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# IMPROVEMENT OF GRANULAR SOIL IN NIZWA AREA

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## ABSTRACT
This study deals with stabilization findings of granular soil selected from three different locations in Nizwa area. Compaction characteristics and compressive strength of stabilized soil were determined using 1, 3, 5, and7% as cement content. Two curing periods of 3 and 7 days were subjected to stabilized specimens. A remarkable improvement of compressive strength and maximum dry density are determined. This improvement showed more effects with increasing cement content and curing time. The strength, dry density and optimum moisture content of stabilized soils found to be higher for more stabilizer content. The stabilized granular soil in Nizwa area provides a ready to use pavement and airport courses with a potentialof improvement of soil characteristics used for design.

**KEYWORDS**: Granular soil, Compressive strength, Cement, Maximum dry density, Moisture content.

## INTRODUCTION
Soil stabilization is an a chemical or mechanical treatment of soil for alteration of one or more properties. It is designed to increase or maintain the stability of soil mass and to create improved soil materials possessing the desired engineering performance. The main properties considered in soil stabilization are strength characteristics, durability, compaction characteristics, volume change and the tendency to water sensitivity.

In the interest of feasibility; using locally available materials is one of the major requirements in minimizing the construction cost. Natural granular soil is available in many locations and over a large area in Nizwa city (170 kM north of Muscat- Oman). It is usually used as pavement courses of filling materials regardless of the lack of engineering information and studies concerning its properties and behaviors under loading systems. The material is a granular soil in nature contains very little fine materials (minus # 200 sieve) ranging from 1.5-2.8%. The properties of stabilized granular soil depend on many factors such as grain size distribution, type of stabilizer, stabilizer content, compaction method and effort and curing conditions [1-9]. In general, the strength and compaction characteristics are remarkably improved with stabilizer content, curing period and temperature [1, 6, 9, 10-12]

In this study the granular soil taken from three locations in Nizwa area stabilized with various percentage of cement are investigated. Effects of cement content and curing period for soil of different locations are evaluated considering the strength and compaction characteristics of stabilized soils.

## MATERIALS AND METHODS
### Materials
#### *Granular soil*
A cohesionless granular soil was chosen from Nzwa area. Three different locations were selected, these locations are making a triangle nodes of approximately 30 kM apart covering a wide representative area of Nizwa city. These are namely kamah, University of Nizwa new campus location and Temsa. Figure (1) shows locations of the investigated soils. Samples are taken from all sites after excavating 0.5-1.0 m of top soil from the natural ground surface to remove any filling or newly transported soil. The soil deposit is extending 3-10 down ground surface. The maximum size of the chosen soils is 50 mm and having a little amount of fine soil (minus # 200 sieve) of about 1.5-2.8%. Index properties grain size distribution curves for selected soils are shown in Table (1) and Figure (2) respectively.


***Figure (1) Locations of investigated soils – Nizwa***

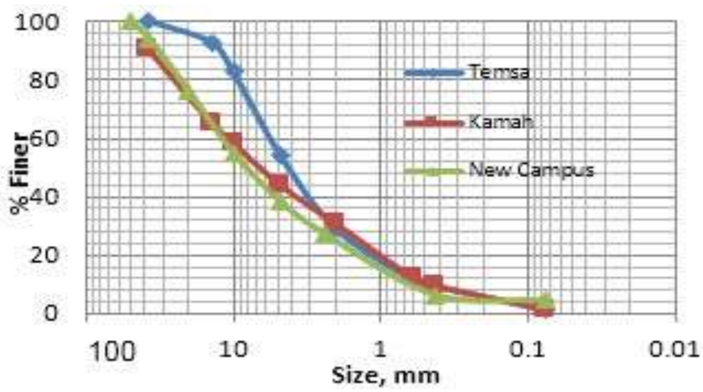


***Figure (2) Gradation of investigated soils***

***Table (1) Index properties of investigated soils***

| Characteristics | UoN | Kamah | Temsa |
|---|---|---|---|
| **Weighted average of Sp. Gr.** | **2.60** | **2.59** | **2.63** |
| **L.L, %**<br>**P.I, %** | **30**<br>**1** | **33**<br>**3** | **33**<br>**3** |
| **Passing # 200 sieve, %** | **1.5** | **2.8** | **2.3** |
| **Organic matter** | **Nil** | **Nil** | **0.05** |
| **Sulphate content, %** | **Nil** | **Nil** | **Nil** |
| **Unified Classification System** | **GP** | **GP** | **SW** |
| **Coefficient of Uniformity, $C_u$** | **16.25** | **26.66** | **10.16** |
| **Coefficient of Curvature, $C_c$** | **0.75** | **0.72** | **1.63** |
| **Wearing percentage** | **34** | **29** | **33** |

***Cement***
Ordinary Portland Cement is used for stabilization of all selected materials.

***Water***
A potable water is used for soil compaction and stabilization processes.

**Preparation of stabilized specimens**
The granular soil selected from the three sites was sieved and the coarse gravel of more than 19 mm in size was substituted by material finer than 19mm and coarse than 4.75 mm (# 4 sieve). The stabilized specimens were prepared for different percentages of cement in accordance with ASTM D1557-2000 [13] and ASTM D558-

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2011 [14]. Modified compactive effort was used for different mixture specimens, and the process of mixing and compaction was performed within a time of less than 40 minutes to avoid any strength loss [5].All selected soils were treated with 1,3,5,and 7% cement. The stabilized compacted specimens were cured for 3 and 7 days at laboratory temperature (21+/- 2ºC) before strength testing.

**Strength test**

The unconfined compression test were carried out after the completion of curing period to determine the stabilized specimen strength using 2000 kN capacity digital compression machine with an accuracy of 0.01 kN. Figures (3) and (4) present a photos of test in progress and failed specimen showing the type of failure mode.

***Figure (3) Testing in progress***

***Figure (4) failed specimen showing failure mode***

## RESLTS AND DISSCUSION OF RESULTS

**Index Properties**

The soils index properties and the gradation curves of the three locations which are shown in Table (1) and Figure (2) indicated that all soils are of a granular cohesionless nature having low percentages of fine materials ranging from 1.5-2.8%.The soils are classified according to Unified Classification System as GP, GP, and SW for UoN new campus location, Kamah and Temsa respectively.

**Compaction Characteristics**

Compaction characteristics of soils selected from Kamah, UoN new campus location and Temsa are shown in Figures (5), (6) and (7) respectively. Each set of curves shows the compaction results of untreated and stabilized specimens using 1, 3,5 and 7 %cement content.

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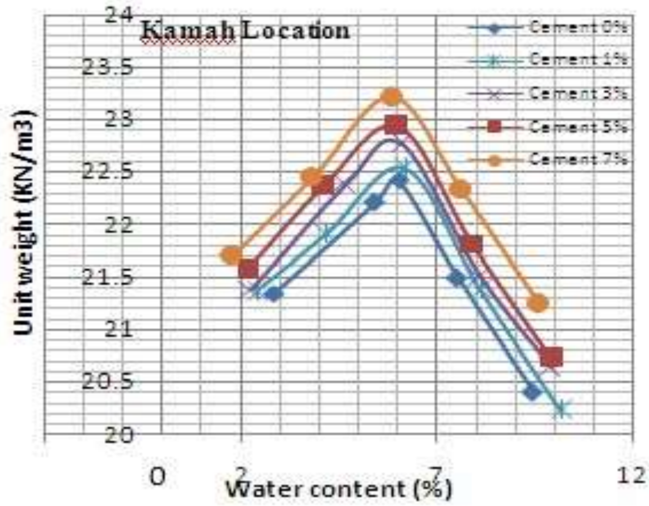


*Figure (5) Compaction curves for various cement content*

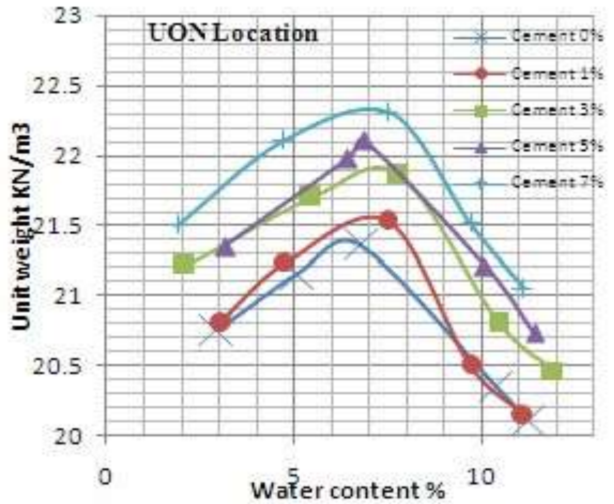


*Figure (6) Compaction curves for various cement content*

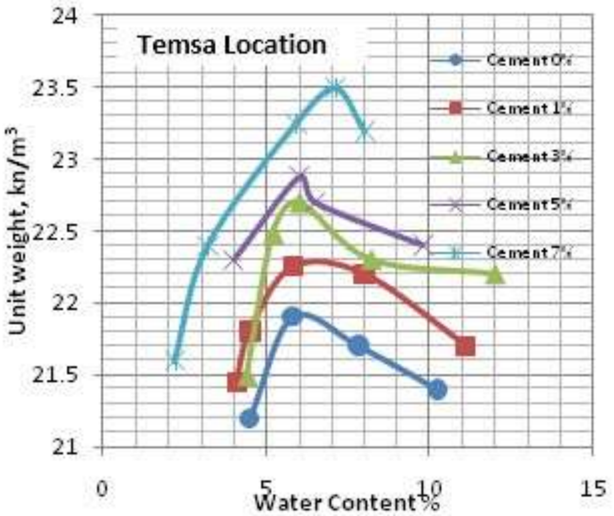


*Figure (7) Compaction curves for various cement content*

**Compaction curves for various cement content**

It can be seen that in genera the maximum dry density – molding water content relations are identical; the rate of increase of dry density in dry side of optimum moisture content is higher than the rate of decrease in wet side of optimum moisture content for all cement content. This may be attributed to presence of a very low amount of fine materials which is less than 3%. The maximum dry density was found to be ranged 22.42 to 23.29 kN/m$^3$ for Kamah , from 21.42 to 22.30 kN/m$^3$ for UoN new campus location and from 21.93 to 23.56 kN/m$^3$ for Temsa location. Similar behaviors were found by Kwon et al [1] and by Yoon Abu-Farsakh [15].

Effects of cement content on maximum dry density and optimum moisture content for all location are shown in Figures (8) and (9) respectively. It can be observed that as the cement content increasing the maximum dry density increases in a linear relationships, this is due to the fact that the specific gravity of cement is higher than the soil solids. Yoon and Abu-Farsakh [15] found similar effect. Optimum moisture content also found to increase linearly with cement content and this is attributed to the additional water required for cement hydration which directs proportional to the amount of added cement.

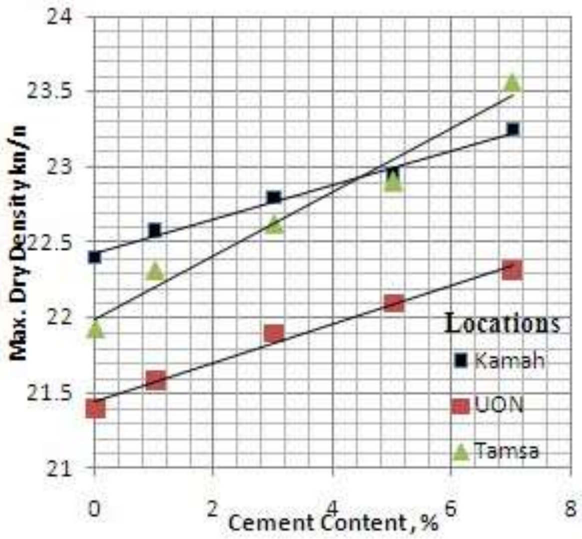


*Figure (8) Maximum dry density Vs. cement content*

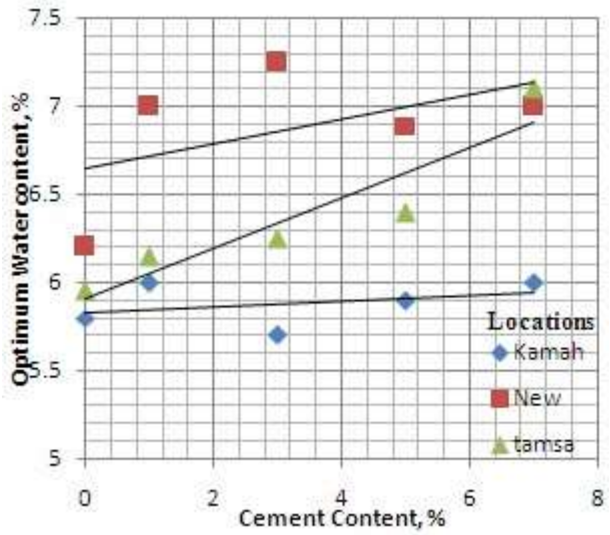


*Figure (9) Optimum moisture content Vs. cement content*

**Compressive strength of stabilized soils**

The compressive strength – water content relations of stabilized soils with various cement content and for all selected location subjected to curing time of 3 and 7 days are shown in Figures (10) to (14).

In general all the relations are identical indicating an increase in strength with increasing water content up to a maximum value after which starts to decrease for further increase of water content. This is due to the fact that the dry density of the stabilized soils was found to increase with water content up to maximum value followed be a reduction in values for higher water content. In addition, water required for cement hydration happened at a proper water cement ratio which much less than that required for compaction at maximum dry density.

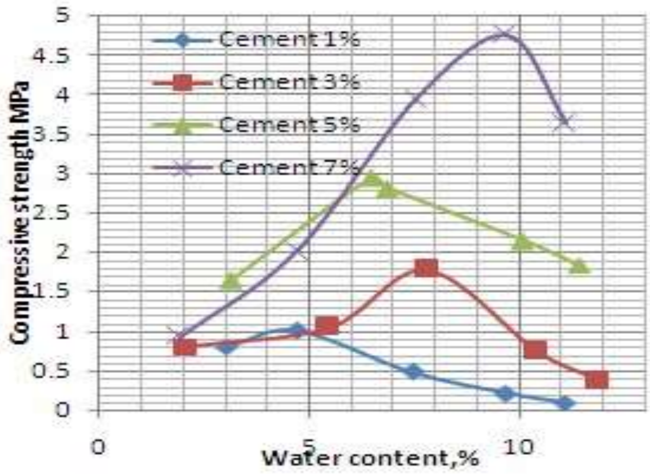


***Figure (10) Strength Vs. Water content at 3 days For UoN New campus***

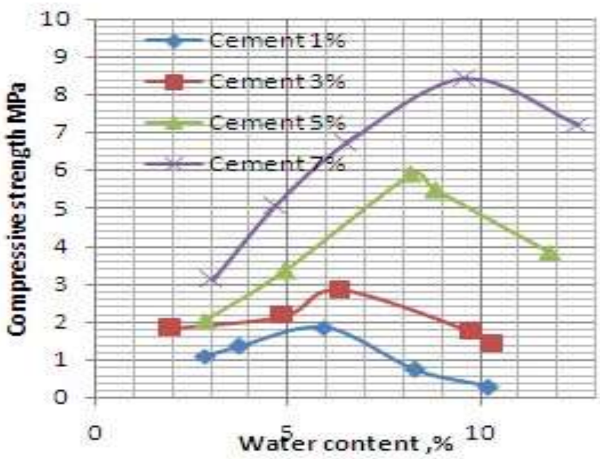


***Figure (11) Strength Vs. water content at 7 days for UoN new campus***

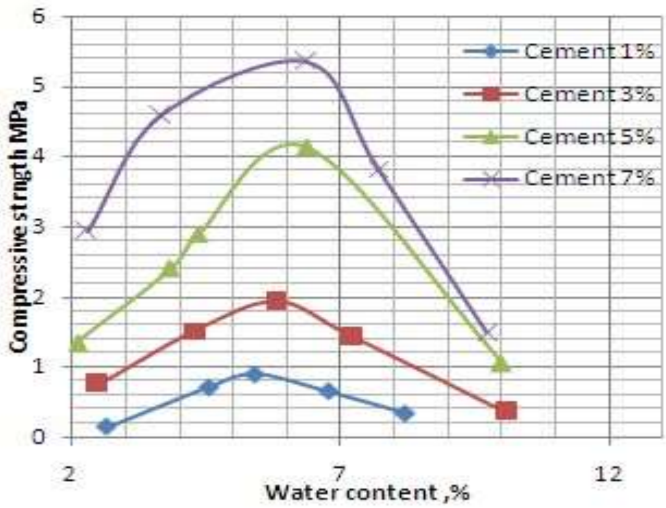


***Figure (12) Strength Vs water content at 3 days For Kamah location***

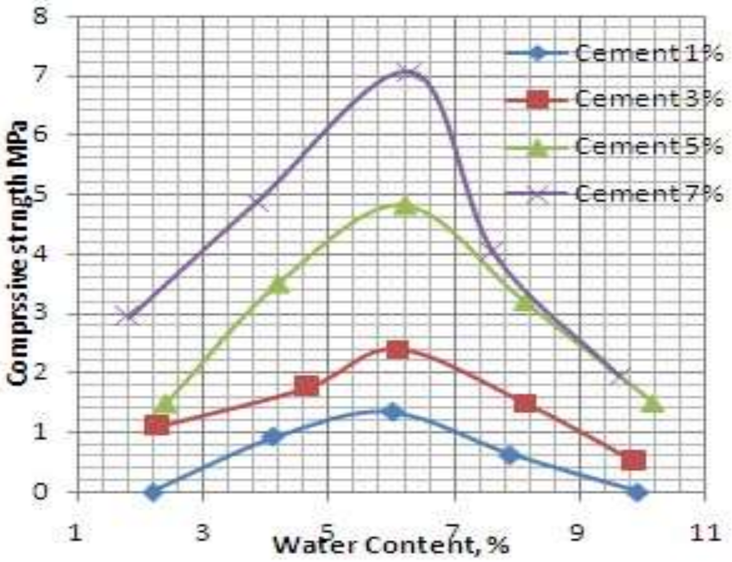


***Figure (13) Strength Vs water content at 7 days for Kamah location***

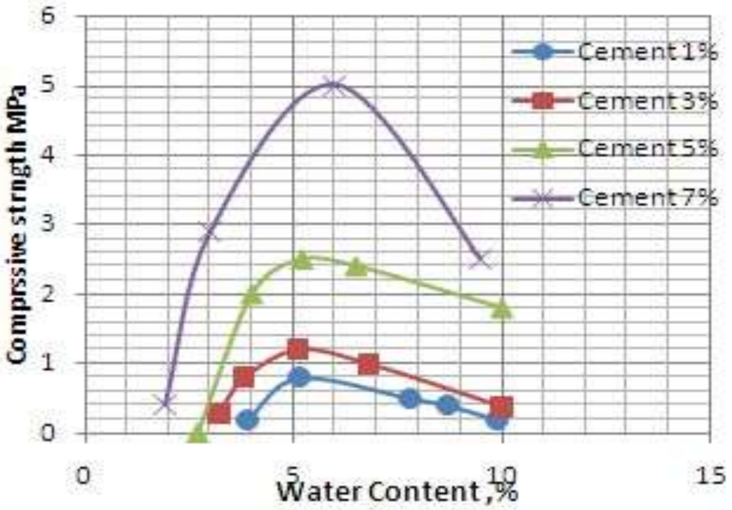


***Figure (14) Strength Vs water content at 7 days for Temsa location***

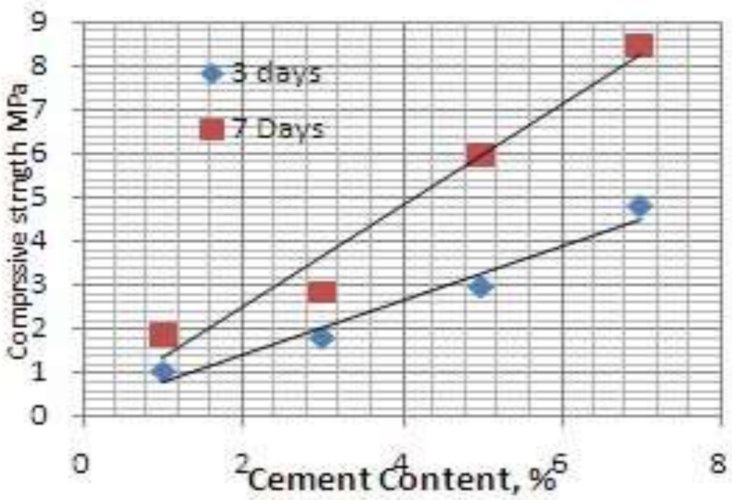


***Figure (15) Maximum strength – cement content relations for UoN new campus location***

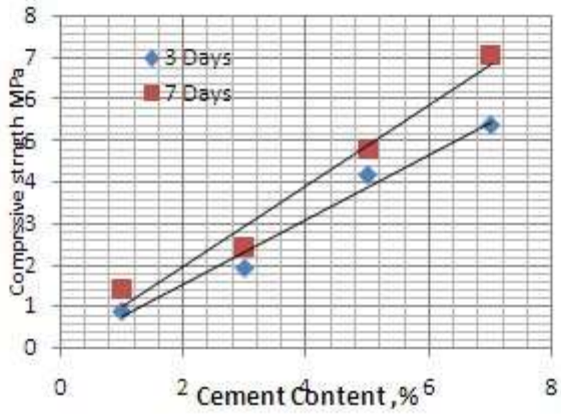


***Figure (16) Maximum strength - water content relations for Kamah location***

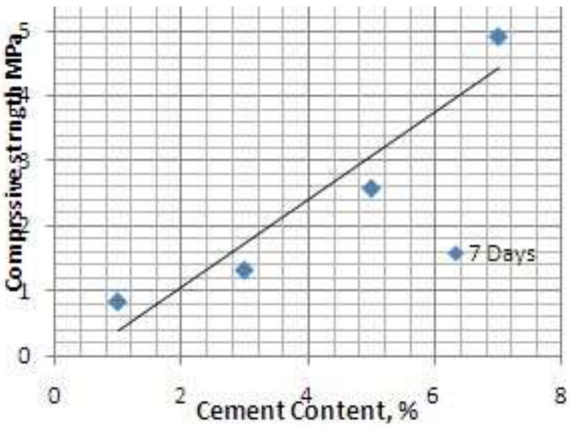


***Figure (17) Maximum strength – water content relation for Temsa***

Figures (15), (16) and (17) show the effect of cement content on compressive strength of stabilized soils selected from UoN new campus location, Kamah and Temsa respectively. In genera these relations indicate an increase in strength with cement content in a linear behavior.

Effect of curing time can be shown as an improving the compressive strength as the time be longer. The rate of strength increase seen to be higher for 7 days than 3 days.

## CONCLUSIONS

- The maximum dry unit weight of stabilized soil increases with increasing cement content.
- The optimum water content of stabilized soil becomes higher as cement content increases.
- Maximum compressive strength of stabilized soils improved many folds by cement stabilization.
- Compressive strength of stabilized soil becomes higher for longer curing time.

## ACKNOWLEDGEMENTS
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## REFERENCES

[1] Kwon, H. M, Le, A. T. and Nguyen, N. T. "Influence of soil grading on properties of compressedcement – soil," KSCE, journal of Civil engineering, 14(6), 845-853, 2010.
[2] Mohmedzein, Y. E. and Al-Rawas, A. A. "Cement stabilization of Sabkha soils from Al-AuzaybaSultanateof Oman," Geotechnical and Geological Engineering, 29(11). 999-1008, 2011.
[3] Kalkan, E. " Effect of west material-lime additive mixtures on mechanical properties of granular soils," Bulletin of Engineering Geology and Environment, 7(1), 99-103, 2012.
[4] De Foneca, a. V., Cruz, R. C. and Consoli, N. C." Strength properties of sandy soil – cement mixture, "geotechnical and Geological engineering, 27(6), 68-686, 2009.

[5] West, G. " A laboratory investigation into the effect of elapsed time after mixing on the compaction and strength of soil cement," Geotechnique, 9(1), 22-28, 1959.
[6] Ingles, O. G. and Metcalf, J. P. " Soil stabilization priciples and practice," John Wiley, New York, 1973.
[7] Yoder, E. G. and Witazak, M. W, " Principles of pavement design ," John Wiley and sons, 1975.
[8] Shamsher, F." Strength characteristics of sea sand stabilized with cement," Proceeding of 1st Engineering conference, Vol. 1, Aden, yemen.
[9] Haeri, S. M. Hamidi, A. Hossieni, S.M.,Asghari, E. and Toll, D.G., " Effect of cement type on the mechanical behavior of gravely sand," Geotecnical and Geological Engineering , 24(2), 335-360, 2006.
[10] Omotosho,O. and Ogboin,A. S., " Active soils of Niger delta in road pavement design and construction, Geotechnical and Geological Engineering,27(1), 81-88, 2009.
[11] El- Arawi, N.M. and toma, R. N, " Investigation on the effect of some chemical additives on the strength of Iraqi soil – Cement," Journal of Building, 6(20, 1987.
[12] George, K. P, " Soil stabilization field trial," Report, Dept. of Civil Engineering , University of Mississippi and Mississippi Dept. of Transportation and Portland Cement Association,2006.
[13] ASTM D1557-2000, American society of Testing Material, " laboratory compaction characteristics of soil using modified effort 2700 kN-m/m3" , 2000.
[14] ASTM D558-2011, American Society of Testing Material, " Standard test methods for moisture – density ( unit weight) relation of soil – cement mixture,"2011.
[15] Yoon,S. and Abu-Farsakh, M, " Laboratory investigation on the strength characteristics of cement – sand as base material," Journal of Civil engineering, 13(1), 15-22, 2009.
[16] Kenai, S., Bahar, R. and Benazzoug, M." Experimental analysis of the effect of some compaction methods on mechanical properties and durability of cement stabilized soil," Journal of Material sciences, 41(21), 6956-6964, 2006.