STABILIZING THE ERODED POLLUTED SOIL WITH LOCAL ECO-FRIENDLY MATERIALS

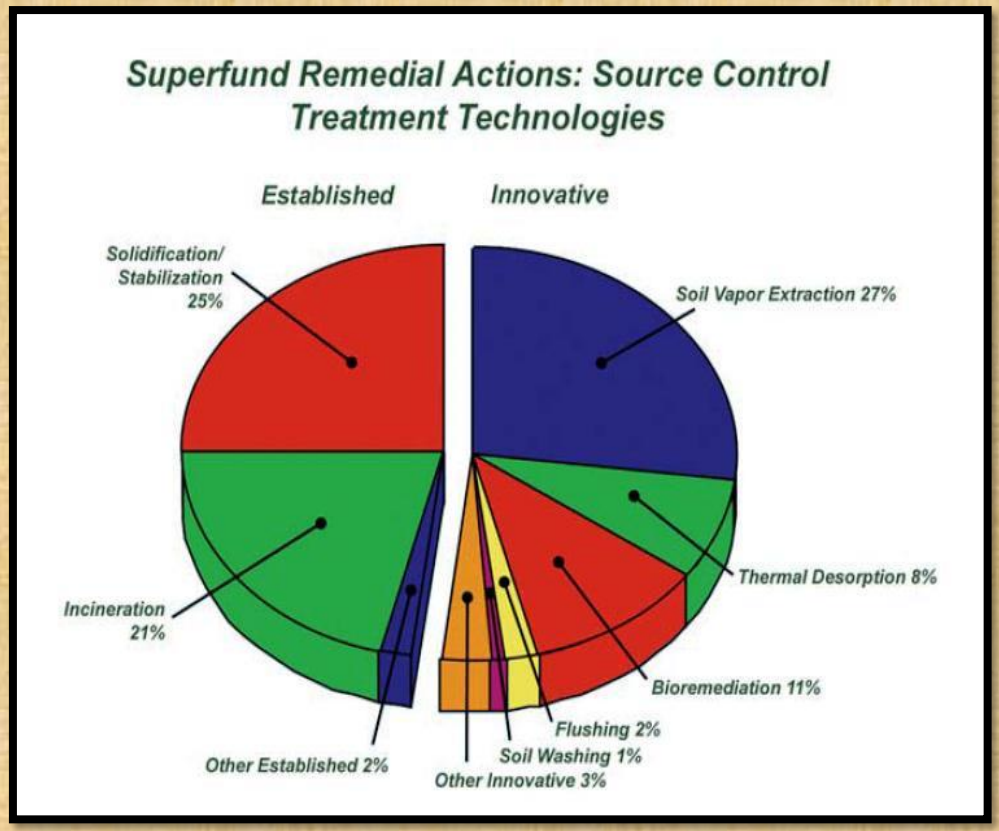
Introduction

Soil stabilization has been performed for ages. For instance, the Mesopotamians and Romans separately discovered that it was possible to improve the ability of pathways to carry traffic by mixing weak soils with a stabilizing agent like pulverized limestone or calcium.

Generally, soil stabilization aims to improve soil strength and increase resistance to softening by water through binding the soil particles together, water proofing the particles or combination of the two.

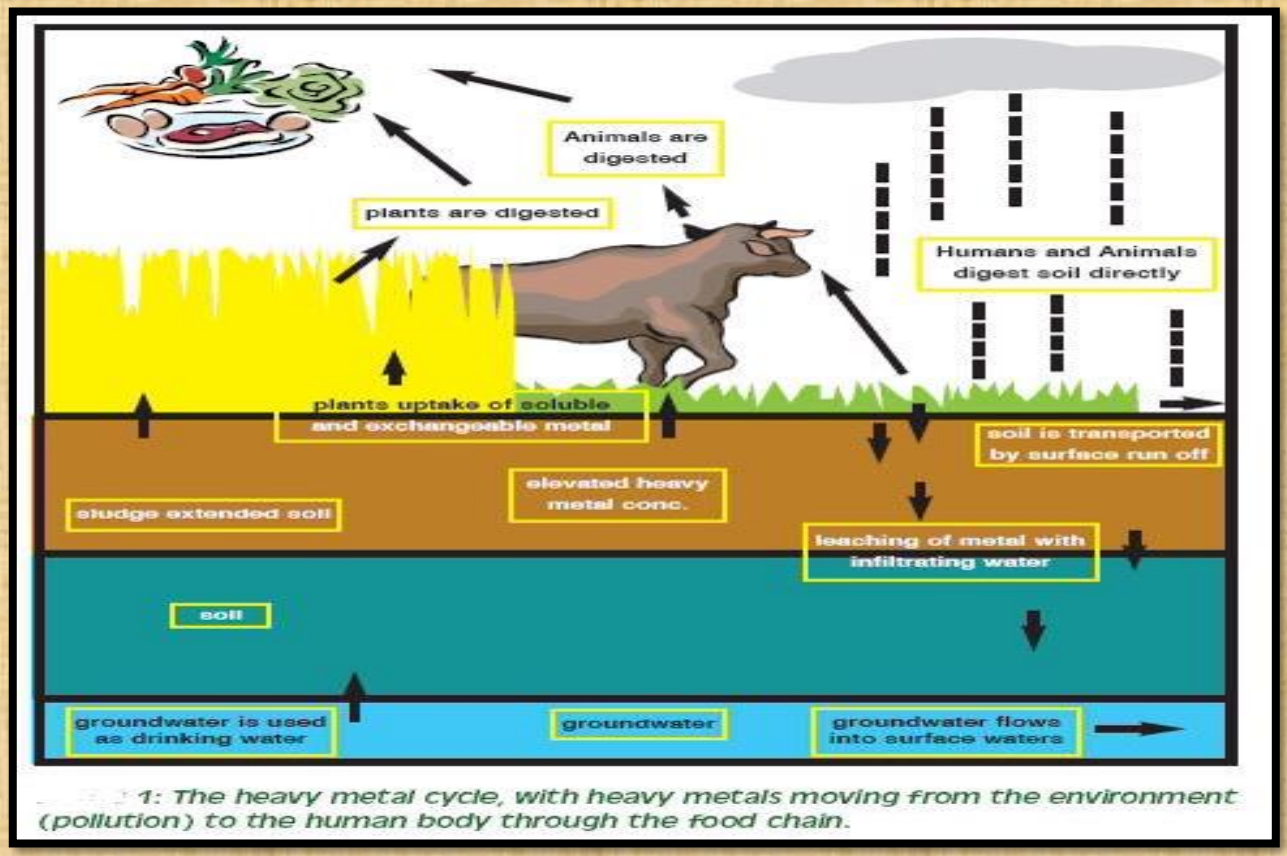
Solidification and stabilization **are the most commonly selected treatment options for metal-contaminated sites. This technique is significant because it is**

- **Relatively cheaper than most alternatives.**
- **The results is well qualified long term physical and chemical stability.**
- **The resultant products often possess superior mechanical and structural characteristics.**



Soil erosion is a natural process that slough off and land transport material through the action of natural erosive agents such as: water, wind, gravity, or artificial processes caused by human activities. Soil erosion is one of the serious world problems that make the soil to become unstable.

The accumulation of heavy metals in soil is an important issue because of the adverse effects that may have on food quality, soil usage, human health, and the environment.



1: The heavy metal cycle, with heavy metals moving from the environment (pollution) to the human body through the food chain.

Recent researches showed that Pb-polluted soil is more erodible than clean soils. Increasing the erodibility of cohesive soils indicated that there is a defect results from pollution on the environment.

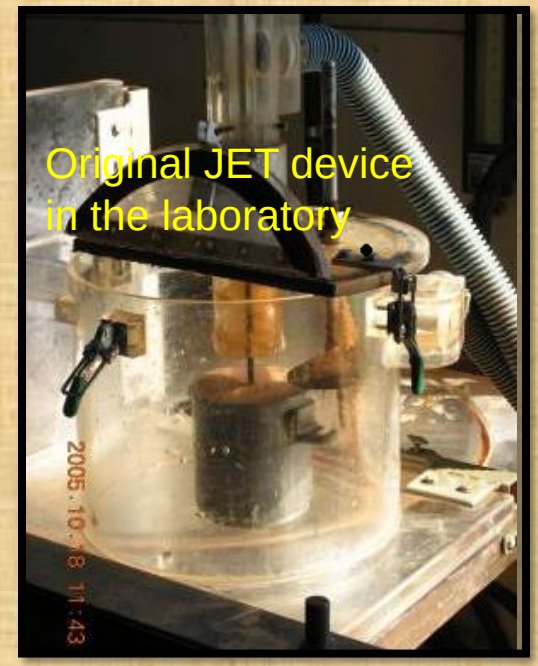
Soil erodibility is typically defined by excess shear stress model depend on two soil parameters:

$$E_r = k_d(\tau_o - \tau_c)^a$$

- **The critical shear stress (τ_c, Pa)**
- **The erodibility coefficient (k_d, cm^3/kN.s)**

One of the techniques to determine soil erodibility that is becoming more widely accepted in practice is the

Jet Erosion Test.



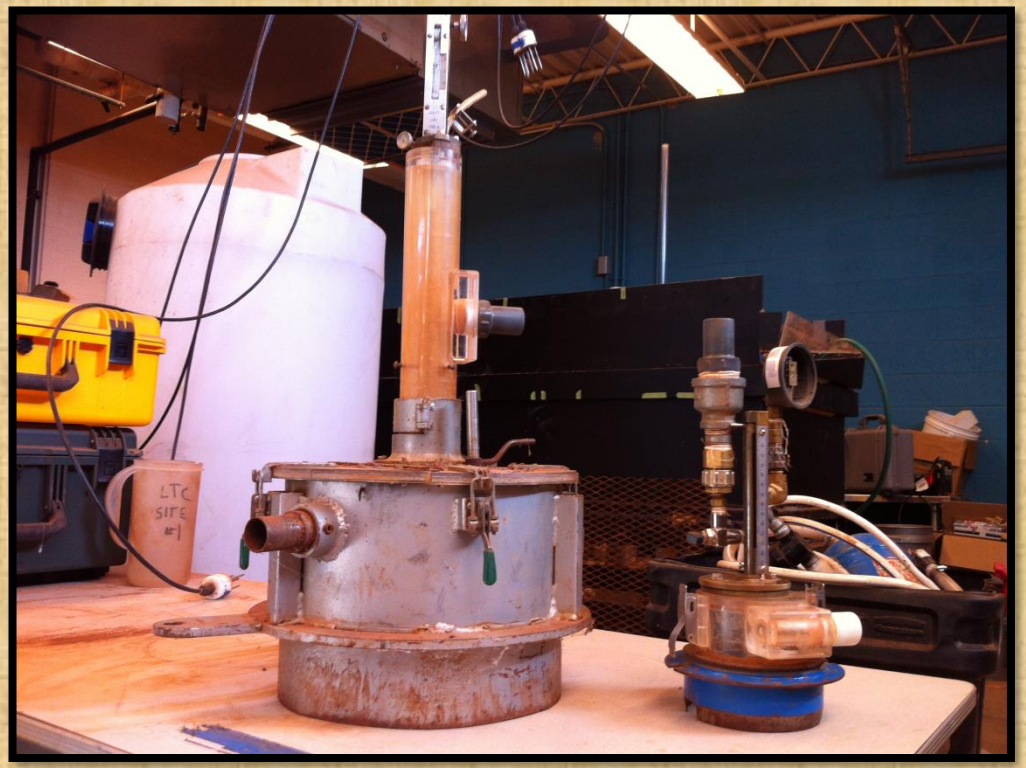
A new miniature version of JET was developed refers as to “mini” JET device.

Mini jet device consists of the following parts:

- **Pressure gage, Outlet and inlet water, Depth gage, Rotatable plate, Submerged tank, Valve, Hoses and adjustable head tank**

The “mini” JET device has several benefits over the original JET device; such as,

- **The small size of the “mini” JET,**
- **more converted to use in many setting,**
- **Consume less water,**
- **It could be used in situ as well as in the laboratory.**



Aim of This Study

1. **Investigate the influence of different percentage of building materials (cement, hydrated lime, and bitumen) on the stability of an artificially Pb-contaminated soil using "mini" JET device as a function of measuring soil erodibility parameters (τc and k_d) at different curing times.**
2. **Develop a relationships between soil erodibility parameters (τc and k_d) and other soil properties; such as Atterberg limits, and hardness.**
3. **Study the statistical and cost analysis of these materials to choose the best stabilizer.**

Materials and Methods used in the Study

Soil

The soil used as a model to carry out the experimental work acquired from Al-Taji region, north of Baghdad city.

All the soil is taken at depth from (0 to 90) cm.

soil classification according to the unified soil classification system (USCS) as Lean Clay CL.

Physical Properties	Sand%	Silt%	Clay%	Soil classification USCS
Value	13	57	30	CL-Lean Clay

Cement

The type of cement use is the ordinary portland cement OPC.

Lime

The type of Lime use is Hydrated lime Ca(OH)2.

Bitumen

The type of Bitumen use is Bitumen emulsion.

The standard mold
and
Manual rammer

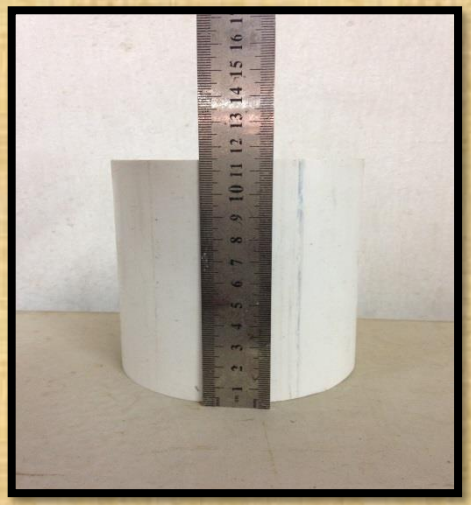
U.S.A standard sieve (4.75 mm)

Sensitive balance

Electrical oven

Digital Shore-D durometer

Casagrande apparatus



(P.V.C) molds

96 Sample

Figure explain the work steps to measure Erodibility parameters (kd and τc)

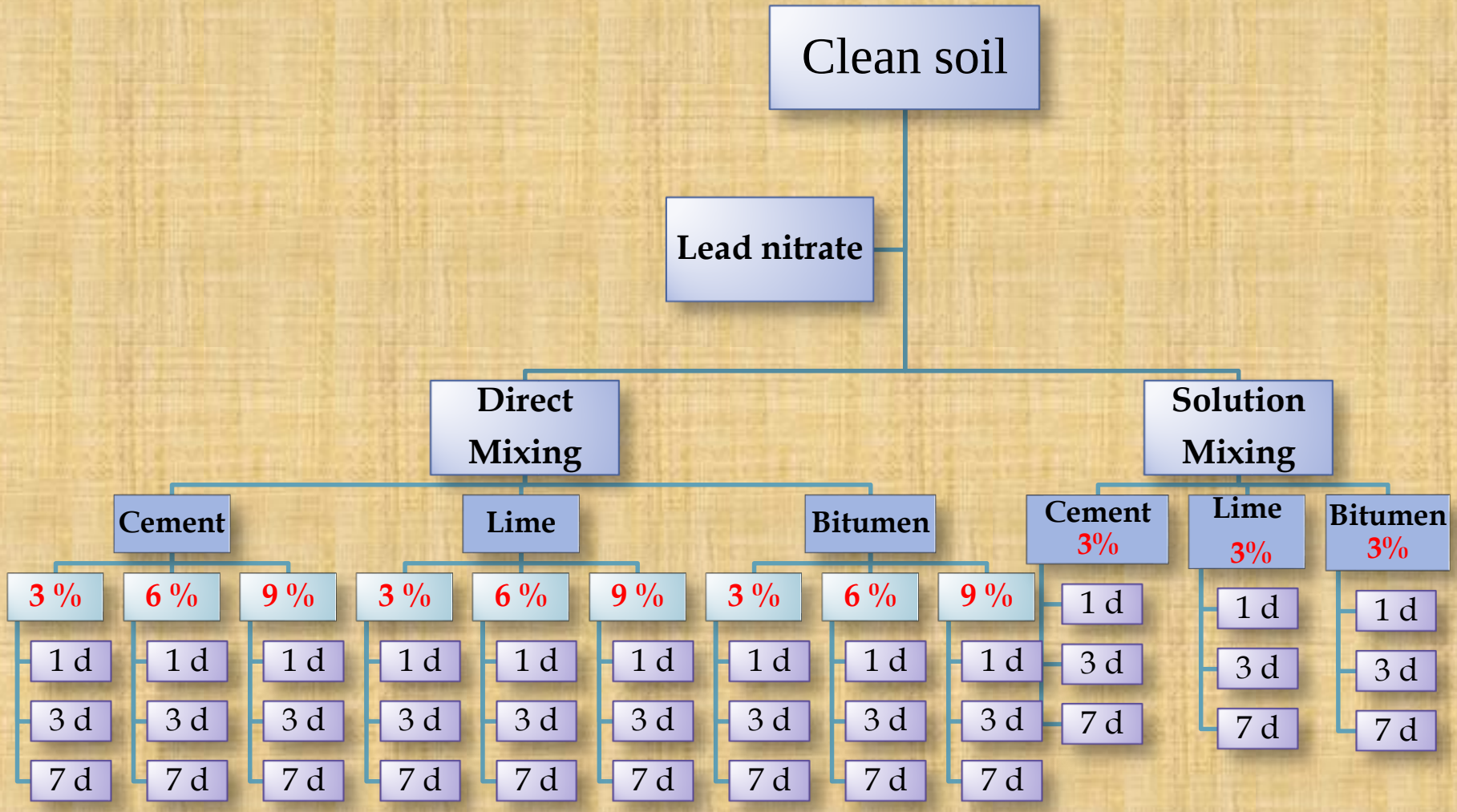
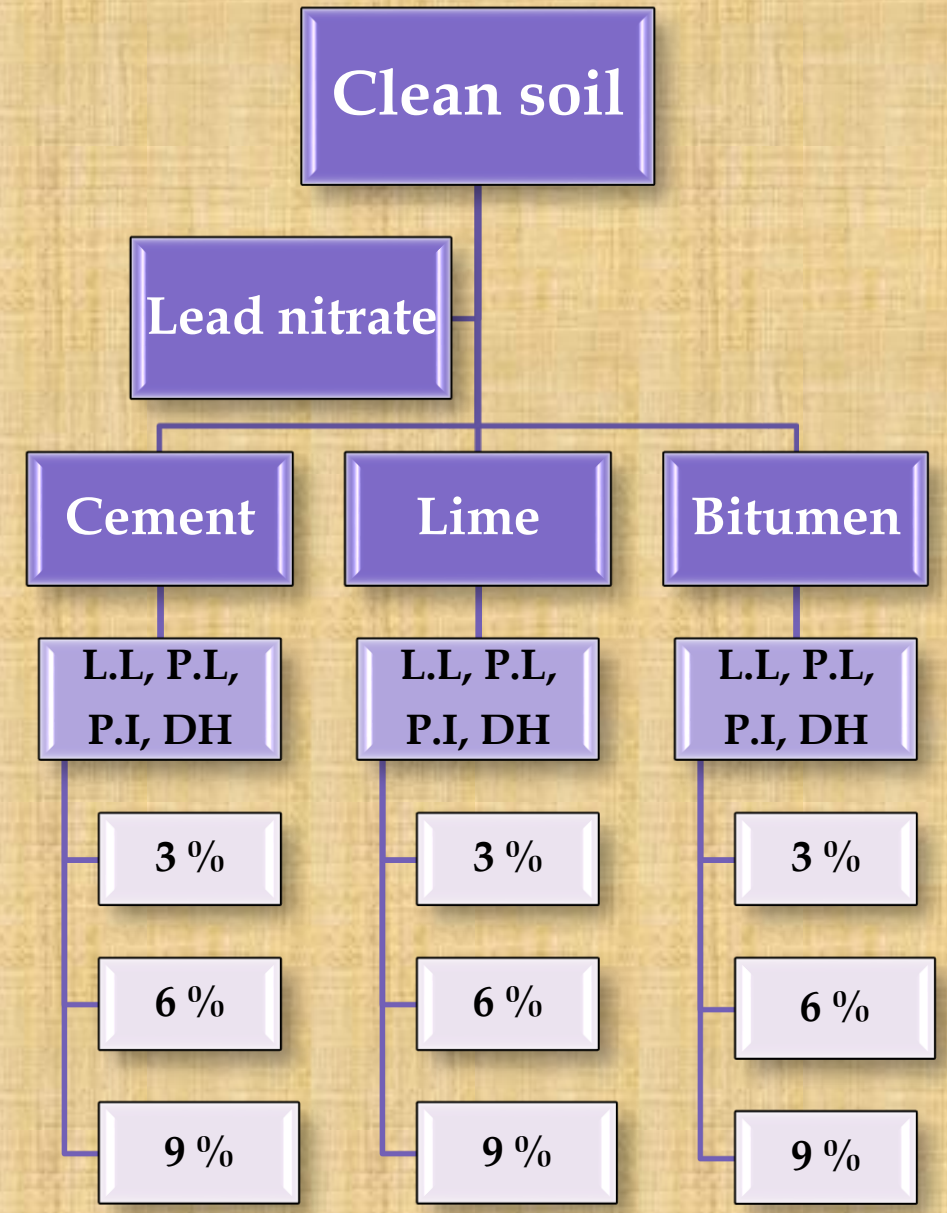
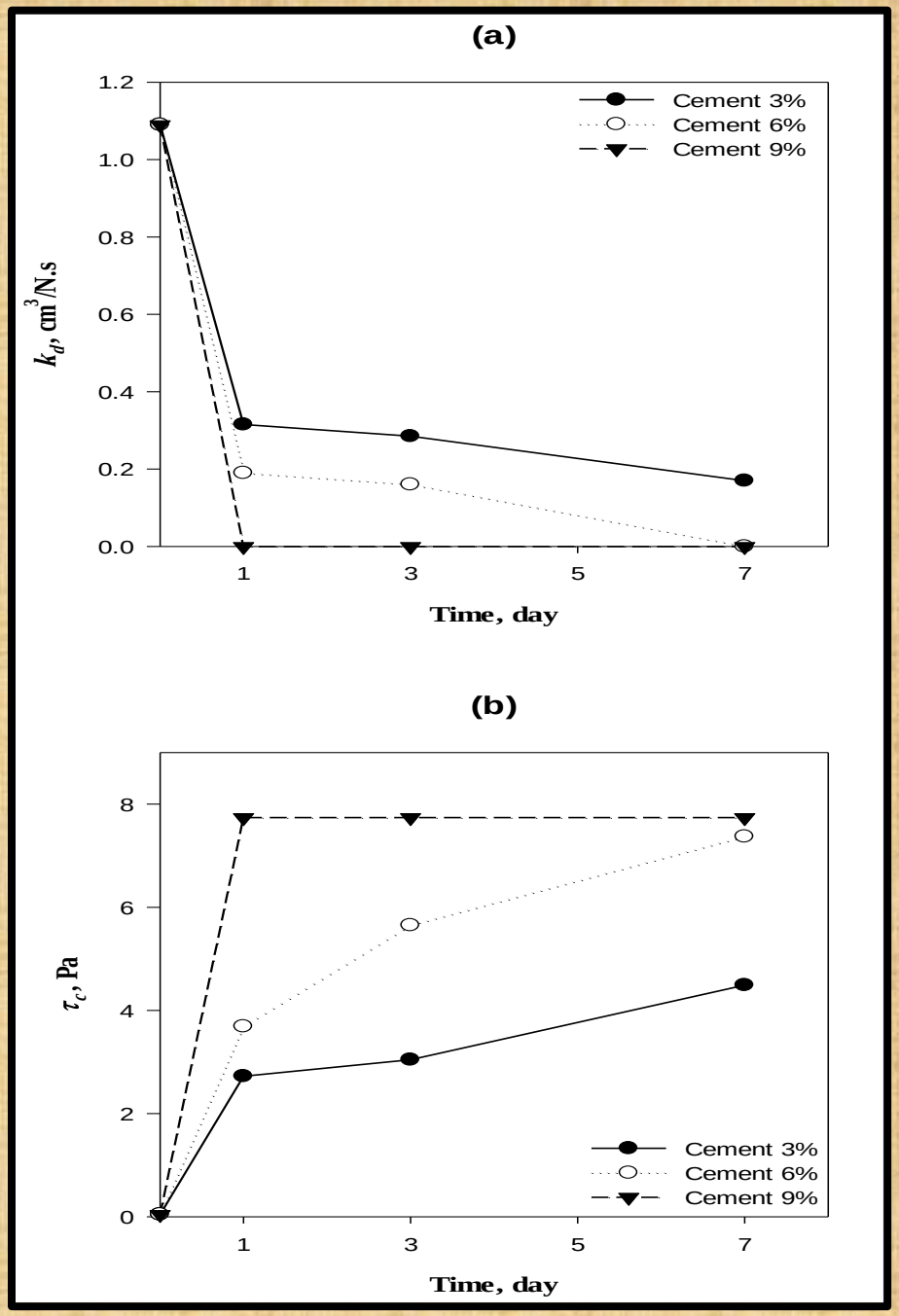


Figure show the work steps to measure the soil properties

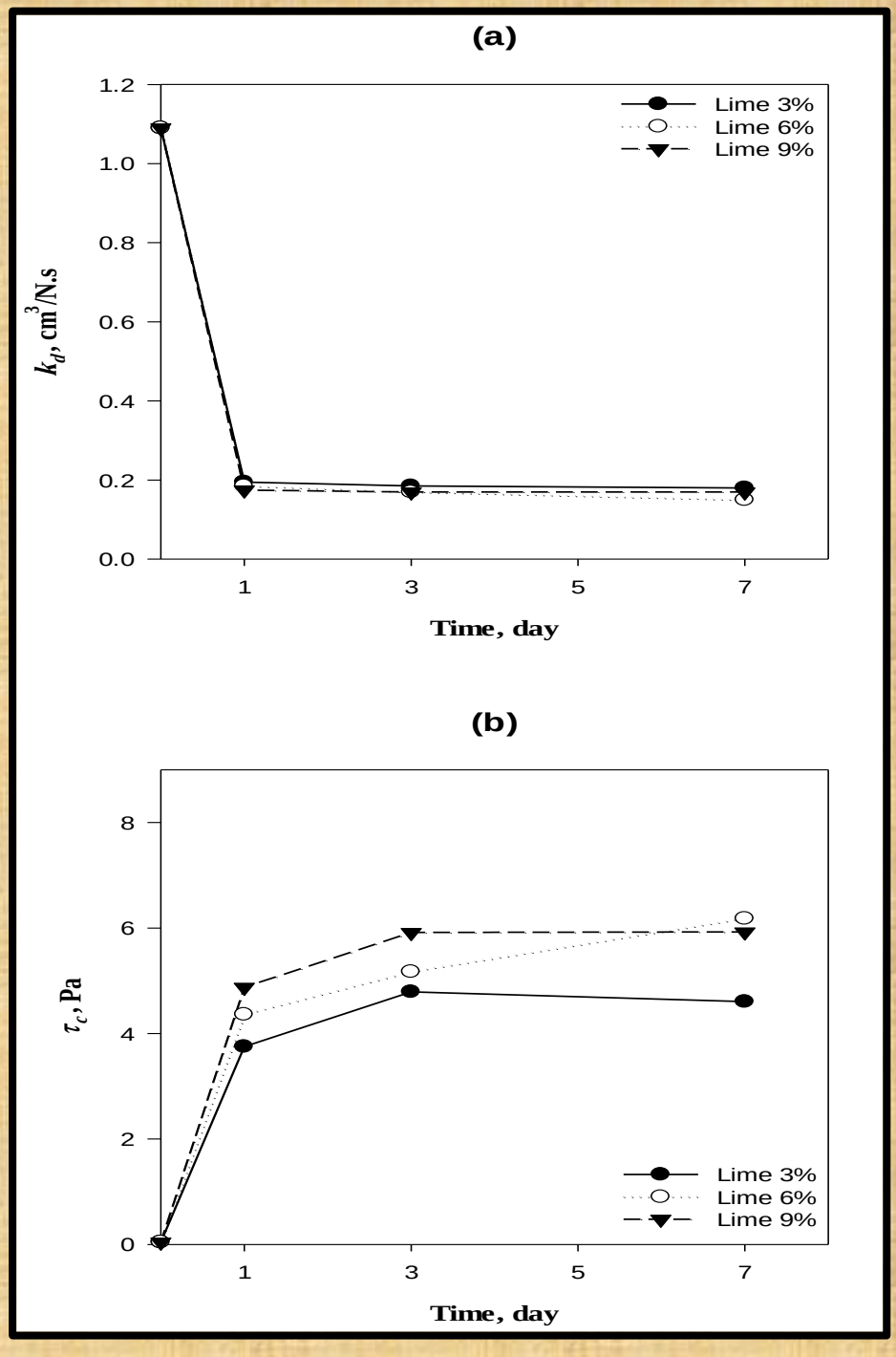


Results and Discussion

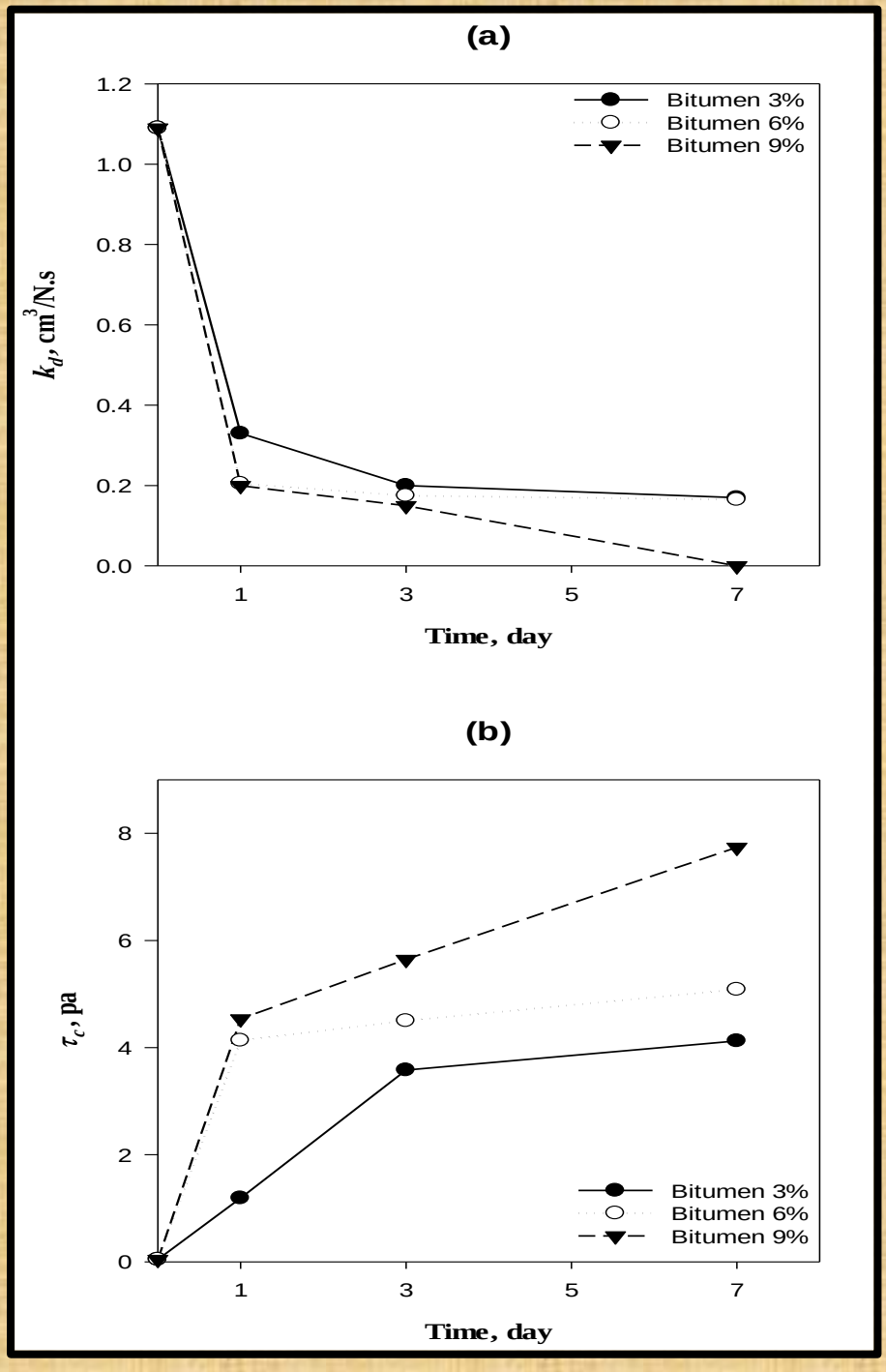
Effect of different percentage of Cement on excess shear stress parameters at different curing times.

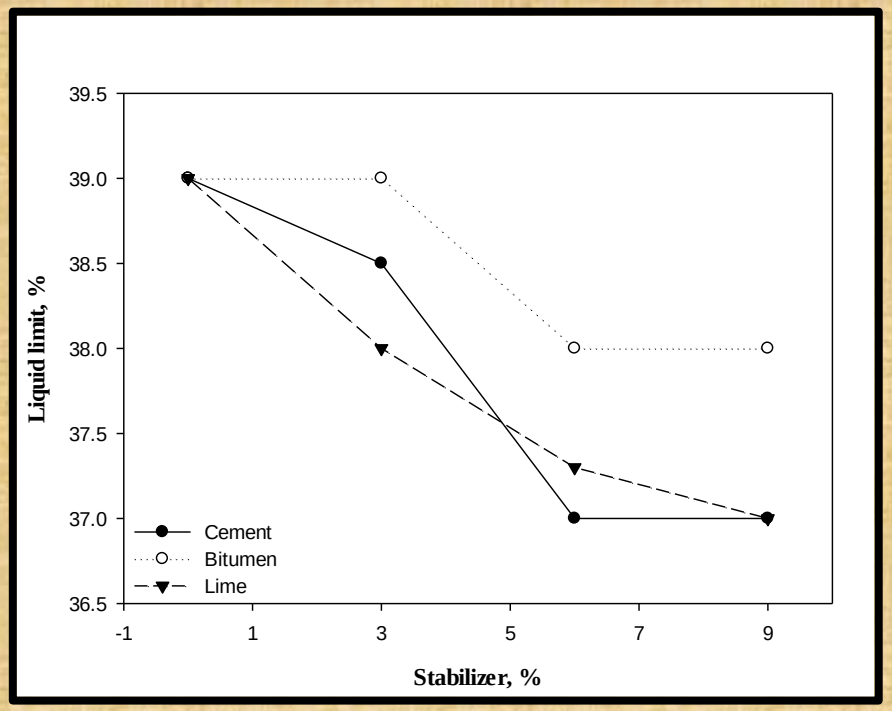


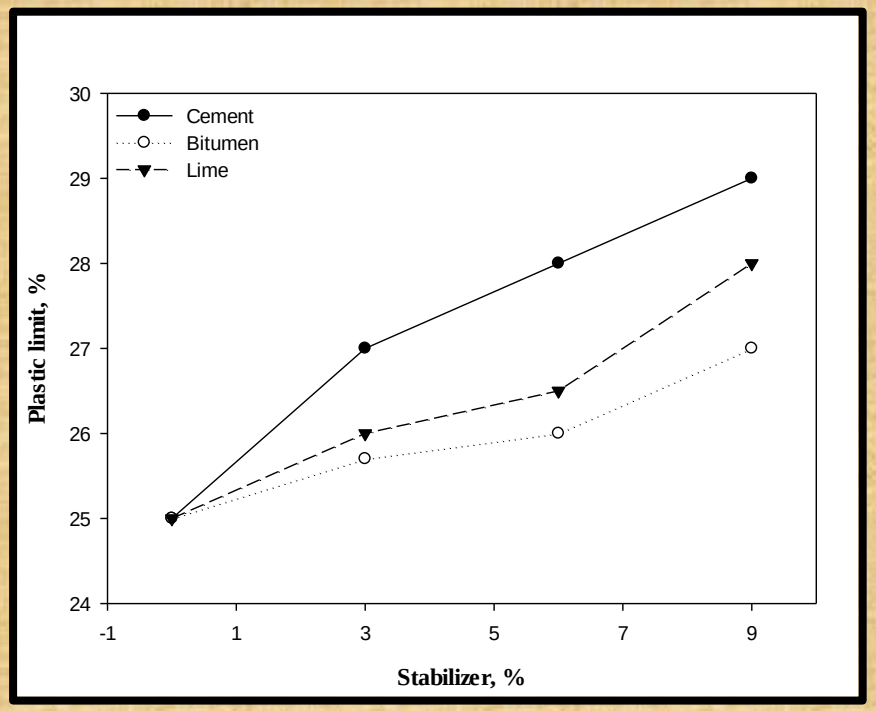
Effect of different percentage of Hydrated lime on excess shear stress parameters at different curing times.



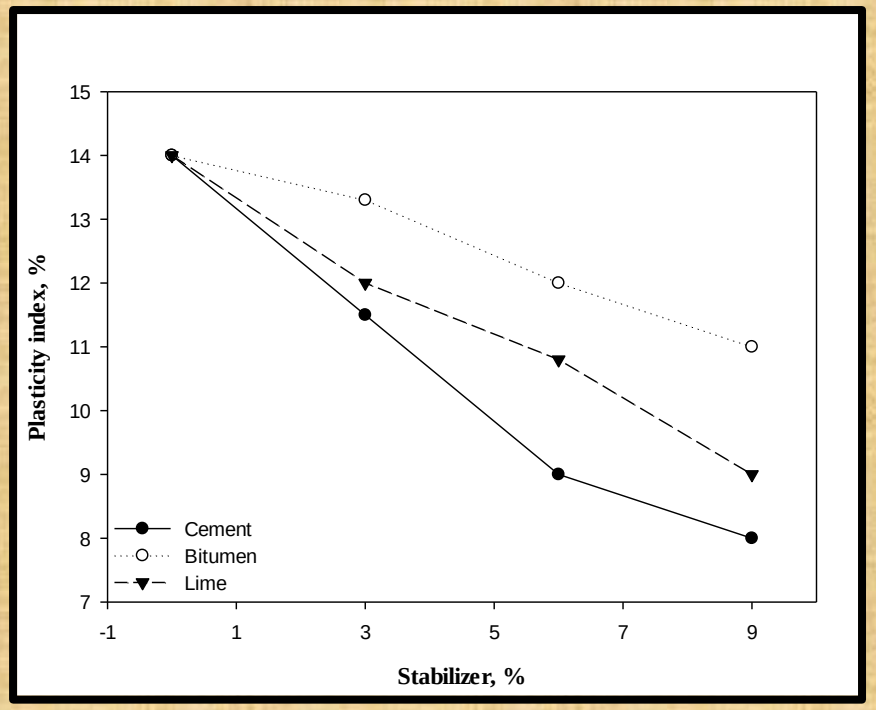
Effect of different percentage of Bitumen on excess shear stress parameters at different curing times

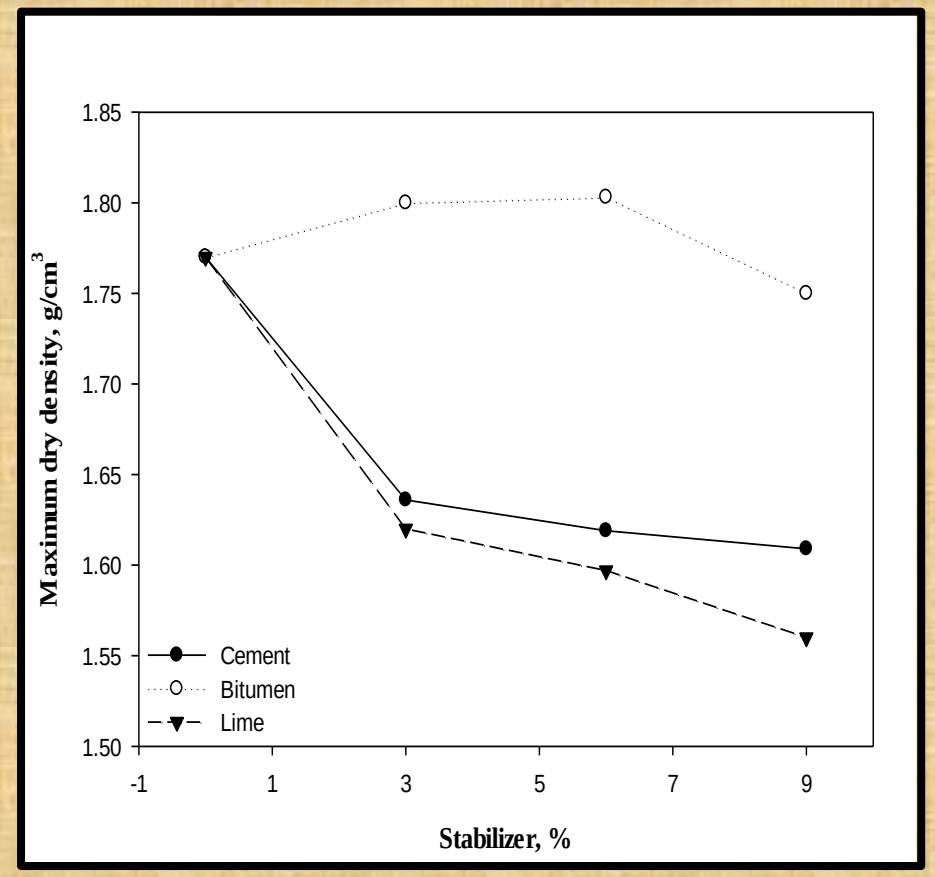


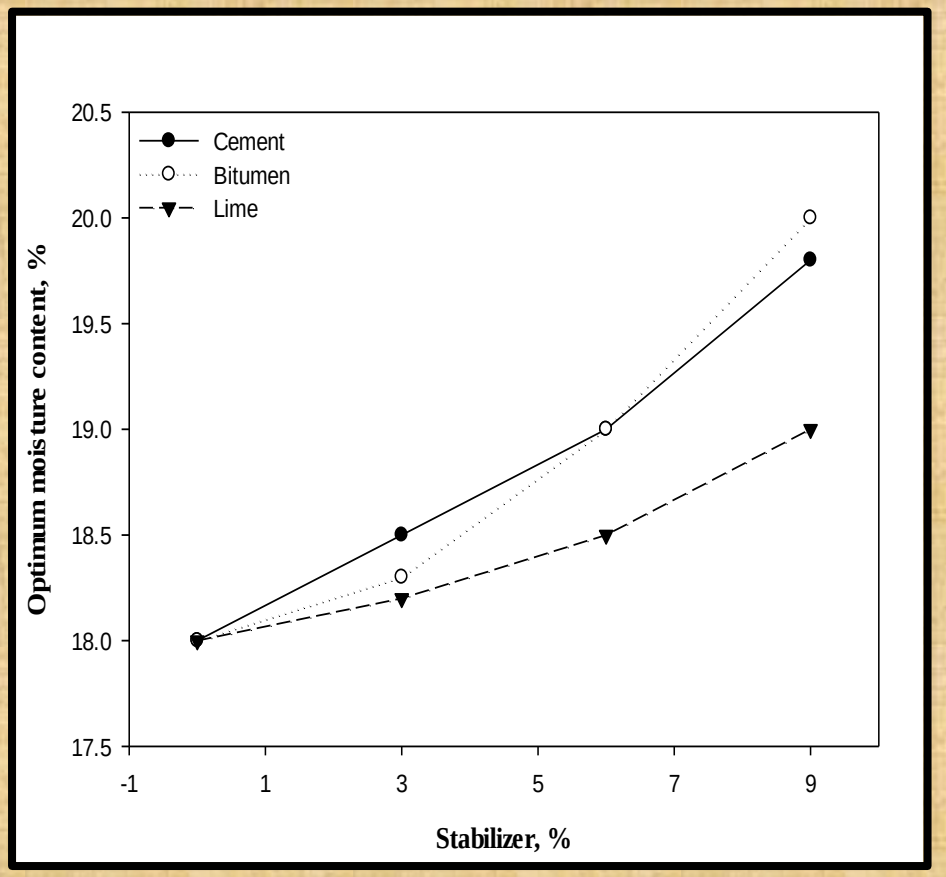




Relationships of Atterberg limits with different percentage of stabilizers (cement, hydrated lime, and bitumen).

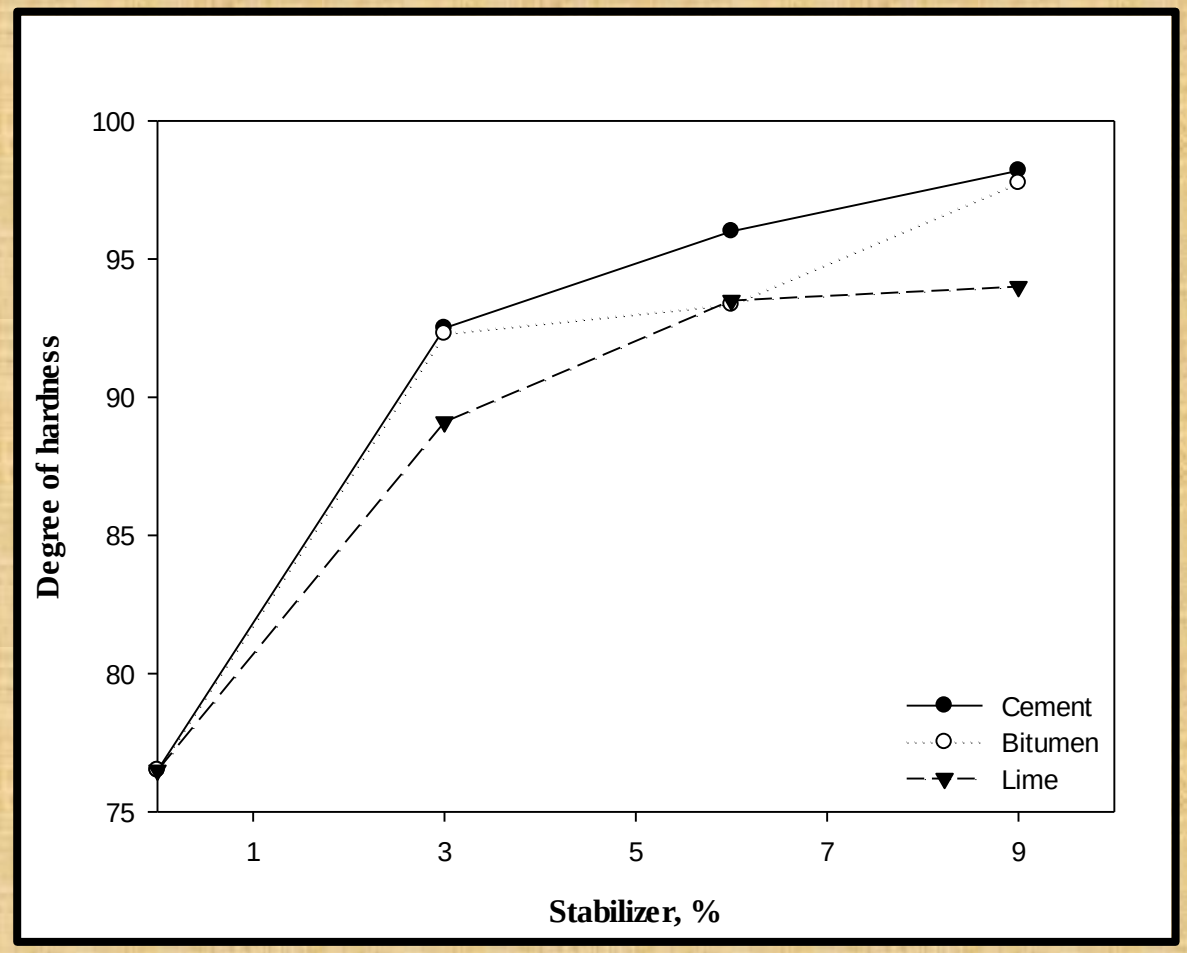






Relationships between different percentage of stabilizers (cement, hydrated lime, and bitumen) with:

Dry density, and Moisture content.



The variation of average degree of hardness on different percentage of stabilizers (cement, hydrated lime, and bitumen).

Cost Analysis

The costs of the ideal ratio of stabilizers used in stabilizing Pb-contaminated soil.

Stabilizer	Ideal ratio, %	Dry density (soil+stabilizer) kg/m^3	Weight of stabilizer, kg in (0.3)m^3,	Cost of 1 kg of stabilizer, IQD*	Cost of stabilizer, IQD
Cement	6	1619	97.14	140	13600
Hydrated lime	6	1597	95.82	400	38500
Bitumen	9	1750	157.5	933	147000

Conclusion

The analysis of the data obtained from the "mini" JET experiments were analyzed with the Linear model using Blaisdell solutions indicates that:

1. **The erodibility coefficient, k_d of the soil decreased with increasing curing time and stabilizer percentage.**

2. **The critical shear stress, τ_c of the soil increased with increasing curing time and stabilizer percentage.**

3. **There is an inverse relationship between k_d and τ_c.**

4. The results showed that the ideal ratios of stabilizing Pb-contaminated soil are 6% cement, 6% hydrated lime and 9% bitumen.

5. The ratio of 3% of stabilizers solutions achieved the desired results.

6. The results showed that these stabilizers can reduce soil erodibility by improving related soil properties through;

- **Decreasing the L.L , P.I, and M.D.D.**
- **Increasing the P.L, O.M.C., and DH**

7. A strong inverse relationship between k_d and the degree of hardness was observed, while the τ_c followed a direct relationship.

8. The results indicated that low k_d values referred to more stable soils.

9 . The cost analysis shown that cement has the reasonable cost comparing with lime and bitumen

10. This study proved the beneficial of using JET device in consume testing time and conserving energy when comparing with other conventional techniques used for studying soil stabilization.

THANK YOU