RECYCLING OF INDUSTRIAL SOLID WASTE MATERIALS FOR CONSTRUCTION PURPOSES

Submitted By

Samy Said Zaher

B.Sc. of Science (Geology), Faculty of Science, El-Menofia University, 1986

Diploma in Environmental Sciences, Institute of Environmental Studies and Research, Ain Shams University, 2001

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A thesis submitted in Partial Fulfillment
Of
The Requirement for the Doctor of Philosophy Degree
In
Environmental Sciences

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APPROVAL SHEET

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This Thesis Towards a Doctor of Philosophy Degree in Environmental Sciences Has been Approved by:

Name	Signature
1-Prof. Dr. Samir Ahmed Awad Emeritus Prof. of Geology Faculty of Science Ain Shams University	
2-Prof. Dr. Ali Ismail Mohamed Ismail Prof. of Engineering Geology, Geological Science Department National Research Centre	
3-Prof. Dr. Hassan H. M. Darweesh Prof. of Technological and Building Materials Engineering Refractories, Ceramics and Building Materials Department National Research Centre	

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Under The Supervision of:

1-Prof. Dr. Samir Ahmed Awad
Prof. of Geology
Faculty of Science
Ain Shams University

2-Dr. Mohie Eldin Mohamed Afifi El-mashad
Associate Prof. at Construction Research Institute
NWRC
Ministry of Water Resources and Irrigation

2018

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سورة التوبة: ١٠٥

صدق الله العظيم،،،

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ABSTRACT

Increasing technology results in an increase of environmental problems due to the accumulation of waste materials. Many researchers come out to explain how to use the waste materials in a safe way. Some waste materials have been use for many applications for the civil engineering as soil improvement and road construction works. The present work aims to study the use of different wastes in the form of additives e.g. CKD, cement, dune sands, to reduce swelling characteristics and improve the behavior of problematic soils such as swelling soil and soft clay. The swelling soil is obtained from Toshka area, southeastern corner of western desert of Egypt. The soft clay is obtained from Sahl El- Tina area, North Sinai governorate. The tested mixtures were classified to ten groups. Four groups (A, E, F, K) contain various percentages of soil mixed with constant ratios of CKD equal to 10%, 20%, 30%, 40% respectively were used to determine the Atterberg limits, free swelling, compaction and CBR. Three groups (G, S, H) contain various percentages of soil mixed with constant ratios of CKD equal to 35%, 30%, 20% and constant ratios of sand equal to 10%, 20%,30% respectively were used to determine the Atterberg limits, free swelling. Three groups (B, C, D) contain various percentages of soil mixed with constant ratios of CKD equal to 20%, 30%, 40% and small ratios of cement equal to 6%, 9%, 12% respectively were used to determine UCS, XRD, SEM and SEM/EDAX. The results showed that the plasticity properties and the free swelling of the soil after mixing decreased compared with the soil before mixing and the soil mixtures considered more stable. All mixtures of group (D) obtained the highest values in UCS all over other groups, although the best mixtures in UCS for each cement ratio was mix B6-12% cement, mix B5-9% cement and mix B6-6% cement. The cement ratio 6% obtained the lowest values of UCS in all three groups, ranging between 21 to 156.3 KN/m^2 (after 90 days curing time).While 9% cement ratio obtained high values of UCS in all groups ranging between 209.9 to 257.6 KN/m^2 (after 90 days curing time).Whereas 12% cement ratio obtained highest values of UCS in all groups ranging between 314 to 389.8 KN/m^2 (after 90 days curing time).The addition of CKD resulted in an increase in the OMC and a decrease in the MDD comparing with soils before mixing. The MDD increases with the increase of CKD ratio to 30% so group (F) shows the maximum dry density 1. 74gm/cm^3 and the optimum moisture content 20.19%. Group (F) shows increasing in the CBR values in all mixtures, comparing with untreated soil. The increase of CKD ratio to 30% increases the CBR values and these mixtures gain higher strength. XRD and SEM analyses after treatment showed that all clay minerals are transformed to new cementitous compounds, such as (C-A-H),(C-S-H), and (C-A-S-H), which has a more complex crystalline structure, as curing time increase. Salinity and pH causing flocculation process, the increase in pH values is responsible for separation of silica causing cementation. The pH values for 6 % cement-treated clay samples for all groups increasing as the curing time increase, the pH value increases with the rise in cement content (9 % and 12%) for all groups. Also the results showed that, the SiO_2 slightly increase as the curing time increases in all groups, causing formation of strong inter particle bond that improves the strength and reduce swelling,

Keywords: Cement kiln dust**,** Soil stabilization, Cement, Problematic soils.

List of Abbreviations

UCS	Unconfined Compressive Strength
CBR	California bearing ratio
PL	Plastic Limit
LI	Liquid Limit
LOI	Loss On Ignition
DDL	Diffused double layer
(C_3S)	Hatrurite
SL	Shrinkage Limit
$CaCO_3$	Calcium Carbonate
$Ca\ (OH)_2$	Calcium Hydroxide
TDS	Total dissolved salts
XRD	X-Ray Diffraction
CKD	Cement kiln dust
CEC	Cation exchange capacity
USCS	Unified soil classification system
C-A-S-H	Calcium aluminum silicate hydrate
DTA	Differential Thermal Analysis
PI	Plasticity index
MDD	Maximum Dry Density
SEM	Scanning Electron Microscopy
(C_2S)	Larnite
RHA	Rice Husk Ash
SIO_2	Silicate Content
C-A -H	Calcium Aluminate hydrate
Fe_2O_3	Ferric Oxide
SSP	Shear Strength Parameters
FS	Free Swell
GGBFS	grand Granulated Blast furnace Slag
G	Specific Gravity
SF	Silica fume
HCO3	Alkalinity
KCL	Potassium Chloride
PPM	Parts per million

pH	Hydrogen ion Concentration
Ps	Swelling pressure
C-S-H	Calcium silicate hydrate
OMC	Optimum moisture content
LSF	Lime silica fume
L	Lime
GBFS	Granulate blast furnace slag
OPC	Ordinary portland cement
SSA	Sewage sludge ash
ISSA	Incinerated sewage sludge ash
$CaCl_2$	Calcium Chloride
$CaSO_4$	Calcium Sulphate
C	Cohesion
HC	Hydraulic Conductivity
PG	Phosphogypsum
CaO	Quicklime
TRD	The trench cutting Re-mixing deep method
DSM	Deep soil mixing
CDF	Confined disposal facilities
MSS	Mass stabilization solidification technology
Cu	Coefficient of uniformity
Cc	Coefficient of curvature
FM	Fineness modulus
SP	poorly graded sand
CFA	Class C fly ash

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