deep troughs, and canyons are encountered under the sea (Toğrol and Özüdoğru, 1992).

When designing the coastal structures, determining the undersea soil structure, detecting scanning requirements and scanning depth, and determining the characteristics of the soil, of which would be the foundation for the structure, is a necessity for previously identifying the tension, bearing capacity, and settlement problems. The soil investigations are implemented in single or several phases according to the details required by the harbor projects. Some preliminary soil data, before the drilling procedure, are obtained by observations, and evaluation of the geological and topographical views and conditions of the place. This information can significantly be beneficiary for the initial settlement plan (Toğrol and Özüdoğru, 1992).

After identifying the water depths and earth altitudes of the area, in which the harbor would be built, and drawing of the leveling curves, the initial form of harbor is designed by also considering the prevailing wind direction. The factors effecting the harbor location and wave effect are evaluated separately and in detail. Furthermore, the inner harbor sea structures (berths) and outer harbor structures (breakwaters) are first formed sketchily (Yüksel et al., 1998). The final formation of this design is related substantially to the soil conditions. Drilling is implemented to the significant points of the structures such as breakwater, wharf, landing decks in relation with the initial plan.

Drill planning

The locations and depths of the drills are determined according to the planned structure. In coastal structures, the drills should be implemented along specific lines. The drills in breakwater axes are implemented according to the breakwater length and construction technique in specific intervals that could enable the drawing of the soil layers. This interval could be taken between 50 and 100 m if the lower soil layers do not display significant changes. The depths of the drills are related to the soil type and rock depth (Yılmaz, 2004).

By implementing drilling procedure, in an area which would be scanned, the soil type to be scanned is identified and the soil's feasibility for filling is examined. In the scanning area, the drilling depth is descended 1 to 2 m lower than the scanning altitude. If rock is encountered in the desired depth, core sample is obtained by descending the depth of several drills by 2 to 4 m and information about the characteristics of rock, such as rock type, fracture condition, and endurance etc., is obtained (Toğrol and Özüdoğru, 1992).

For the breakwaters, especially for the ones to be built on soft soil, the drills should be implemented at 30 to 35 m below the mean water level by skipping the soft soil. If heavy wharf walls do sit directly on the soil surface, the drills of these structures should also be implemented 25 to 30 m below the mean water level with 50 m intervals (Demirkıran, 2002).

For the piled berths, the drills should be implemented with intervals and depths of which the pile lengths can be determined because drill lengths, to be determined according to these drilling data, should generally do not differ more than 1 to 2 m. If the piles do sit over the rock and the upper levels consist of soft soil, then the drills

Table 1. Quality classification of filling materials to be used in harbors according to CIRIA/CUR (1991) standard.

	CIRIA/CUR (1991) criteria			
Test name	**Very good**	**Good**	**Medium**	**Bad**
Dry density (t/m^3)	≥ 2.9	2.6 - 2.9	2.3 - 2.6	≤ 2.3
Absorption by weight (%)	≤ 0.5	0.5 - 2.0	2.0 - 6.0	≥ 6.0
$MgSO_4$ resistance (%)	≤ 2.0	2.0 - 12.0	12.0 - 30.0	≥ 30.0
Freezing and thawing (%)	≤ 0.1	0.1 - 0.5	0.5 - 2.0	≥ 2.0
Methylene blue absorption (g/100 g)	≤ 0.4	0.4 - 0.7	0.7 - 1.0	≥ 1.0
Point load index (MPa)	≥ 8.0	4.0 - 8.0	1.5 - 4.0	≤ 1.5
Mill abrasion index, k_s, (%)	≤ 0.002	0.002 - 0.004	0.004 - 0.015	≥ 0.015
Impact strength index, I_d (%)	≤ 2.0	2 - 5	5 - 15	≥ 15.0

should be descended to the altitude of rock.

The geological investigation drills can also be implemented with the aim of identifying the structural material, as well as the foundation soil, and determining the material specifications. With the rock drills, soil or material identification purposed, core samples are taken; and, especially in the stone pits, obtaining information regarding the type, qualifications, and layer thickness of the stones, and their prevailing joint and discontinuity locations and frequencies, bears a great significance, especially in the stone pits, as regards to the faultless functioning of the work (Ayhan, 2005). During the drills, site tests (SPT etc.) are implemented. By conducting the necessary laboratory tests on the undisturbed and intact samples taken by drilling procedure, the geological examination is finalized.

Load bearing capacity and settlement analyses

According the values to be found following the drilling procedure and site and laboratory tests, which would define the soil and rock environment, the safe load bearing value of the soil is calculated. Benefiting from the load bearing values, the decision of whether the coastal structure would have piles, or not, is made. After the preliminary selection of the foundation system, the settlement analysis should be made. The settlement of a structure can be divided into three sections:

1. The sudden settlement occurring during the placing of the building,
2. Consolidation settlement occurring due to the compression of the clay layers under the structure,
3. Long term settlements occurring mainly due to the iterative wave loads.

Based on the experiments from land structures, the settlements can be stated to be at a level of the sum of first two settlement values. After finalizing the settlement analyses of preliminary project, the preliminary project is decided as suitable or the foundation system of project is changed.

Specifications of the materials used in harbor fill

The natural materials, concrete, and steel used in the coastal structures should be durable to the physical and chemical effects of the sea for years. The effect of waves causes the armour stones to gradually contact with each other to cause friction and decay, and, at the same time, compression by wedging due to the movement. The natural materials used should have hardness values that could endure such types of effects and be durable against an adequate level of pressure. Therefore, the density, hardness, compressive strength, frost resistance, corrosion, and water absorption tests are implemented on the materials to be used. The chemical effects of the sea water on the armour stones, due to the existence of microscopic clay seams on some limestone types, can be encountered as dissolving of these clays and thus, dispatching of the stone. On the other hand, this condition is not encountered for every limestone type. The endurance of the samples, to be obtained from the rocks to be used in the breakwaters, against chemical effects is tested by keeping these samples inside sulphated water solutions (Ayhan, 2005).

Various standards, enforced with the purpose of evaluating the adequateness of armourstones to be used in coastal and harbor structures, do exist. In Turkey, the density of armourstones and the specifications of the material to be used were defined in Turkish Standards and General Technical Specifications of Harbor and Sea Works.

The definitions of quality parameters belonging to the natural stones to be used as aggregates or filling materials in harbors, according to CIRIA/CUR (1991) criterion are presented in Table 1.

Besides being conscious of the physical and mechanical specifications of the natural materials to be used in the harbor fill, the other geological features regarding the unit in the pit, from which the material is obtained, should be determined. In the pit, from which the materials would be obtained, the locations, distances, and intervals of the discontinuities contained by the geological unit, discontinuity form, disintegration conditions, type of discontinuity fill, number of joint sets, block shape to be obtained, and volumetric joint count consist of significant parameters which should be known (Ayhan, 2005).

The concrete materials under the water, due to the sulfates in the composition of sea water, are encountered by two dangers. The first, among these, is the puffing and swelling caused by the formation of candlot salt, expressed by the formula $Al_2O_3.3CaO.3CaSO_4.30H_2O$. The second, on the other hand, is the danger of decomposition due to the continuous hydrolysis (disintegration of lime) for the case of having excess amounts of free lime and tricalcite aluminates in the cement. Another precaution taken for against the corrupting effect of the salts in sea water is prevent the corruptive chemical reactions of a significant type aggregate and cement by avoiding the use of that type of aggregate. Consequently, before using a type of aggregate in concretes, the aggregate sample should be examined petrographically; and its use should be avoided if they contain harmful silica. For the construction of concrete that is durable against the salts in the sea water composition, by using cement which is resistant against sea water, the corruptive effect of sea water on the concrete can be prevented. When there exists 8% or less tricalcium aluminate (3 CaO, $Al2O_3$) in the composition of Portland cement, it is known that this cement is durable against the corruptive effect of sea water (TS-802, 1996; Baradan, 1998).

The effect of sea water on the steel piles and steel pile planks stands out as the corrosion of materials at the sections where the sea level is changing. The long term safety of the materials should also be enabled by taking adequate precautions against oxidization (Baradan, 1998).

Harbors and inner harbor structures

Although the shores are used in various aspects by the society, the wide use of the shores includes shipping trade, tourism, and fishing purposes. The ships and small crafts employed in these activities are kept at regions built with the purpose of protection against the wave and current effects. If the various requirements of ships are met, their maintenance and repairs are implemented and they can be built; thus, loading and unloading services are provided, and the storage facilities do exist in these areas called harbors (Kapdaşlı, 1992). The harbors can be classified into three as natural, semi-natural, and artificial. Regardless of their type, a land sector should be protected against all sorts of wave effects in order for them to be called harbor or port (Bilge, 2003).

The functions of the harbors have become significantly diversified parallel to the increase in the shipping trade and ship dimensions. The harbors can be grouped, according to their functions, as commercial harbors, military harbors, ship-building yards, fishing ports, and marinas. One of the significant parameters that determines the location and size of any commercial harbor is the region it services and affects. This region is called the hinterland of the harbor (Kapdaşli, 1992).

Evaluation of geological and geotechnical implementations in Alanya Marina construction

In Turkey, yachtsmanship bears a great significance since the shores are very suitable for yachting. The marinas are should be designed and dimensioned specifically due to both general specifications of yachts and the services expected and required by the yachtsmanship. Determination of the specifications required by these marinas, and deciding about their locations, differs from other types of harbors. The marinas are to be located along a coastline preferably outside the city center but also easily and quickly accessible by the people. On the other hand, the marinas are living spaces for the yachters. Therefore, it should not be disregarded that the yachters should easily access the main centers. The marinas should be regions around which the sea sports should comfortably be exercised because the main function of these marinas is to provide services for touristic activities. As well as generally for every marina, it is a cost redundancy factor that the marina is not designed for other touristic purposes along the coastline.
While deciding the location of Alanya Marina, which is examined within the scope of this study, it was observed that the aforementioned factors were complied:

1. For the technical factors, such as the coastline condition, depths, under sea condition, coastal structure, surrounding topography, currents, and sand movements, the topographical, hydrographical, hydrological, seismic, geological, and geotechnical surveys were conducted.
2. Environmental impact assessment report was prepared (Doğan et al., 1998).
3. The necessary protected area survey was conducted; and natural protection possibilities were investigated.
4. For the settlement region (Alanya), its condition, commercial possibilities, urban context, requirements by the tourism industry, and touristic growth potential were examined.

As the result of the aforementioned examinations conducted, an area that is close to the city and suitable regarding the coastline were determined towards Alanya-Antalya direction. The location of marina and its general view are, respectively, presented in Figures 1 and 2.

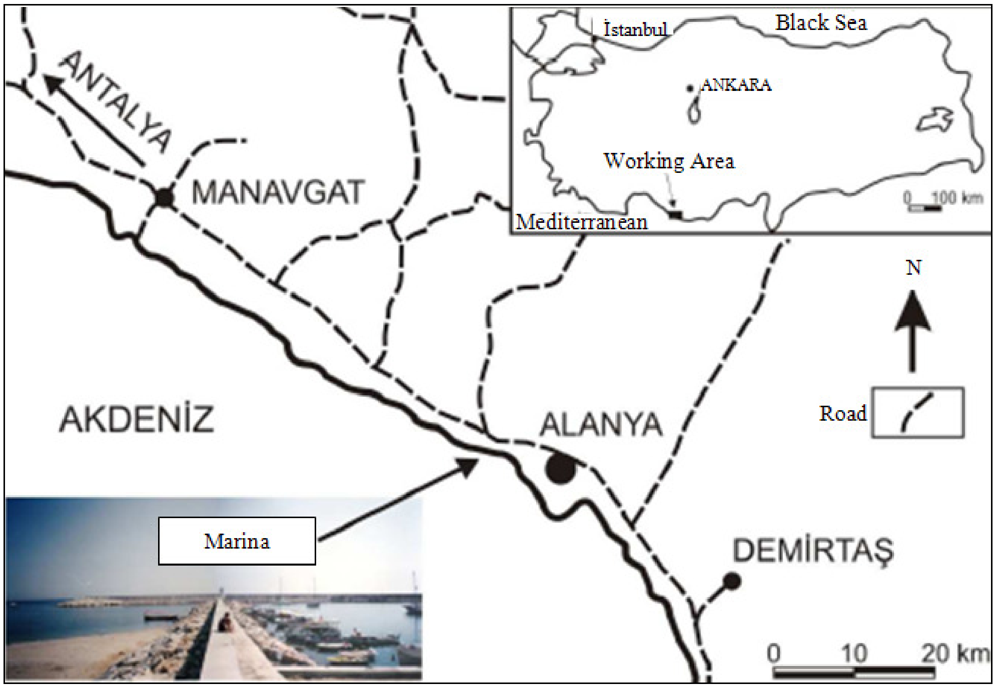

Figure 1. Location of the examined marina**.**

Figure 2. General view of the marina and breakwater built by using natural stones (schist and limestone) in the inner harbor (lighthouse region).

Geology of Alanya Marina site and geological survey drills

The investigation area consists of three metamorphic naples placed on top of each other in a section, called Alanya Assembly, that extends from 20 km east of the district center to west. According to the regional studies, the lithological units in the investigation area are the elements of Alanya Assembly. These naples, which display different stackability and metamorphism in Alanya Assembly, are called, from bottom to top according to their structural position; Mahmutlar formation (bottom naples), Sugözü formation (middle naples), and Yumrudağ formation (top naples). In the project site, only the units belonging to the Yumrudağ Naple, which is the top level of Alanya Massive, are encountered (Figure 3). Two units in Yumrudağ Group, constituting the top naples of Alanya Assembly, were identified in the project site. One of these is the upper levels of Cebireis formation. The other levels consist of pelitic schists- topped by recrystalized limestone-, lime schists, and meta-dolomites. The other one is Asmaca formation that is surfaced with all its levels. This unit, on the other hand, consists of pelitic schists-interfinger in sections-, lime schists, and graphite schists (Özgül, 1984).

Within the scope of Alanya Marina soil survey, 9 drills inside the sea were implemented; of which their locations were determined by the General Directorate of Railroads, Harbors, and Airports Construction. The drills were implemented, by using Crealious- XCH-90 type drilling

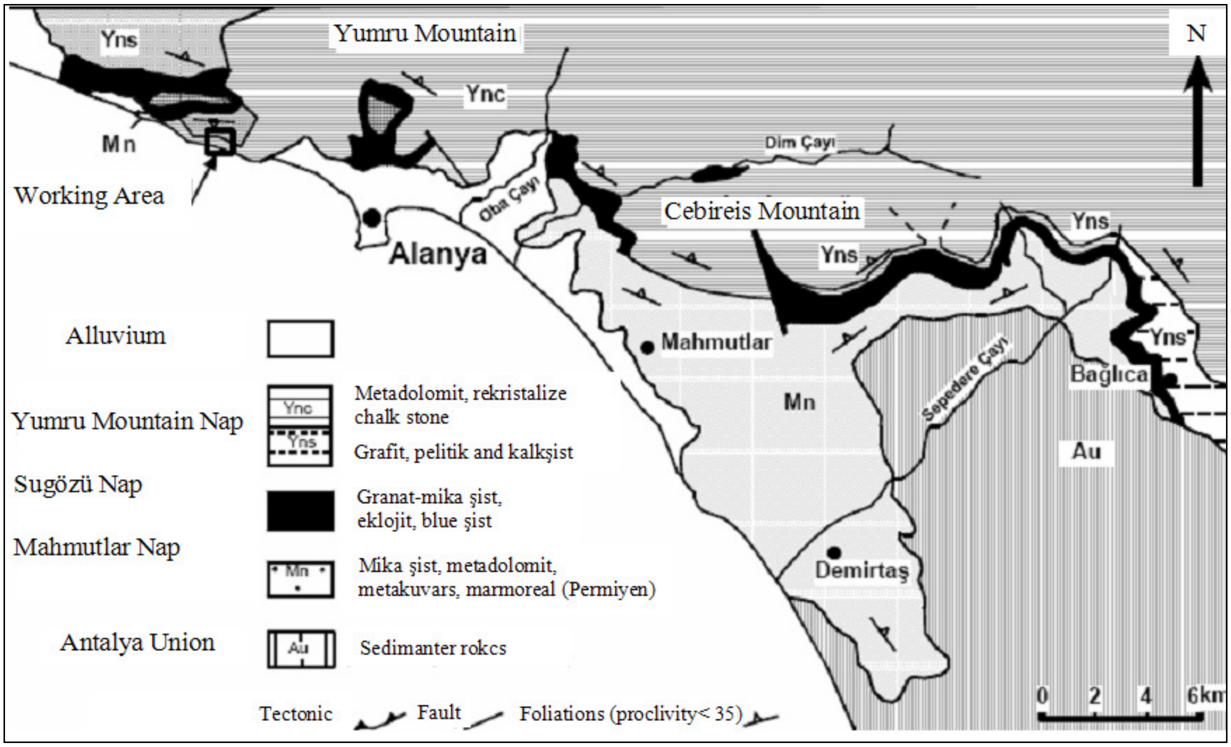

Figure 3. General geology of the investigation site (Koçkar and Akgün, 2004).

Table 2. Data regarding the drills (Muhtesip et al., 1995).

Drilling number	Water depth (m)	Drilling depth (m)
DW -1	7.50	34.00
DW -2	7.20	33.70
DW -3	6.60	27.80
DW -4	7.10	31.00
DW -5	5.70	26.20
DW -6	4.20	24.10
DW -7	3.00	26.20
DW -8	4.70	16.20
DW -9	5.80	36.20

machine that is mounted on the pontoons, working with rotary system. The studies were conducted by a team of three under the supervision of a geology engineer. In the 9 drills implemented, the maximum distance from the coast to the sea was 260 m; and the maximum water depth was measured as 7.5 m. The depth information about the drills is presented in Table 2.

The soil section, formed by using the data obtained from the conducted drills, can be seen in Figure 4. The loose gravelous sand unit under the sea water was cut in all three drills. The sandstone unit, positioned under this unit, however, presents a lens shaped distribution and was not cut in SK1 drill. These limestones do appear, during the site investigations, along the coastline with their wide mostras (Figure 5). The conglomerate, positioned lower than these units, as the hard and durable unit, on the other hand, could be encountered in SK1 and SK9 drills. Below all of these units, however, stone and marl sediments, again cut in all three drills and continuing generally along the drilling depths, are positioned.

The data belonging to SK 7 and SK 1 drills and definitions regarding the cut lithologies are presented all together in Tables 3 and 4. The definitions, created by using SPT results, were made according to the soil classifications table in Section 12 of the Regulations Regarding the Structures to be Built in Disaster Areas (Disaster Regulations, 2007).

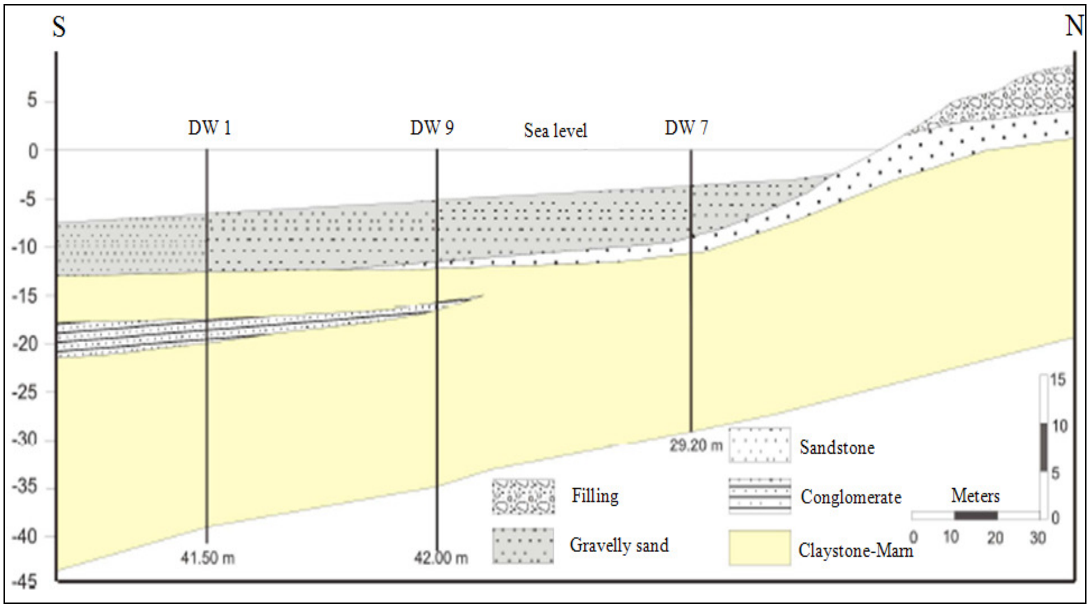

Figure 4. Soil profile revealed by the data belonging to the drills abridged through the marina route (Changed from Muhtesip et al., 1995).

Figure 5. View of the sandstones, which outcropped in the investigation area.

Table 3. Evaluation of test results belonging to SK7 (Muhtesip et al., 1995).

Depth (m)	SPT	Nature of soil	Description
1.50	31	Sand*	Dense
3.00	R	Sand*	Dense
4.50	R	Claystone	Hard
7.50	R	Claystone	Hard
10.50	R	Claystone	Hard
13.00	R	Sandstone	Hard
16.50	R	Claystone	Hard
19.50	R	Claystone	Hard
22.50	R	Claystone	Hard

*Gravelous sand that includes partly gravel dimension material; R: Refusal.

Table 4. Evaluation of test results belonging to SK1 (Muhtesip et al., 1995).

Depth (m)	SPT	Nature of soil	Description
1.50	33	Sand*	Dense
3.00	R	Sand*	Very dense
4.50	R	Sand*	Dense
6.00	R	Sand*	Dense
9.00	R	Claystone	Dense
12.00	R	Conglomerate	Very dense
15.00	R	Claystone	Hard
18.00	R	Claystone	Hard
21.00	R	Claystone	Hard
24.00	R	Claystone	Hard
27.00	R	Claystone	Hard
30.00	R	Claystone	Hard
33.00	R	Claystone	Hard

*Gravelous sand that includes partly gravel dimension material; R: Refusal.

Table 5. Evaluation of test results belonging to SK9 (Muhtesip et al., 1995).

Depth (m)	SPT	Nature of soil	Description
1.50	31	Sand*	Very dense
3.00	34	Claystone	Hard
4.50	R	Claystone	Hard
6.00	R	Claystone	Hard
7.50	R	Claystone	Hard
9.00	R	Claystone	Hard
10.50	R	Conglomerate	Very dense
12.00	R	Claystone	Hard
13.50	R	Claystone	Hard
15.00	R	Claystone	Hard
18.00	R	Claystone	Hard
21.00	R	Claystone	Hard
24.00	R	Claystone	Hard
27.00	R	Claystone	Hard
30.00	R	Claystone	Hard

*Gravelous sand that includes partly gravel dimension material; R: Refusal.

The values and definitions related to the SPT test data belonging to SK 9 drill are presented in Table 5.

Laboratory tests

The basic physical and mechanical tests, by using the disturbed and undisturbed samples from the drills taken from the drills, with the purpose of determining the characteristics of soils were conducted by a private company. By conducting water content, Attenberg limits, and sieve analysis tests on the disturbed samples, were classified with TS-1500 (2000) soil classification system. The mechanical properties of the soil, on the other hand, were determined by conducting shear box tests on the undisturbed soil samples. According to the laboratory test results, conducted on the soil samples obtained from SPT tests implemented during the drills, the main soil types (excluding sandstone and conglomerate) were classified into three groups; and their specifications, which can be used during the designing of project, are summarized in Table 6. Among these units, the unit separated as schist, is the unit at the bottom of the section cut by drilling and totally display rock specifications.

Table 6. Basic engineering parameters of the units located in the investigation site (Muhtesip et al., 1995).

Feature	Sand	Hard clay (claystone-marn)	Schist
Nature of soil	SM	CL	Rock
SPT	29-63 (Medium-very dense)	R	R
Cohesion (kN/m^2)	0	120	Unspecified
Friction angle (°)	30-43	15	43

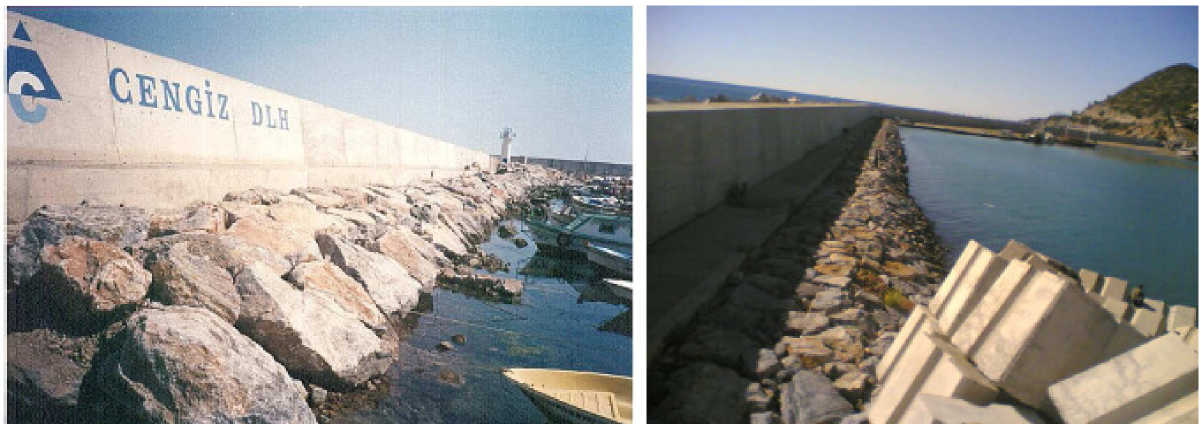

Figure 6. Armour stones and concrete blocks that are obtained from the stone pits and spread in front of the harbor structure.

Geotechnical evaluations

The bearing capacities of the previously described soil types, by considering that the structure to be built would be rubble mound and their being in a water logged environment, as well as the cohesion of soil, were calculated by using SPT-N values according to the formula (Terzaghi and Peck, 1948):

$$Q_a = \frac{N-3}{10}$$

SPT impact numbers were corrected according to the depth values; and these new values were used for the calculation of bearing capacity. For the non cohesive and medium compact- high compact gravelous sand layer that is observed from the sea water and its length changing from 3.00 to 10.50 m, found with the help of geological sections, the strength value (2.7 kg/cm^2) was calculated as in extremely adverse conditions of bearing capacity.

The permissible bearing capacity value for the firmly consistent and partly gravelous “clay” (claystone- marl) layer was calculated as Q_a = 2.9 kg/cm^2. The same value for sandstone, observed as a thin layer (approximately 1 m. thick) between sand and clay layer in some sections, and for “conglomerate” layer, encountered as a strip between the upper and middle layers of the clay layer again in some sections, were calculated, respectively, as $Q_a \leq$ 2.9 kg/cm^2 and Q_a = 2.9 kg/cm^2. For the bedrock schist, on the other hand, the bearing capacity was determined as Q_a = 4.0 kg/cm^2.

In the design of the project, the safe bearing capacity value for “gravelous sand” was taken as Q_{em} = 2.0 kg/cm^2; for “clay”, “sandstone”, and “conglomerate”, the value was determined as Q_{em} = 2.5 kg/cm^2; and this value was taken as Q_{em} = 3.0 kg/cm^2 for “schist” within minimum safety conditions.

When the safe bearing capacity values of the soils were examined, it was observed that all of them had sufficient strength. It was determined that, as a result of the soil survey, no need for implementing any scanning procedures on the section that the rubble mound breakwater would be located on; and, at the same time, it was found out that no subsidence or total collapse problem would be encountered. The values for wharf were around -3 and -5 m; and it was suggested that, by conducting -1.50 m scanning, 0 to 0.250 ton under wharf armourstones would be placed under the concrete inside the water. As regards to the soil specifications, piling was not necessary in the deck section. Therefore, a floating deck or concrete block deck was suggested for this project (Muhtesip et al., 1995). As the armourstone material, sandstone, limestone, and schist units, which are abundant in the region, were used (Figure 6). Building of a concrete block deck was designed and then constructed.

RESULTS

Designing the projects and construction of the coastal and harbor structures is a practice that requires the contribution of many disciplines such as geology, geotechnics, and hydraulics. The coastal structures, which do not harm the environment and can present service suitable to its building purpose, are engineering structures that has many contributions to the country's economics due to the liveliness it provides to the commercial life, tourism, and transportation sector. Many coastal structures, which need to be built considering the requirements of the country, are planned and included in the investment scheme by the Ministry of Transportation in Turkey. Some of these structures, because of their expenditures, are built by the methods such as external loan or build operate transfer. When the resources in Turkey are considered, the adequate design of the coastal structure and the selection of most suitable and economical construction method bear a great significance in relation with the national economy. For designing the coastal structures, the adequate determination and evaluation of geological and geotechnical factors would affect the structure type and construction method, and provide the required data for the economical construction of the structure.

In the project examined, it was determined that the coastal structure, which was previously projected to have piled deck, had sufficient durability values; and therefore, there was no need for building the piles. The coastal structure was then designed and constructed as having a concrete block deck.

This study revealed, with the case of Alanya Marina, the effect of existing soil conditions on the structural project and how it completely changed the construction method. The soil investigation, conducted on the project phase of the examined harbor building, enabled the design of a project that could safely be built with the natural resources of Turkey.

DISCUSSION

For the construction of Alanya Marina, still ongoing in Alanya district of Antalya province, the landing deck was projected as piled; and the soil investigation was structured according to the piled preliminary project. As the result of the drills and soil surveys conducted, it was observed that the soil had sufficient durability; and therefore, there was no need for constructing piles. It was then projected by the management that the landing deck should be built as floating deck or concrete block deck instead of constructing piles.

The preliminarily designed project and suggested project following the soil surveys differed completely from each other as regards to structure, cost, and construction movements, currents taken by the wharf, static forces formed in the wharf, and implementation methods. With the determination of the fact that there was no need for constructing piles, the construction cost and construction time was decreased. The local geological and soil conditions constituted the most significant parameter for determining the marina type, designing the project, and selecting the construction method. The significance and contribution of earth sciences in designing coastal and offshore structures were once more put forth with this study.

ACKNOWLEDGEMENTS

The authors would like to offer their gratitude to Turkish Republic Ministry of Transportation, General Directorate of Railroads, Harbors, and Airports Construction (GDCRSA), 8. Region Antalya Directorate for presenting information.

REFERENCES

Ayhan N (2005). Coastal-Port Planning and Design. Arkan Publishing House, İstanbul.

Baradan B (1998). Material of Construction I-II. Dokuz Eylül University Engineering Faculty, İzmir.

Bilge S (2003). Coastal and Port Structures. Pamukkale Universty Engineering Faculty. Civil Engineering Department. License Thesis, Denizli.

CIRIA/CUR (1991). Manual on the Use of Rock in Coastal and Shoreline Engineering. Construction Industry Research and Information Association. London. Ciria Pub. 83/Cur Report 154.

Demirkıran A (2002). Used in Harbour Excavation Fill and Construction Techniques. Pamukkale University Science Institute, Master Thesis, Denizli.

Disaster Regulations (2007). Regulations Regarding the Structures in Disaster Areas. Turkish Republic Ministry of Public Works and Settlement, Ankara 26582.

Doğan A, Türker E, Karagüzel R, İkiz R, Sevindir C (1998). Alanya Marina Environmental Impact Assessment Report. Turkish Republic Ministry of Transportation, General Directorate of Railroads, Harbors, and Airports Construction, 8^{th} Region Antalya Directorate. Antalya.

Kapdaşlı S (1992). Coastal Engineering. İstanbul Technical University, İstanbul.

Koçkar KM, Akgün H (2004). Ilıksu Tunnel Geotechnical Assessment. Chamber of Civil Engineers Tech. J. Ankara, 15(2): 3191-3214.

Muhtesip Y, Örün D, Özbudak M (1995). Alanya Marina Geologic Survey Report. Teksan Foundation AS. DLHİ Directorate General of 8 District Office, Antalya.

Özgül N (1984). Alanya Tectonic Window and Geology of its Western Part. Geological Society of Turkey. Ketin Symposium. Ankara.

Terzaghi K, Peck RB (1948). Soil Mechanics in Engineering Practice. John Wiley, New York.

Toğrol E, Özüdoğru K (1992). Marina Geotechnics. Boğaziçi University. İstanbul.

TS-802 (1996). Design Concrete Mixes. Turkish Standards Institutions, Ministries, Ankara.

TS-1500 (2000). Classification of Soils for Civil Engineering Purposes. Turkish Standards Institutions, Ministries, Ankara. December.

Yılmaz R (2004). Foundation Construction. Birsen Publishing House, İstanbul.

Yüksel Y, Çevik E, Çelikoğlu Y (1998). Coastal and Port Engineering. TMMOB Chamber of Civil Engineers, Ankara.