IMPROVEMENT OF SWELLING SOIL FOR CONSTRUCTIONS BY INDUSTRIAL CHEMICAL WASTES

Submitted By

Marwa Salama Hussein Mohammed

B.Sc. (Chemistry), Faculty of Science, Al-Azhar University, 2008

A thesis submitted in Partial Fulfillment
Of
The Requirement for the Master Degree
In
Environmental Sciences

Department of Environmental Basic Sciences
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APPROVAL SHEET

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Acknowledgment

First I would like to thank God for the mercy and support and giving me the strength to complete this study.

Special thanks are extended to my supervisor **Prof. Dr. Mohamed Gharib Elmalky,** Professor of Geophysics, Environmental Research Institute, Basic Science Department - Ain Shams University for his great help and continuous scientific directing along this study and for his supervision through the M.Sc. research.

I gratefully acknowledge the supervision and support of **Prof. Dr. Mohie Eldin Mohamed El mashad**, Associate Professor at Construction Research Institute. National Water Research Center (NWRC) for his sincere support, He suggested the research point and kindly guided me with his distinctive advice till this work finally came true.

I am also extremely grateful to **Dr. Samy Said Zaher** Researcher at Construction Research Institute (NWRC); for his support and comments throughout this thesis. Deep thanks go to the staff of Laboratory Soil Mechanics and Foundation in the CRI and to everyone who participated in some way or another, in this work; I owe my thanks and gratude.

Thanks also to my friends and colleagues especially Al shimaa Embaby, Thanks for your good thoughts and encouraging words; she is very meaningful for me. I am also thankful to the lawyer Ayman Elgendy and agriculture engineers Osama Diab, Hussien Mohamed Ali, and also grateful to engineer Mohamed Awad for their kind cooperation and support.

Would like to acknowledge the financial support of Abu Zaabal Phosphatic Fertilizer Plant and Helwan Cement Factory for permission to collect waste slurry and acknowledge Construction Research Institute and National Research Center for the laboratory facilities.

Finally, my most appreciations are to my family my precious parents, my loving sons Mahmoud and Mohammed, my sisters Eman, Zainab and Mona, brothers Hassan and Ahmed and my husband social worker Hassan for their full support, help and patience. I am so grateful to have you in my life... this work is dedicated to you.

ABSTRACT

Many arid and semi-arid regions have a problem of swelling soil which is one of the problematic soils that face many geotechnical engineers in the field (others include collapsible soil, soft clay, etc.). Swelling soil is known to cause severe damage to structures that are founded on it as a result; some houses and roads were destroyed. The presence of montmorillonite clay in these soils imparts them high swell–shrink potentials.

To overcome this problem there are two solutions one is replace the swelling soil by good quality granular material. The second is stabilizing the subgrade clayey soil by using various industrial wastes. The volume of by-product materials generated from industries such as Phosphogypsum, cement dust, and other mining and heavy industries are increasing, the cost of removal of wastes is continuing to rise day-by-day in our society.

Phosphogypsum (PG) is a solid waste generated from natural phosphate rock in phosphoric acid fertilizer production (H_3PO_4), composed of calcium sulfate contaminated by other impurities; it is produced in large quantities worldwide. Theses wastes pollute the environment. Most phosphogypsum is stockpiled while lesser quantities are recycled or dumped into water. On the other hand cement kiln dust (CKD) is fine dust results from cement plants, the disposal of this fine dust becomes an environmental danger; Theses waste pollutes the soil, air and water. Now-a-days easily available industrial by-products are used for the enrichment of soil properties and become economically sound and environmentally friendly.

In this research i have targeted to use Phosphogypsum (PG), cement kiln dust (CKD) and NaCl for swelling soil improvement by mixing them mixing them with bentonite in three groups (A, B, C).

This study carried out to check the improvement of the properties of swelling soil with phosphogypsum in various percentages i have tried to use the small ratio of PG (i.e., 0.6, 1.2, 1.8, 2.4 and 3%) with in various small ratio of CKD (i.e., 0.6, 1.2, 1.8, 2.4 and 3%) and chemical additives like NaCl.

After treatment of soil the properties of the mixture samples were investigated, the natural soil properties were used as control points for comparison purposes. Since the swelling soil has the same property of bentonite, I used bentonite as a substitute of the swelling soil.

In this regard important chemical analysis determined for all samples, and engineering tests like free swell test determined for all samples, Atterberg's limit test were conducted on some samples. Analytical technique x-ray diffraction (XRD) used to identify composition of bentonite and the reaction Products of the clay fraction of some test bentonite mixed with various amount of PG, CKD and NaCl. This pure clay test soil was used to ease identification of the reaction products.

Some good results were obtained to use PG, CKD and NaCl for improvements of the properties of swelling soil by mixing them with bentonite, and I obtained good results as follows:

For all additives used in the tests, the free swelling of bentonite generally decreased when the additive percentages increased and change its chemical and mechanical properties as pH increase due to cations exchange reactions occurred between the soil and additives, But all the mixtures cannot have the same type of influence over the swelling soil, The swelling rate of bentonite decreases strongly with increasing the percentages of NaCl and It is also observed that group B (PG + NaCl + B) has more_effective additive than the others.

All the examined samples consisted mainly of SiO_2, Al_2O_3 and Fe_2O_3 (R_2O_3) and CaO in a descending order of abundance. A minor to trace amounts of MgO were also detected of the treated samples indicated the presence of kaolinite clay. Low loss on ignition (LOI) as in appendix and alkalinity (high pH) improve the swelling properties and reduce the plasticity index (PI).

Liquid limit, plasticity index of bentonite for some mixtures is also decreased with the increase of percentages of the chemical wastes and NaCl, while the plastic limit for these mixtures is decrease but slightly increased for few samples when the concentration of the chemical wastes and NaCl percentages increased.

The results from XRD analyses of the bentonite and some mixtures showed that large amounts of montmorillonite were approximately transformed to other phases during the reaction that are (a non-swelling clay mineral commonly Kaolinite and Microcline).

The aim of this study is to treatment of swelling soil using wastes and to determine the rate of change in swelling behavior of swelling soil when exposed to chemical wastes .This achieves the double objective of reducing the problems of this type of soil by improvement its characteristics, and also of providing a use for the additives (wastes), thus eliminating the economic and environmental cost involved in managing them.

Key Words: Swelling soil; waste Phosphogypsum; waste cement kiln dust; NaCl; soil improvement; free swell; liquid limit; plastic limit; plasticity index; x- ray diffraction.

LIST OF ABBREVIATIONS

Al	Aluminum
Al_2O_3	Aluminium Oxids
B	Bentonite
BC	Black Cotton Soil
Ca	Calcium
C	Cohesion
°C	degree Celsius
$CaCl_2$	Calcium Chloride
$CaCo_3$	Calcium Carbonate
$Ca(OH)_2$	calcium Hydroxide
$CaSO_4$	Calcium Sulphate
CBR	California Bearing Ratio
CKD	Cement kiln dust
CEC	Cation exchange capacity
CL	Chlorine
DFS	differential free swell
DTA	Differential Thermal Analysis
E	Axial Strain
EC	Electrical Conductivity
ESP	Egg Shell Powder
ESP	Exchangeable Sodium Percentage
FA	Fly Ash
Fe_2O_3	Ferric Oxide
FSI	Free Swell Index
FS	Free Swell
GGBS	Ground Granulated Blast Furnace Slag
G	Specific Gravity

HC	Hydraulic Conductivity
HCl	Hydrochloric acid
HCO_3	Alkalinity
IP	Index Plasticity
KCl	Potassium Chloride
k_e	Correlation Factor
LL	Liquid Limit
LOI	Loss On Ignition
LS	Linear Shrinkage
MDD	Maximum Dry Density
Na^+	Sodium Ions (Cations)
NaCl	Sodium Chloride Salt
O.M	Organic Material
O.M.C	Optimum Moisture Content
PG	Phosphogypsum
pH	Log $_{10}$ (Hydrogen Ion Concentration)
PI	Plasticity Index
PL	Plastic Limit
PPM	Parts per million
P_S	swelling pressure
RHA	Rice Husk Ash
SEM	Scanning Electron Microscopy
SI	Free Swell Index
SIO_2	Silicate Content
SL	Shrinkage Limit
SO_3	Sulfate As Sulfur Trioxide
SP	Shear Strength Parameters
SR	100% : Saturation Line
TDF	Tire Derived Fuel
UCS	Unconfined Compressive Strength
WC	Water Content
XRD	X-Ray Differaction
Φ	Friction Angle

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