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AN INVESTIGATION OF THE PROPERTIES, EFFECTS, AND HOW OF USING SAND IN CONSTRUCTION. SANDS OF WADI KAAM (ZLITEN, LIBYA) AND EASTERN SAND DUNES

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الملخص

تناولت هذه الدراسة الخواص الكيميائية والفيزيائية لرمال الشواطئ والكثبان الرملية وقيمت أيضًا إمكانية استخدام الرمال كمواد في صناعة البناء، وجد أن هناك اختلافات في الخواص الكيميائية والفيزيائية بين الكثبان الرملية ورمال الشاطئ، حيث كانت أيونات الصوديوم والتوصيل الكهربائي والخصائص الكيميائية الأخرى في الكثبان الرملية هي الأقل ضغطًا مع رمال الشاطئ، لذلك كانت رمال الكثبان صالحة للاستخدام في صناعة البناء وخاصة إنتاج الخرسانة والطوب الإسمنتي.

الكلمة الرئيسية: صناعة البناء. رمل الشاطئ. أسمنت. الخصائص الكيميائية والفيزيائية

Abstract

This study has investigated the chemical and physical properties of beach sand and dunes and has assessed the possibility of using sand as a material in the construction industry.

It was found that there are differences in chemical and physical properties between dunes sand and beach sand.

Sodium ion, electrical conductivity and other chemical properties in dune sand were the lowest in compression with beach sand.
Therefore, the dune sands were valid for the construction industry especially, concrete production and cement bricks.
Keyword: Construction Industry. Beach Sand. Concrete. Chemical and Physical Properties.

Introduction

Sand beach dunes have the physical and chemical properties which makes it desirable as a raw material in many industries. these sands have suitable size and hardness, as well as its inertness and lack of chemical reactions. The building materials industry such as concrete production and bricks manufacturing is the main industry which required huge amount of sand. this requirements can be covered by beach sand dunes as the of the natural resources(Diwan, 2013). Al-Harthy et. al., (2006), studied effect of sand dune on the properties of concrete (such as workability, compressive strength, tensile strength, modulus of elasticity and initial surface absorption test) made from sand dunes by preparing different concrete mixtures using Ordinary Portland Cement and their results showed an improvement in workability of concrete when the fine aggregates were partially replaced by dune sand by maximum rate less than 25%.

However, The aim of this study is to investigate some chemical and physical properties of beach sand dunes in Wadi Kaam beaches and estimate the ability of usage sand dunes as a raw material in the building materials industry such as concrete production and bricks manufacturing.

Sediments sampling

Six location in Zliten beach were selected to examine some of chemical and physical properties of sediments (GPS coordination shown in Table 1). These locations were chosen carefully to provide good area coverage in June 2020. Five of these location were Mediterranean sea sand and last location was sand dunes as they illustrated in figure 2. Each beach location was divided to three Sampling sites and the distance between sites were 500 meter. Three dunes sand samples were collected one from the top of dune and two from the different sides of the dunes.

Table 1: The relationship between wind velocity and the size of sand grains according to Bagnold, (1973)

The diameter of grains of sand (mm)	The speed required to transport grains of sand (m/s)
0.25	4.5-6.7
0.50	6.7-8.9
1.10	8.9-11.4
1.50	11.4-13.0

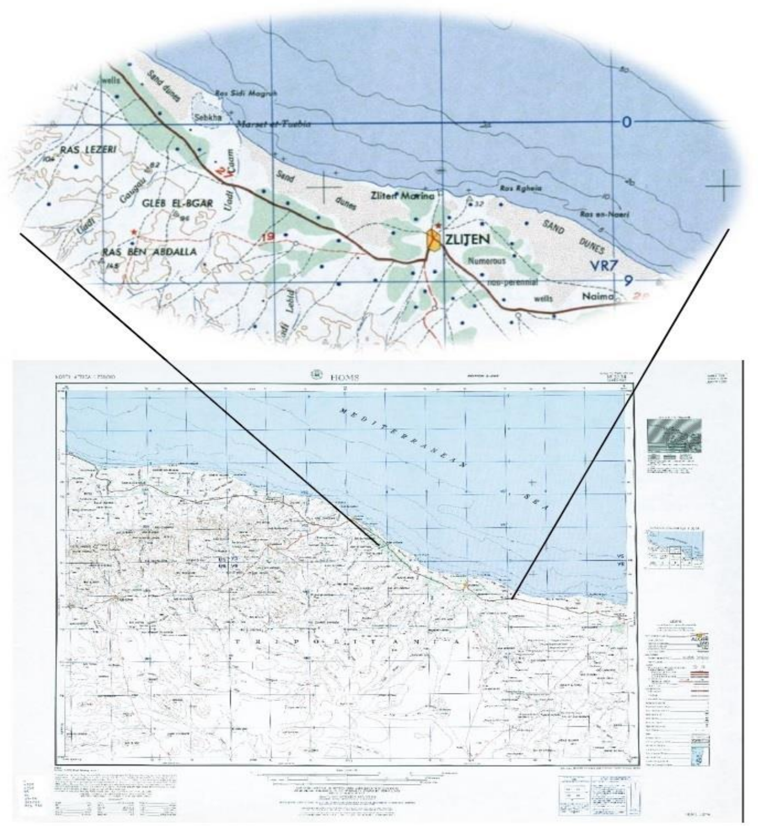

Figure 1: Study area and sampling locations

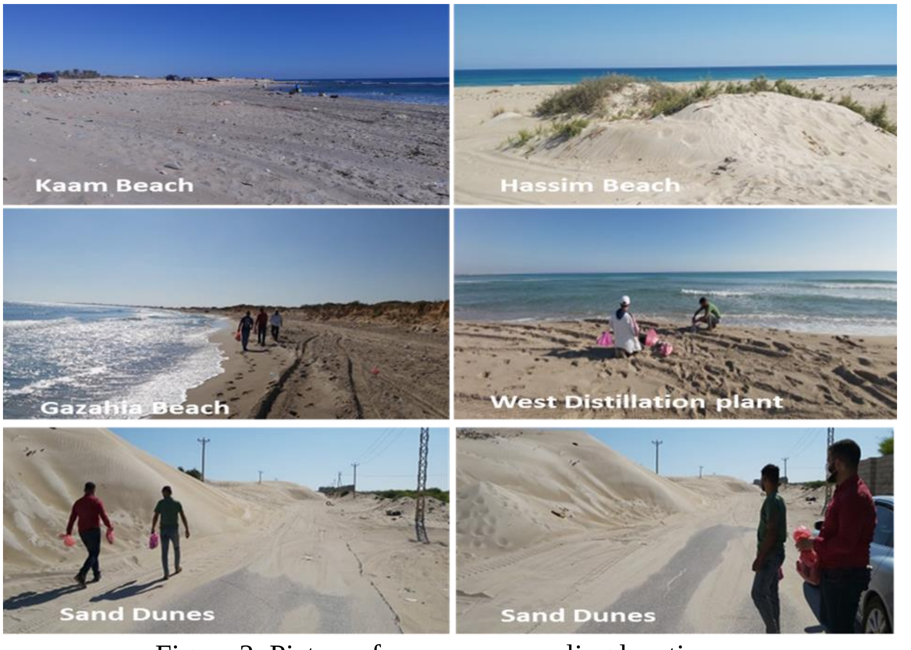

Figure 2: Pictures from some sampling location

Methods of controlling the movement of sand dunes by exploiting them in the manufacture of building materials (fixing sand dunes)

The phenomenon of sand encroachment is the last stage of the degradation of the natural environment, which begins either from the sand sources in the deserts, especially the arid desert or from fixed sand areas (Etrab 1993). The imbalance in the environment and its degradation mostly arise from human factors, often due to the inappropriate exploitation of available resources such as water, soil and vegetation (Corachi, 1992). However, sand encroachment can be a natural process resulting from a variety of factors (high rates of wind speed and temperature, low levels of precipitation and humidity, as well as reduced Vegetation cover). possibility of using sand dunes as a raw material in the building materials such as concrete and cement bricks by comparing of the important chemical and physical properties of sand with the Libyan and British standards.

Impact of sand dune encroachment

Sand dune movement is continuous that affects human activities. The effects of sand dunes movement can be divided into two parts as shown below:

1- Effects of sand encroachment on agricultural and pastoral activities

Sand movement covers agricultural, marginal lands and pastoral lands (Draz, 1995). Al-Jadidi (1992) reported that sand movement causes two types of damage cost.

The first type is the decrease in the productivity of the land due to the salinity of the land, about 40% of the productivity.

The second type is the cost of addressing this problem, in terms of assessing the devastating effects of this phenomenon.

2- Effects of sand encroachment on buildings and transportation

The continuous and permanent movement of sand dunes affect the buildings which to be covered in a short time, especially in areas that suffer from prolonged drought.

Libya has also been exposed to this phenomenon in previous periods. Alquan Beachy (1821-1822) mentioned that some coastal villages of Libya were covered with quicksand during that period.

Material and methods

Study area:

this study has been applied on costal of Mediterranean sea in Zliten city between Wadi Kaam (N32º31'38.40"and E14º28'2.00") and Zliten port (N32º29'55.60"and E14º33'45.60"). Zliten city is located in the northwestern part of Libya, It is about 157 Kilo meter away from the city of Tripoli (Figure 1). The area population is 231000 According to the 2010 census and people are distributed over 3600 square kilometers, the study area dominated climate is Mediterranean climate, with the annual rainfall in it ranges between 200 to 300 mm and the rainfall is during short period of rain, which is not sufficient for the needs of the region. The hours of sunshine in the region are not less than 2500 annually (Al-Zaya, 2005). Holocene deposits is represented the rock of costal area, which are formations of deposits of modern valleys, deposits of modern marsh deposits and wind sediments, and beach sand covers about 25% of the area, and the Pleistocene region represented by the deposits of ancient marsh deposits and these sediments consist of fine sand, silt and gypsum, and these sediments cover an area that does not exceed 6% (Industrial Research Center, 1975).

Sediments sampling:

Six location in Zliten beach were selected to examine some of chemical and physical properties of sediments (GPS coordination shown in Table 2). These locations were chosen carefully to provide good area coverage in June 2020. Five of these location were Mediterranean sea sand and last location was sand dunes as they illustrated in figure 1. Each beach location was divided to three Sampling sites and the distance between sites were 500 meter. Three dunes sand samples were collected one from the top of dune and two from the different sides of the dunes.

Table 2: The GPS coordination of Sampling Location

The GPS coordination of Sampling location		Location	
2.00'''E14°28	38.40'''N32°31	B 110	Kaam Beach
10.30'''E14°28	31.30'''N32°31	B 120	
21.70'''E14°28	26.50'''N32°31	B 130	
56.10'''E14°26	57.90'''N32°30	B210	Gazahia Beach
56.10'''E14°26	53.40'''N32°30	B 220	
56.10'''E14°26	48.90'''N32°30	B 230	
6.40'''E14°30	23.10'''N32°30	B 310	Hassim Beach
19.20'''E14°30	21.70'''N32°30	B 320	
32.40'''E14°30	20.40'''N32°30	B 330	
23.00'''E14°31	16.70'''N32°30	B 410	West Distillation plant
37.70'''E14°31	13.20'''N32°30	B 420	
50.60'''E14°31	11.10'''N32°30	B 430	
45.60'''E14°33	55.60'''N32°29	B 510	Zliten Marine Club
58.00'''E14°33	52.90'''N32°29	B 520	
6.40'''E14°34	56.80'''N32°29	B 530	
10.60'''E14°30	13.90'''N32°30	D 010	Sand Dunes
11.10'''E14°30	14.20'''N32°30	D 020	
11.70'''E14°30	17.50'''N32°30	D 030	

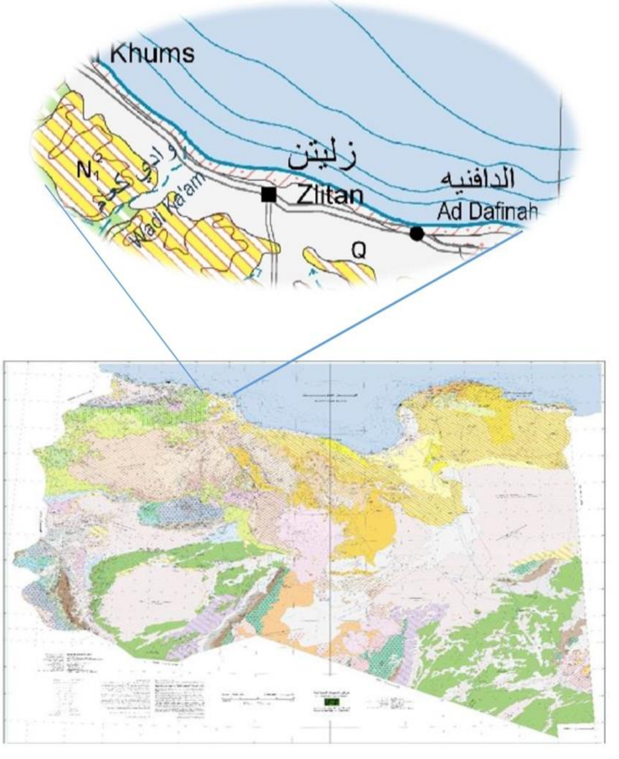

Figure 1: Study area and sampling locations

Result and Discussion

The physical properties of sand

The physical properties of sand samples are presented in Table 4. The solid density of sand samples ranged between 2.69 g cm-3 to 2.57 g cm-3. The values of solid density are are lower in comparison with Brady (1974) results which were reported that, the solid density of sandy soil are 2.89 g cm-3.this difference can attributed to the sand of beaches have higher carbonate percentage due to shield of died marine animals and the carbonate density less than quartz. The difference between sampling locations and between sample sites in same location are un-significant. For example, Kaam Beach sample , the solid density of sand was 2.69 g cm-3 in

site 1 while in site 2 and site 3 were 2.67 and 2.67 gcm-3 respectively, This behaviour were observed in all sampling locations (Table 4). The difference between sampling locations are un-significant ,
for example ,the solid density of West distillation plant samples were 2.51, 2.64 and 2.65 g cm-3 in site a ,site 2 and site 3 respectively, while they were 2.58, 2.61 and 2.62 g cm-3 in site a ,site 2 and site 3 of Gazahia beach respectively. Moreover, the solid density of sand dune were 2.58, 2.57 and 2.58 g cm-3 in site a ,site 2 and site 3 respectively(Table 3).

Table 3: Physical properties of sand samples in different locations of Zliten beaches

silt and clay	very fine sand	fine sand	medium sand	coarse sand	very coarse sand	Porosity	Bulk Density	Solid Density	Locations	
%						-	g/cm^3	g/cm^3		
0.00	0.26	11.00	88.26	0.48	0.00	0.506	1.33	2.69	Site 1	Kaam Beach
0.00	0.00	3.20	94.60	2.00	0.20	0.399	1.61	2.67	Site 2	
0.00	0.26	17.86	81.4	0.48	0.00	0.438	1.50	2.67	Site 3	
0.00	0.40	19.02	79.86	0.60	0.12	0.445	1.43	2.58	Site 1	Gazahia Beach
0.00	0.10	9.61	88.89	1.40	0.00	0.474	1.37	2.61	Site 2	
0.00	0.04	13.01	85.27	1.64	0.04	0.465	1.40	2.62	Site 3	
0.00	0.12	14.80	84.00	1.00	0.08	0.404	1.54	2.58	Site 1	Hassim Beach
0.00	0.64	37.60	60.60	1.00	0.16	0.417	1.50	2.57	Site 2	
0.00	0.40	48.80	50.06	0.60	0.14	0.444	1.44	2.58	Site 3	
0.00	1.26	20.20	78.60	0.14	0.00	0.514	1.27	2.61	Site 1	Sand Dune
0.10	1.00	36.20	62.40	0.10	0.00	0.403	1.54	2.58	Site 2	
0.10	1.20	44.52	54.00	0.18	0.00	0.332	1.73	2.59	Site 3	
0.00	1.66	46.00	52.20	0.14	0.00	0.320	1.71	2.51	Site 1	West Distillation plant
0.00	0.80	30.66	67.12	1.40	0.02	0.442	1.47	2.64	Site 2	
0.00	1.00	52.60	44.40	2.00	0.00	0.387	1.62	2.65	Site 3	
0.00	0.46	5.80	83.40	2.00	1.34	0.398	1.58	2.62	Site 1	Zliten Marine Club
0.00	0.62	17.80	80.40	1.00	0.18	0.423	1.53	2.65	Site 2	
0.00	0.80	12.80	84.20	2.00	0.20	0.405	1.55	2.61	Site 3	

The difference between sampling site in Gazahia beach and Zliten marina club were un-significant as they are illustrated in Table 4. For example, the bulk densities of sand in Zliten marina club were 1.58 g cm-3 , 1.53 g cm-3 and 1.55 g cm-3 in site1,site2 and site3 respectively. In sand dune the wind play significant role in the value of sand bulk density

Table4: Percentage of sand by mass passing sieve

Sieve size	West Distillation plant	Zliten Marine Club	Sand Dune	Hassim Beach	Gazahia Beach	Kaam Beach
	Percentage of sand by mass passing sieve					
10.00 mm	100.00	100.00	100.00	100.00	100.00	100.00
5.00 mm	100.00	100.00	100.00	100.00	100.00	100.00
2.36 mm	100.00	99.96	100.00	100.00	99.95	100.00
1.18 mm	99.93	99.43	100.00	99.87	99.86	99.93
600 µm	99.39	89.43	99.86	99.01	98.65	98.95
300 µm	72.66	13.43	34.86	34.12	14.05	10.86
150 µm	16.26	0.69	1.22	0.39	0.18	0.17

The Chemical Properties Of Sand

The pH of sand solutions are shown in figure 3. The pH values were fluctuated between slight acidity in most samples to slight base. These value are ranged from 6.51 to 7.42. In sampling location Zliten marine club beach and west distillation plant beach, the pH value are slight base, the pH value were 6.96, 7.23 and 6.99 in site 1, site 2 and site 3 of Zliten marine club beach respectively. In west distillation plant beach, the pH value were 7.03, 7.42 and 7.25 in site 1, site 2 and site 3 respectively. The pH value decreased significantly with increase distance from sea. These value was 7.09 in front of sea side of dune and decreased to 6.77 in top of dune and become more acidity in the porosities of sand dune and riche 6.56.

the pH of sand samples in Kaam beach, Hassim beach and Gazahia beach were slightly acid. For example , the pH were 6.67, 6.75 and 6.77 in site 1, site 2 and site 3 of Gazahia beach respectively, and this behaviour can mentored in Kaam beach and Hassim beach (figure 3).

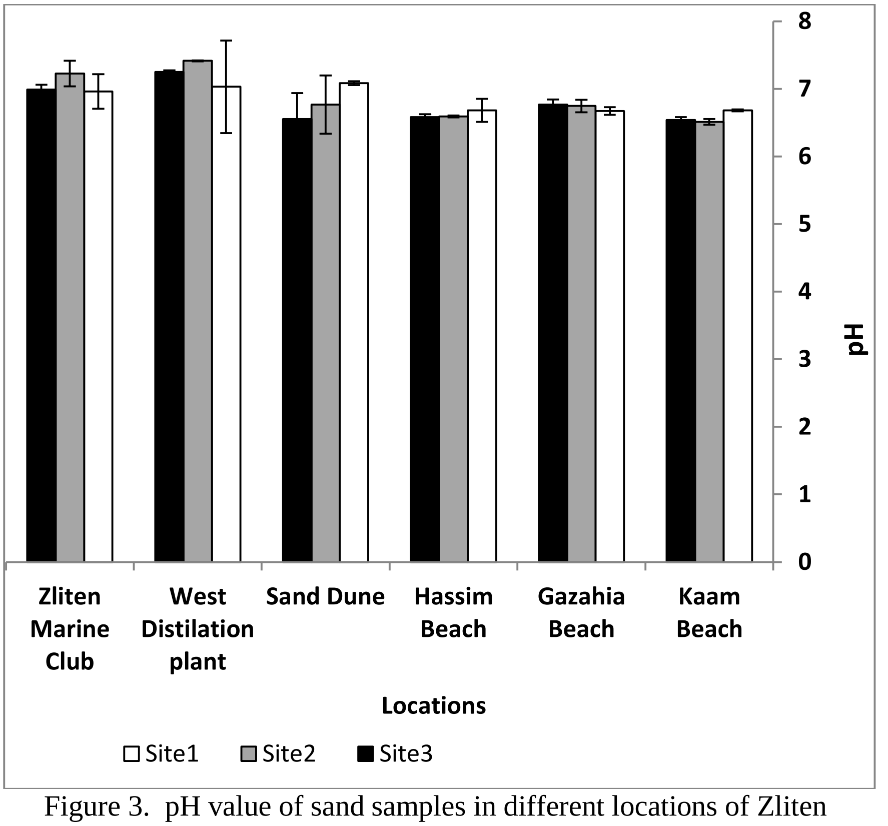

Figure 3. pH value of sand samples in different locations of Zliten beaches

How to take advantage of coastal sand dunes

The diameter of sand particular is very important in concrete manufacturing. Therefore, the Libyan and the British standards take in consideration the percentages of sand passing different sieve diameters as the one of the most important criterion for concrete production. The percentages of sand beaches and dunes which passing different sieve diameters are illustrated in Table 5.

Table 5: Percentage of sand by mass passing sieve

Sieve size	West Distillation plant	Zliten Marine Club	Sand Dune	Hassim Beach	Gazahia Beach	Kaam Beach
	Percentage of sand by mass passing sieve					
10.00 mm	100.00	100.00	100.00	100.00	100.00	100.00
5.00 mm	100.00	100.00	100.00	100.00	100.00	100.00
2.36 mm	100.00	99.96	100.00	100.00	99.95	100.00
1.18 mm	99.93	99.43	100.00	99.87	99.86	99.93
600 µm	99.39	89.43	99.86	99.01	98.65	98.95
300 µm	72.66	13.43	34.86	34.12	14.05	10.86
150 µm	16.26	0.69	1.22	0.39	0.18	0.17

Conclusion and Future work

Conclusion:

This study aimed to examine the possibility of using sand dunes as a raw material in the building materials such as concrete and cement bricks by comparing of the important chemical and physical properties of sand with the Libyan and British standards.

The physical properties of beaches sand and dune sand were studied and the solid, bulk densities and porosities regarded with Libya sandy soil values with small differences due to differences in parent materials. The percentage of sand depending on sieves were ranged from Coarse sand to silt and clay. However, The percentage of Coarse sand, very fine sand and silt and clay were very small. The greater part of the sand percentage were in medium sand and fine sand.

The pH of beaches and dune wand were normal and the chemical properties of sand beaches such as Chloride ion. Sodium ion, Potassium ion and Electrical conductivity affected by sea water, However, in Kaam beach, due to fresh water from valley, the salt leaching is dominated, the concentration of these chemical properties were low. The concentration of Calcium, Magnesium and calcium carbonate were affected by parent rock material. The chemical contents of dune sands were lower than beaches sand that can attributed to distances between dunes and the sea and rolls of rain water in the process of e salt leaching.

Research aims

The aim of this work is to investigate some chemical and physical properties of beach sand dunes in Wadi Kaam beaches and estimate the ability of usage sand dunes as a raw material in the building materials industry such as concrete production and bricks manufacturing.

Research objectives:

1. To determine the sand dunes physical properties such as particle size distribution, bulk density, parent density and porosity of sand dunes .

2. To determine the sand dunes chemical properties such as pH, electrical conductivity, chloride ion. sulfate ion, phosphate ion, sodium ion, potassium ion, calcium ion, magnesium ion , percentage of organic matter and percentage of carbonate of sand dunes.

3. To estimate the possibility of usage sand in concrete production and bricks manufacturing.

How to take advantage of coastal sand dunes :

The sand dunes movements is a natural process resulting from a variety of factors such as high rates of wind speed, temperature, low levels of precipitation and humidity, as well as reduced Vegetation cover. Therefore, this phenomenon is considered as the massive serious environmental dangerous on the natural environment. Moreover, the dangerous of this movements will increased in sensitive area such as arid and semiarid lands which effect on many economy sectors in Zliten city such as agriculture, tourism, transportation and buildings. There are many suggested methods to mitigation or control this problem. Moreover, all various methods are only aimed to stabilizing and or restricted sand movement, such as vegetation fixation by planting the most suitable types of plants on sand dunes and mechanical fixation by reducing wind velocity through the use of barriers. All of these mitigation methods are prone to failure due to formation of sand dunes near the city and the fact that these areas are used for swimming and fishing, and the vegetation fixation could be need amounts of water which is not available due to the rate of water rain is fluctuating from year to year and the lack of good water to irrigate the vegetation. Moreover, the low awareness of the population can contributes to the low yield of these operations. These solutions are not economically feasible, as they need annual care that requires financial expenses over the years. Moreover, the accumulation of sand and size of the dunes will increased annually due to sedimentation from the sea that make these barriers are unfeasible. In this study, it is suggested the economically effective- cost methods by using the sand of dunes in the building materials industry as the source of sand for concrete and cement bricks. These can offer jobs and produce low price products.

The usage of sand and aggregates in the building materials industry requires the availability of certain properties in sand and aggregates. These properties must be correspond with the building materials industry standards. In this study, the Libyan and British standards were used for their compatibility with each other in the important characteristics. These standards are illustrated in Appendix A to D.

The diameter of sand particular is very important in concrete manufacturing. Therefore, the Libyan and the British standards (Appendix A) take in consideration the percentages of sand passing different sieve diameters as the one of the most important criterion for concrete production. The percentages of sand beaches and dunes which passing different sieve diameters are illustrated in Table 5. The sand dunes and sand from Kaam, Hassim, Gazahia and Zliten Marine Club are correspond with the overall limits and grade f limits of the British standards standard which illustrated in Appendix A., while there is no corresponding with grade C and D limits, only in the percentage of sand passing sieve 600 µm. The sand from West Distillation plant beach doesn't corresponding with grade C, D and F limit and overall limits in the percentage of sand passing sieve 600 µm and 300 µm. The sand especially from sand dunes able to use in many type of concrete depending on percentage of sand passing sieves.

The percentage of fine aggregate which passing the 75 µm sieve have another definition is clay and silt. The percentage of clay and silt in sands of beaches and dune are very small and ranged between 0.00% to 1.66%. these percentages are correspond with the Libyan and the British standards which illustrated in Appendix b. The percentage of Sulphate in sand of beaches were ranged between 265.6 mg/l (0.0265%) to 989.58 mg/l (0.099%), while in sand dunes the Sulphate content. These percentages are lower than the percentage values in Libyan and the British standards. Therefore, these sands able to use in the building materials industry.

The Chloride contents in sand dunes and sand of beaches were ranged between 0.27 g/l (0.027%) to 12.90 g/l (1.29%), while in sand dunes the Sulphate content were 0.53 g/l (0.053%), 0.27 g/l (0.027%) and 0.27 g/l (0.027%) in site 1, site2 and site3 respectively. The Chloride content values in sand beaches are exceeded the maximum permissible content of Chloride in the Libyan and the British standards (Appendix C) and the usage of the beaches sand in concrete will correspond with higher dangerous due to higher Chloride contents in all concrete types except type of concrete which don't have steel. Due to the Chloride content in dunes low than 0.03%, the sand of dunes can used in concrete production which required Chloride contents between 0.03% to 0.05% such as concrete containing embedded metal made or cement bricks (Appendix c).

The Sulphate contents in sand dunes and sand of beaches are correspond with the Libyan and the British standards. The percentage of Sulphatein sand of beaches were ranged between 265.6 mg/l (0.0265%) to 989.58 mg/l (0.099%), while in sand dunes the Sulphate content were 302.1 mg/l (0.030%), 265.6 mg/l (0.027%) and 322.9 mg/l (0.032%) in site 1, site2 and site3 respectively. These content values lower than the maximum permissible content of Sulphatein the Libyan and the British standards which was 0.5 % for Concrete containing embedded metal and 1.0% for other concrete (Appendix d).

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Appendixes

Appendix A

Guidance on the Sand percentage depending on British Standard BS 882:1992 and Libyan Standard No. 49.

Sand

Sieve size	Percentage by mass passing BS sieve			
	Overall limits	Additional limits for grading		
		C	M	F
10.00 mm	100	—	—	—
5.00 mm	89 to 100	—	—	—
2.36 mm	60 to 100	60 to 100	65 to 100	80 to 100
1.18 mm	30 to 100	30 to 90	45 to 100	70 to 100
600 µm	15 to 100	15 to 54	25 to 80	55 to 100
300 µm	5 to 70	5 to 40	5 to 48	5 to 70
150 µm	0 to 15[a]	—	—	—

NOTE Individual sands may comply with the requirements of more than one grading. Alternatively some sands may satisfy the overall limits but may not fall within any one of the additional limits C, M or F. In this case and where sands do not comply with Table 4 an agreed grading envelope may also be used provided that the supplier can satisfy the purchaser that such materials can produce concrete of the required quality.

[a] Increased to 20 % for crushed rock fines, except when they are used for heavy duty floors.

Appendix B

Guidance on the Fine (material passing the 75 µm sieve which are Silt & clay) depending on British Standard BS 882:1992 and Libyan Standard No. 49.

Fines

Aggregate type	Percentage by mass passing 75 µm sieve (max.)
Uncrushed, partially crushed, or crushed gravel coarse aggregate	2
Crushed rock aggregate	4
Uncrushed, partially crushed or crushed gravel sand	4
Crushed rock sand	16 (9 for use in heavy duty floor finishes)
Gravel all-in aggregate	3
Crushed rock all-in aggregate	11
NOTE The nature of the fines can vary between different aggregates. The limits given above are appropriate for most aggregates found in the UK. Evidence of performance in use or the result of trial mixes may be used to justify the adoption of higher or lower limits.	

Appendix C

Guidance on the chloride content of aggregates depends on British Standard BS 882:1992 and Libyan Standard No. 49.

Limits for chloride content of aggregates

Type and use of concrete	Chloride ion content expressed as percentage by mass of combined aggregate
Prestressed concrete and heat-cured concrete containing embedded metal	0.01
Concrete containing embedded metal made with cement complying with BS 4027	0.03
Concrete containing embedded metal and made with cement complying with BS 12, BS 146, BS 1370, BS 4246, BS 6588, BS 6610 or combinations with ground granulated blastfurnace slag (ggbs) or pulverized-fuel ash (pfa)	0.05
Other concrete	No limit

Appendix D

Guidance on the sulphate content depending on Libyan Standard No. 49

Type of concrete	Sulphate ion content expressed as percentage by mass of combined aggregate
Concrete containing embedded metal	0.5
Other concrete	1.0