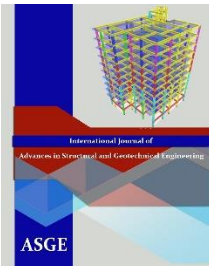

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Relation between EBS of Some Syrian Clay Minerals and Atterberg Limits

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ABSTRACT

The demand of clay as a raw material for many industries has increased in recent years due to their physical–chemical and plastic properties. The main property that distinguish the clay is its plasticity therefore; several attempts have been made to achieve a numerical index to emphasize the relationship between mineralogy and plasticity. (EBS) Equivalent Basal Spacing maybe is the most recent contribution for this purpose. In this paper, we analyze different types of Syrian clay samples, from five locations, by measuring their Atterberg limits and their mineralogical composition, in order to check the validity of the EBS method. As consequence, we find a positive connection between Atterberg limits and the relative amount of phyllosilicates present in samples. The EBS factor provides a good relationship between mineralogy and plasticity of the samples, by giving an easy and reliable correlation based on the direct determination of the liquid limit and plasticity index based on the mineralogical composition of the studied clays. We recommend for further researches to study the relations between EBS and Atterberg limits for other types of clay around Syria in order to validate EBS parameters in most applications.
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Keywords: *Clay, Plasticity Index, Plastic Limit, Basal Spacing, Minerals, Syrian Clay.*

INTRODUCTION

Clays, according to the mineralogical structure, have different physical-chemical and plastic properties which cover the needs of many type of industries. Therefore, many researches concentrate on studying the influence of properties of clay on its plasticity. Atterberg [1] attempt to evaluate the influence of many factors in clay sample such as mineralogical composition, shape and size distribution of particles, interaction among clays or with water or dissolved salts, the effect of cementin. Casagrande [2] published his chart while Dumbleton and West [3] try to define how much the component of clay components could affect on engineering properties of soil. Decleer et al. [4] undertake a chemical, physical and mineralogical investigation to evaluate the Belgian Clay as a raw material for the structural clay product industry and Hawkins et al. [5] concluded that there is a positive correlation between Atterberg limits and the clay minerals by doing analysis on clay from UK. While Ohtsubo et al. [6] examined the correlation of clay mineral composition with the consistency limits and activity of the clays for marine clays from Singapore, Korea, and Japan. Al-Homoud et al. [7] evaluated the chemical and engineering properties of the clayey beds in some locations in Jordan and correlated the clay minerals associated with the clayey beds with their engineering properties. The main property that distinguishes the clay is its plasticity therefore; several attempts have been made to achieve a numerical index to emphasize the relationship between mineralogy and plasticity. Equivalent Basal Spacing (EBS) is the most recent contribution for this purpose that is introducing by Schmitz et al. [8]**.** EBS is a parameter obtained by multiplying the relative amount of a clay with its basal spacing (Å) known from the literature. Schmitz proposed that the best method for specifying the effect of clay minerals, in geotechnical engineering. Where by using EBS, it could be expected the liquid limit for mixtures of two types of clays.
In this research, we measure the Atterberg limits and the mineralogical composition of different types of Syrian clayey samples, from five locations, in order to check the validity of the EBS method.

What is EBS?

Clay minerals are different according to it structure, for example: kaolinite consists of multilayer; each layer contains one sheet of tetrahedral and one sheet octahedral (mineral 1:1) whereas, montmorillonite consists of multilayer, each layer contain two sheets of tetrahedral and one sheet octahedral (mineral 2:1). The distance between layers is BS Basal Spacing which is measured by Å. Table 1 shows BS for wide spread clay minerals [9]

Table 1: BS for some Clay Minerals [9]

Clay Mineral	BS (Å)
Kaolinite	7.13
Hydrate Halosite	10
Illite	10
Sodium Montmorillonite	12.20
Calcium Montmorillonite	14.2

Schmitz et al. [8] suggested the use of equivalent basal spacing (EBS), given by the following formula (1):

$$EBS = TCF^{TRP} \cdot \sum_{i=1}^{n} CF_i^{FOA} \cdot BS_i^{(001)FOA} \qquad (1)$$

where EBS is the equivalent basal spacing; TCF the total amount of clay minerals in the sample, indicated as weight fraction; CFi the weight fraction of each clay mineral type determined from oriented aggregate XRD patterns of the <2 lm granulometric fraction; and $BS_{i(001)}$ is the average basal spacing of that ‘‘i” clay mineral.

MATERIALS AND METHODS:

We choose five locations of Syrian clay soils which are used in ceramic manufactory: MKH (Mkharam), MK (Mkemen), RY (Rkhemeh), GD (Gdedet Yabous), F (Sergaya) as shown on Syria map Fig.1.

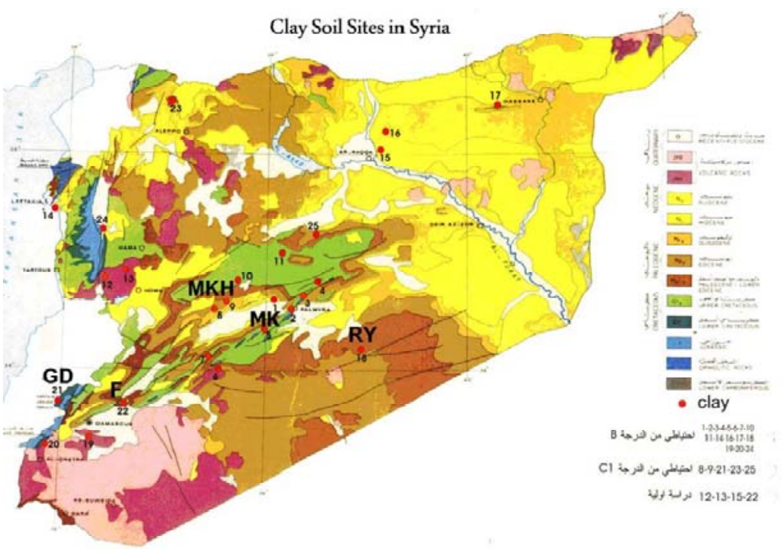

Fig.1 Clay Soil Locations in Syria

After choosing specific samples from each sites (MK, MKH, RY, GD, F) we have applied sieve and hydrometer analysis on theses soils according ASTM D422[1] Standards shown in figures 2,3,4,5,6. Then, we have applied chemical analysis by X-ray fluorescence (XRF)[2] as illustrated in table 2. Moreover, mineralogical analysis by X-ray diffraction (XRD)[2]has applied on all soils e.g.as shown in figures 7,8 for two types MK and MKH, and table 3 clarify the quantitive analysis for all types of soils, in order to calculate the EBS for each type of clay soil. Next, we did Atterberg limits according ASTM D 4318[3] to know the liquid limit, plastic limit and plasticity index and to classify the soils as illustrated in table 4. After getting all required parameters, we calculate EBS according the equation 1 and analyze the results to check the relation between EBS for each type of clay soils and its liquid limit and plasticity index.

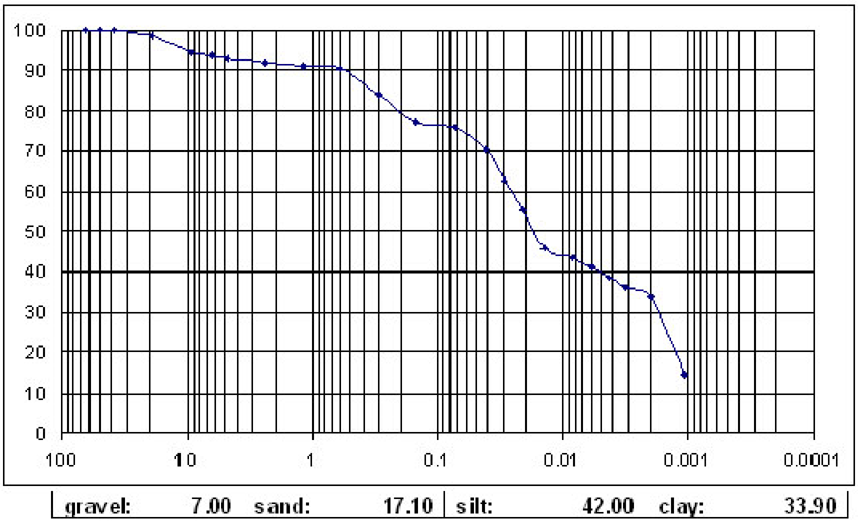

Fig.2 Sieve Analysis for MK

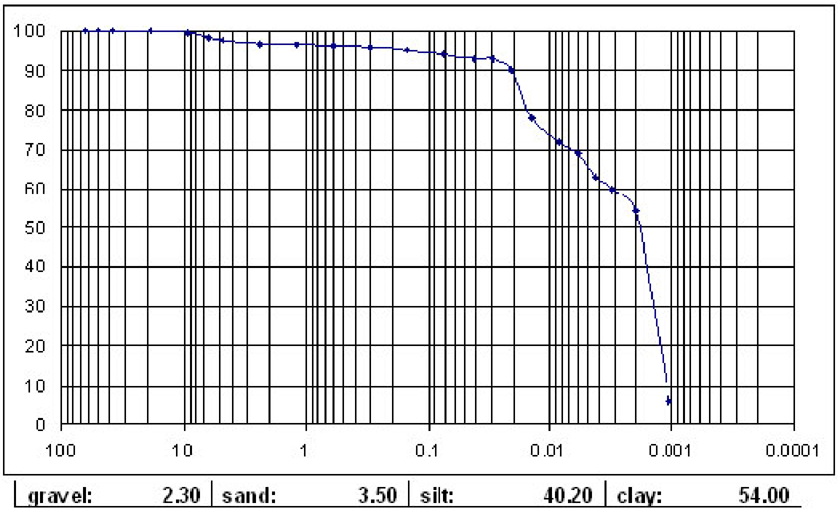

Fig.3 Sieve Analysis for MKH

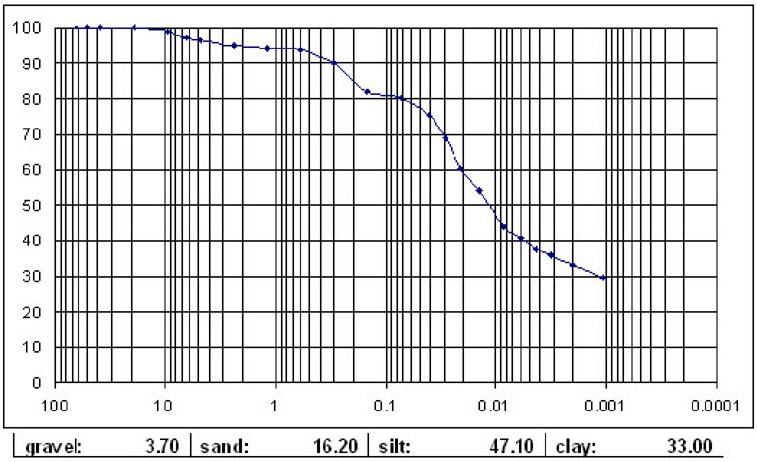

Fig.4: Sieve Analysis for RY

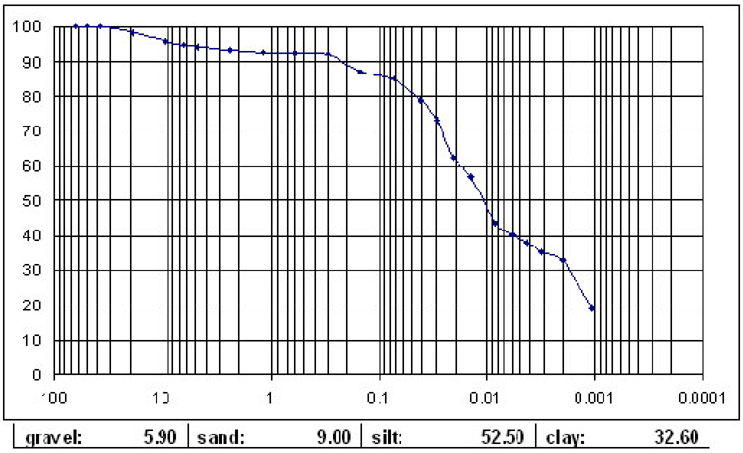

Fig.5: Sieve Analysis for GD

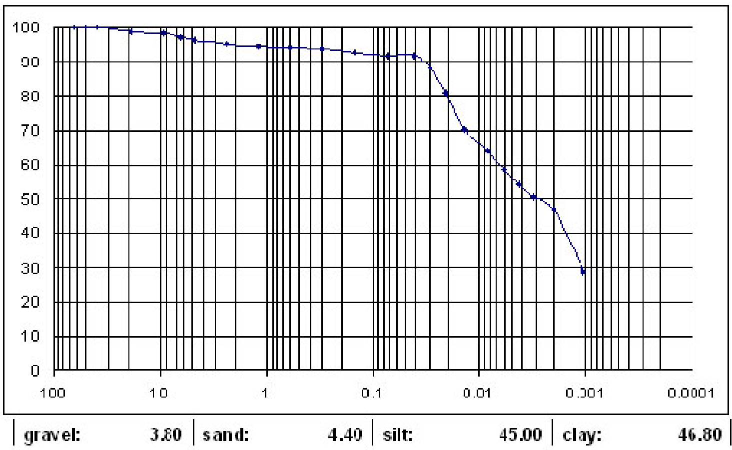

Fig.6: Sieve Analysis for F

Table 2: Chemical Analysis for soils

	GD	F	RY	MK	MKH
SiO_2	75.11	67.4	51.95	50.9	43.9
Al_2O_3	14.65	20.5	20.8	22.9	20.34
TiO_2	0.29	0.39	0.59	0.39	1
Fe_2O_3	2.9	3.5	6.25	4	9.61
MgO	0.44	0.6	2.48	3.3	2
SO_3	0	0	0	0	0
Na_2O	0.8	0.6	1.2	2	1
K_2O	0.2	0.15	0.25	0.4	0.2
$CaCO_3$	1.25	0.5	8.25	8.75	15.75
L.O.I	5.1	6.1	10.95	12.6	13.6
CaO	0.62	0.6	5.25	3	8.35

Mineralogical analysis as shown in fig.7 for soil MK, fig. 8 for soil MKH and we have detailed the percentage of minerals included in each type of soil in the table 3.

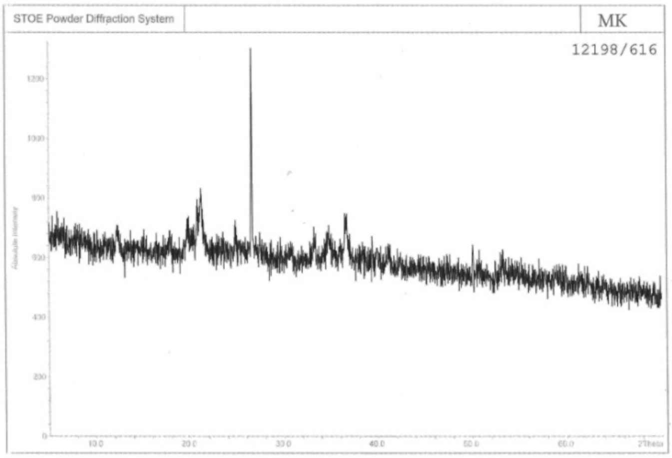

Fig.7: Mineralogical analysis for MK soil

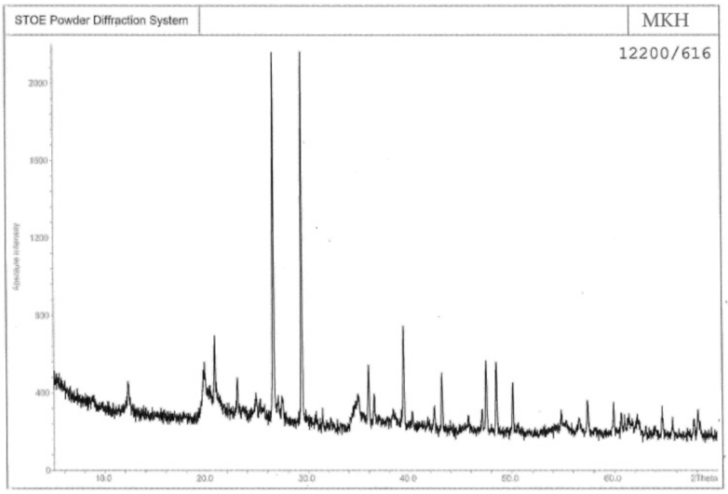

Fig.8: Mineralogical analysis for MKH soil

Table 3: Minerals Percentage in the soils

	MK (%)	MKH(%)	RY(%)	GD(%)	F(%)
Calcite	7	14	8	0	0
Kaolinite	38	42.1	32.5	22.7	35.2
Quartz	51	32.8	50.1	65.3	58.71
Illite	4	11.1	9.4	12	6.09

Atterberg limits have been defined for all soils and then according USCS the soils was classified as presented in table 4.

Table 4: Atterberg Limits for all Soils

	GD	F	MK	RY	MKH
Liquid Limit	0.2058	0.27	0.2339	0.3475	0.495
Plastic Limit	0.179	0.22	0.1127	0.188	0.212
Plasticity Index	0.0268	0.05	0.1212	0.1595	0.283
Classification	ML	CL-ML	CL	CL	CH

RESULTS:

According to the results in previous we could calculate EBS from equation (1) and we find the values as illustrated in table 5.

Table 5: EBS value for soils

Soil	TCF	CF	BS (Å)	EBS (Å)
GD	2	0.227	7.13	5.63702
		0.12	10	
F	2	0.352	7.13	6.23752
		0.0609	10	
MK	2	0.38	7.13	6.2188
		0.04	10	
RY	2	0.325	7.13	6.5145
		0.094	10	
MKH	2	0.421	7.13	8.22346
		0.111	10	

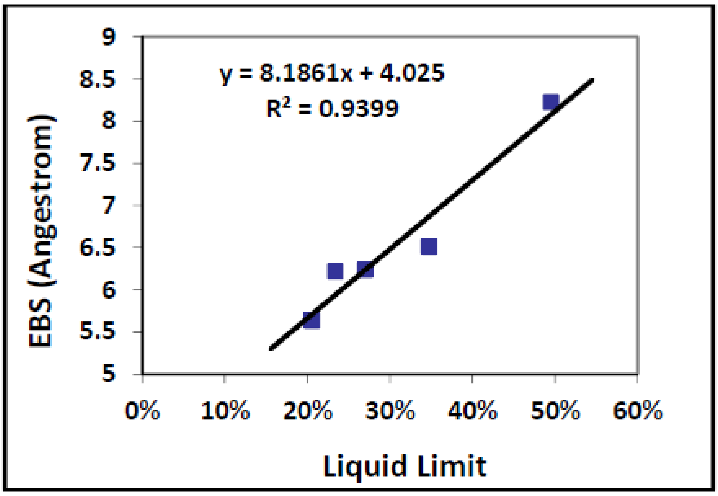

Fig.9: Liquid Limit vs EBS

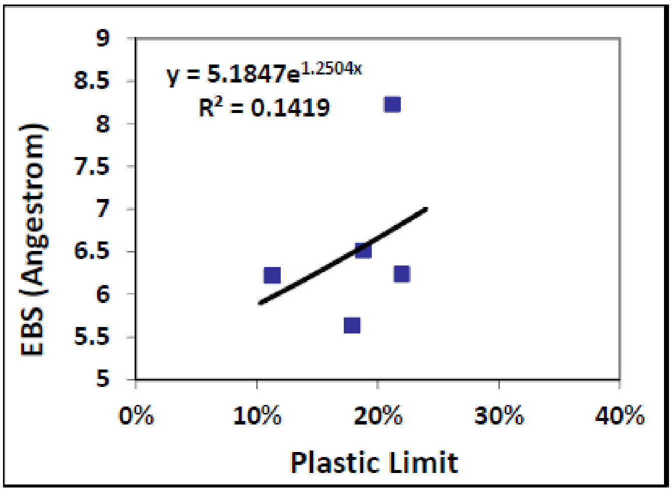

Fig.10: Plastic Limit vs EBS

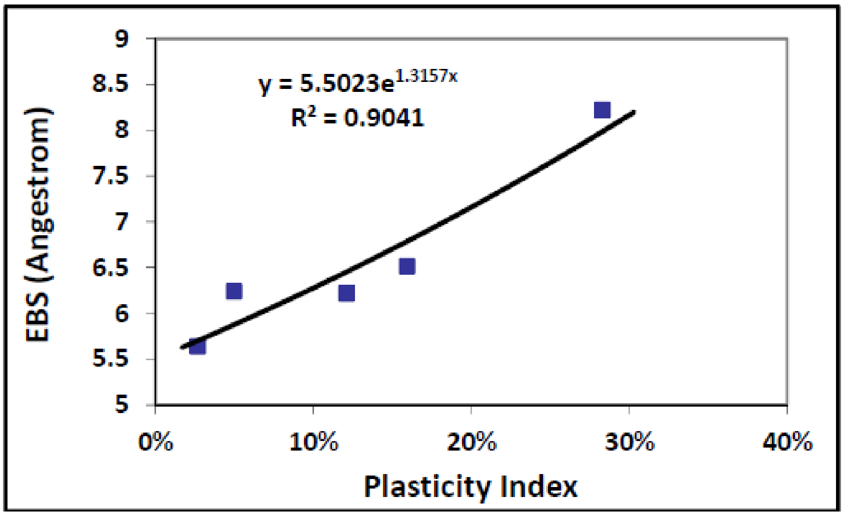

Fig.11: Plasticity Index vs EBS

As shown in Fig.9 we find strong relation between EBS values and LL percentage. However, there is weak relation between EBS and plastic limit as illustrated in fig.10.
The relationship between EBS factor and LL is shown in fig. 9. is quite clear that there is direct relation between LL and EBS, where as much as EBS increase as much as LL increase and this is logic because EBS increase by increasing the clay mineral amount in the soil and by increasing the BS of clay minerals itself, which subsequently increase the liquid limit of clay soil. The correlation coefficient between the liquid limit and EBS is 0.94 (fig. 9), which proves the straight relationship between these two parameters. We can also obtain the linear Eq. (2), from which we can estimate the liquid limit by knowing the mineralogical composition of the sample:

$$LL = \frac{EBS - 4.025}{8.1861} \qquad (2)$$

Since the plastic behavior of the studied samples is mostly affected by liquid limit variations. Fig.11 presents an exponential relation between the plasticity index and EBS. The correlation coefficient between the liquid limit and EBS is 0.9 (fig. 11), which proves the exponential relationship between these two parameters we can also obtain Eq. 3 from which we can estimate the plasticity index by knowing the mineralogical composition of the sample:

$$PI = \frac{\ln EBS}{6.48} \qquad (3)$$

CONCLUSION:

As presented, the correlation illustrates a tight positive connection between Atterberg limits and the relative amount of phyllosilicates present in samples. The EBS factor provides a good relationship between mineralogy composition and the plasticity of the samples, by giving an easy and reliable correlation based on the direct determination of the Atterberg limits based on the mineralogical composition of the studied clays. It will be very vital method for expectation the plasticity of clay according its content of minerals, and for many applications. We recommend for further researches to study the relations between EBS and Atterberg limits for other types of Syrian clay around Syria.

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