CORRECTION PROCEDURE FOR THE DETERMINATION OF SOIL SPECIFIC SURFACE

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ABSTRACT:
Specific surface has a very important role in geotacnic especially with that home dell with gypseous soils or other types of salty soils. Because its calculation need for high accuracy, a procedure is presented to calculate a correction factor for Specific surface determination.
In a previous work, grain size distribution curves of many soil samples are collected. A value for the specific surface of each soil is determined summing the surface area of subintervals in the distribution curve.
In this work, the values of specific surface are obtained from these gradation curves and compared to those calculated using the values of the equivalent diameter for each soil. Fitting has been made and gets the best equation representing these points. From this equation, new values for specific surface are obtained by interning the specific surface calculated from the equivalent diameter and again the point is draw with the origin point (specific surface obtained from these gradation curves). Fitting is made again and the new equation is obtained. Finally, the equation of the calculated corrected specific surface is written. The results showed a very good agreement when using the corrected procedure.

الخلاصة
ان المساحة السطحية النوعية لها اهمية كبيرة في مجال ميكانيك التربة و بخاصة لاولئك الذين يتعاملون مع الترب الجبسية او الترب الحاوية على الاملاح بانواعها. ولان حسابها يتطلب دقة عالية اقترح في هذا البحث منهج عملي لحساب معامل تصحيح لحساب مساحة سطحية نوعية دقيقة .
في بحث سابق تم جمع بيانات لمنحني التوزيع الحبيبي للعديد من النماذج وتم تعيين قيمة المساحة السطحية النوعية لكل عينة بحساب المساحة السطحية للمسافات الثانوية في منحني التوزيع .
في هذا البحث اجريت مقارنة لقيم المساحة السطحية النوعية التي تم الحصول عليها من منحنيات التوزيع الحبيبي مع تلك المحسوبة باستخدام القطر المكافئ لكل عينة. تم ايجاد افضل معادلة تمثل هذه النقاط ومن هذه المعادلة تم حساب قيم جديدة للمساحة السطحية النوعية من تلك المحسوبة من القطر المكافئ ومرة ثانية رسمت هذه

النقاط كعلاقة بين المساحة السطحية الاصلية التي وجدت باستخدام منحني التوزيع الحبيبي مع هذه المساحة السطحية الجديدة ومن هذه العلاقة تم ايجاد افضل معادلة تمثل هذه النقاط . اخيراً اعيد كتابة معادلة المساحة السطحية المصححة وقد اظهرت نتائج جيدة جداً يمكن استخدامها لايجاد مساحة سطحية دقيقة بمقدار كبير.

KEY WORDS:
Specific surface, grain size distribution, correction

INTRODUCTION

The usual method to calculate the specific surface of a soil is the summation of the surface area of several sub divisions of the soil grains according to corresponding intervals on the gradation curve.

There are various techniques to measure the specific surface of solids. Gas adsorption (i.e., the condensation of molecules on the mineral surface) determines surface area from the relationship between applied pressure and volume of gas forced into the specimen (water vapor is included in this group). Another technique is the absorption of molecules from solution onto a solid surface, in particular, dyes such as methylene blue. Additionally, specific surface values can be inferred from known thermodynamic properties (e.g., heat of immersion of a powder in a liquid), the rate of dissolution of soluble materials, microscopy, and the diffusiveness of X-ray diffraction patterns. Details of these measurement techniques can be found in Adamson (1990).

The potential use of specific surface in various geotechnical engineering applications and in the characterization of mineral resources.

A few examples are as follows: (i) assessing the extent of internal and interconnected micro porosity; (ii) characterizing the average slenderness of fine particles; (iii) computing the charge density on particle surfaces ,knowing the specific surface and the cation exchange capacity ; (iv) identifying the extent of fines coating coarse particles; n petroleum production, fines coating coarser particles may detach when the pore fluid is changed ("water shock"), migrate, and clog pore throats, thereby causing a dramatic decrease in permeability ("formation damage "); and (v) quality control and process monitoring, including natural and industrial situations such as the evolution of residual soils ,cement hydration, pyro-etamorphosis of minerals (e.g., ochre, bentonite),and the effectiveness of mineral separation processes, (Santamaria et al, 2002).

DEFINITION OF THE EQUIVALENT DIAMETER AND THE SPECIFIC SURFACE

The usual method to calculate the specific surface of a soil is the summation of the surface area of several sub divisions of the soil grains according to corresponding intervals on the gradation curve.

If a grain size distribution curve such as the one shown in **Fig.1** is divided into *n* intervals, the specific surface of the soil, assuming spherical particles, is calculated according to the following. The average surface area of particles in an interval *i* of this gradation curve is

$$S_{piav} = \pi D_{iav}^2 \qquad (1)$$

Where D_{iav} is the average diameter in this interval, while the average volume of a particle in this interval is

$$V_{piav} = \frac{\pi}{6} D_{iav}^3 \qquad (2)$$

Hence, the total surface area of particles of this interval will be: -

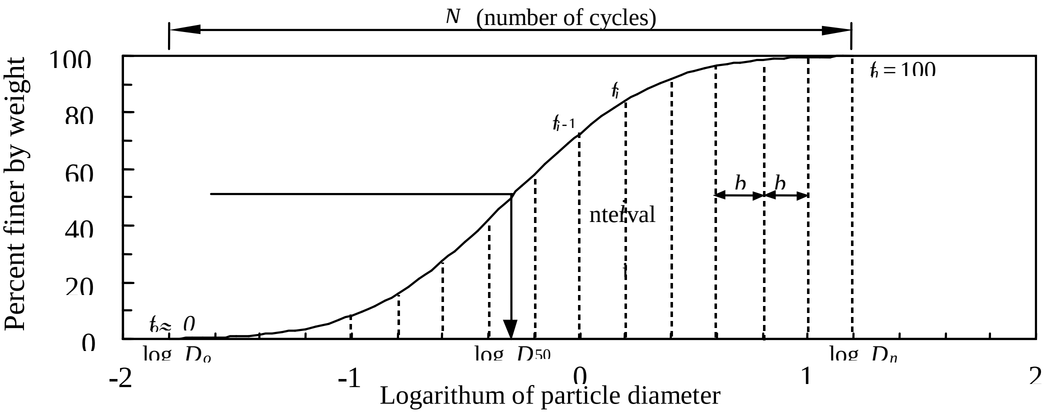


Fig. 1. A typical gradation curve of a soil divided into *n* equal intervals, Al-Mufty and Al-Hadidi, (2005)

$$S_i = \frac{(f_i - f_{i-1})W}{V_{piav} G \rho_w} S_{piav} = \frac{6(f_i - f_{i-1})W}{D_{iav} G \rho_w} \tag{3}$$

where W is the total weight of soil particles in grams, f_i and $f_{i\text{-}1}$ are the cumulative percentages by weight of the particles finer in diameter than those at the beginning and the end of the interval i respectively, substituted in decimals, G is the average specific gravity of soil particles and ρ_w is the density of water = 1gm/cm^3. To unify the units, diameters are substituted in centimeters and the surface areas are obtained in cm^2. The specific surface of the soil, in cm^2 per 100gm of soil, may then be computed as: -

$$S_s = \left(\sum_{i=1}^{n} S_i \right) * \frac{100}{W} = \frac{6}{G\rho_w} \sum_{i=1}^{n} \frac{f_i - f_{i-1}}{D_{iav}} * 100 \tag{4}$$

In 2005 Al-Mufty and Al-Hadidi, presented a procedure to predict the effective diameter. The equivalent diameter is defined as the diameter that may substitute the whole soil grains for calculating the specific surface. The specific surface in cm^3 per 100gm of a soil may be calculated from the equivalent diameter as: -

$$S_s = \frac{100 S_{pe}}{G \rho_w V_{pe}} = \frac{600}{G \rho_w D_e} \tag{5}$$

where S_{pe} and V_{pe} are the surface area in cm^2 and the volume in cm^3 respectively, of a particle having a diameter equal to the equivalent diameter, D_e in cm.
Equating the specific surface from Eq. (5) and Eq. (4), the following is obtained: -

$$\frac{1}{D_e} = \sum_{i=1}^{n} \frac{\left(f_i - f_{i-1}\right)}{D_{iav}} \tag{6}$$

From which the equivalent diameter may be obtained for a specific grain size distribution curve. It is obvious that the equivalent diameter represents the harmonic mean of the particle diameters available, cf. Kezdi (1974).

Al-Mufty and Al-Hadidi (2005) reformed Eq.(4) to get this equation

$$S_s = \frac{600}{G\rho_w}\frac{10^b - 1}{b\,ln(10)}\sum_{i=1}^{n}\frac{f_i - f_{i-1}}{D_i} \quad (7)$$

THE EQUIVALENT DIAMETER EQUATIONS

In 2005 Al-Mufty and Al-Hadidi presented the equivalent diameter which could be used to calculating the specific surface.

The aforementioned steps which were presented by Al-Mufty and Al-Hadidi, (2005) were devoted to determine an average diameter for a specific interval of a small width within the grain size distribution curve. Next, it is required to assess the value of the percentage finer corresponding to the diameter closest to the effective equivalent diameter, the latter being adopted to calculate the average specific surface of the soil as a whole. It is plausible to assume that the required value of the percentage finer is dependent on the number of logarithmic cycles and on the properties of the cumulative distribution of the grains.

The cumulative distribution which assumed following the well-known cumulative normal probability distribution. This enables the calculation of the cumulative function corresponding to a certain diameter and vise versa. The most significant range of the probability distribution assumed as from μ-3σ to μ+3σ, μ and σ being the mean and the standard deviation of the distribution, giving a confidence level of 99.73%. This is called the "3σ rule" advised by Duncan (2000) for reliability problems in geotechnical engineering. Thus, the N cycles will correspond to 6σ of the by weight distribution of the logarithms of diameters of particles. Then, it is possible to determine the standard deviation of the distribution.

$$\sigma = N/6 \quad (8)$$

The standard random variable of the standard normal probability distribution will be

$$z = \frac{log\ D - \mu}{\sigma} \quad (9)$$

Substituting Eq.(9) in Eq.(5) and Eq. (7) and equating the latter equations as in Eq. (6), the following is obtained: -

$$\frac{1}{10^{z_e\sigma + \mu}} = \frac{10^b - 1}{b\,ln(10)}\sum_{i=1}^{n}\frac{f_i - f_{i-1}}{10^{z_i\sigma + \mu}} \quad (10)$$

The mean μ is the logarithm of D_{50} which may be easily determined. Nevertheless, its value is cancelled out from both sides if the equation is multiplied by (10^{μ}). The variables z_e and z_i represent the standard normal variables that correspond to the effective diameter in question and the diameter at the end of the interval *i* in the gradation curve.

If a standard cumulative normal distribution curve is divided into n intervals within the range z=–3 to z=+3, z_e may be easily found as; -

$$z_e = \frac{1}{\sigma}log\left\{\frac{b\,ln(10)}{10^b - 1}\left(\sum_{1}^{n}\frac{f_i - f_{i-1}}{10^{z_i\sigma}}\right)^{-1}\right\} \quad (11)$$

For a specified number of intervals, *n*, and a known value of the number of cycles *N*, the values of the standard deviation σ and the interval width *b* are determined. For each interval *i*, the value of z_i is determined from the inverse of the cumulative standard normal distribution function as the random variable corresponding to f_i ,the cumulative frequency.

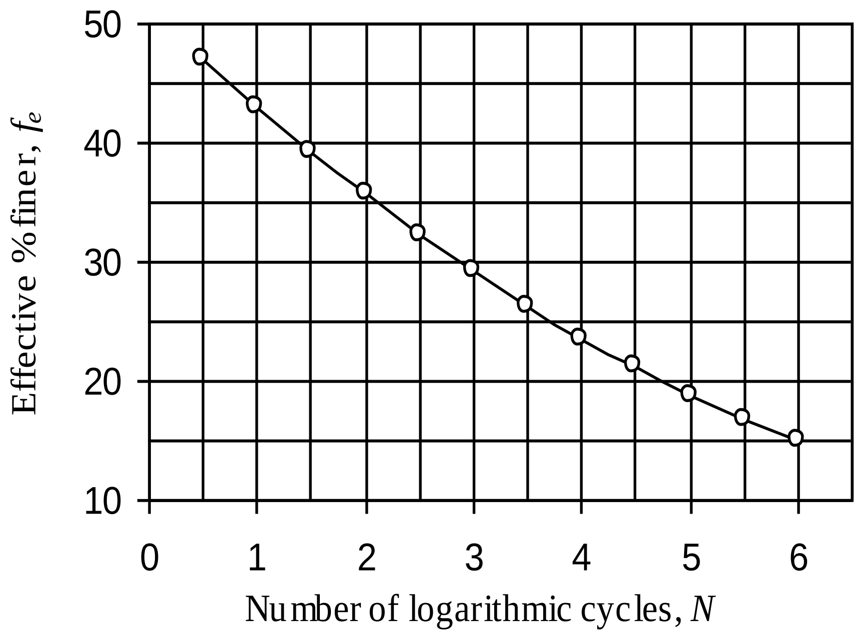
After z_e is found, the corresponding cumulative frequency f_e may be found from the cumulative standard normal distribution function as being the percentage finer that corresponds to the required effective diameter D_e. The specific surface of the soil may be determined through Eq. 5 using a single diameter obtained from the gradation curve.

To put a single equation for simple assessment of f_e , several trials to solve Eq. 11 are performed using different number of intervals and logarithmic cycles. The results of these trials are given in Table 1. Of course, the range of *N* for natural soils is from about one cycle for uniform soils to about five or six cycles for widely sorted soils (very well graded). The results have shown that 200 intervals would be enough to assess properly accurate values for f_e.

Table 1. The percentage finer f_e corresponding to the equivalent diameter

n	N					
	1	2	3	4	5	6
10	42.446	34.868	28.118	22.346	17.615	13.870
20	42.774	35.480	28.937	23.281	18.584	14.810
40	42.856	35.634	29.144	23.520	18.834	15.056
100	42.879	35.677	29.202	23.587	18.905	15.125
200	42.883	35.683	29.211	23.597	18.915	15.135

The values for the effective percentage of finer particles for the case of 200 intervals are plotted against the number of logarithmic cycles of the gradation curve in **Fig. 3**.



N	f_e , %
0.5	46.8413
1.0	42.8826
1.5	39.1971
2.0	35.6833
2.5	32.3480
3.0	29.2108
3.5	26.2896
4.0	23.5970
4.5	21.1390
5.0	18.9146
5.5	16.9171
6.0	15.1350

Fig. 3. The percent finer corresponding to the equivalent diameter for the case of 200 intervals for different *N* values

The plotted values in the figure are tabulated to the right of the plot in the same figure. A regression analysis has been performed and a best-fit curve is found to be the following: -

$$f_e = 0.43N^2 - 8.6N + 51.12 \quad (12)$$

with f_e in percent. The coefficient of correlation is found to be 0.999994, which is very high indeed. The equation is limited to the range $N \in [0.5,6]$ where the trend of the relation with f_e is completely different for N values lower than 0.5, while for $N>6$, the fitting equation should be changed (particle diameters in natural soils yield no values out of this range practically).

It is obvious now that for a certain soil, the equivalent diameter can be easily determined from the grain size distribution curve of that soil. It will be the diameter corresponding to the effective percentage finer determined from the table or from the graph given in **Fig. 3** or using Eq.(12) directly. As the equivalent diameter is determined, the specific surface of the soil can be calculated using Eq. (5).

The target equivalent diameter may be calculated by using equation derived in 2005 by Al-Mufty and Al-Hadidi .

THE TEST RESULTS

Grain size distribution curves for 154 different soil samples have been analyzed. The particle diameter values are taken in centimeters and plotted on the usual logarithmic axis against which the percentage finer is plotted. The curves are subdivided into intervals each of width b=0.2. The tails of the curves in the direction of small diameters are extended to determine an approximate value for the D_o to start calculation.

Table 2. Grain size distribution of the samples

D mm	0.00001	0.000016	0.000025	0.00004	0.000063	0.0001	0.00016	0.00025	0.0004	0.00063	0.001	0.0016	0.0025	0.004	0.0063	0.001	0.016	0.025	0.04	0.063	0.1	0.16	0.25	0.4	0.63	1	1.6	2.5	4	6.3	10
Log D	-5	-4.8	-4.6	-4.4	-4.2	-4	-3.8	-3.6	-3.4	-3.2	-3	-2.8	-2.6	-2.4	-2.2	-2	-1.8	-1.6	-1.4	-1.2	-1	-0.8	-0.6	-0.4	-0.2	0	0.2	0.4	0.6	0.8	1
Soil No.																F%															
1														0	5.2	11	35	72.6	82.6	87.8	93.5	95.2	97.7	98.6	99.1	100					
2												0	0.8	2.6	4.3	8.6	40	74.3	83.4	90	93.4	96.5	98.6	99.1	100						
3														0	5.2	11	45	76.9	86	92.1	95.2	97.8	99.5								
4												0	1.7	4.3	6.9	12	50	86	93	98	99.5										
5												0	1.7	4.3	7.8	13.4	74.3	90.8	96.9	100											
6													0	3	7	10	20	36	70	83.9	90.8	95.2	98.6	99.1	100						
7														0	4.3	11.3	33.9	86	93.4	97.8	100										
8													0	3	6.9	13.4	47.8	90.8	96.9	100											
9													0	4.3	8.6	16	75.2	93.4	100												
10														0	2.5	10.6	20	30	48.1	53.7	63.7	73.7	76.2	78.1	81.2	88.8	93.7	100			
11															0	2.5	10	20	33.7	40	41.2	45	50	55	61.2	72.5	82.5	91.2	100		
12															0	1.2	1.3	2.5	5	10	15	25	34	43	66.2	70	80	95	100		
13																	0	1.8	2.5	6.2	12	20	25	35	50	60	71.2	85	100		
14																	0	1.2	1.8	3.7	5.6	13.7	25	45	72	83.7	87.5	96.3	100		
15																0	1.2	2.5	3.7	7.5	13.7	28.7	40	52	70	80	90	98	100		
16																			0	2.5	7.5	15	25	40	67.5	80	90	99	100		
17																0	1.2	1.8	5.6	10	15	23	30	37	48	62	72	85	100		
18													0	0.8	3.4	8.6	17.3	31.7	51.7	71.3	83.5	91.7	96	98.6	100						
19											0	0.8	5.2	8.6	13	20.8	36	57.8	74.7	84.4	91.3	94.4	96.9	100							
20													0	0.8	3.4	8.6	22.6	64.3	81.7	91.7	97.8	100									
21													0	2.1	5.2	10.8	26.9	82.6	94.3	100											
22														0	5.2	12.6	60	85.2	93.4	97.8	100										
23														0	1.7	14.3	70	90	96.9	100											
24													0	1.3	4.3	10.8	24.3	66.9	80	88.6	92.6	95.6	96.9	97.8	98.6	100					
25													0	2.6	6.9	12.6	27.8	72.6	84.3	91.7	96	96.9	98.2	98.6	99.1	100					
26												0	1.7	4.3	6.9	12.6	27.8	81.7	90	96	97.8	98.6	100								
27											0	0.8	2.6	4.3	7.82	14.3	31.7	86.9	94.3	100											
28												0	1.7	3.4	6.9	10.8	70	90	95.2	100											
29											0	0.8	1.7	3.4	5.2	10	25	61	77.3	86	91.7	95	96.9	97.8	98.6	100					
30											0	0.8	1.7	3.4	6.9	13.4	27.8	66.9	80	88.6	93.4	96.9	98	98.6	99.4	100					
31											0	1.7	3.4	5.6	9.5	15.2	31.7	78.6	87.8	94.3	97.3	99.5	100								
32											0	1.3	3	4.7	8.6	13	27.3	95	100												
33														0	4.3	13.9	40	93.4	100												
34														0	5.2	10.8	24.3	66.9	80	88.6	93.4	95.6	96.9	98.2	99.1	100					
35											0	0.4	1.3	3.4	7.3	12.6	27.8	72.6	84.3	92.6	95.6	97.8	98.5	99.4	99.7						
36											0	0.4	1.3	3.4	6.9	12.6	27.8	80.8	90	96	98.6	99.5									
37												0	2.6	4.3	8.2	14.3	32.6	86.9	95.2	100											
38												0	1.3	3.4	8.2	14.3	70	90	96	100											
39									0	3.4	8.6	25.2	75	85.6	91.7	95.6	98.2	98.9	99.5												
40									0	3.4	8.6	65	78.6	87.3	92.6	96	98.2	99.5													
41								0	3	6.5	11.7	34.3	76	86.5	92.6	96.5	98.2	99.5													
42								0	1.6	3.4	10	57.8	82.6	91.7	96	98.6	100														
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46														0	3.4	10	26.9	75	85	91.7	95.2	97.3	98.6	99.5							
47													0	1.3	4.3	10	35	78.6	86.9	92.6	96.5	99.5									
48												0	1.3	2.6	5.6	11.7	35	80.4	89.1	94.3	97.8	99.5									
49											0	1.7	3.4	5.2	8.6	13.4	35	86.5	95.2	100											
50												0	2.6	4.3	6.9	12.6	65	87.8	96	100											
51													0	1.3	4.3	11.3	26.9	85	93.4	97.8	98.6	100									
52											0	0.8	2.1	4.3	6.9	10.8	16.9	35	70	83.4	90.8	95.2	97.8	98.6	99.5						
53											0	0.8	2.1	4.3	6.9	12.6	30	90	96.9	100											
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55														0	3.4	10.8	25	50	66.9	78.6	86	92.6	96	98.6	99.5						
56														0	3.4	12.6	30	54.3	72	82.6	90	95.2	97.6	99	100						
57													0	2.6	6	15.2	40	76.9	86.9	94.3	97.6	100									
58													0	2.6	6	15.2	43.4	83.4	93	97.8	99.5										
59													0	2.6	6	15.2	65	91.3	98.6	100											
60														0	2.6	9.5	22.6	75	85	91.3	95	96.9	97.8	98.6	99.5						
61													0	1.3	3.9	10.8	30	80	90	95.2	97.8	99.1	100								
62												0	0.8	3.4	5.6	10	25	76.9	86.9	93	96	97.8	98.6	99.5							
63												0	0.8	3.4	5.6	12.6	30	82.6	91.7	96	98.6	100									

64											0	1.7	2.6	4.3	6.9	12.6	30	85.2	93	97.8	100										
65											0	1.7	3.4	5.6	8.2	14.3	32.1	90	96	100											
66														0	2.1	6.9	30	75.6	85.2	91.7	95	96.9	97.8	98.6	99.5						
67														0	1.5	6.9	30	77.8	86.9	93.4	96	97.8	98.6	99.1	99.5						
68													0	1.7	3.4	8.6	55	82.6	91.3	96	98.2	99.1	100								
69													0	2.6	4.3	11	55	85.2	93.4	97.8	100										
70												0	1.7	4.3	6.9	12.1	66	90	96.9	100											
71											0	1.7	3.4	5.6	9.1	15	70	91.3	97.8	100											
72														0	3.4	10	60	80	88.5	94.3	96.7	98.2	99.5								
73														0	3.4	10	60	80.8	89.5	95	96.9	98.6	99.5								
74														0	1.3	6.9	30	71.7	82.6	90	93.4	95.2	96	96.9	99.5						
75														0	2.6	7.8	45	76.9	86.5	92.6	95	96.5	97.3	98.2	99.1	100					
76													0	2.6	5.2	11.3	65	86	93.4	97.3	98.6	100									
77													0	3	6	12.6	70	91.7	97.8	100											
78													0	1.7	4.7	10.8	23.4	60	77.8	86.9	92.6	95	96.9	97.8	98.6	100					
79													0	3.4	7	13.4	30	65.6	80	87.8	94.3	96.9	98	98.6	99.5						
80												0	1.7	5.2	10	15	30	77.4	87.8	94.3	97.6	98.6	100								
81												0	1.7	4.3	9	13	30	86.9	95.6	100											
82														0	4.3	13.4	36	93.4	100												
83													0	1.7	4.3	11.7	35	80.8	96	98.6	99.5										
84														0	3.4	10	26.9	84.7	94.3	98.6	99.5										
85													0	1.7	4.3	10	30	76.9	86	92	94.7	96.9	97.8	98.2	99.5						
86													0	1.7	4.3	12	50	80	88.6	94.3	96	98.2	98.6	99.1	99.5						
87													0	4.3	6	14.3	70	90	96.9	100											
88													0	4.3	6	13	45	87.8	96	100											
89														0	3.9	10	25	73.9	83.9	90	93.9	96	98.2	98.6	100						
90														0	3.9	11	26	75	84.3	91	94	97	98.3	98.7	100						
91														0	3.9	12	27	76	86	92	95	96	98	98.7	100						
92														0	3.9	13	25	80	88.6	94.3	96.9	98.6	99.5								
93														0	6	13.8	30	89.2	96	100											
94														0	6	14.3	33	93	97.8	100											
95														0	4	6	13	24	45	52	56	63	67	73	83	100					
96															0	6	13	30	53	66	80	88	92	95	98	100					
97														0	5	13	18	48	85	95	98	98.7	99.3	100							
98														0	5	11	22	45	83	92	96	98.7	100								
99														0	5	20	36.8	68.7	82.5	88	94	97.5	98	99	100						
100															0	1	1.5	4.2	5.2	7.3	8.4	12.1	20	33.1	61.5	87.3	96.3	100			
101															0	5	12.1	45.2	75.2	87.8	90	91	92.1	93.1	97.3	99.4	100				
102														0	0.8	3	7.8	21.3	61.7	91.7	96	97.8	98.6	99.1	100						
103														0	0.4	1.7	3	10.8	30	56	61.7	66	73.4	84.3	92.6	97.8	100				
104																0	2.6	8.6	25	40	43.4	47.8	56.9	76.9	86	93.4	100				
105															0	1	2	6	21	37.5	44	49	55	65	82	100					
106														0	1.5	3	5	15	30	44.5	47.5	49.5	52	58.5	74	91	100				
107													0	1.5	2.5	4	7.5	20	54	73	75	76	78	83	90.5	96	100				
108																0	3	9	30	55	61	63	65.5	70	84	100					
109															0	1.5	4	11	25	46.5	50	57	65	76	91	100					
110																0	2	3	4	6	9	14	24	45	75	91	100				
111																		0	3	8	12	17	25	34	56	85	92	95	100		
112															0	4	13	35	71	88	90	92	95	97	99	100					
113														0	1.5	3	5	25	33	37	40	42	47	64	90	95	100				
114																	0	2.5	3.5	7	11	16	20	26	42	75	86.5	91	100		
115			0	4.5	9	13	18	23	27	31	37	42	48	55	60	68	75	82	91	95	97	97.5	97.7	97.9	98	98.5	99	99.5			
116		0	4	8	13	18.5	23	29	33	38	44	48.5	55	62	69	78	86	92	96	98.9	99	99.8	100								
117					0	5	11.9	16	22	28	32	38	43	50	64	78	89	94	99	100											
118				0	4	6	6.5	7.5	8	14	28	48	71	91	97	98.9	99	100													
119				0	5	6	7	14.5	32	35	36	37	39	42	54	66	78	96	100												
120			0	2	4	6	9	12	15	21	28	37	45	55	64	72	82	88	96	98	99	99.5									
121			0	4	8	12	15	19	22	26	29	33	37	40	44	48	54	59	69	79	85	90	94	96	98	99	100				
122												0	3	6	12	26	48	85	99	99.1	99.8										
123		0	8	16	26	34	44	54	64	72	77	82	86	90	94	97	99	100													
124				0	6	11	20	28	36	44	48	54	62	70	80	83	85	88	89	91	93	94	95	98	100						
125				0	10	16	22	30	39	48	54	64	74	79	83	85	86	89	90	92	92.8	94	95	96	98	98.8	99	100			
126			0	10	20	28	38	50	60	68	73	77	81	86	90	93	94	96	98	99	99.5										
127						0	3	6	11	16	20	25	33	40	48	67.5	68.5	77	84	90	94	96	97	97.5	98	98.8	99	99.5			
128																			0	6.25	11.3	15	47.5	83.8	96.3	97.5	97.5	97.5	98	99	100
129																		0	7.5	12.5	18.8	23.8	56.3	87.5	98.8	98.8	98.8	99	99.5		
130																0	5	11.3	16.3	22.5	26.3	32.5	57.5	82.5	93.8	96.5	97.5	98	99.8		
131										0	11.3	18.8	20	22.5	23.8	26.3	27.5	28.8	29.5	30	32.5	40	65	90	98	98.8	99	99.5			

132								0	7.5	15	26.3	32.5	35	38.8	45	51.3	52.5	57.5	65	66.3	70	72.5	83.8	95	98.8	99	99.5				
133																			0	3.75	8.75	15	47.5	83.8	96.3	97.5	97	98	99	99.5	
134											0	47.5	51.3	53.8	62.5	65	67.5	72.5	78.8	79	83.8	90	93.8	97.5	98.8	99	99.8				
135																			0	7.5	12.5	20	51.3	85	93.8	95.5	96.3	97.5	98	100	
136																			0	4.5	10	17.5	47.5	82.5	96.3	98	98	98.2	98.5	99	100
137											0	57.5	58	61.3	68.8	73.8	76.3	80	88.8	90	93.8	97.5	98	98.5	99	99.5					
138											0	72.5	76.3	82.5	92.5	93	94	94.5	95	95	97.5	98	98.5	99	99.5						
139										0	27.5	55	60	67.5	81.3	90	95	96	97	97.5	98	98.5	99	99	99	99	99.8				
140										0	28.8	54.5	60	68.8	82	91.3	98.8	98.8	98.8	98.8	98.8	98.8	98.8	98.8	99	99	99.8				
141											0	18.8	20	22.5	26.3	28.8	30	30.5	31.3	33.8	38.8	47.5	70	92.5	98	99.5					
142										0	10	18	20	22.5	26.3	27.5	28.8	31.3	32.5	36.3	50	68.8	80	93.8	98	99.5					
143								0	8.75	16.3	23.8	28.8	40	48	52.5	57.5	61.3	65	71.3	76.3	85	92.5	95	97.5	98	98.5	99	99.9			
144											0	50	53.8	58.8	65	67.5	70	70	72.5	80	87.5	93.8	96.3	97.5	99.5						
145										0	20	42.5	44.5	50	60	67.5	72.5	81.3	92.5	96.3	97.5	98	99	99.5							
146										0	16.3	35	37.5	40	48.8	58.8	60	72.5	85	97.5	98	98.5	99	99.5							
147											0	40	43.8	47.5	61.3	66.3	71.3	78.8	92.5	98	98	99	99.8	100							
148											0	5	15	18.8	23.8	31.3	40	47.5	55	62.5	66.3	70	71.3	73.8	76.3	78.8	82.5	85	88.8	93.8	100
149											0	18.8	20	23.8	28.8	33.8	35	42.5	50	57.5	70	80	82.5	85	85.1	87.5	90	91	93	95	100
150										0	12.5	22.5	23.8	27.5	32.5	40	43.8	57.5	78.8	92.5	96.3	98	99	100							
151										0	7.5	14	15	17.5	22.5	25	28.8	32.5	40	50	71.3	97.8	98	98.8	99	99.5					
152											0	60	62.5	68.8	80	85	88.8	90	91.3	92.5	93.8	96.3	97.5	98.8	99	100					
153											0	62.5	66.3	73.8	80	87.5	90	90	90	90	92.5	95	96.3	97.5	98.8	100					
154											0	3.5	5	8.75	23.8	33.8	38.8	45	50	57.5	61.3	63.8	65	67.5	72.5	75	78.8	82.5	86.3	91.3	100

Al-Mufty and Al-Hadidi (2005) draw the relation between the ratio of the specific surface calculated using the equivalent diameter to the specific surface calculated through summing the interval surface area of particles (S_{pe}/S_{PT}) and the coefficient of curvature (C_C which is equal to $(D_{30}^2/(D_{60}*D_{10}))$) as show in Figure 4.

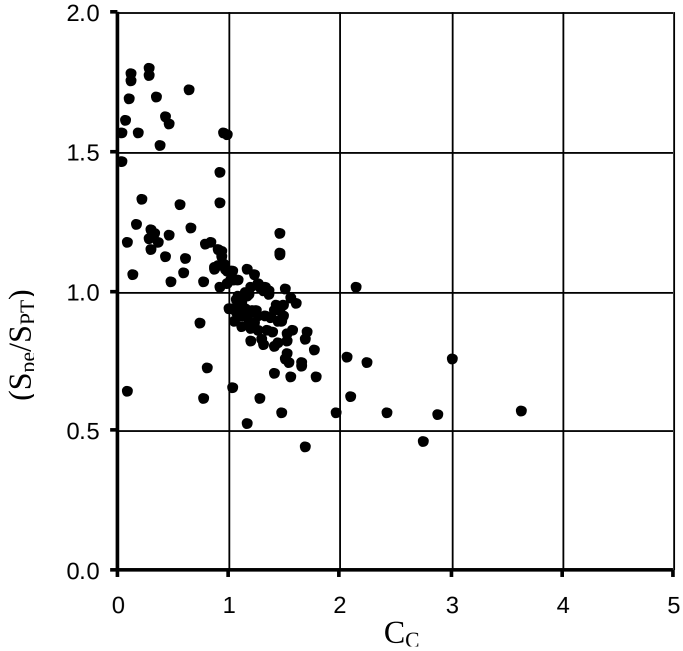


Fig. 4. Comparison between (S_{pe}/S_{PT}) values and coefficient of curvature (C_C) for uniformly graded samples

Al-Mufty and Al-Hadidi (2005) found that the ratio (S_{pe}/S_{PT}) decreases with the increase in the coefficient of curvature (C_C). Ratios closer to 1.0 are found for values of the coefficient of curvature in the range 1.0 to 3.0.

Considering the soil type and gradation, it is found that the results are less accurate in clayey soils than in sandy soils.

THE COMPUTER PROGRAM

Simple computer program has been written for this research in order to find C_C, C_u the f_e and D_e for the 154 samples as shown in Table (3).

Table 3. The results of the program for all the

Sample no.	Cu	C_c	N	f_e	D_e	S_{pe}	S_{PT}	Gradation Type
1	2.33	1.04273	2.4	39.689	0.01679	14582	13634	UNIFORM
2	2.03	0.88527	2.6	41.428	0.01616	15844	14718	GAP
3	2.13	0.92038	2	40.8167	0.01498	15916	14677	GAP
4	2.16	1.02884	2	40.6574	0.01415	16687	17939	UNIFORM
5	1.88	1.19515	1.6	42.4153	0.01245	18386	20170	UNIFORM
6	4.60	1.69923	2.4	31.7842	0.02225	9657	11693	WELL
7	2.17	1.1693	1.4	40.5599	0.01681	13294	14561	UNIFORM
8	2.30	1.09874	1.4	39.8645	0.01425	15581	17235	UNIFORM
9	2.05	1.28265	1.2	41.3364	0.01218	18235	20116	UNIFORM
10	8.73	0.15255	2.8	25.3741	0.0203	8755	8289	GAP
11	59.72	0.22156	2.8	12.1995	0.01754	6234	4705	GAP
12	57.73	7.77115	2.8	12.353	0.07836	1063	1529	GAP
13	6.54	2.10094	2.4	28.136	0.29021	613	992	WELL
14	4.00	1.20	2.4	33.3026	0.30411	737	902	WELL
15	6.43	0.75	2.6	28.3026	0.15657	1242	1406	GAP
16	4.77	1.32	2	31.3837	0.30557	638	792	WELL
17	8.03	0.79	2.6	26.1478	0.19496	793	1291	GAP
18	4.49	1.09	2.4	32.0358	0.02531	8594	9223	WELL
19	5.79	1.42	2.6	29.3687	0.01296	15988	20037	WELL
20	2.29	1.18	1.8	39.9216	0.01919	11955	12269	UNIFORM
21	2.23	1.36	1.4	40.267	0.0177	12590	14666	UNIFORM
22	2.45	0.79	1.4	39.0702	0.01293	17041	16527	GAP
23	1.71	1.04	1.2	43.6872	0.01275	17759	17111	UNIFORM
24	2.47	1.29	2.6	38.9822	0.01858	12948	12797	UNIFORM
25	2.72	1.47	2.6	37.7804	0.01756	13475	14436	UNIFORM
26	2.57	1.54	2.2	38.4596	0.01736	13266	16226	UNIFORM
27	2.72	1.55	1.8	37.7728	0.01667	13411	18136	UNIFORM
28	1.61	1.01	1.6	44.4564	0.01299	17920	19155	UNIFORM
29	2.73	1.27	3	37.7667	0.01866	13290	14317	UNIFORM
30	2.95	1.45	3	36.8324	0.01763	13794	15532	UNIFORM
31	3.19	1.66	2.4	35.914	0.01652	13849	19131	UNIFORM
32	2.71	1.80	1.6	37.8364	0.01703	12996	18925	UNIFORM
33	2.27	1.13	1	40.0144	0.01585	13669	15749	UNIFORM
34	2.49	1.30	2.4	38.87	0.01855	12769	12616	UNIFORM
35	2.77	1.49	3	37.5891	0.01753	13822	15534	UNIFORM
36	2.59	1.54	2.6	38.4026	0.01738	13558	16063	UNIFORM
37	2.77	1.52	1.6	37.588	0.01653	13341	17756	UNIFORM
38	2.02	1.23	1.6	41.5055	0.01252	18198	19589	UNIFORM
39	2.10	1.21	2.2	40.9816	0.00183	128919	127354	UNIFORM
40	1.50	0.92	2	45.3843	0.00135	178197	155676	GAP
41	2.45	1.16	2.2	39.0838	0.00167	140266	150460	UNIFORM
42	1.92	1.04	1.8	42.1567	0.00136	171269	160370	UNIFORM
43	16.93	10.19	1.6	19.8062	0.01036	18312	20600	GAP
44	2.34	1.45	1.8	39.6484	0.01198	18944	23418	UNIFORM
45	2.19	1.12	1.8	40.4693	0.0167	13753	14767	UNIFORM
46	2.37	1.33	2.2	39.4795	0.01788	13065	12966	UNIFORM
47	2.25	1.10	2	40.1396	0.01673	13927	14236	UNIFORM
48	2.32	1.15	2.2	39.7347	0.01663	14222	15681	UNIFORM
49	2.75	1.42	1.8	37.6754	0.01623	13769	19554	UNIFORM
50	1.87	1.10	1.6	42.4848	0.013	17704	19552	UNIFORM
51	2.24	1.39	1.8	40.161	0.01761	12939	14385	UNIFORM
52	3.84	1.54	3	33.7814	0.02435	10256	13237	UNIFORM
53	2.46	3.03	1.8	39.0104	0.01698	13284	17685	GAP
54	2.12	1.27	1.4	40.8563	0.01233	18165	21220	UNIFORM
55	3.47	0.96	2.4	34.9308	0.01903	12110	11057	GAP
56	3.32	1.18	2.2	35.4368	0.01757	12929	12018	UNIFORM

57	2.64	1.10	1.8	38.1582	0.01532	14815	15699	UNIFORM
58	2.49	1.10	1.8	38.8738	0.01472	15558	16429	UNIFORM
59	1.96	1.13	1.4	41.8641	0.0128	17681	18364	UNIFORM
60	2.16	1.28	2.4	40.6245	0.01857	12801	12481	UNIFORM
61	2.20	1.44	2	40.3897	0.01744	13312	14118	UNIFORM
62	2.28	1.34	2.6	39.9594	0.0181	13216	14587	UNIFORM
63	2.45	1.58	2	39.0921	0.01716	13346	15647	UNIFORM
64	2.51	1.66	2	38.7639	0.01705	13377	18146	UNIFORM
65	2.74	1.58	1.8	37.7143	0.01657	13482	19662	UNIFORM
66	2.02	0.99	2.4	41.5154	0.0178	13609	12651	GAP
67	1.99	1.00	2.4	41.6945	0.01774	13627	12737	UNIFORM
68	1.70	0.88	2	43.7528	0.01417	16992	15713	GAP
69	1.83	0.93	1.6	42.7604	0.01394	16671	16564	GAP
70	1.81	1.09	1.6	42.8946	0.01301	17741	19307	UNIFORM
71	2.15	1.30	1.8	40.6824	0.0124	18478	22475	UNIFORM
72	2.15	1.47	2	40.6824	0.01327	17548	15510	UNIFORM
73	2.15	1.47	2	40.6824	0.01327	17548	15585	UNIFORM
74	2.08	0.62	2.4	41.153	0.01793	13571	12221	GAP
75	1.92	0.86	2.4	42.1838	0.01531	16276	13909	GAP
76	1.67	1.00	1.8	43.942	0.01323	17822	17411	UNIFORM
77	1.75	1.08	1.4	43.3347	0.0128	17848	18523	UNIFORM
78	1.55	2.15	2.6	44.9464	0.02078	12636	12533	UNIFORM
79	2.98	1.62	2.6	36.6829	0.01728	13722	14405	UNIFORM
80	2.71	1.79	2.2	37.8402	0.0171	13450	17102	UNIFORM
81	2.85	2.07	1.6	37.2135	0.0168	13093	17219	UNIFORM
82	2.28	1.22	1	39.9512	0.01636	13261	15434	UNIFORM
83	2.27	1.12	1.8	40.0444	0.01667	13738	14981	UNIFORM
84	2.29	1.42	1.6	39.8898	0.01758	12787	13795	UNIFORM
85	2.37	1.38	2.6	39.5051	0.0174	13794	13858	UNIFORM
86	2.08	0.94	2.6	41.107	0.01423	17510	15643	GAP
87	1.85	1.13	1.4	42.6179	0.01264	17980	18946	UNIFORM
88	2.27	1.07	1.4	40.0245	0.01475	15084	17053	UNIFORM
89	2.68	1.53	2.2	37.9508	0.0179	12848	12795	UNIFORM
90	2.33	1.32	2.2	39.7039	0.01803	12971	13046	UNIFORM
91	2.42	1.38	2.2	39.2138	0.01778	13094	13321	UNIFORM
92	2.47	1.50	2	38.9542	0.01781	12826	13612	UNIFORM
93	2.50	1.71	1.2	38.7961	0.01697	12829	15083	UNIFORM
94	2.48	1.41	1.2	38.9427	0.01659	13144	15537	UNIFORM
95	10.00	0.48	2.4	24.1408	0.0252	7269	7056	GAP
96	3.92	1.24	2.2	33.5355	0.02696	8120	7685	UNIFORM
97	3.47	1.48	2	34.9334	0.02055	10695	11935	UNIFORM
98	3.25	1.24	1.8	35.6682	0.02084	10377	11745	UNIFORM
99	3.01	1.06	2.2	36.5738	0.01575	15024	14520	UNIFORM
100	5.05	1.70	2.6	30.792	0.36708	587	1338	WELL
101	2.28	0.95	2.4	39.9664	0.02335	10490	9210	GAP
102	2.29	1.15	2.2	39.9327	0.03106	7630	7727	UNIFORM
103	3.64	0.37	2.6	34.3807	0.04302	5420	4632	GAP
104	10.33	0.31	2.2	23.8572	0.03855	4198	3463	GAP
105	11.13	0.29	2.2	23.2006	0.04233	3853	3249	GAP
106	20.86	0.32	2.6	18.275	0.02778	5294	4614	GAP
107	2.65	1.03	2.8	38.1103	0.0321	7683	7411	UNIFORM
108	3.61	0.35	2	34.4782	0.04323	5031	4188	GAP
109	8.01	0.44	2.2	26.1736	0.04082	4576	4093	GAP
110	4.57	1.49	2.2	31.849	0.29837	706	1259	WELL
111	8.46	1.97	2.2	25.656	0.25976	555	992	WELL
112	2.54	1.09	2.2	38.6048	0.0263	8981	8668	UNIFORM
113	20.09	0.18	2.6	18.544	0.02165	6027	4880	GAP
114	9.10	2.76	2.4	24.9884	0.36837	457	994	WELL
115	825.40	0.08	5.2	8.91957	6.3E-05	1398620	869652	GAP
116	72.92	0.48	4.4	11.3533	5.4E-05	1617321	1355615	GAP

117	39.62	0.82	3	14.2455	0.00021	307105	425130	GAP
118	4.34	1.17	2.8	32.4078	0.00111	210221	404403	WELL
119	41.69	0.09	3	13.9696	0.00024	601038	513625	GAP
120	27.83	1.29	4	16.3403	0.00044	296826	484244	WELL
121	331.13	0.60	4.8	8.13421	6.4E-05	788814	741184	GAP
122	3.40	1.19	2.2	35.1544	0.01211	18685	21228	UNIFORM
123	11.75	0.68	3.2	22.7411	5.4E-05	3138395	2569744	GAP
124	24.55	0.39	4.2	17.1573	0.00014	1208252	795101	GAP
125	14.45	0.66	4.8	21.0355	0.00015	1666790	970095	GAP
126	593.38	0.00	4	8.39877	3.7E-05	2862777	1834184	GAP
127	23.07	1.47	4.8	17.5756	0.00076	228785	190241	WELL
128	3.30	1.46	2.4	35.4893	0.21188	1087	1170	UNIFORM
129	5.30	2.25	2.4	30.2827	0.17386	1231	1659	WELL
130	11.48	2.88	2.8	22.9371	0.06658	1635	2964	WELL
131	241.11	79.84	3.8	8.34206	0.00089	29844	50690	GAP
132	63.10	0.13	4	11.9566	0.00052	247684	141378	GAP
133	2.69	1.19	2.4	37.948	0.21939	1087	1103	UNIFORM
134	5.02	0.29	3.4	30.8455	0.00135	171290	96978	GAP
135	3.56	1.50	2.2	34.6172	0.19658	1136	1249	UNIFORM
136	3.73	1.57	2.4	34.1048	0.2045	1106	1143	UNIFORM
137	3.08	0.45	3.6	36.3153	0.00134	180835	111758	GAP
138	1.37	0.94	3.4	46.6226	0.00134	187377	142730	GAP
139	1.96	1.00	3.6	41.8692	0.00127	228897	147270	GAP
140	1.98	0.96	3.6	41.7754	0.00126	233226	149259	GAP
141	160.12	0.01	3.2	8.97641	0.00125	25500	40133	GAP
142	100.00	2.44	3.4	10.216	0.00101	28227	50250	WELL
143	31.62	0.48	4.2	15.5466	0.0006	238698	149579	GAP
144	3.98	0.36	3.2	33.3659	0.00136	171702	101628	GAP
145	21.70	0.11	3.2	17.9999	0.00095	188646	112153	GAP
146	20.57	0.14	3.2	18.3741	0.00105	166502	93679	GAP
147	5.39	0.29	3	30.0951	0.00141	158795	88648	GAP
148	27.12	0.79	4	16.5039	0.00302	35710	30659	GAP
149	54.12	0.57	4	12.6528	0.00136	56857	43627	GAP
150	29.08	1.04	2.8	16.0631	0.00118	42691	65994	WELL
151	65.64	3.65	3.8	11.7864	0.00135	23706	41733	GAP
152	32.92	0.04	3	15.3047	0.00112	177618	121592	GAP
153	1.45	0.93	3	45.9261	0.0014	179217	126336	GAP
154	20.73	0.20	4	18.3188	0.00534	35382	22621	GAP

CORRECTION PROCEDURE

By using Eq. (7), the specific surface of soil particles is obtained. Meanwhile, the number of logarithmic cycles, *N*, for each soil is determined and the percent finer corresponding to the equivalent diameter is found using Eq. (12). Accordingly, the equivalent diameter is determined and the corresponding specific surface is calculated using Eq. (5). The results from the latter equation are compared with those obtained from Eq. (7) and plotted in **Fig. 5**.

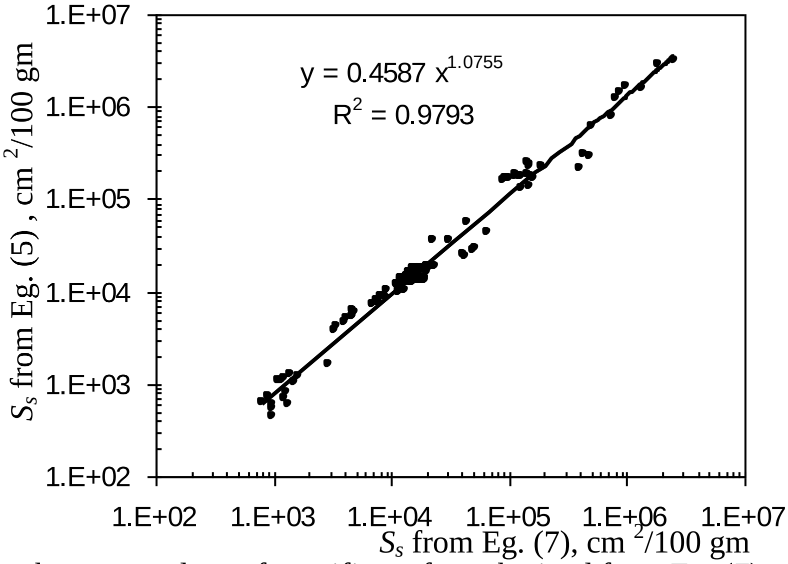


Fig. 5. Comparison between values of specific surface obtained from Eq. (7) and Eq. (5) for the analyzed soils

Fitting has been made for specific surface obtained from eq.(7) and that obtained from eq.(5) and from this fitting it is found that the best equation representing this relationship is:

$Y = (0.4587)*X^{(1.0755)}$ (13)

by using this equation new Spe is found as follows:

$S_{pe(new)}=(1/0.4587)*S_{pe}^{(1/1.0755)}$ (14)

And this $S_{pe(new)}$ is re drawn with original S_{PT} obtained from equation no. (7), as shown in **Fig. 6**

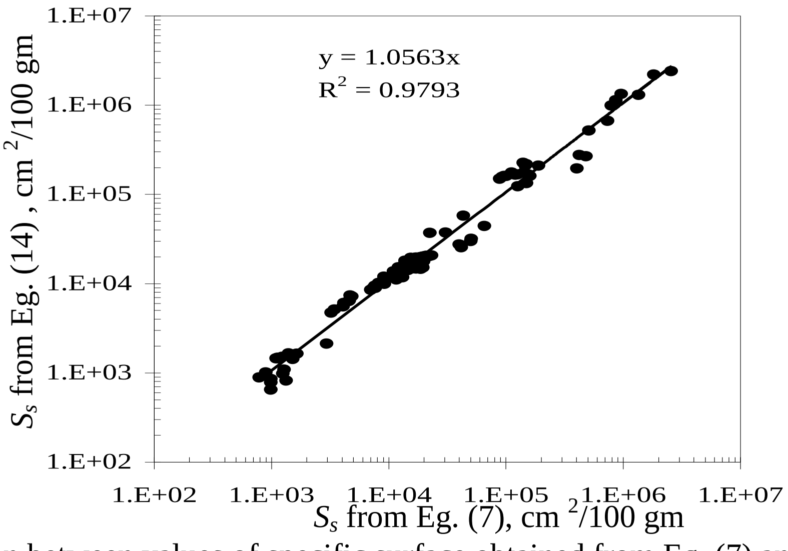


Fig. 6. Comparison between values of specific surface obtained from Eq. (7) and Eq. (14) for the analyzed soils

Fitting has been made for specific surface obtained from eq.(7) and that obtained from eq.(14) and from this fitting it is found that the best equation representing this relationship is:

$Y = (1.0563)*X$ (15)

By using this equation another new Spe is found as follows:

$S_{pe(final)} =(1/1.0563)* S_{pe(new)}$ (16)

And this $S_{pe(final)}$ is re drawn with original S_{PT} obtained from equation no. (7), as shown in **Fig. 7**

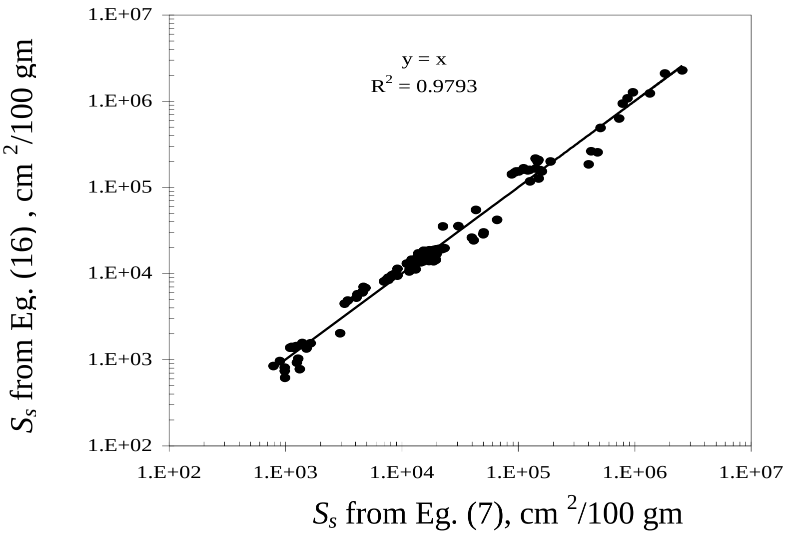


Fig. 7. Comparison between values of specific surface obtained from Eq. (7) and Eq. (16) for the analyzed soils

Fitting has been made for specific surface obtained from eq.(7) and that obtained from eq.(16) and from this fitting it is found that the best equation representing this relationship is:

$$Y=X \quad (17)$$

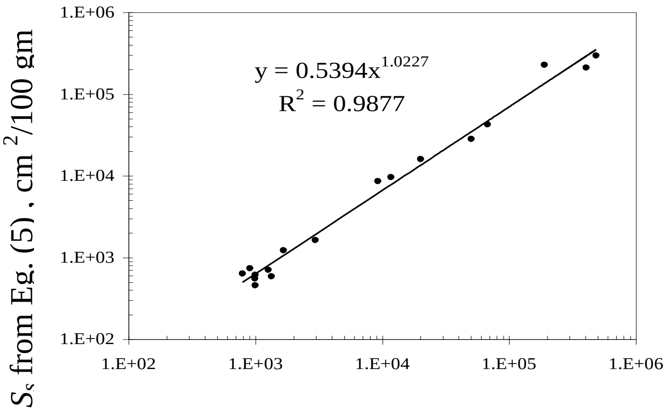
The comparison has proved better agreement and the coefficient of correlation between the results of the two equations is found to be 0.982921.The values obtained for the ratio of the specific surface calculated using the equivalent diameter to the specific surface calculated through summing the interval surface area of particles ($S_{pe(new)}/S_{PT}$) varied from 1.594972 to 0.453831 with an average of 1.025342, which is more close to 1.0. The standard deviation of the ratio distribution is found to be 0.225367 .

SEPARATING THE SAMPLES

In order to find the best correction equation, the samples are separated to gap, well graded and uniformly graded samples.

Well Graded Samples:

Fitting has been made for specific surface obtained from eq.(7) and that obtained from eq.(5) for well graded samples as shown in **Fig.(8)**



S_s from Eg. (7), cm ^{2}/100 gm

Fig. 8. Comparison between values of specific surface obtained from Eq. (7) and Eq. (5) for the well graded analyzed samples.

from this fitting it's found that the best equation could represented this relationship is:

$S_{pe(final)} = (S_{pe}/0.59394)^{(1/1.0227)}$ (18)

And this $S_{pe(final)}$ re draw with original S_{PT} that obtained from equation no. (7), as shown in **Fig. 9**

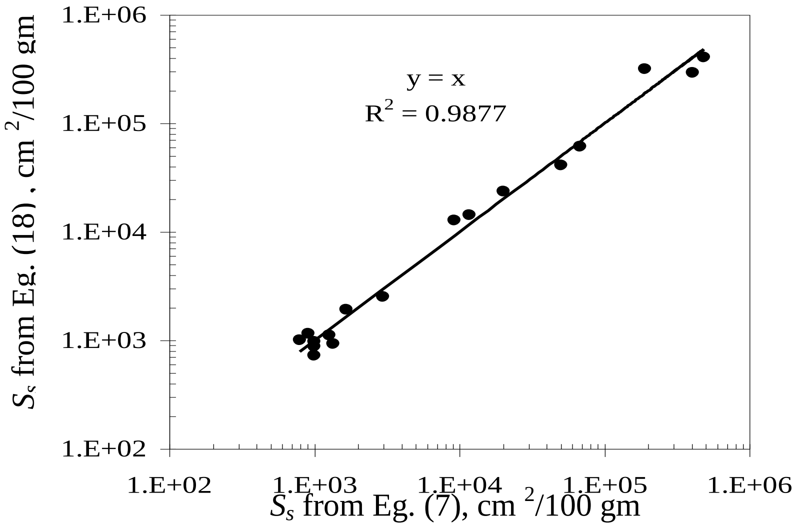


Fig. 9. Comparison between values of specific surface obtained from Eq. (7) and Eq. (18) for the well graded analyzed samples.

The comparison has proved better agreement and the coefficient of correlation between the results of the two equations is found to be 0.985730.The values obtained for the ratio of the specific surface calculated using the equivalent diameter to the specific surface calculated through summing the interval surface area of particles ($S_{pe(new)}/S_{PT}$) varied from 1.67 to 0.5031 with an average of 0.9438, which is more close to 1.0. The standard deviation of the ratio distribution is found to be 0.2008.

Gap Graded Samples:

Fitting has been made for specific surface obtained from eq.(7) and that obtained from eq.(5) for gap graded samples as shown in **Fig.(10)**

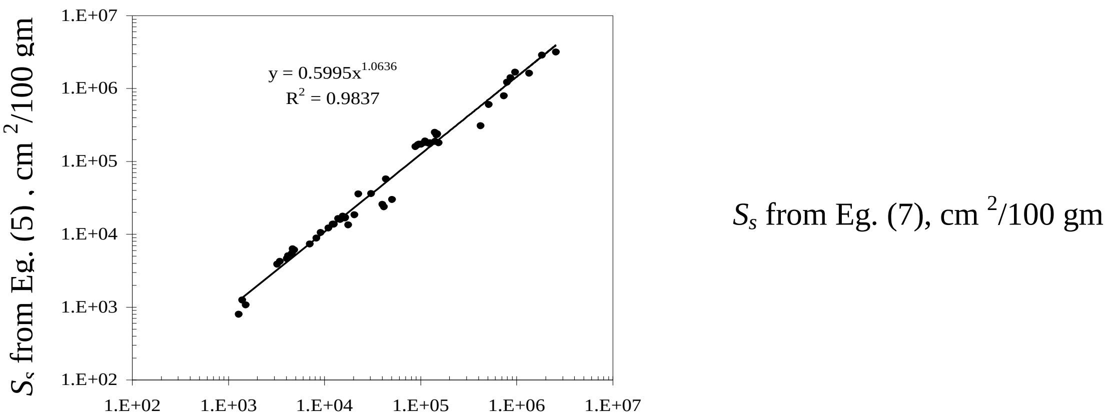


Fig. 10. Comparison between values of specific surface obtained from Eq. (7) and Eq. (5) for the gap graded analyzed samples.

from this fitting it's found that the best equation could represented this relationship is:

$S_{pe(final)} = (S_{pe}/0.5995)^{(1/1.0636)}$ (19)

And this $S_{pe(final)}$ re draw with original S_{PT} that obtained from equation no. (7), as shown in **Fig. 11**

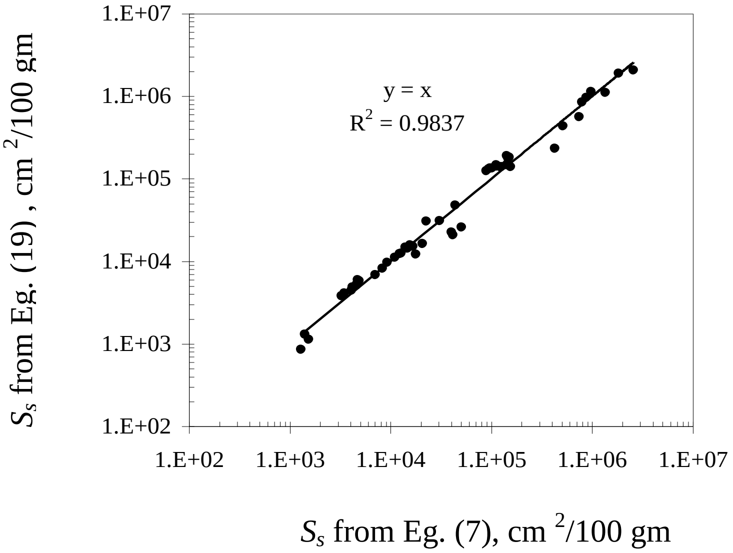


Fig. 11 Comparison between values of specific surface obtained from Eq. (7) and Eq. (19) for the gap graded analyzed samples.

The comparison has proved better agreement and the coefficient of correlation between the results of the two equations is found to be 0.985421.The values obtained for the ratio of the specific surface calculated using the equivalent diameter to the specific surface calculated through summing the interval surface area of particles (Spe(new)/SPT) varied from 1.420 to 0.3256 with an average of 0.8975, which is more close to 1.0. The standard deviation of the ratio distribution is found to be 0.2166 .

Uniform Graded Samples

Fitting has been made for specific surface obtained from eq.(7) and that obtained from eq.(5) for uniform graded samples as shown in **Fig.(12)**

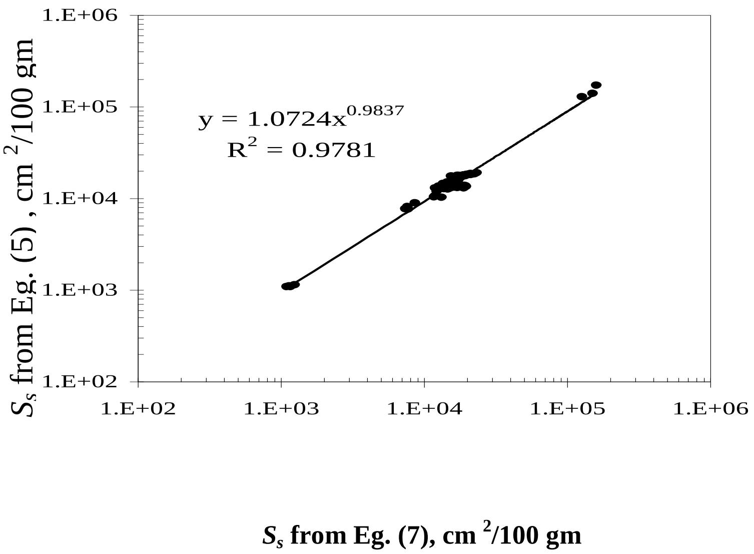


Fig. 12 Comparison between values of specific surface obtained from Eq. (7) and Eq. (5) for the uniform graded

from this fitting it's found that the best equation representing this relationship is:

$$S_{pe(final)} = (S_{pe}/1.0724)^{(1/0.9837)} \qquad (20)$$

And this $S_{pe(final)}$ re draw with original S_{PT} that's obtained from equation no. (7), as shown in **Fig. 13**

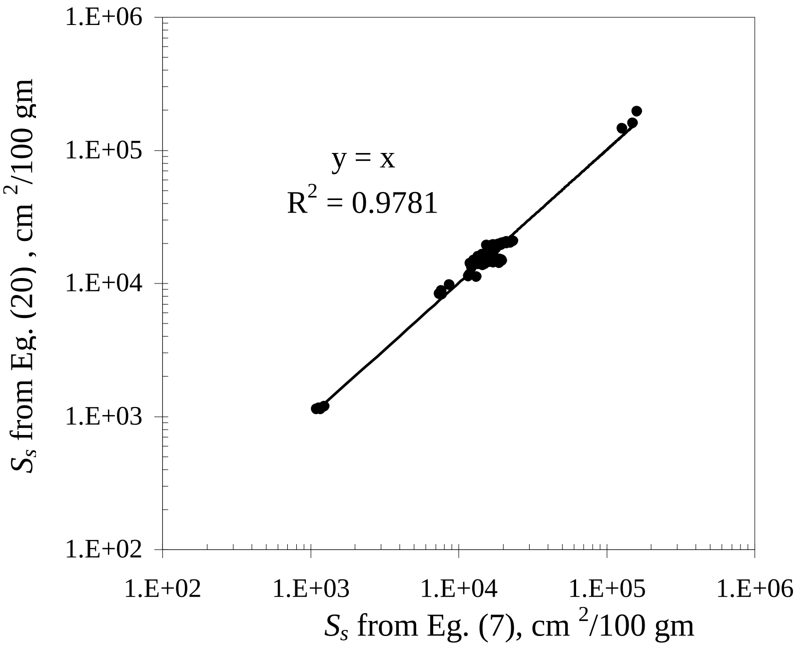


Fig. 13 Comparison between values of specific surface obtained from Eq. (7) and Eq. (5) for the uniform graded analyzed samples.

The comparison has proved better agreement and the coefficient of correlation between the results of the two equations is found to be 0.98545.The values obtained for the ratio of the specific surface calculated using the equivalent diameter to the specific surface calculated through summing the interval surface area of particles (Spe(new)/SPT) varied from 1.4161to 0.3256 with an average of 0.9712, which is more close to 1.0. The standard deviation of the ratio distribution is found to be 0.2170 .

CONCLUSIONS

Al-Mufty and Al-Hadidi proposed procedure for calculating the equivalent diameter by which the equivalent specific surface could be calculated. In this paper the equivalent specific surface could be corrected by a proposed procedure.

Analysis of 154 soil gradation curves has shown a very good agreement between the surface area values cumulated from gradation curves and the corrected specific surface which was obtained from the proposed equation.

NOTATIONS

D_{iav}	The average diameter
S_{piav}	The average surface area of a particle
V_{piav}	the average volume of a particle
S_i	the total surface area of particles of each interval
W	The weight of the whole soil in grams.

f	The values in percents representing the percentage of soil grains by weight passing the corresponding sieve size (diameter) on the gradation curve.
G	The average specific gravity of the soil particles.
ρ_w	The density of water = 1 gm/cm^3
S_s	The specific surface of the soil
S_{pe}	The specific surface of the particle having the equivalent diameter
V_{pe}	The volume of the particle having the equivalent diameter
D_e	The equivalent diameter
S_{pt}	The specific surface calculated through summing the interval surface area of particles
N	Number of logarithmic cycles
n	Number of classes
b	The width of each interval
f_e	The % finer on the gradation curve that yields a diameter which is the equivalent diameter required
z	The standard normal distribution variable
σ	The standard deviation
μ	The mean
π	The constant ratio
C_C	The coefficient of curvature

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