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The Construction of Economic Green Buildings in Sinai and Suez Canal Zone Using Compressed Stabilized Earth Technique

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Abstract

Currently, there are several technologies applied in many societies to improve the use of the environmental resources such as the use of soil with some binders in the construction of buildings, and the usage of the stabilized earth architecture technique by new urban communities. One of the advantages of these buildings is that they make good use of the environment and save energy and expenditure.

This project deals with the use of the sandy soil which resulted from the excavation of the buildings. It also targets the design and building of whole low energy, ecological, and low-cost green building/villages in the future projects in Sinai and Suez Canal zone, using stabilized earth architecture. The sandy soil under study is that of the sand on the east side of the Suez Canal in Sinai which is a by-product of the dry excavation and wet drilling of the canal.

This paper shows that passive and energy efficient techniques incorporated in building designs can reduce the electricity requirements. The most effective parameter is the thermal efficiency of building envelope and blocking sun rays. The available renewable energy systems can meet parts of building loads. Thermal bridges are not so common in the bearing wall construction method.

Herein in this paper, several specimens were collected from different sites in Elferdan and Serapum in Sinai (Suez canal zone) along the east side of the Suez Canal to investigate the suitability of stabilizing this soil for the production of compressed earth blocks for low-cost ecologic building construction. Several tests, e.g., sieve analysis and the proctor test, were made of the specimens. The results showed that the ratio of salts, chlorides, and sulfates were low. In addition, the specimens collected sieve analysis ranged from coarse to fine sand.

Stabilizing the materials resulted from the by-production in the industry can be used for minimizing the coast of compressed stabilized earth buildings with high engineering properties. Experiments on the produced compressed stabilized earth bricks (CSEB) with different level of stabilizing agent (by-product materials) were made using one of the specimens collected from Elferdan zone. The results showed that the 35% CKD ratio of sand weight can be considered as the optimum CKD content; which provides the best properties for the admixture as long as the percentages of cement (OPC) and the fiber-reinforced polymer (FRP) are 5% and 0.07% of sand weight, respectively. The rest of this research will be completed in the next parts, which includes finding more mechanical, engineering, and thermal properties of the produced CSEB.

Keywords

Green buildings; Compressed stabilized earth buildings; Sinai; Suez canal zone

1. Introduction

The construction of Sinai and Suez Canal Zone is an important national project. The sand installed on the east side of the Suez Canal in Sinai, and that resulted from the dry excavation and wet drilling of this canal, can have many environmental benefits. The project includes using this installed sand in designing and building whole zero energy, low coast ecological green building/communities using stabilized earth architecture technique especially in Sinai on the east side of the Suez Canal, to take part in the prosperity of the Suez Canal Zone. The proposal scheme appears from figures 1 to figure 6 below, show example of building models that can be constructed using compressed architecture technique.

Figure 1: The plan of a residential one story prototype building

Figure 2: The isometric of a residential one story prototype building

Figure 3: The plan of a two stories residential prototype building.

Figure 4: Back side view of the two stories residential prototype building.

Figure 5: Front side view of the two stories residential prototype building.

Figure 6: The suggested layout for the prototype house

Scheme 1: Full design proposal for the prototype building

The project objects to have internal thermal comfortable day lighted buildings, contributing towards solving the housing and city crowd problem, and the possibility of building in remote desert lands without being connected to any electricity or water or sewage grid, only road & moderate ground water aquifer is needed.

The project includes, first the determination of soil and defining its classification and characteristics. The soil is stabilized with a binder depending on soil type, to improve soil properties. The mixture is then compressed into molds to produce compressed stabilized earth blocks (CSEB). The engineering and mechanical properties of the CSEB are then determined. The architecture design of the building is then made according to green architecture parameters, and CSEB design constrains, to provide moderate thermal environment inside the building and take advantage of natural lighting and ventilation, and renewable energy sources. The structural design is made according to the Egyptian codes including the earthquakes' construction requirements to assure its efficiency and safety. Finally, the execution process begins according to the Egyptian rules and specifications to achieve the requirements of safety, operation, and maintenance.

Part one in this paper tackles with the analysis of energy efficiency buildings and if the sandy soil installed on east side of the Suez Canal in Sinai be used in the construction of these buildings using compressed stabilized earth technique? And what type of stabilizer (by-product material) which can be used to produce low cost ecologic CSEB?

2. Literature Review

2.1. Introduction to energy efficiency

The rate of electricity consumption is increasing rapidly in Egypt. The residential and industrial sectors are considered as the two major end users of electricity in Egypt. The average annual growth rate of the residential sector is 7.5% over the last five years. It is increasing rapidly. (Mourad, Ali, Abdel-Rahman, & Ookawara, 2014)

Occupant's need for thermal, biologic and visual comfort can be considered during Building design with the reduction of the energy consumption level. Energy efficiency and passive technique can be incorporated in building design at the early design stage to minimize loads of the conventional systems such as lighting, ventilation, cooling and heating, and to design energy efficient lighting. The renewable energy systems like solar photovoltaic and solar heating water systems can be used to meet part of building energy loads and reach the comfortable zone, Figure 1.

A national energy efficiency plan for promoting more efficient use of energy has been prepared. It includes using of renewable energy systems, improving energy efficiency in public buildings and street lighting, and increasing use of light emitted diode lamps (LEDs).

2.2. Compressed stabilized earth

Many studies have focused on the investigation of alternative low coast construction materials. This is due to the increasing costs of traditional and ordinary building materials. The aim is to develop inexpensive energy efficient construction materials for the construction of low cost sustainable buildings.

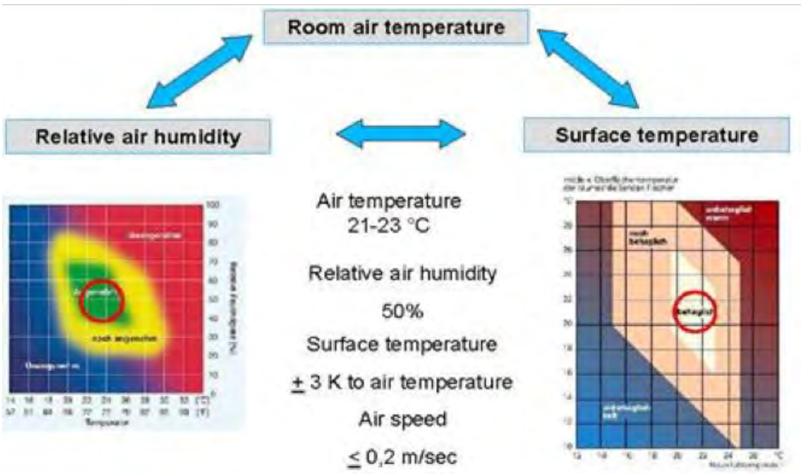

Figure 1. Comfortable zone

Masonry is one of the popular materials for building construction due to its useful properties such as durability, relatively low price, good heat and sound insulation, acceptable fire resistance, appropriate and satisfactory resistance to weathering, and likable appearance.

Adequate erosion resistance and compressive strength are normally required in the materials used for the construction. The direct use of earth soil for building construction without any modification has some disadvantages like low mechanical characteristics and durability, low performance, and dissatisfying resistance to weathering. These disadvantages can be enhanced by stabilizing the soil with a binder, depending on the soil type, for improving chemical and mechanical properties of this soil (Fetra, Rahman, & Zaidi, 2011; Deboucha & Hashim, 2011). The process of compaction improves the strength of the stabilized soil and leads to high compressive strength and good resistance to erosion. The stabilization and compacting techniques produces compressed stabilized earth blocks(CSEB). They are a low cost, strong, and durable blocks for building construction.

CSEB have some advantages which includes the use of local materials, the production is in site so the transportation coast is reduced. Compressed stabilized earth construction method is a fast and easy construction method, and generates local economy. The produced CSEB have good strength. The carbon emission and embodied energy in the production phase are low, so a low level of waste is produced which cause no environmental pollution (Deboucha & Hashim, 2011).

The remarkable difference between the conventional bricks and CSEB is the energy consumed and carbon emission during the production process. The concrete blocks, common fired clay bricks, and aerated concrete blocks creates during their production 143, 200, 280-375 kg CO2/ton respectively, while the CSEB creates 22 kg CO2/ton (Fetra, Rahman, & Zaidi, 2011).

2.3. Stabilizing materials

Portland cement, lime, fly ash, silica fume, fly ash with cement or lime, and cement kiln dust (CKD) can be used as stabilizing materials added to the soil to enhance its properties. Cement is usually used in the stabilization of sandy soil. Lime is usually used in stabilization of fine grained soils like clay. The coal combustion in power plants produces fly ash as a by-product. The engineering properties of soil can be improved by the addition of fly ash to lime or cement. Silica fume can be used also.

The cement manufacturing process produces CKD as a by-product material. The raw material and energy that was wasted to produce CKD are considered as a loss of money for cement industry, as CKD is a disposable material. Therefore, using CKD would be much more cost effective than just getting rid of it away as a waste material. The CKD contain higher concentration of sulfates, alkalis, and free lime. The adding of CKD affects the compaction characteristics of the soils.

3. Energy Efficiency in Buildings

As one of the aims, is to design a low coast energy efficient buildings at early stage of planning of new societies in Egyptian desert, a single and two story house prototypes were introduced. The housing unit is of area 112 m2 and a garden of 90 m2. This suggested prototypes are designed for the habitation of people in Egyptian new cities which consider one of the key solution for the crowdedness in the delta and around the river Nile.

The proposed prototypes are making use of passive and energy efficiency techniques that are incorporated in building design than regular design technique. They also can make use of the available renewable energy resources. Although renewable energy systems are expensive now a day, with the fast development in technology, the prices become more manageable.

3.1. The passive and energy efficiency techniques

The passive and energy efficiency approach includes different environmental design strategies to avoid heat transfer through the building envelope. Sun rays are blocked away from building envelop through tress and external shadings devices, which decreases the solar heat gain, Figure 3. The solar heat gain through roof is reduced either by shading or insulation. The vertical east and west facades are subjected to the largest solar intensities, the heat gain can be reduced when the smaller facades are on the east and west sides. The building orientation along the east-west axis is the preferred orientation. However in the neighborhood the buildings shades each other, Figures 1-3. Optimization of building form reduces the building heated volume, decrease the geometric heat bridges and improve daylight.For the one story prototype house the calculated energy demand (electricity required) for cooling the building decreased by about 50% from 25.8 kwh (regular design) to 13.9 kwh (energy efficient design) as the thermal balance decreases from 20.25 kw to 11.1 kw, as shown in Equation 1. The CO2 emission decreases by 50% from 14 tons/year to 7 tons/year. It worth mention that the thermal resistance (U value) of CSEB is assumed to be 1.4 w/m2c (U value of cement mortar).

For the two story prototype house the calculated energy demand (electricity required) for cooling the building decreased by about 46% from 47.41 kwh (regular design) to 25.57 kwh (energy efficient design) as the thermal balance decreases from 37.9 kw to 20.6 kw, as shown in Equation 1. The CO2 emission decreases by 46% from 27.45 tons/year to 14.92 tons/year.

$$
\begin{aligned}
&Q\,total\ =\ Q\,Transmission\ +\ Q\,Ventilation\ -\ Q\,Internal\ loads\ -\ Q\,Solar\\
&Where\ Q\,Transmission\ =\ Thermal\ transmit\tan ce\\
&Q\,Ventilation\ = Ventilation\ loads\\
&Q\,Internal\ loads\ = Internal\ heat\ loads\\
&Q\,Solar\ = Solar\ Gain
\end{aligned}
\tag{1}
$$

Building envelope design (size and window location) provides the minimum required daylight access, minimum heat gain and maximum external reflection. The maximum window wall ratio is 18% of building envelope and the maximum glazed area is 10% for south oriented room, such that daylight should not drop than the intensity needed by our biologic and visual systems. For the one story prototype house, the window wall ratio for north, south, and west facades are 18.8%, 8.7% and 6.22%. While there are no openings in the east façade except the house entrance. For the two story prototype house, the window wall ratio for north, east, south, and west facades are 17.2%, 6.22%, 9% and 12.4%. The best way to daily reset our circadian clocks and stimulate our bodies to produce a healthy dose of Vitamin D is 1-2 hours (complete activation duration) of exposure of a minimum of 1000 lux (starting quantity) of natural light each morning (duration of exposure is inversely proportional to quantity of luminance at the eye), Figure 2.This exposure should not drop below fifteen minutes under any circumstances. Then daylight quantity can be reduced (after 2:00 PM) such that the quantity of daylight enclosed in the space is enough to support vision system. The design of the openings system thus must fulfill the previous considerations (Abdel-latif, 2005). Light Nano-coat paintings are preferred to be used as they are thermal resistance.

Internal reflected light isn't affected by the change in window opening shape, within an elevation angle of 50° from the horizontal. However once the elevation angle is above 50° from the horizontal, the vertical window configuration is better than the horizontal window configuration (Abdel-latif, 2014).

$$
\begin{aligned}
&Q\,Trans.\ =\ \Sigma Ai * Ui * \Delta T\ =\ A\,Exterior\,wall\ \times\ U\,Ext.r\,wall\ \times\ \Delta T\ Ext.\,wall\ +\ A\,win \times\ U\,win \times\ \Delta T\ win\\
&+A\ roof\ \times\ U\ roof\ \times\ \Delta T\ roof
\end{aligned}
\tag{2}
$$

Where A=Area of building element (m2); U=Thermal resistance (w/m2c); ΔT=Temperature difference between external and internal temperature.

Thermal insulation of energy efficient building envelop play a great role in energy saving as it reduces the heat transfer to the indoor spaces. The better insulation capacity lowers the thermal transmittance (U value). For the one story prototype house, the thermal transmittance decreases from -8.1 kw (regular design) to -3.7 kw (energy efficient design) as shown in equation 2. For the two stories prototype house, the thermal transmittance decreases from -15.1 kw (regular design) to -5.2 kw (energy efficient design). For the two prototypes, the thermal resistance of walls decreases from 2.46w/m2c (regular design) to 0.66w/m2c (energy efficient design), Figure 3.The thermal resistance of the roof is 0.43w/m2c. The internal temperature decreases about 4 °C from 26 °C to 22 °C. It worth mention that the used windows are single glazed window (U= 5.8w/m2c). Although, double glazing windows

(U= 2.8 w/m2c) are more thermal resistance, but they are very expensive (about 1500 L.E/m2). For the one story prototype house, upon installing double glazing windows, the energy demand (electricity required) for cooling the building decreased to 12 kwh (energy efficient design) as the thermal balance decreases to 9.5 kw, and the thermal balance decreases to -2.9 kw. The CO2 emission decreases to 6.9 tons/year. For the two story prototype house, upon installing double glazing windows, the energy demand (electricity required) for cooling the building decreased to 21.57 kwh (energy efficient design) as the thermal balancedecreasesto17.25kw,andthethermalbalancedecreasesto-5.2kw.TheCO2 emission decreases to12.49 tons/year. The using of double glazing windows didn't decrease the energy demand for cooling loads, thermal balance, and Co2 emission very much. It is better to use single glazed windows as they are very cheaper than the double glazing windows

The construction method is bearing walls such that the thermal bridges are avoided in the building envelope. A thermal bridge is an area within building elements, in which the heat energy is rapidly transported to the inside than in the remainder of these elements. However, thermal bridges are very common in the common construction method which is the reinforced concrete structure (columns, beams and floor slabs) filled in with block work or brick walls (Visser & Yeretzian, 2013).

Natural air ventilation uses both wind and temperature difference to cool the building interior. The courtyard and openings placed in the north elevation help in cooling down the air flow before entering the house spaces and is used to release heat and humidity.

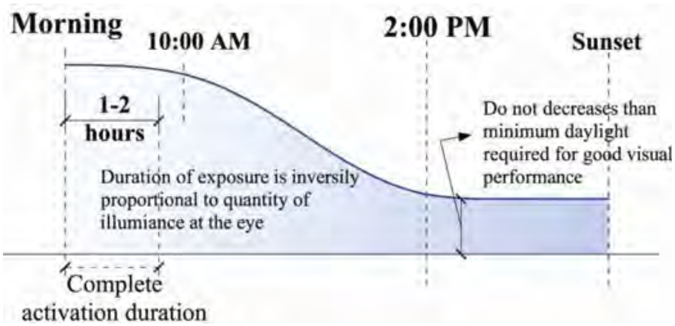

Figure 2. Healthy day-lighting system along the day

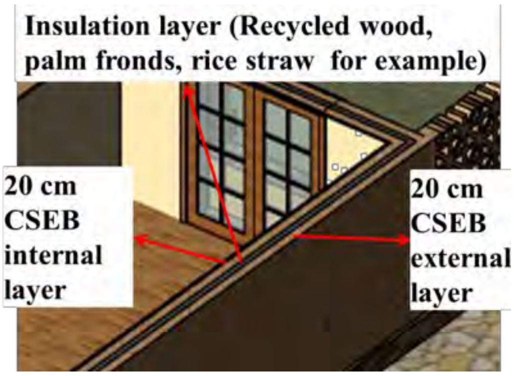

Figure 3. Isometric of the multi-shell wall for the energy efficient envelope of the residential building.

3.2. Integrated renewable energy resources

The total electric daily loads of the house lighting and appliances are about 7.6 kwh/d, as shown in Table I. The PV size is 2.1 Kwp, and this is corresponding to a number of 10 PV modules of 220 watt (total area 16 m2).). For the one story prototype house, the building applied PV (BAPV) are installed on more than one third of the roof of the living area (total area 50m2), as shown in Figure 4. For the two story prototype house, the building applied PV (BAPV) are installed on more than two third of the roof of the living area (total area 50m2), as shown in Figure 5. The solar charger controller and inverter sizes are 100 watt or greater and 1400 watt or greater, respectively, per each apartment unit. The number of batteries (600 Ah) needed is 10, per each apartment unit. The batteries are divided into two groups connected in series to double the voltage (obtain the 24 v), and each group contain 5 batteries (600Ah) connected in parallel. Solar heaters are installed on the roof for hot water supply.

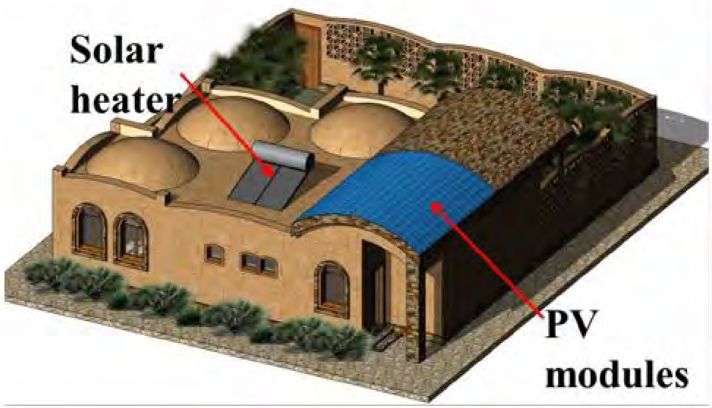

Figure 4. Renewable energy resources in the one story prototype house

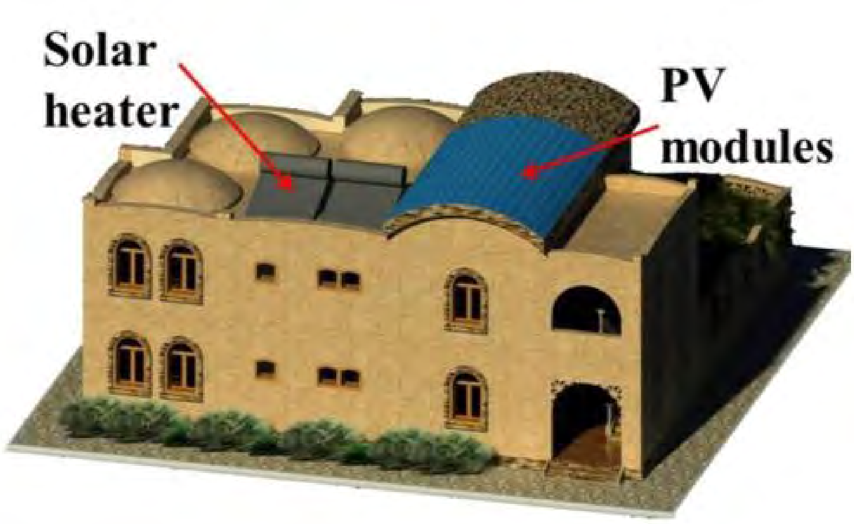

Figure 5. Renewable energy resources in the two story prototype house

Table 1. Daily load profile of the prototype residential building

Load	Quantity	Power	Hrs/d	Power	Total
Inside LED tube lamps (120 cm)	14	15	8	210	1680
Outside LED lamps	4	15	8	60	480
Fans	4	60	5	240	1200
Computer	1	300	5	300	1500
Refrigerator	1	175	12	1§75	2100
TV & receiver	1	80	8	80	640
Total daily loads (kwh/d)Total daily loads (kwh/d)					7.6
Peak daily power (Wp/d)Peak daily power (Wp/d)				1065	

4. Materials and Methods

4.1. Divisions of Suez canal province

The Suez Canal province is divided into three parts; the North zone covers the area from south of Port-said in north running south to Elferdan. The middle zone covers the area from Elferdan running south to Serapum, Figure 6. The South zone covers the area from Serapum running south to ElSuez.

4.2. Soil specimen location

The herein study covers the middle zone where twelve specimens were collected. Figure 6, shows the map of the second zone. Seven specimens were collected along about 3.5 km of the east bank of the Suez Canal from 65.1E km running south to 69.1E km in Elferdan area (Suez Canal east side numbering from Portsaid in the North). Five specimens were collected along about 2.5 km of the east bank of the Suez Canal from 88.1E km running south to 90.5E km in Serapumarea.

The characteristics of the soil were conducted through different tests. Sieve analysis was conducted using the BS set of sieves. The optimum moisture content and maximum dry density were determined through Proctor test. Chemical analysis was performed to determine the ratio of salts, chlorides, and sulfates, and the PH value.

Figure 6. The second zone covers the area from Elferdan running south to Serapum.

5. Result and Discussion

5.1. Sieve analysis

The result of the sieve analysis were illustrated in Figures 7-18. The soil classification of specimens from 65.7E km running south to 66.8E km is medium to fine sand. However, the soil classification of specimens at 67.3E km and 67.9E km is medium to coarse sand. The soil classification of specimens at 68.5E km and 69.1E km are medium fine silty sand.

The soil classification of specimen at 89E km is coarse to fine sand. The soil classification at 88.1E km, 88.5E km, and 89.6E km are medium to coarse sand. The soil classification of specimen at 90.5E km is medium to fine sand with silt.

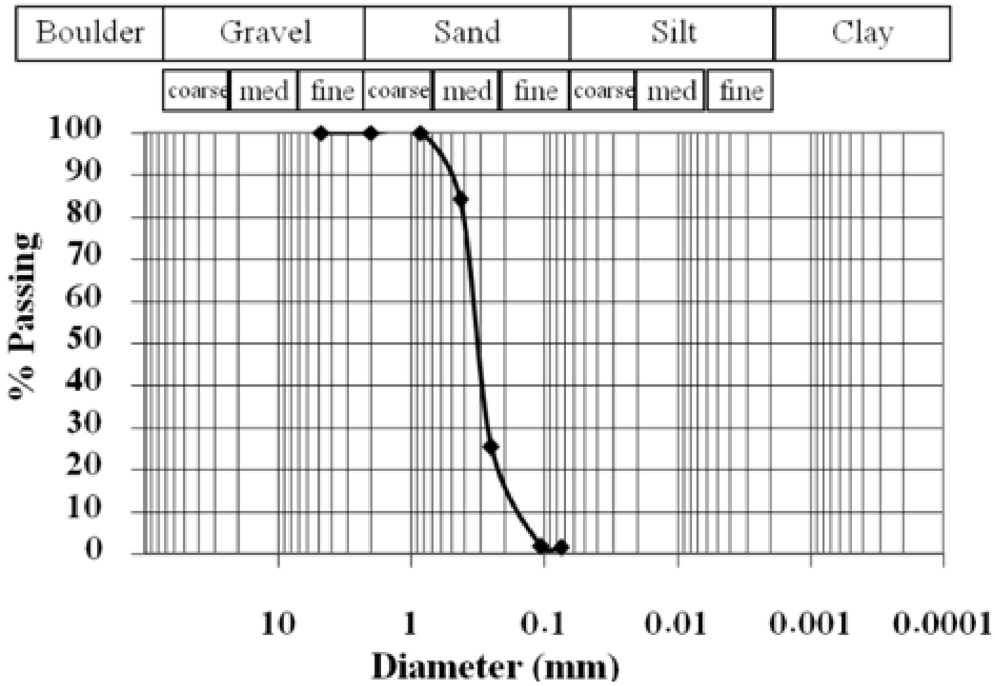

Figure 7. The sieve analysis of specimen 1 at 65.7E km at El-ferdan

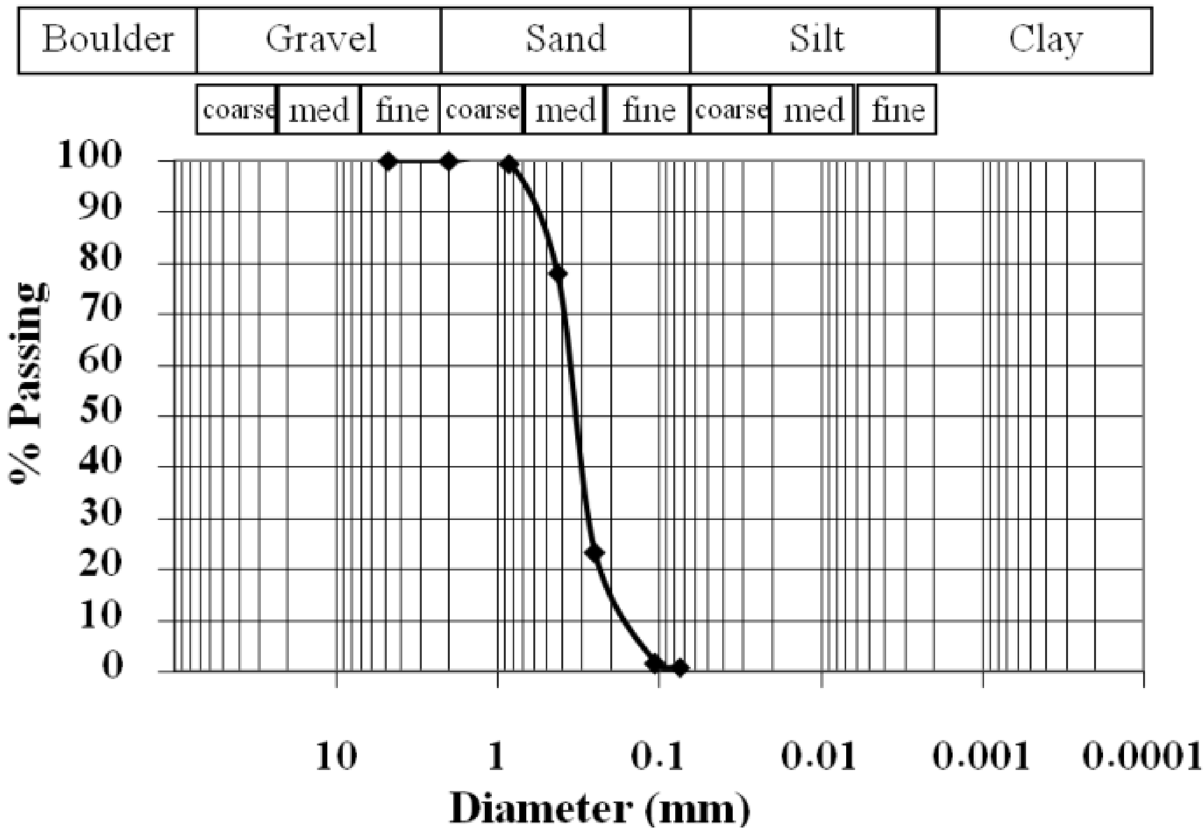

Figure 8. The sieve analysis of specimen 2 at 66.2E km at El-ferdan

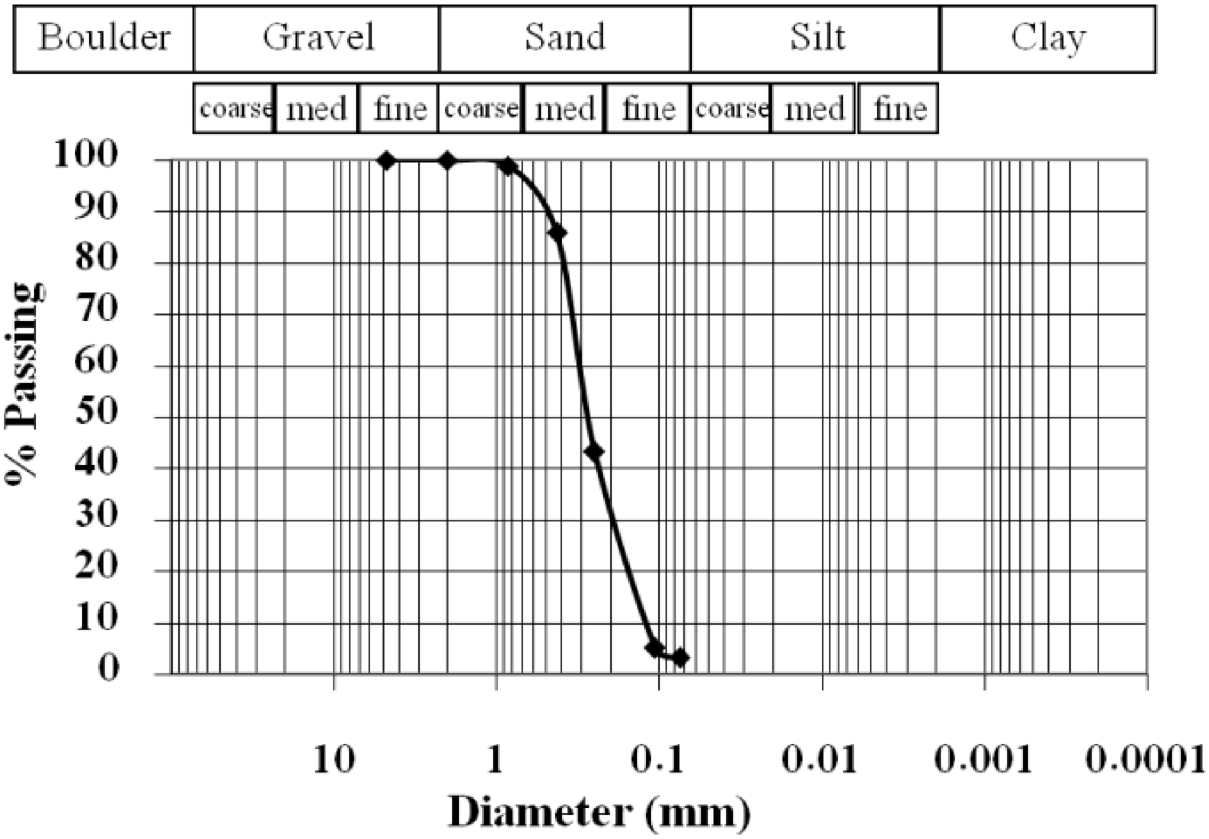

Figure 9. The sieve analysis of specimen 3 at 66.8E km at El-ferdan

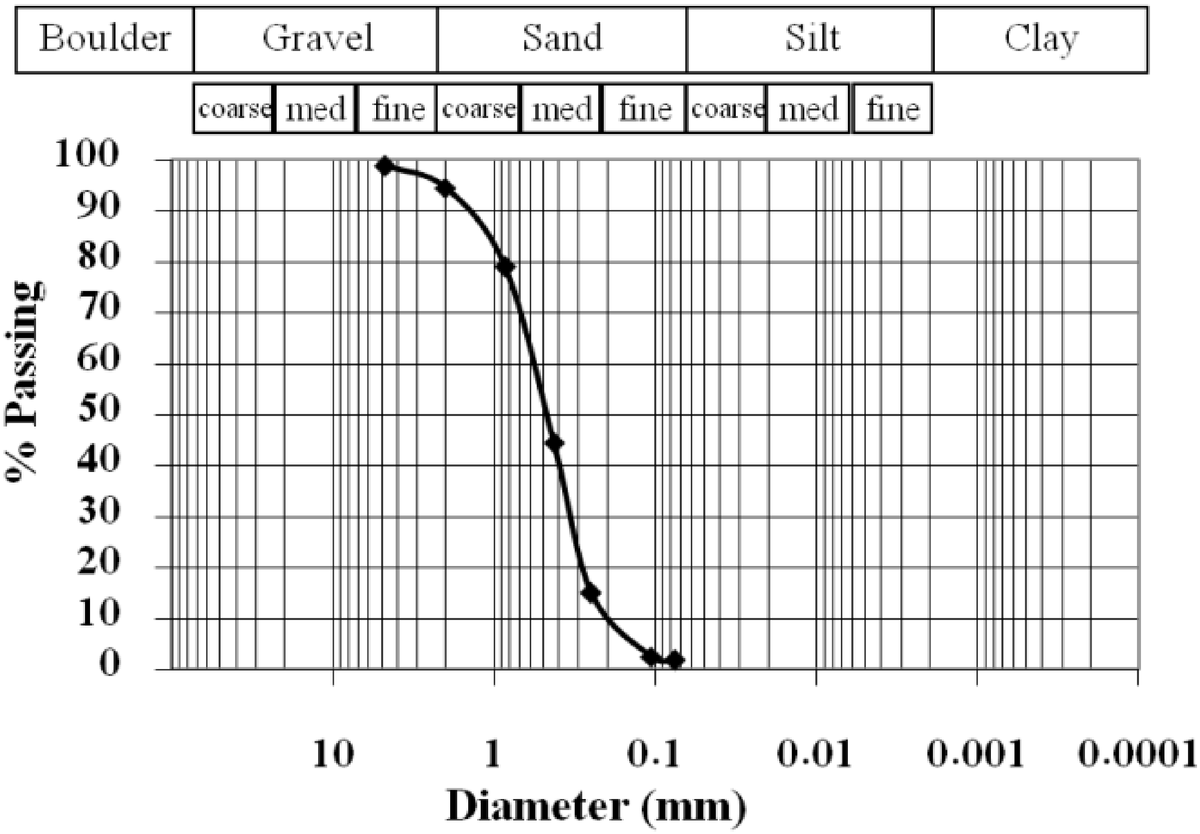

Figure 10. The sieve analysis of specimen 4 at 67.3E km at El-ferdan

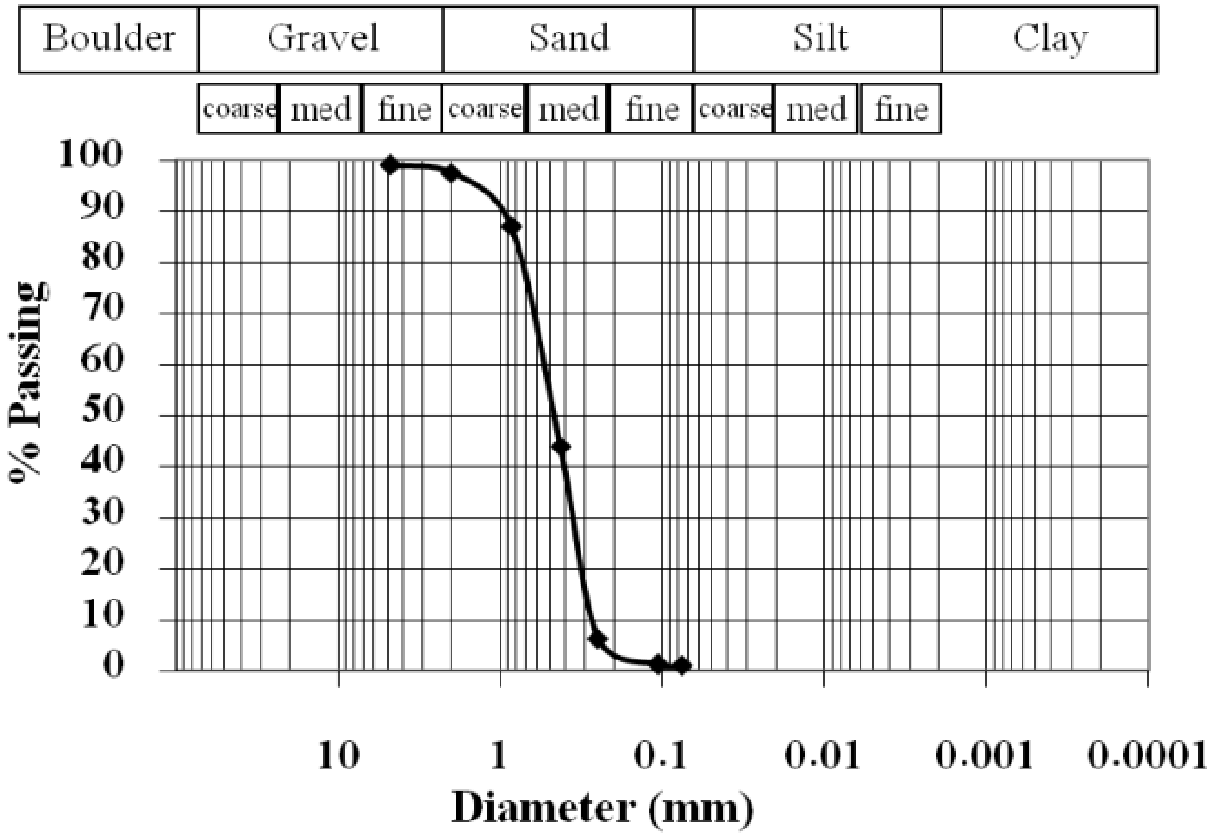

Figure 11. The sieve analysis of specimen 5 at 67.9E km at El-ferdan

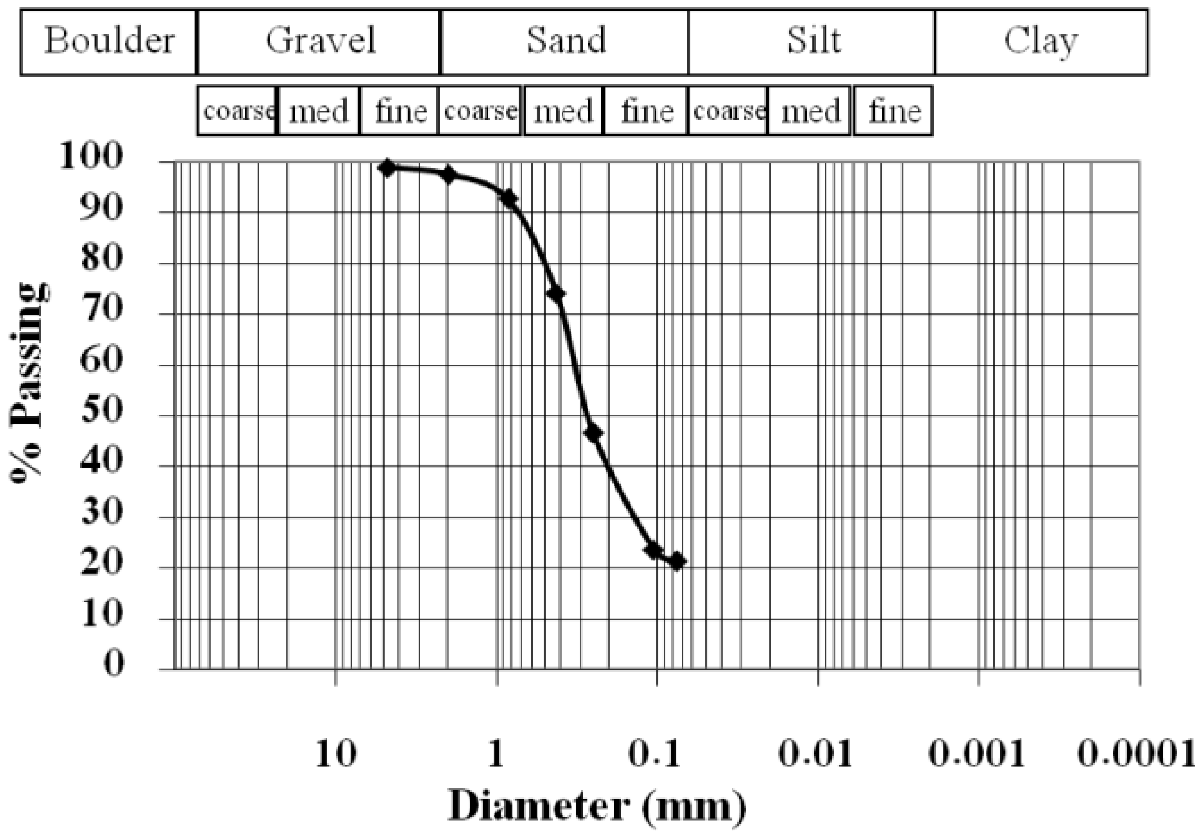

Figure 12. The sieve analysis of specimen 6 at 68.5E km at El-ferdan

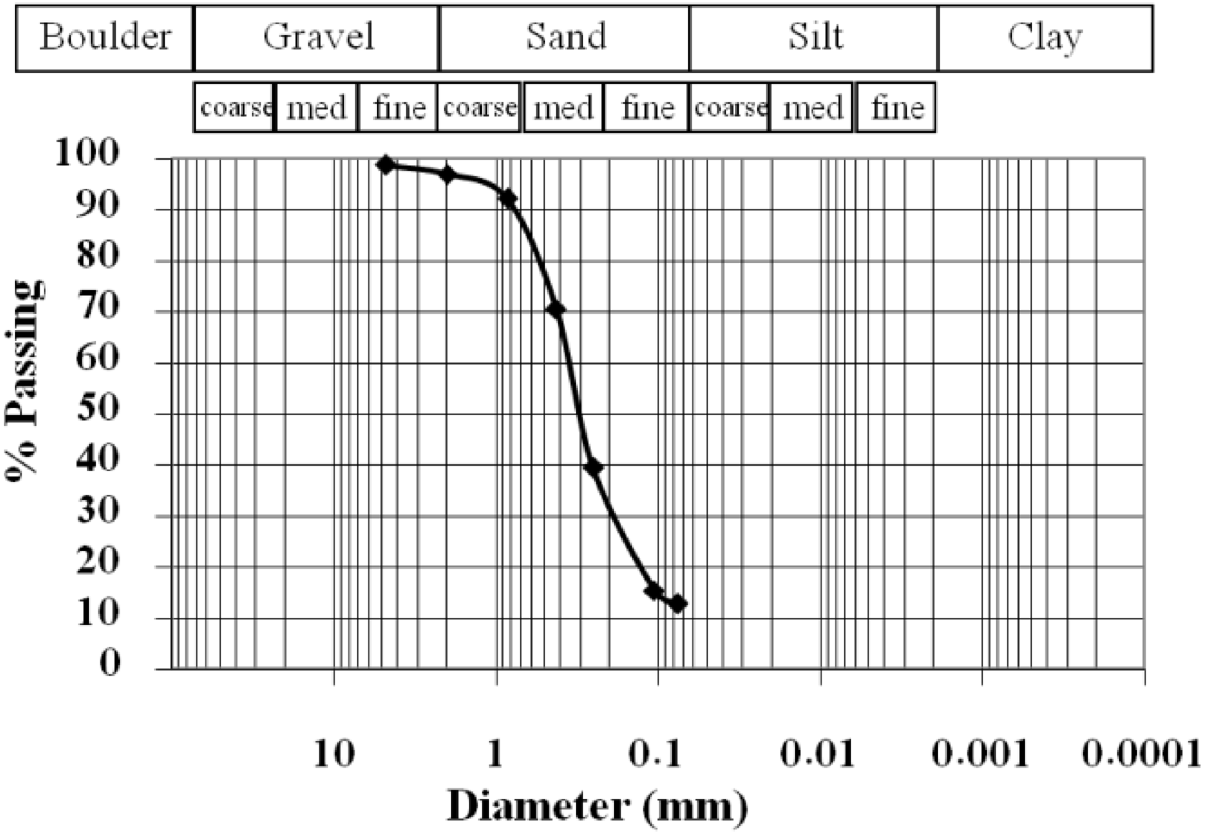

Figure 13. The sieve analysis of specimen 7 at 69.1E km at El- ferdan

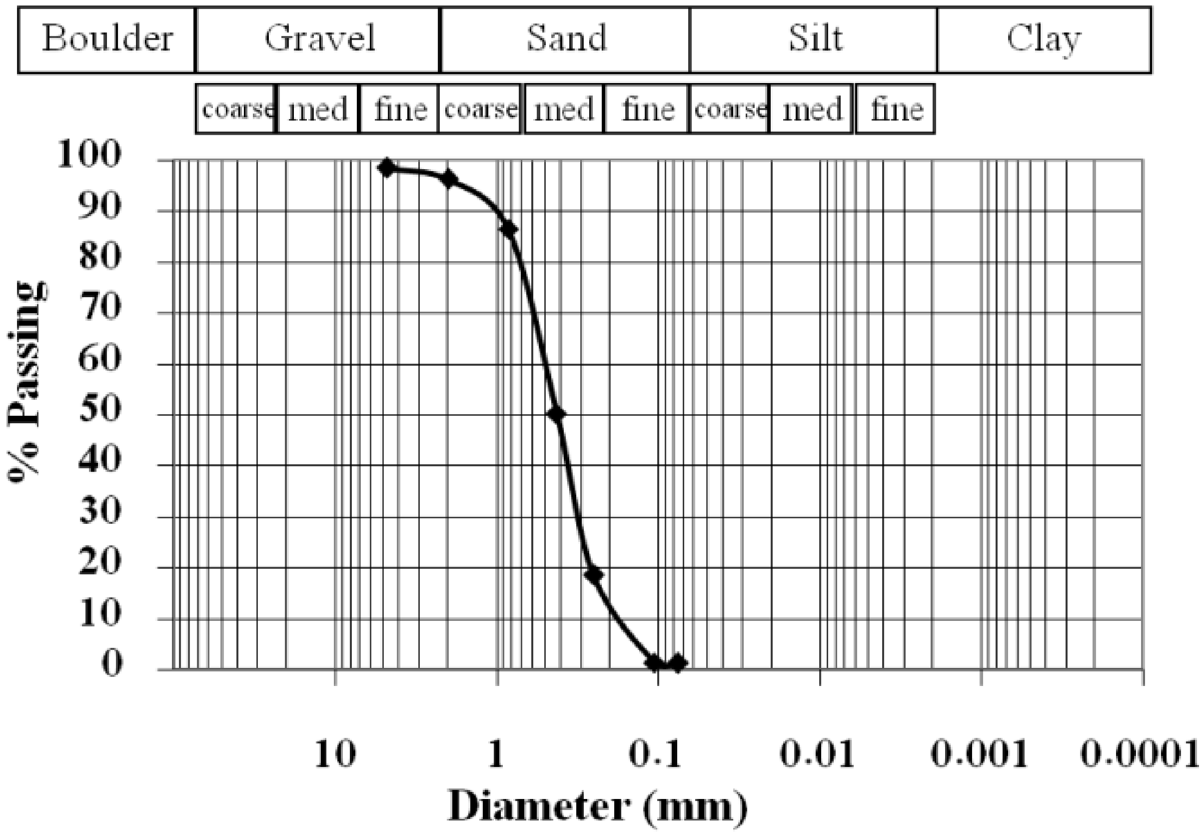

Figure 14. The sieve analysis of specimen 8 at 88.1E km at Sarapum

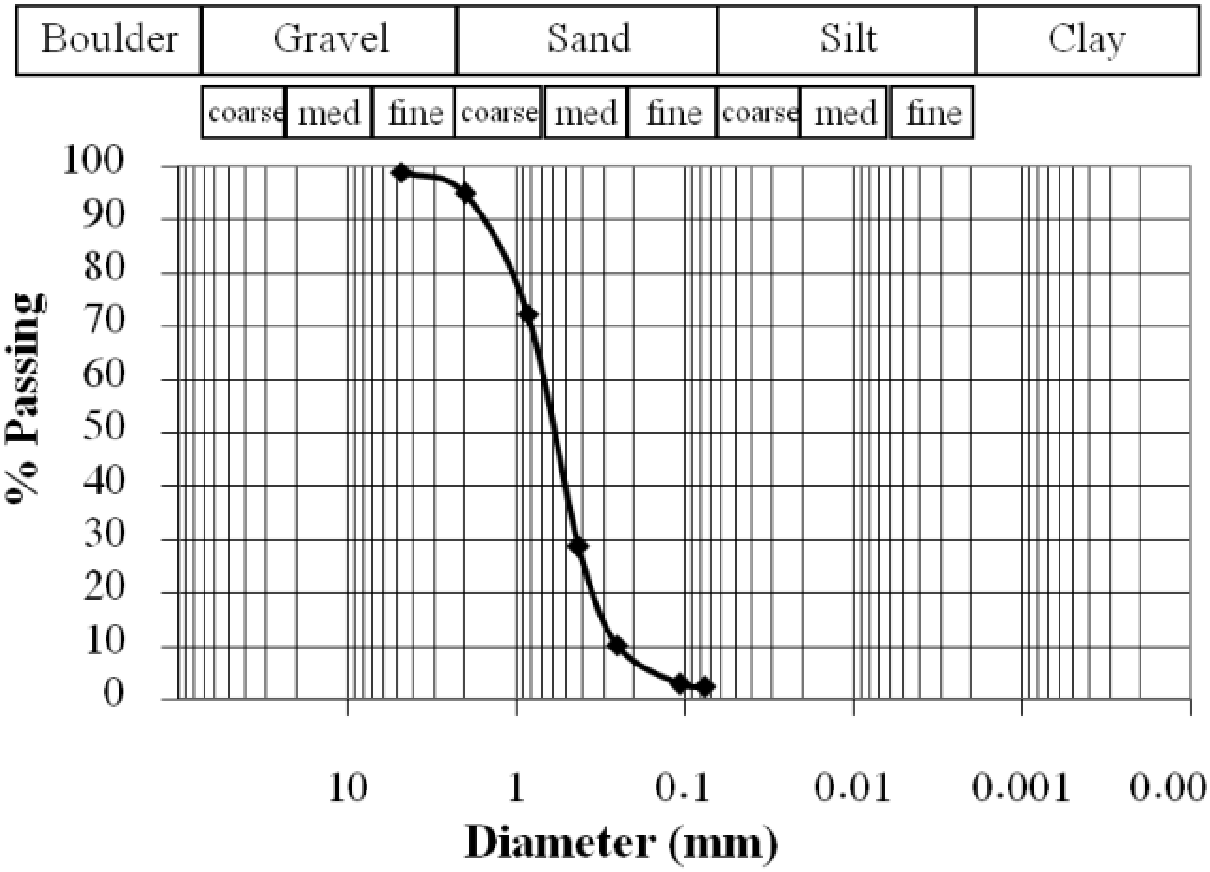

Figure 15. The sieve analysis of specimen 9 at 88.5E km at Sarapum

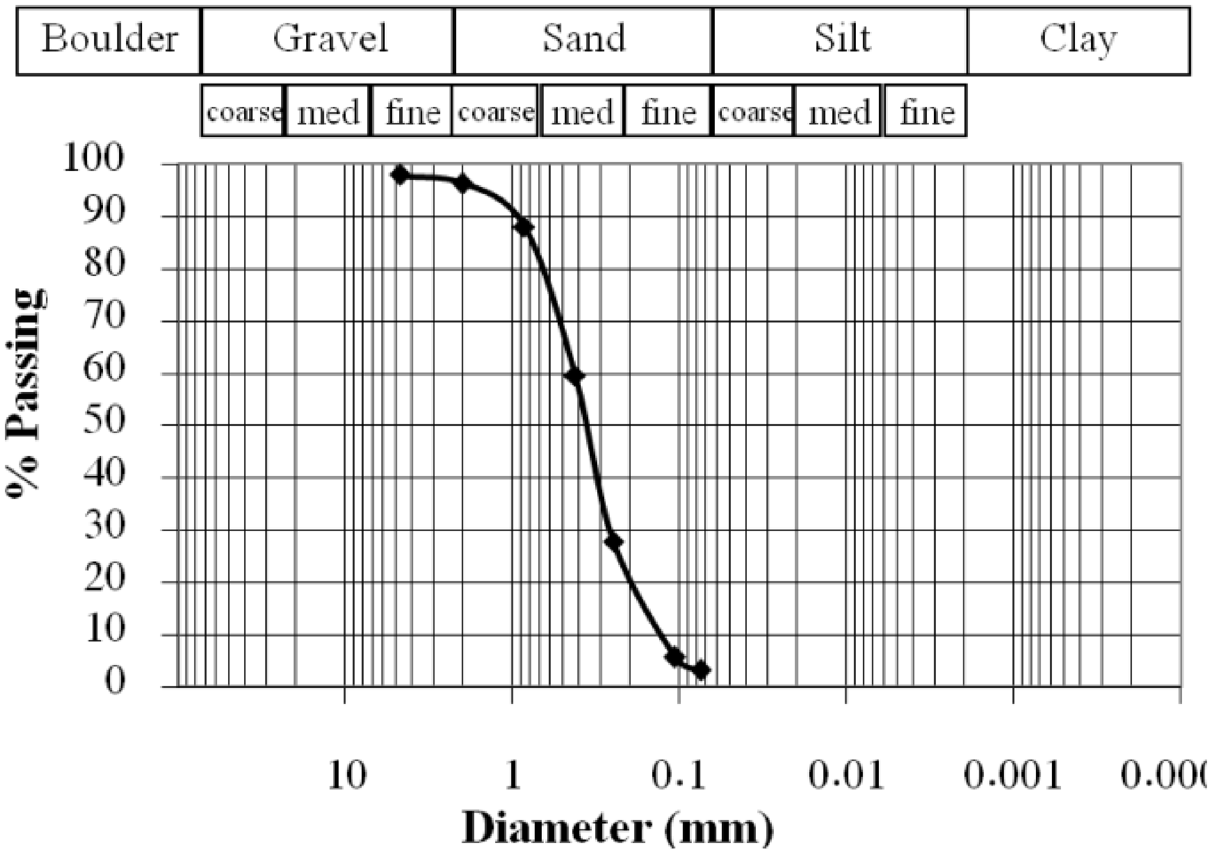

Figure 16. The sieve analysis of specimen 10 at 89 E km at Sarapum

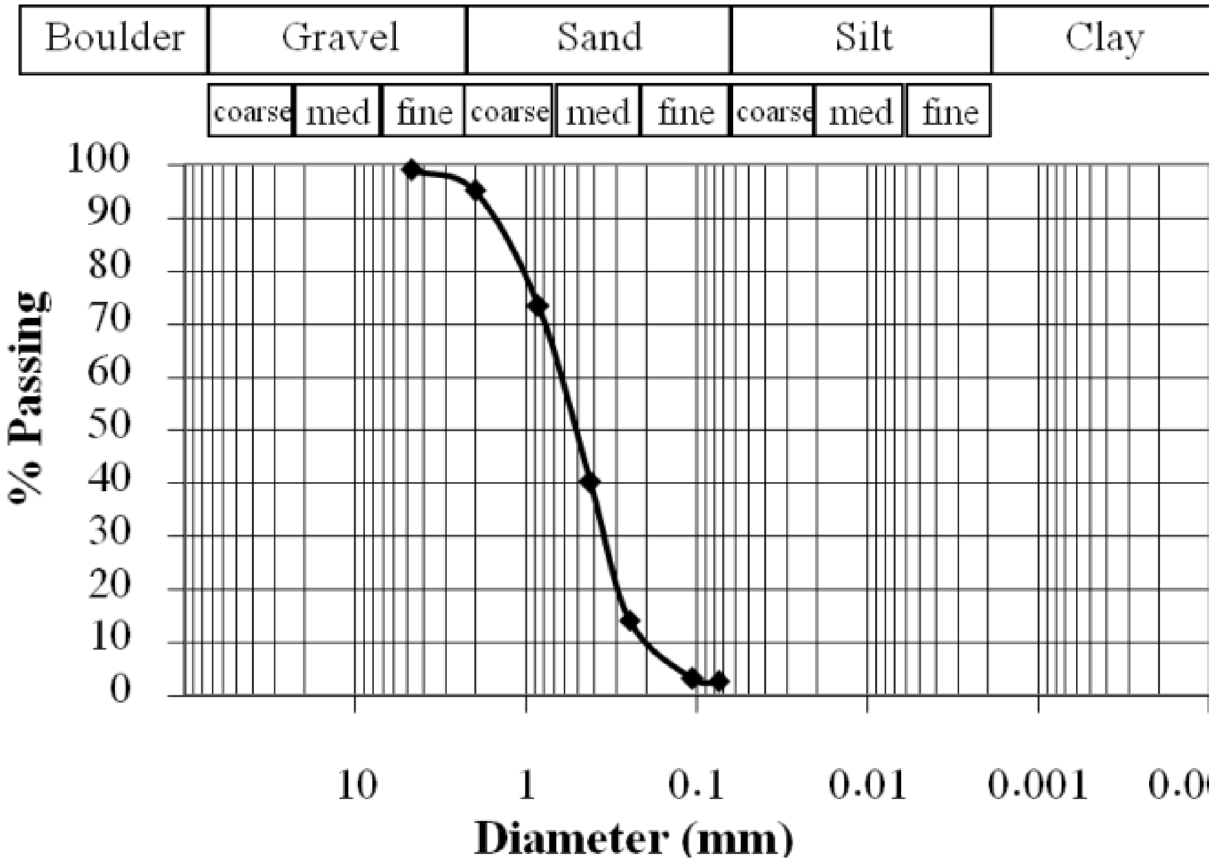

Figure 17. The sieve analysis of specimen 11 at 89.6E km at Sarapum

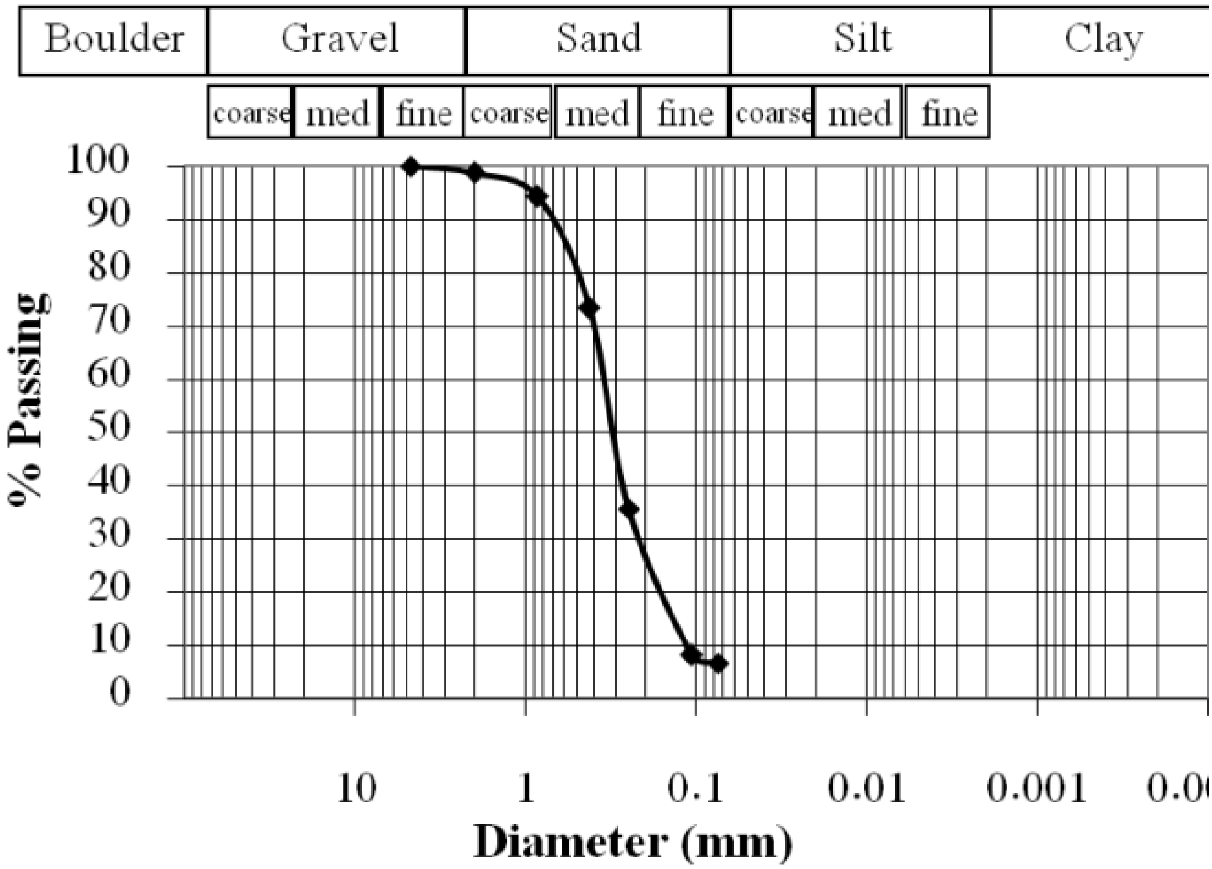

Figure 18. The sieve analysis of specimen 12 at 90.5E km at Sarapum

5.2. Characteristic properties

Table II, and Figures. 25-28, show the results of the maximum dry density and ideal moisture distribution of the soil specimens. Table show that the maximum dry density of the specimens from 67.3E km to 69.1E km in Elferdan is the highest, and the maximum dry density of the specimens from 88.1E km to 89E km in Serapum is the lowest. The maximum dry density of specimens from 65.7E km to 67.3E km and from 89E km to 90.5E km is relatively equal. The ideal moisture content of the specimens from 67.3E km to 69.1E km and from 89E km to 90.5E is relatively equal. The ideal moisture content of the specimens from 65.7E km to 67.3E and from 88.1E km to 89E km are relatively equal.

Table 2. Some characteristic properties

	Elferdan in North		Serapum in South	
	from 65.7E km to 67.3E km	from 67.3E km to 69.1E km	from 88.1E km to 89E km	from 89E km to 90.5E km
Maximum dry density (gm/cm^3)	1.87	1.925	1.776	1.898
Ideal moisture content (%)	8.9	9.7	10.4	8

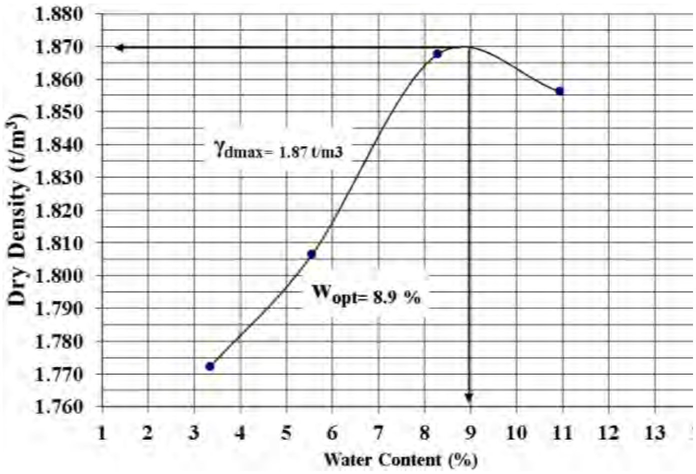

Figure 19. Modified proctor test for specimens from 65.7E km to 67.3E km at Elferdan area

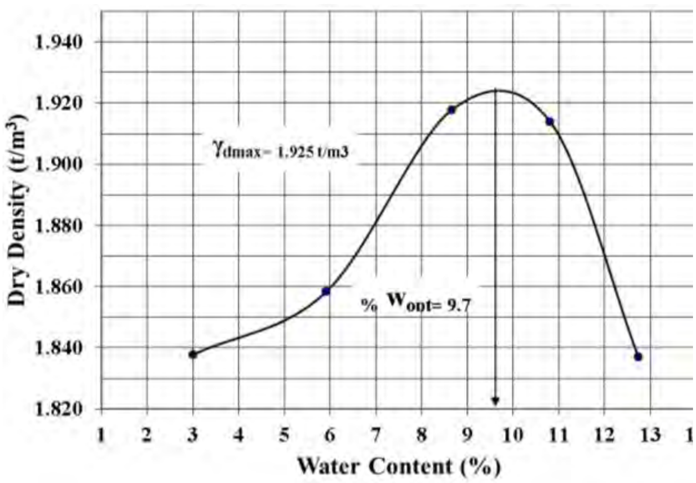

Figure 20. Modified proctor test for specimens from 67.3E km to 69.1E km at Elferdan area

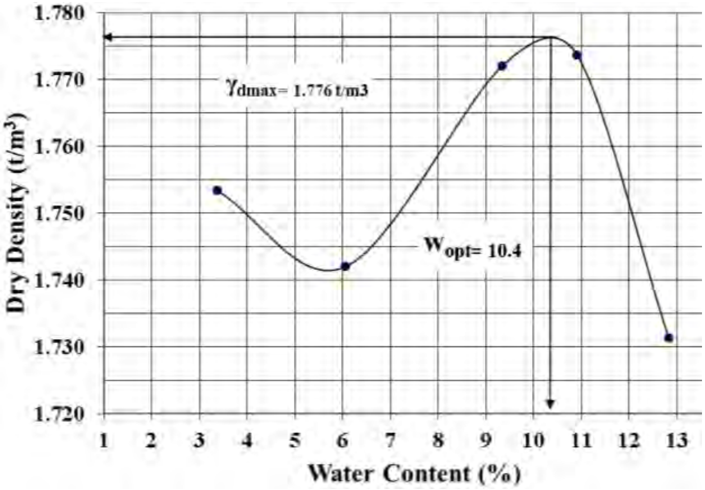

Figure 21. Modified proctor test for specimens from 88.1E km to 89E km at Serapum area

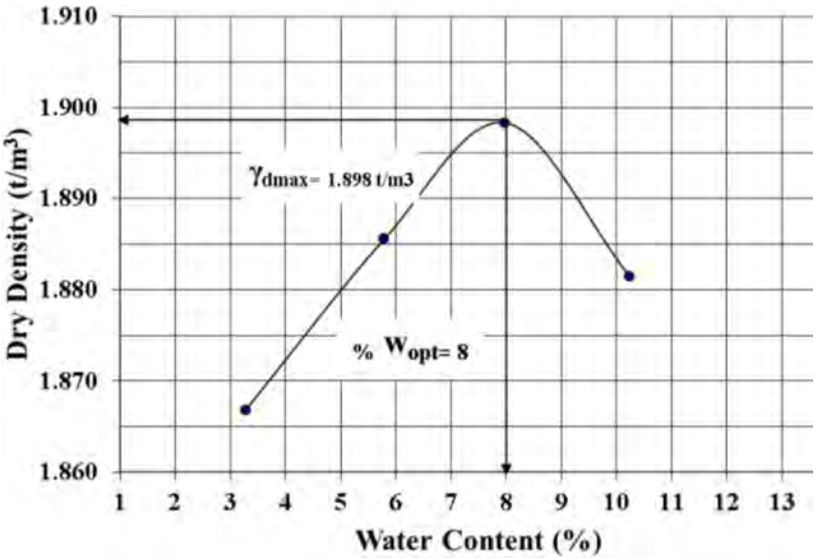

Figure 22. Modified proctor test for specimens from 89E km to 90.5E km at Serapum area

Table 3. Some chemical properties

	Elferdan in North		Serapum in South	
	From 65.7E km to 67.3E km	From 67.3E km to 69.1E km	From 88.1E km to 89E km	From 89E km to 90.5E km
Total Salts	0.151%	0.775%	0.227%	0.435%
Chlorides (CL)	0.06%	0.35%	0.115%	0.14%
Sulfates (SO3)	0.0349%	0.0422%	0.0225%	0.086%
The PH values	9.2	8	7.4	6.4

5.3. Liquid and plastic limits

This test was performed on specimen part passing sieve No. 40 (0.425 mm). All specimens show that the liquid limit is zero and soil is non-plastic.

5.4. Chemical characteristics

Table 3 show the ratio of salts, chlorides, and sulphates, and the PH value of the collected specimens.

Table 3 revealed that the chlorides ratio does not exceed 1% stipulated in the Egyptian code for the construction using stabilized earth (part one; compressed stabilized earth bricks). (Housing and Building National Research Center, under publication)

5.5. Analysis and Discussion

The results showed that the soil is mainly sandy soil. The experiment program deals with using CKD as a main stabilizing agent. To study the effect of CKD in sandy mixtures, the following variables were considered in this study:

1. Percentage of CKD as a ratio of sand 25%, 30%, 35%, 40%, and 45%.
2. Percentage of cement (OPC) as a ratio of sand is 5%.
3. Percentage of fiber-reinforced polymer (FRP) as a ratio of sand is 0.07% or 0.9 kg/m
4. Curing period of mixtures is 28 days.
5. Mixtures were mechanically compressed at 20 kg/cm
6. Optimum water content is 20% of sand weight.

The experiment results of specimens 6 at 68.5E km at Elferdan are illustrated here in, however the results of the other specimens will be illustrated in further research.

Different mixtures were produced to obtain the optimum CKD content which provides the best properties of the admixture as long as the percentages of cement (OPC) and the FRP are 5% and 0.07% of sand weight, respectively. The tests include dry compressive strength, dry flexure, dry density, and absorption.

The testing takes place using laboratory prepared samples (4x4x15cm). Several samples were prepared by adding CKD ratios to the sand according to the testing conditions and, hand or mechanical mixed thoroughly. Optimum water content is then added and mechanical mixing continues until a uniform mix is obtained. The admixtures are mechanically compressed. The produced samples are then cured for 28 days using water. The compressive strength is measured by ASTM D 422-63 test methods.

Figure 23 showed the dry compressive strength of sand-CKD mixtures, the relation can be represented as in equ.3. Maximum dry compressive strength was recorded at 35% CKD ratio of sand weight. Figure 30 showed that Maximum dry flexure was recorded at 35% CKD ratio of sand weight. Figure 31 showed that the density of sand-CKD mixture is relatively constant. Figure 32 showed the minimum absorption was recorded at 40% CKD ratio of sand weight. The difference in the absorption measures at 35% and 40% CKD ratio is low.

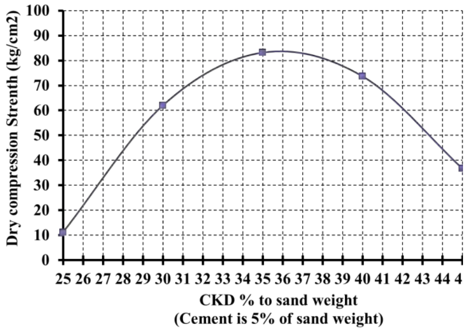

Figure 23. Dry compressive strength.

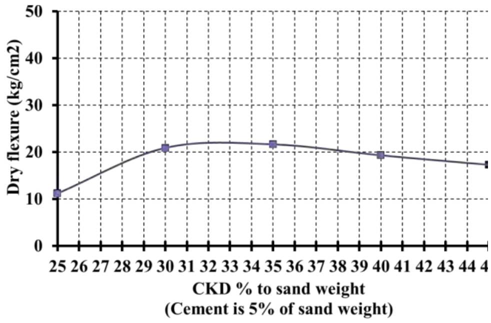

Figure 24. Dry flexure

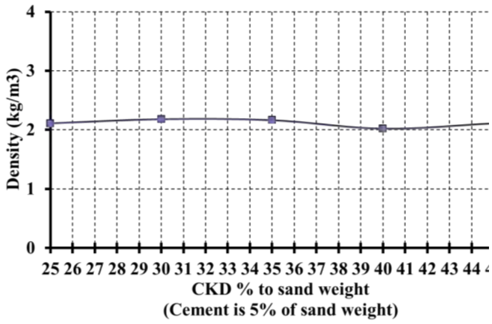

Figure 25. Dry Density

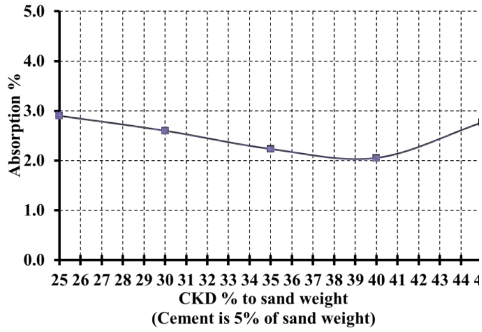

Figure 26. Absorption

$$
\begin{aligned}
&Q = -0.5891r2 + 42.49r - 682.71 \\
&Where\ Q = Dry\ compressive\ strength\ at\ 28\ days(k/cm2) \\
&r = CKD\ ratio\ to\ sand\ weight\ (\%)
\end{aligned}
\tag{3}
$$

6. Conclusion

The herein paper represents the first part of the project that deals with the use of the sandy soil in the design and build, ecological, and low coast green building in the future projects that will be held in Sinai on the east side of the Suez Canal, using stabilized earth architecture The sandy soil used is that resulted from excavation of the buildings, sand installed on the east side of the canal in Sinai and that resulting from the dry excavation and wet drilling of the Suez Canal.

The herein paper (part one) study the passive and energy efficient design approach in buildings that can reduce energy consumption and the electricity coast. The analyses of the prototype residential buildings were presented, where the passive and energy efficient design approach was considered. The energy and electricity coast were reduced. The paper also study several specimens collected from different sites in Elferdan and Serapum in Sinai along the east side of the Suez Canal to investigate the suitability of stabilizing the soil for the production of CSEB for low-cost ecologic building construction.

It showed that passive and energy efficient technique incorporated in building design can reduce the electricity requirements. In the prototype residential buildings, the energy demand (electricity required) for cooling, Co2 emission, and thermal balance decreases by about 50%. The internal temperature decreases about 4 °C. The most effective parameter is the thermal efficiency of building envelope and blocking sun rays. The available renewable energy systems can meet part of building loads. Thermal bridges aren't so common in the bearing wall construction method.

The experiment were made on specimens 6 at 68.5E km at Elferdan using different levels of stabilizing agent. The results showed that the 35% CKD ratio of sand weight can be considered as the optimum CKD content which provides the best properties for the admixture as long as the percentages of cement (OPC) and the FRP are 5% and 0.07% of sand weight, respectively. The results provide an indicator of the potential uses of CKD, cement and FRP mixture and sand in producing CSEB and in building construction.

The rest of this research will be completed in the next parts. Part two includes finding more mechanical, engineering and thermal properties for the produced CSEB. More experiments can be performed on the other specimens.

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