The Effects of Basra Gulf Salt Water on the Proctor Compaction and CBR Test Results of Soil Samples at *Baniyas* City, Abu Dhabi, UAE

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ABSTRACT

In this work the effect of salty water of the Basra Gulf (a.k.a. Persian Gulf, as well as Arabian Gulf) was investigated on the proctor compaction tests on the SP-SM (poorly graded sand with silt and gravel) soil samples which were taken from five trial bits in Baniyas City. The maximum dry unit weight increased by adding Arabian Gulf water compared to the samples tested using tap water in the Lab, to the extent that the maximum dry unit weight increased from the range of (17.4 – 18.6) kN/m^3 to (18.0 – 20.1) kN/m^3 and the optimum moisture content decreased from (11 – 15) % to (9.8 – 13) %. CBR value has also varied for the tested samples from (11 – 28) % to (35 – 63) %.

KEYWORDS: Arabian Gulf, Basra Gulf, Persian Gulf, Proctor Compaction Tests; Optimum moisture content; Maximum unit weight; California Bearing Ratio (CBR).

INTRODUCTION

Several studies have been conducted in the past on improving the properties of sensitive soils using some additives such as Ca_2CO_3, Gypsum, Cement such as works by Pyne (1955), Chen (1981), Ghafoori & Cai, (1997), Ghafoori (2000), López & Castaňo (2001), Muntohar (1999) Muntohar & Hantoro (2000), Mahasneh (2004), and Azadi *et al*. (2008).

Form the previously mentioned studies, it is expected that metal oxides, hydroxides, or halides additives can enhance soil stabilization. However, none of these studies investigates the use of a mixture of these compounds as a soil stabilization agent.

The water of Basra Gulf (a.k.a. Persian Gulf, and Arabian Gulf) contains 503 grams of salt per liter of water. In this paper, The idea of using Arabian Gulf water as soil properties improvement agent comes as a result of understanding what the others did regard using calcium chloride, metal oxides, etc, and the idea comes to investigate the ability of using the Arabian Gulf water because it contains many kinds of salts (Sodium chloride, Potassium, etc.), as well as the economic benefit of using Gulf water in a country such as the countries bordering the Gulf (Iraq, Iran, Kuwait, Qatar, Bahrain, Saudi Arabia and UAE) or any other countries that have a big shore (seacoast) on a salty water sea, so it will be more economic to use this water in soil stabilization, pavement design, and foundation construction.

MATERIALS AND METHODS

Study Area and the Gulf

Baniyas City; 35 km SE Abu Dhabi city; is one of the new developed cities in the Emirates of Abu Dhabi, the Capital of the United Arab Emirates (Fig. 1).

The Emirate of Abu Dhabi has an onshore area of 77,700 km^2, compared with about 84,000 km^2 for the whole of the UAE, plus some 30,000 km^2 of offshore area on the Arab side of the Gulf, The costal flats of Abu Dhabi are part of the southeast Gulf carbonate province (Alainachi & Alobaidy, 2009).

The climate of UAE (Southwest area of the Gulf) is wet and hot. The temperature in Summer may reach as high as 45°C or more, and in Winter may decrease about 25°C, and the average annual temperature is about 35°C. Furthermore, the average annual rainfall is about 7.4 mm, and the maximum relative humidity reaches 95% or more. The economical importance of the Gulf evolves from its location and water chemical composition, the dissolved minerals (Salt Concentration), as mentioned above, reaches up to 503 gm/liter. Table 1 below shows the ionic (mineral) contents of the water sample from Gulf and tap Water in the Lab.

Table 1: Chemical Tests results of Ions in the Gulf Water and Tap Water in the Lab. (g/lit)

Minerals (Ion)	**Ca^{++}**	**Na^{++}**	**Mg^{++}**	**K^{+}**	**Cl^{-}**	**SO_4^{--}**	**Other Salts**	**TDS**
Tap Water	0.167	0.364	0.036	0.002	0.070	0.279	0.032	0.950
Gulf Water	0.72	175.86	13.77	3.50	265.87	35.40	7.84	502.96

Figure 1: Study Area: **A.** Gulf and United Arab Emirates
B. Emirates of Abu Dhabi **C.** Study Area

Scope of Work

The scope of work comprised five trial pits to a depth of 2 m, the location of pits is shown in Fig.2, coordinates of the pits are given in Table 2.

Table 2: Trial Pits Coordinates

Pit #	Coordinates	
	N	E
T.P. A	2689603	0262291
T.P. B	2689675	0262643
T.P. C	2689169	0262876
T.P. D	2689191	0262661
T.P. E	2689175	0262265

Figure 2: Layout Showing the Location of Trial Pits

Each weights of 10 kg from each type where brought from the site, while the salty water was brought from the Gulf of Abu Dhabi. The five samples were examined, labeled, described and classified, placed in proper sequence in plastic bags and were sent to laboratory for testing, while the salty water was placed in closed containers and saved in the Lab at room temperature.

Laboratory tests were performed on the soil samples. The tests were carried out in accordance with British Standard (BS) and American Society for Testing and Materials (ASTM) in order to determine the physical, mechanical and chemical properties of the ground materials. The following soil parameters were determined in the laboratory:

- Size Analysis of soil (Particle size distribution of Soils).
- Soil Compaction (Proctor) test.
- Determination of California Bearing Ratio (CBR).

Chemical Analysis was carried out for the Gulf water sample to determine the Dissolved solids. The Proctor and CBR Tests were carried out using tap water (T.W) and carried out again with Gulf water (A.G.W).

RESULTS & DISCUSSION

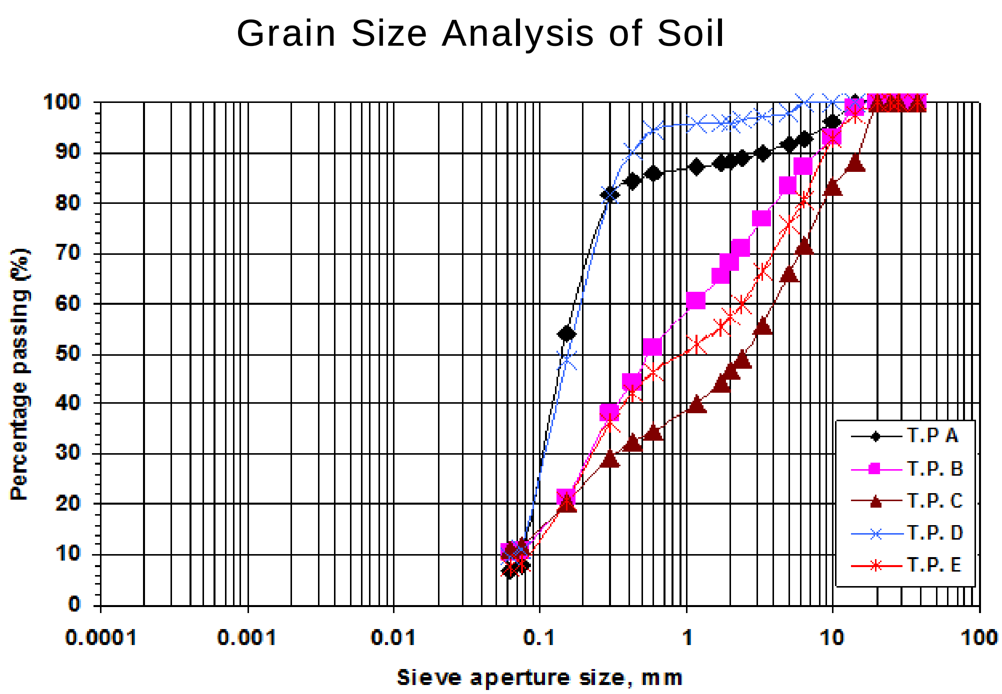

Figure 3: Grain Size Distribution Curves for Soil Samples obtained from the Study Area

Soil Compaction (Proctor) Test

Table 3: Proctor Test Results – T.P. ***A***

Assumed particle density (Mg/m^3)	2.60	
Retained on 37.5/20 mm (%)	Nil	
Test Results		
Water used in test	T.W	A.G.W
Optimum Moisture Content %	13	11
Maximum Dry Density kN/m^3	18.1	18.5

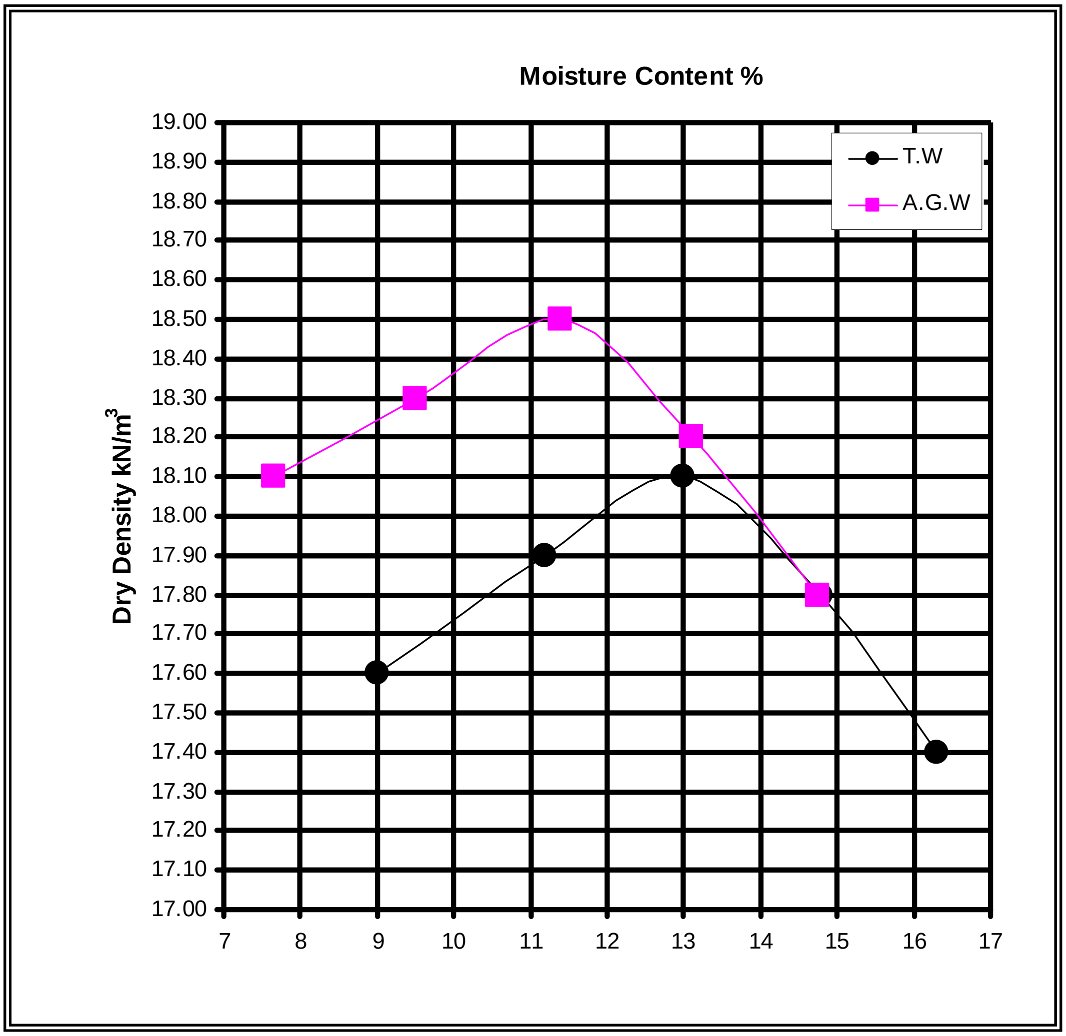

Figure 4: Proctor Test Result – T.P. ***A***

Table 4: Proctor Test Results – T.P. ***B***

Assumed particle density (Mg/m^3)	2.60	
Retained on 37.5/20 mm (%)	Nil	
Test Results		
Water used in test	T.W	A.G.W
Optimum Moisture Content %	15	11
Maximum Dry Density kN/m^3	17.4	19.0

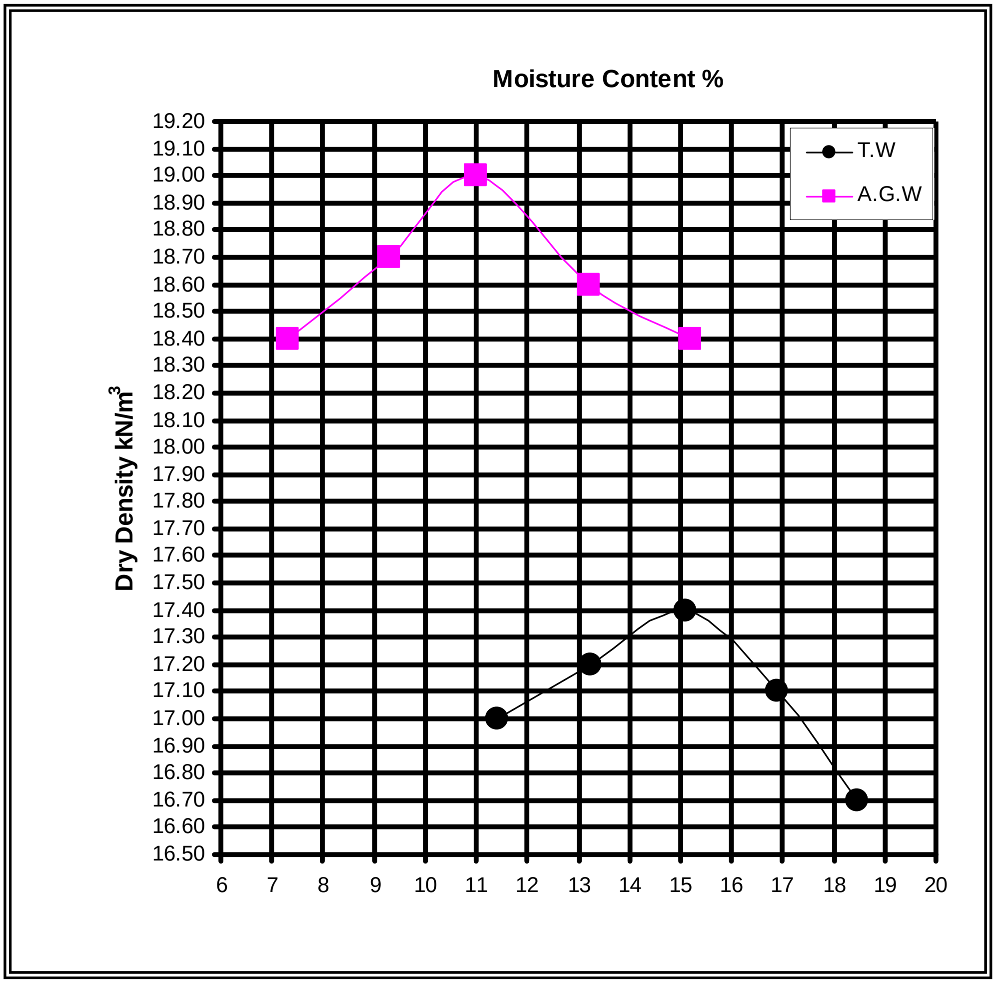

Figure 5: Proctor Test Results – T.P. ***B***

Table 5: Proctor Test Results – T.P. *C*

Assumed particle density (Mg/m^3)	2.60		
Retained on 37.5/20 mm (%)	Nil		
Test Results			
Water used in test	T.W	A.G.W	
Optimum Moisture Content %	14	11	
Maximum Dry Density kN/m^3	18.6	18.8	

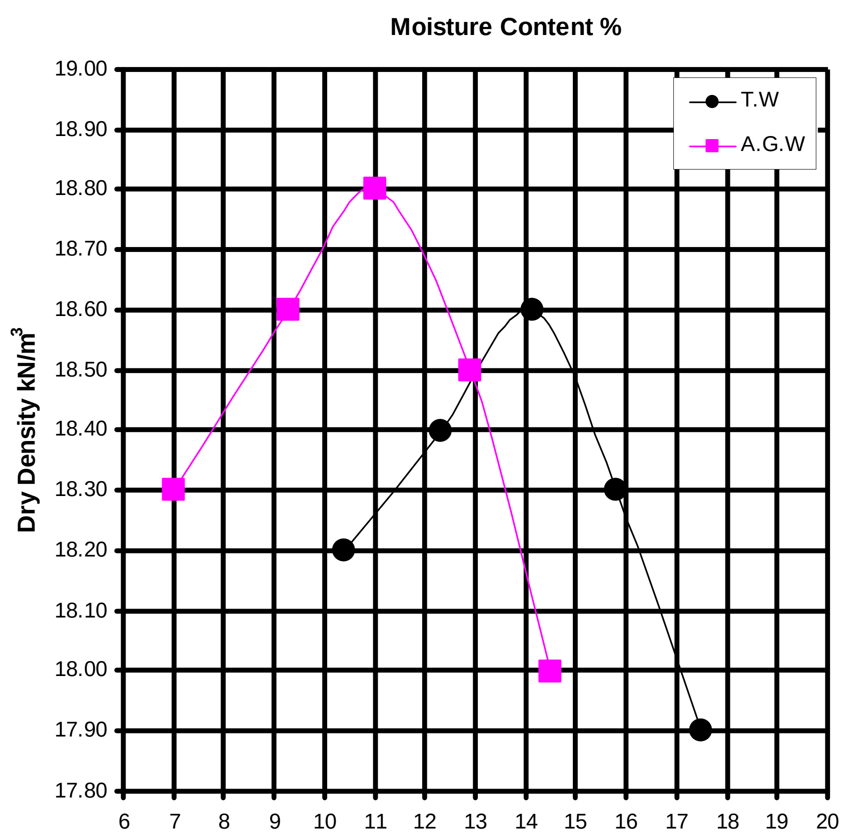

Figure 6: Proctor Test Result – T.P. ***C***

Table 6: Proctor Test Results – T.P. D

Assumed particle density (Mg/m^3)	2.60	
Retained on 37.5/20 mm (%)	Nil	
Test Results		
Water used in test	T.W	A.G.W
Optimum Moisture Content %	13	10
Maximum Dry Density kN/m^3	18.0	18.8

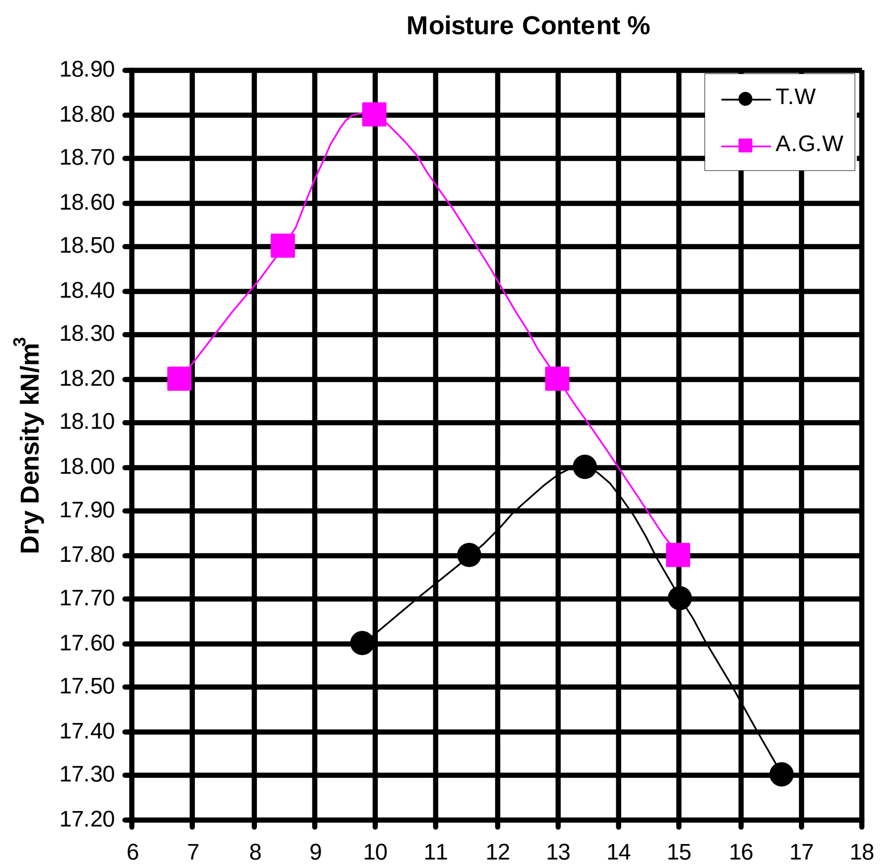

Figure 7: Proctor Test Result – T.P. ***D***

Table 7: Proctor Test Results – T.P. ***E***

Assumed particle density (Mg/m^3)	2.60	
Retained on 37.5/20 mm (%)	Nil	
Test Results		
Water used in test	T.W	A.G.W
Optimum Moisture Content %	14	9.8
Maximum Dry Density kN/m^3	18.3	20.1

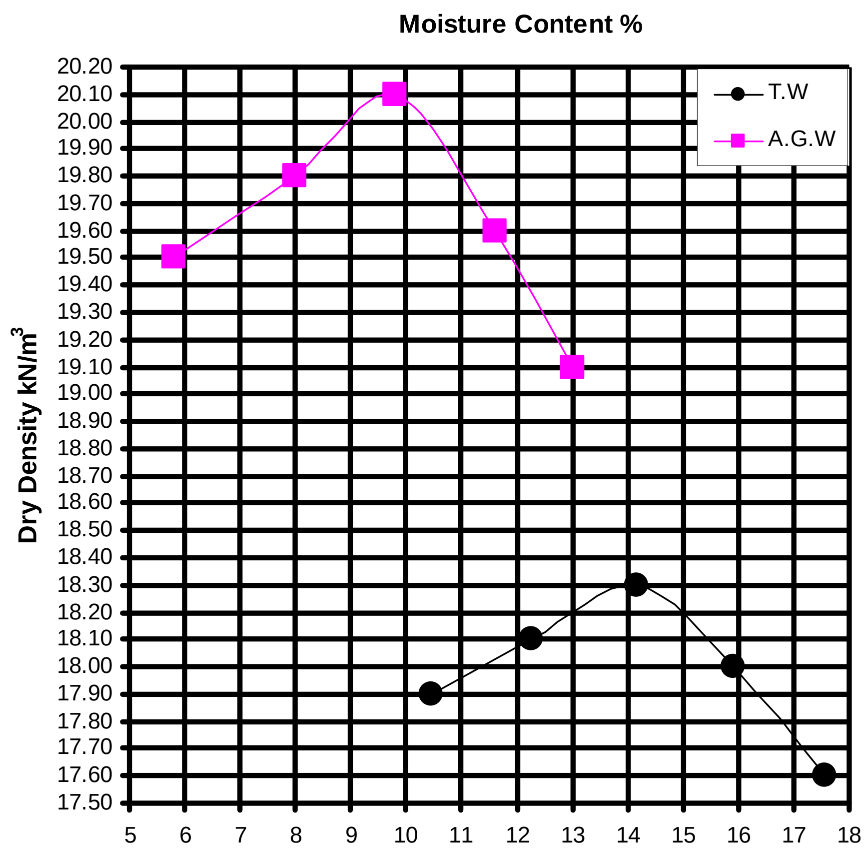

Figure 8: Proctor Test Result – T.P. ***E***

California Bearing Ratio (CBR)

Table 8: CBR Test Results – T.P. ***A***

Test Results				
Water used in test	T.W			
Swell (%)	Nil		A.G.W	
C.B.R (%)	Top		Nil	
at penetration 2.5 mm	28	Bottom	Top	Bottom
at penetration 5.0 mm	25	22	63	42

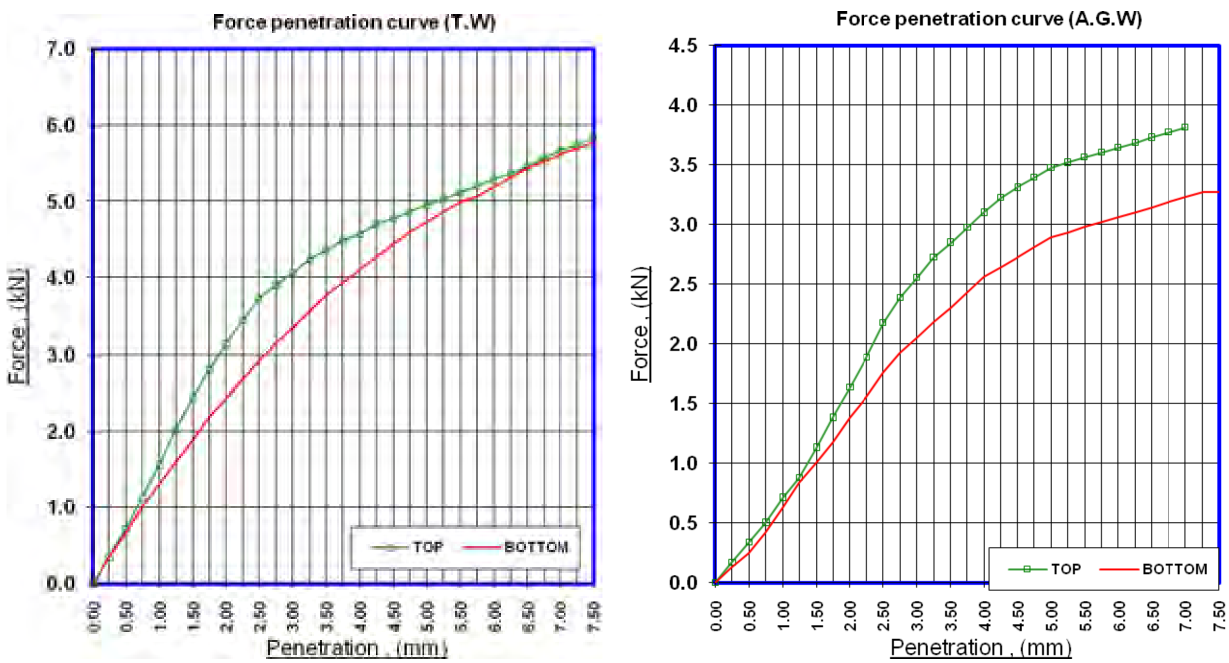

Figure 9: CBR Test Result – T.P. ***A***

Table 9: CBR Test Results – T.P. ***B***

Test Results				
Water used in test	T.W		A.G.W	
Swell (%)	Nil		Nil	
C.B.R (%)	Top	Bottom	Top	Bottom
at penetration 2.5 mm	11	14	37	35
at penetration 5.0 mm	13	15	39	36

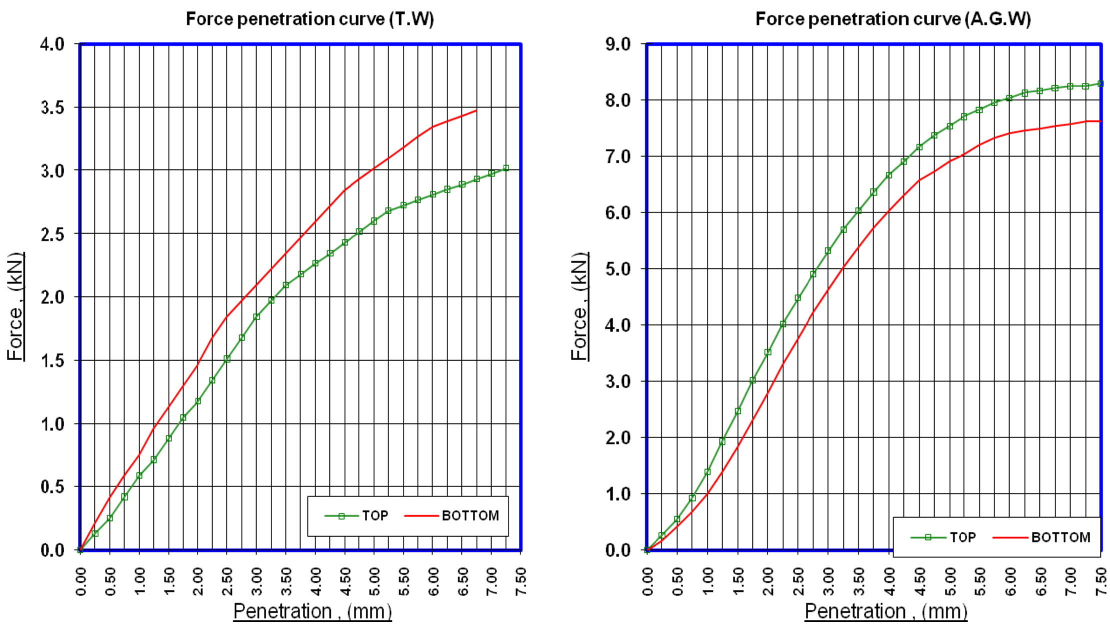

Figure 10: CBR Test Result – T.P. ***B***

Table 10: CBR Test Results – T.P. ***C***

Test Results				
Water used in test	T.W		A.G.W	
Swell (%)	Nil		0.91	
C.B.R (%)	Top	Bottom	Top	Bottom
at penetration 2.5 mm	17	18	46	40
at penetration 5.0 mm	21	20	48	39

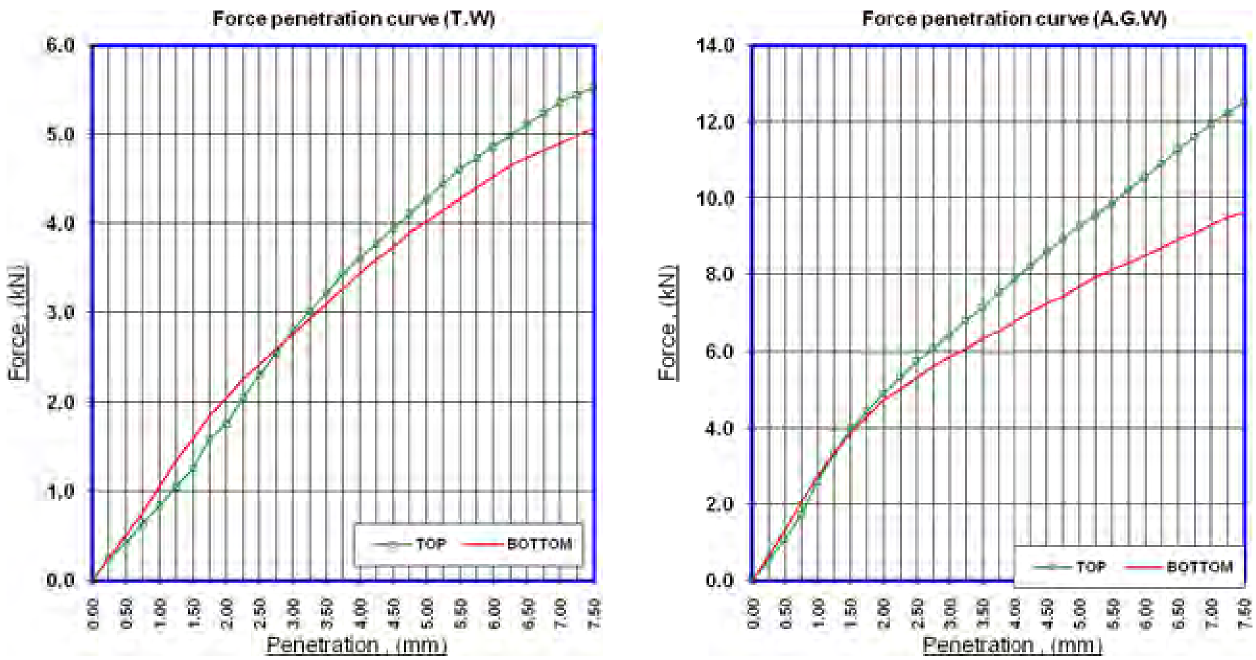

Figure 11: CBR Test Result – T.P. ***C***

Table 11: CBR Test Results – T.P. ***D***

Test Results				
Water used in test	T.W		A.G.W	
Swell (%)	Nil		Nil	
C.B.R (%)	Top	Bottom	Top	Bottom
at penetration 2.5 mm	13	15	19	14
at penetration 5.0 mm	14	16	21	13

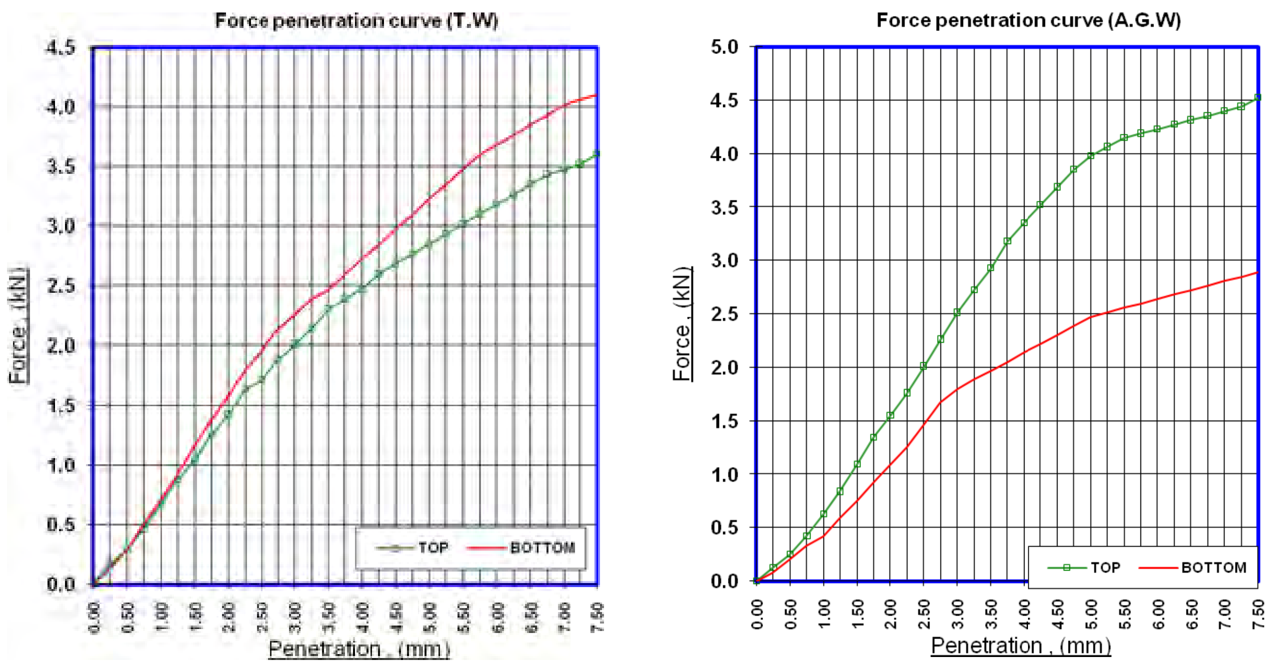

Figure 12: CBR Test Result – T.P. ***D***

Table 12: CBR Test Results – T.P. ***E***

Test Results				
Water used in test	T.W		A.G.W	
Swell (%)	Nil		0.91	
C.B.R (%)	Top	Bottom	Top	Bottom
at penetration 2.5 mm	17	14	49	43
at penetration 5.0 mm	19	16	48	37

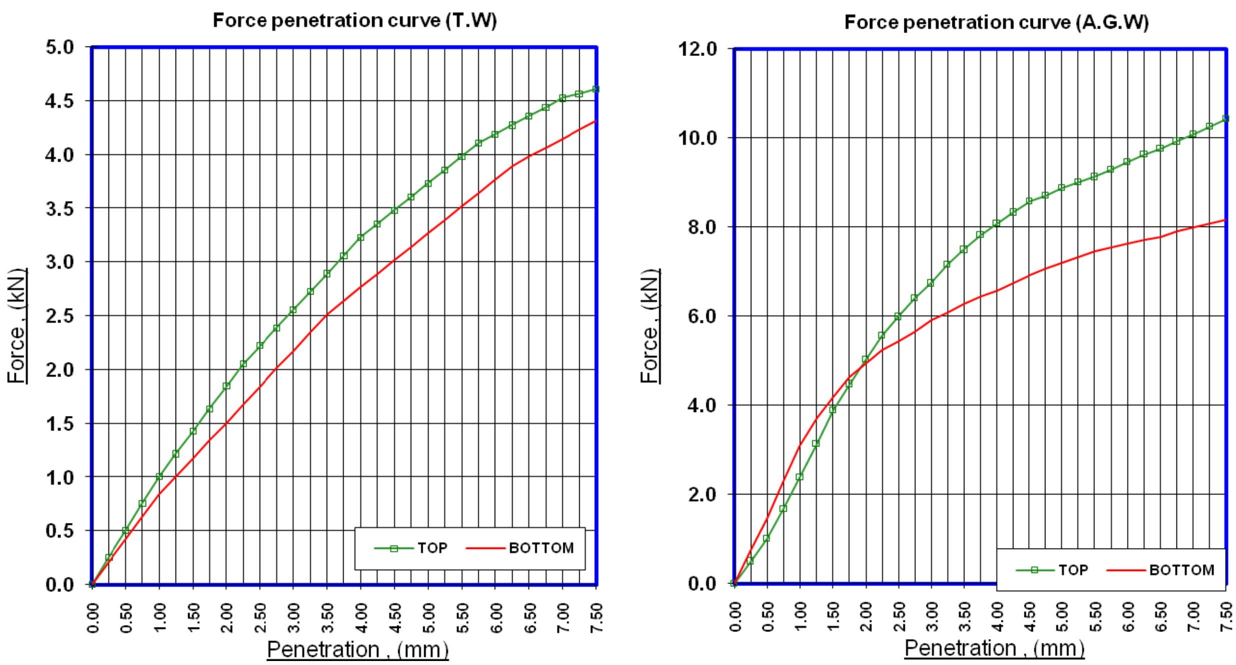

Figure 13: CBR Test Result – T.P. ***E***

Chemical Analysis

The chemical test results are shown in Table 1 as mentioned above.

CONCLUSIONS

Reference to the above results and discussion, the study reached the following conclusions:

The maximum dry unit weight increased by adding Gulf water compared to the samples tested using tap water in the Lab.

The optimum moisture content decreased by adding Gulf water compared to the samples tested using tap water in the Lab.

CBR value has also varied for the tested samples by adding Gulf water compared to the samples tested using tap water in the Lab.

Soil CBR is an important index to be determined for usage as the road base or sub-base material. Our CBR tests gave values in the range of 35%-63% for the tested A.G.W soil samples. It is shown that CBR of soil samples increases very significantly adding Gulf water in compaction mould instead of tap water.

Gulf Water could be used as effective and economic soil improvement agent.

Further studies to be done in the rest areas of this city, to make more accurate result for the city.

Abu Dhabi Emirates generally is still virgin area from the geological and geotechnical point of view, so that similar studies is highly recommended to be done in the emirates cities such as Khalifa City – A, Khalifa City – B, Mussaffah, etc., because all these areas are rich in engineering geological data, and there is no accurate studies were done there.

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