

Improvement of Calcareous Sand by Using Chemical Grouting

M. Hassanlourad, H. Salehzadeh, H. Shahnazari

ABSTRACT

In this paper, the improvement potential of calcareous sand produced in Kish Island by using a chemical grout is investigated. The main characteristics of this sand are its high voids ratio and tendency to be crushed under moderate stresses. The improvement process of sand is conducted using a sodium silicate grout injected with additives such as formamide and sodium aluminate. Samples were prepared in different initial relative densities and then grouted. It is observed that the maximum uniaxial strength, initial tangent modulus and failure strain are obtained in water/silicate ratio of 0.5. Uniaxial strength and initial tangent modulus are increased with time but failure strain variation with time is a function of water/sodium silicate ratio and additives content. Formamide increases and sodium aluminate decreases the uniaxial strength and initial tangent modulus. Furthermore, increasing of grain size decreases grouted sand uniaxial strength. Uniform grading results in brittle and non-uniform grading results in ductile stress-strain behavior. Presence of sulphates and chlorides solved in water reduces the uniaxial strength and increases the initial tangent modulus of grouted sand.

KEYWORDS

دانشجوی دکتری دانشگاه علم و صنعت ایران

Email: mhassanlourad@iust.ac.ir

ⁱⁱ استادیار دانشکده عمران دانشگاه علم و صنعت ایران salehzadeh@iust.ac.ir

ⁱⁱⁱ استادیار دانشکده عمران دانشگاه علم و صنعت ایران hshahnazari@iust.ac.ir

Calcareous sand, particle crushing, chemical grout, uniaxial strength.

[]

)

(...

[] Semple

[] Coop

[] Airey Carter

BS-

XRF XRD

[] [] []

()

(SEM)

XRD

/

CaCO₃

(

) MgCaCO₃

[] [] [] []

BS-

()

()

kPa

(CD)

()

()

[] []

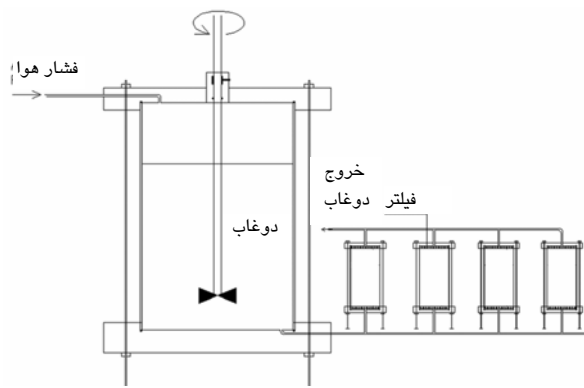
[] Alaa Ata



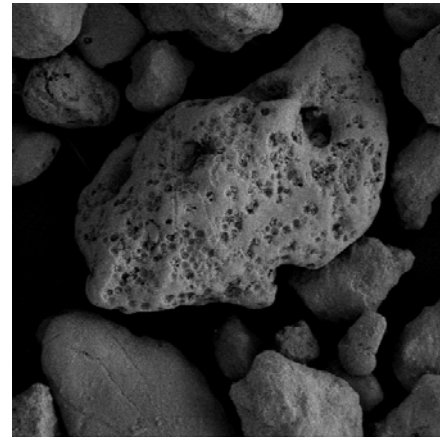
:()

e_{min}	e_{max}	$\gamma_{d(max)}$	$\gamma_{d(min)}$	Gs
/	/	/	/	/
XRF			CaCO ₃ (%) (BS)	
Mg(%)	Si(%)	Ca(%)		
/	/	/		

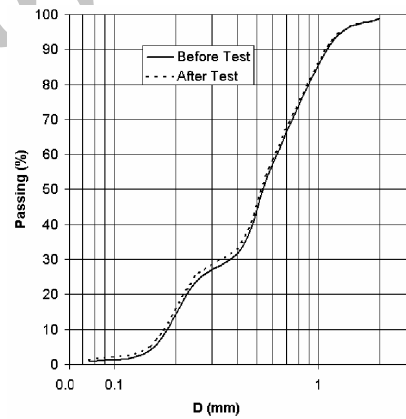
(Plaxi glass)



(Dry deposition)



:()



:()

mm

(CD)

cm

cm

(/)

/

(Na₂O₂SiO₂)

[]

W/S=

/ /

/

W/S< /

Archive of SID

(HCONH₂)

(NaAlO₂)

()

[]

()

:()

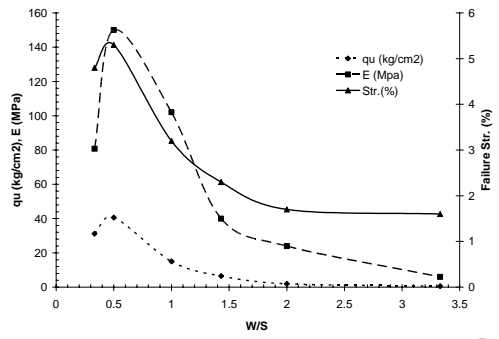
W/S	(%)	(%)
/ /		/ /



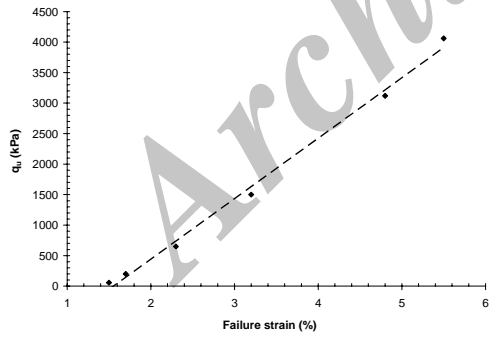
/ / / /

()
 % () W/S < 1.43
 %

MPa
 MPa
 % /



(qu) (E) ()
 W/S = /
 W/S
 W/S = /



()

()

Alu.S. (%)	/	/	/	/	/	/
(%)						
(min)						

()
 $q_u = 991\varepsilon_u - 1540$ ()

q_u (%) ε_u
 (kPa)

()

(%)

(%)

(%)

[]

()

()

()

()

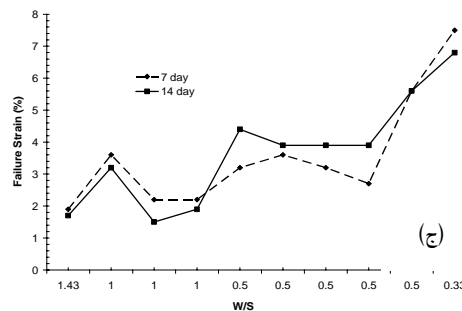
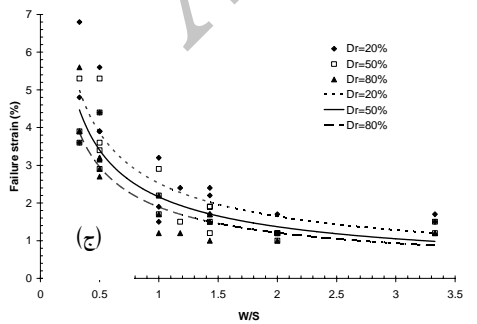
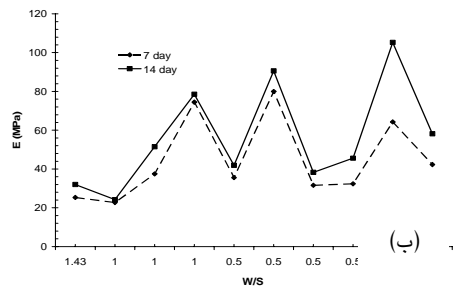
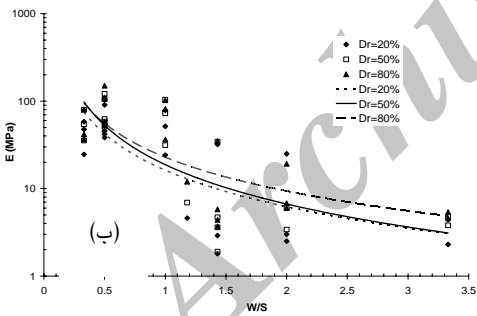
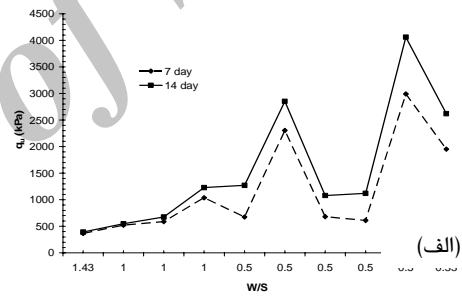
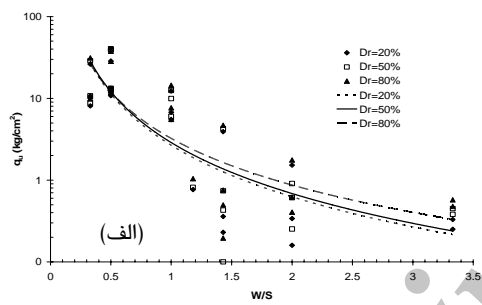
%

W/S

W/S

()

()



()

()

() : ()

()

: ()

W/S

()

()

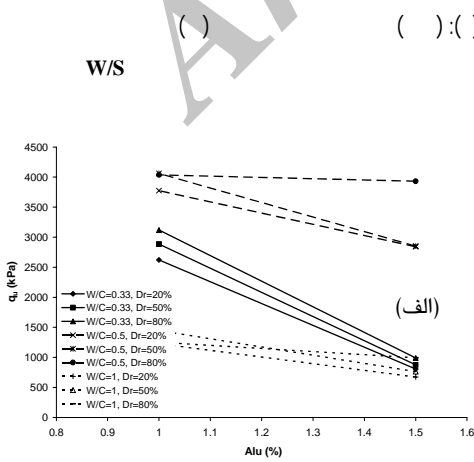
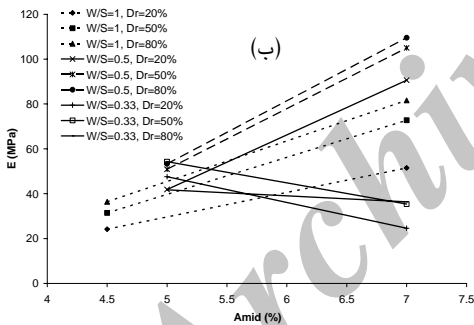
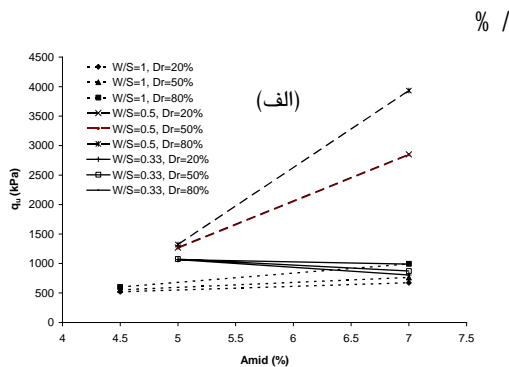


/ / / /

()

()

W/S=



% /

W/S

()

W/S= /

W/S= /

W/S

()

W/S= /

W/S

W/S= /

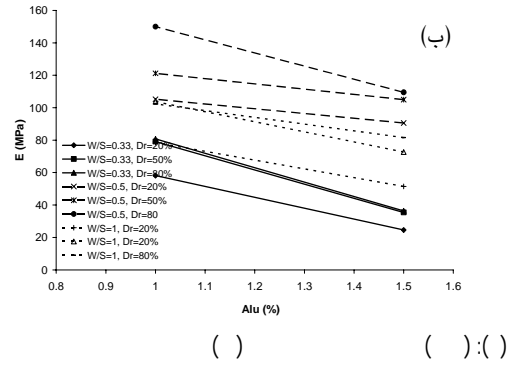
W/S

()

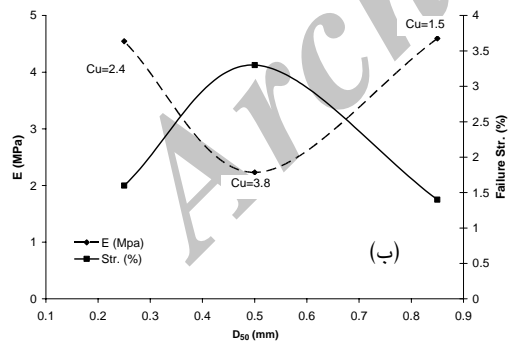
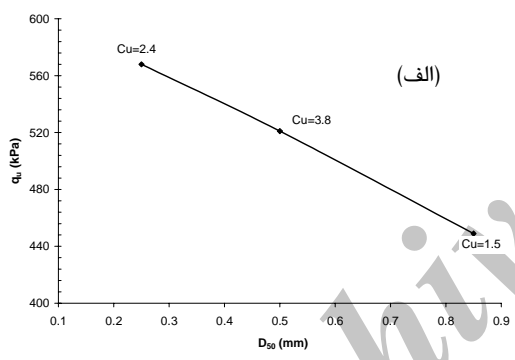
W/S

W/S

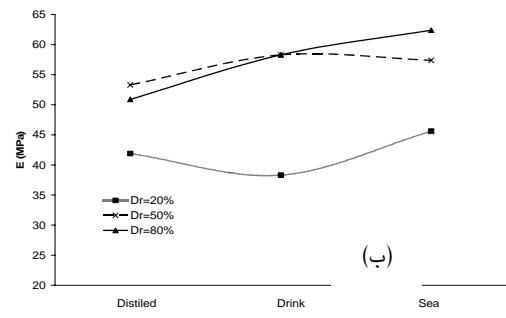
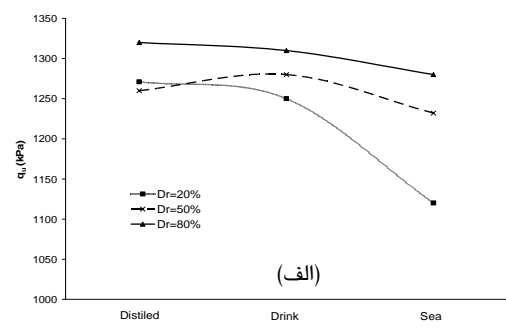
()
) (Cu= /) (Cu= /
 (Cu= /



() () (D₅₀)



W/S
 PH= / /
 () ()



() ()
 (W/S=1) ()

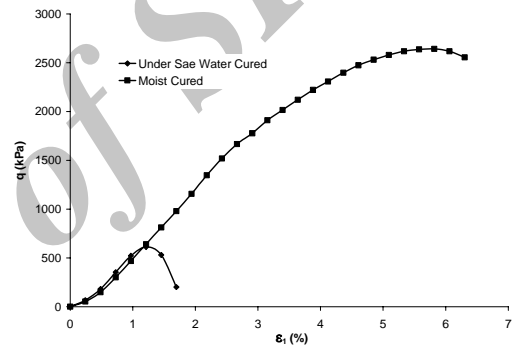
W/S= / (Dr=%)
)
(Ph= / / /

/ W/S

W/S=0.5

kPa

W/S



()

:()

()

:

MPa

MPa

Alaa Ata; Cumaraswamy Vipulanandan; "Factors Affecting Mechanical and creep Properties of Silicate-Grouted Sands", Journal of Geotechnical and Geoenvironmental Engineering, Vol. 125, No. 10, pp. 868-876, (1999). []

US Army Corps of Engineers, "Chemical Grouting", EM 1110-1-3500, 1995. []

Sample, R.M.; "Mechanical Properties of Calcareous Soils: State of the Art Report", Proceeding of 1st International Conference on Calcareous Sediments, Perth, Australia, Vol.2, 1988. []

Coop, M. R.; "The Influence on In-Situ State on the behavior on carbonate sands", Proceedings of the Second International Conference on Engineering for Calcareous Sediments, Bahrain, 21-24 February, 1999. []

Carter, J.P.; Airey, D.W. and Fahey, M.; "A Review of Laboratory testing of Calcareous soils" Proceedings of the Second International Conference on Engineering for Calcareous Sediments, Bahrain, 21-24 February, 1999. []

Coop, M.R. and Lee, I.K.; "The Behavior of Granular Soils at Elevated Stresses", Predictive Soil Mechanics, Proceeding C.P.Wroth Mem Symposium, Thomas Telford, London, pp. 186-198, 1993. []

Luzzani, L. and Coop, M. R.; "On the Relationship between Particle Breakage and Critical State of Sands", Soils and Foundation Journal, Vol. 42, No. 2, pp. 77-82, 2002. []

Coop, M.R., Sorensen, K. K., Bodas, T. & Georgoutsos G.; "Particle breakage during shearing of a carbonate sand", Geotechnique, Vol. 54, No. 3, pp. 157-163, 2004 []

Ismail, M.A., Joer, H.A., Merit, A., and Randolph, M.F.; "Cementation of Porous Material Using Calcite", Geotechnique, Vol. 52, No. 5, pp. 313-324, 2002. []

Ismail, M.A., Joer, H.A., Merit, A. and Randolph, M.F.; "Sample Preparation Technique for Artificially Cemented Soils", ASTM, Geotechnical Testing Journal, Vol. 23. No. 2, pp. 171-177, 2000b. []

Ismail, M.H., Joer, H.A., Sim, W.H., and Randolph, M.F.; "Effect of Cement Type on Shear Behavior Of Cemented Calcareous Soil" Journal of Geotechnical and Geoenvironmental Engineering, Vol. 128, No. 6, pp. 520-529, 2002. []

Salehzadeh, M.; "The Behavior of Non-Cemented and Artificially Cemented Carbonate Sand under Monotonic and Reversed Cyclic Shearing" Ph.D. Thesis, Univ. of Manchester, UK, 2000. []

