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MATLAB PROGRAM FOR RATING SOILS BASED ON ENGINEERING BEHAVIOURS

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Abstract — Engineering behaviour of soils is an important attribute to be considered as the foundation or even construction materials for civil engineering structures. One critical issue encountered by geotechnical engineers in construction works is predicting the engineering behaviour of soil with a view to assessing its suitability for any given construction purpose. Rating of soils based on their engineering behaviours can be achieved by classifying the soil into different groups and sub-groups of similar characteristics. Soil classification systems usually involve the use of charts, tables and curves, which is no longer fashionable because it might be very rigorous when many soils are involved. The use of software techniques simplifies the whole process. This study developed an algorithm in the form of a MATLAB program for easy classification of soil based on the Unified Soil Classification System (USCS), American Association of State Highway and Transport Officials (AASHTO), Plasticity Chart and the Indian Soil Classification Systems (ISCS), which makes the program unique. Soil samples used for illustration were collected and characterised depending on particle size analysis as well as consistency indices. A comparative study was carried out between classifying the soil using a manual approach and the MATLAB program. The MATLAB program rated Soil Sample A to be fine-grained, which belongs to soil groups A-7-6(15), CL (inorganic clay that has medium plasticity) and MI or OI (inorganic silt of medium plasticity or organic silt of medium plasticity) while Soil Sample B was rated to be coarse-grained belonging to A-1-b (0), SM (Silty Sand) and SM (Silty Sand) in the AASHTO, USCS and ISCS classification systems respectively. The results of the classification systems from the MATLAB program were completely in conformity with the results obtained from the manual approach. Thus, the MATLAB program gave a very high degree of accuracy of almost 100%.

***Keywords*:** MATLAB program, soil rating, engineering behaviour

1.0 INTRODUCTION

Soil is the outermost part of the earth's crust. It is of a wide variety and differs in composition and properties. Soil is arguably indispensable to man and its use depends upon its type and characteristics. Soils are usually encountered or utilised in treated form for many purposes in civil engineering works such as foundation soils, earth embankments for dams and waste containment, as well as road pavements [1–12]. Therefore, in order to ascertain the level at which soil can adequately perform for any particular purpose, as a matter of [13]necessity a geotechnical engineer should predict their engineering behaviours before selecting any soil. Soils are peculiar in their structures and consequently differ in characteristics. In other words, it is very difficult to have two soils that are identical in every aspect though may vary significantly from the engineering point of view. In a case for illustration, two soils might share some similarities in consistency indices but may be entirely different in the grading of the soil grains and as such they would be completely different in some characteristics as well as their engineering behaviour. One of the greatest challenges geotechnical engineers encounter is that some soils find it difficult to conform to conventionally stipulated treatment procedures and testing requirements, culminating into variations in results obtained during testing [13] The aforementioned variabilities have been extensively expounded by [14] from the standpoint of the pedology of the soils. In view of the inherent complexities in soils, one of the simplest and most reliable means of rating soils based on their engineering characteristics and behaviour is through soil classification. Thus, the idea of soil classification is aimed at grouping soils with similar characteristics and ultimately similar engineering behaviours together. Soil classification has been defined as the organizing of soils into various sets in a manner that the soils with similar properties are placed in the same group [15].

There are different methods soils classifications from various standards, such as American Association of State Highway and Transport Officials (AASHTO), Unified Soil Classification System (USCS), Indian Soil Classification System (ISCS), International Classification System (ICS), Textural Classification. In most of these classification systems, classifying soils into groups are usually achieved by the use of charts in the form of tables and plots of curves. In cases where the geotechnical engineer is confronted with the task of classifying many soils, the process of going through the charts might become very rigorous.

In view of the foregoing, the rigorous use of charts of the classification systems is no longer fashionable. Many researchers had adopted the use of software programs to make the soil classification process less laborious. The deep learning approach has been applied in classifying tropical soils in the USCS classification system. The deep learning prediction is an Artificial Intelligence method that could only classify soils in the USCS classification system [16]. A Long Short-Term Memory (LSTM) deep learning classification algorithm with 6 layers was used to model the dataset. A code has been published on soil classification which is based on USDA classification system, but this was found to have many constraints; as it needs definition of parameters and variables for the execution of the program [17]. Previous researchers also developed a Matlab program to classify soils but only limited to AASHTO classification systems [18]; while [19] developed a phone application used for the classification of soil but this is also limited to USCS classification system. Thus, this study focused on developing a Matlab program which is user friendly and is capable of classifying soils in four different soil classification systems. Therefore, the geotechnical engineer has the opportunity of classifying soil in American Association of State Highway Transportation Officials (AASHTO), Plasticity Chart, Unified Soil Classification System (USCS) and Indian Soil Classification System (ISCS) using the Matlab program.

2.0 SOIL CLASSIFICATION SYSTEMS

Some of the soil classification systems depend only on textural or visual properties such as colour of which are inadequate to predict the behaviour of soils. Among the methods, AASHTO [20] and USCS [21], are most predominantly used because the index properties and textural characteristics are well considered in the classification systems.

AASHTO [20] is usually a reference standard for classifying soils for highways purposes. The foregoing focuses on ascertaining the ability of the soil to adequately perform for earthworks, embankments, and road bed materials [22]. In general, the AASHTO classification system makes use of the grain size distribution, liquid limit and the plasticity index of the soil for classification. In AASHTO [20]system, soils are usually arranged into 7 main groups, from A-1 to A-7. Soils are rated to be in A-1, A-2 or A-3 groups are referred to as coarse-grained soils and it is when smaller than 35% of the particles are finer than sieve number 200.However when greater than 35% of the soils' particles are finer than sieve number 200, they are rated to be A-4, A-5, A-6, or A-7 groups as shown in Tables 1 and 2 respectively.

Table 1 Classification of highway subgrade materials [20]

General Classification	**Granular Materials (35% or less of total sample passing No. 200)**						
Group classification	**A-1**		**A-3**	**A-2**			
	A-1-a	A-1-b		A-2-4	A-2-5	A-2-6	A-2-7
Sieve classification (percent passing)							
No.10	50 max						
No.40	30 max	50 max.	51 min.				
No.200	15 max	25 max.	10 max.	35max	35 max.	35 max.	35 max.
Characteristics of Fraction passing No 40							
Liquid Limit				40 max	40 min.	40 max.	41 min.
Plasticity Index	6 max		NP	10 max	10 max	11 min.	11 min.
Usual types of significant constituent materials	Stone fragments gravel, and sand		Fine sand	Silty or clayey gravel and sand			
General subgrade rating	Excellent to good						

Table 2 Classification of Highway material [20]

General Classification (Silt-clay materials (more than 35%of total sample passing No. 200)				
Group classification	A-4	A-5	A-6	A-7 A-7-5* A-7-6[1]
Sieve analysis (percent passing)				
No. 10				
N0. 40				
No. 200	36 min	36 min	36 min	36 min
Characteristics of fraction passing No. 40				
Liquid Limit	40 max	41 min	40 max	41 min
Plasticity index	10 max	10 max	11 min	11 min
Usual types of significant constituent materials	Silty soils		Clayey soils	
General subgrade rating	Fair to poor			

$$\mathrm{GI} = 0.2T + 0.005TY + 0.01\,XZ \quad (1)$$

Equation (1) is from AASHTO [20] for calculating the group index of any soil and inserted in a bracket beside the soil group.

The following are the descriptions of the parameters in Equation (1),

GI = Group Index

$T =$ the proportion of the percentage of the particles finer than sieve No. 200 more than 35 but should not be above 75, given as a non-decimal integer (between$= 1\ to\ 40$);

$X =$ the proportion of the percentage of the particles finer than sieve No. 200 more than 15 but should not be above 55, given as a non-decimal integer (between$= 1\ to\ 40$);

$Y =$ the proportion of the liquid limit higher than 40 but not above 60, given as a non-decimal integer (between$= 1\ to\ 20$);

$Z =$ the proportion of the plasticity index higher than 10 but not above 30, given as a non-decimal integer (between$= 1\ to\ 20$);

The USCS [21] originated first for the purpose of airfield construction and subsequently re-designed to suit the application to dams and various construction purposes [23]. Major groups of the USCS [21] are shown in Table 3, group notations are assigned to the soils which comprises a primary as well as a secondary symbol.

Table 3 Symbols used in USC system [21]

	Symbols	Description
Primary	G	Gravel
	S	Sand
	M	Silt (Symbol M is obtained from the Swedish word 'mo')
	C	Clay
	O	Organic
	Pt	Peat
Secondary	W	Well-graded
	P	Poorly graded
	M	Non-Plastic fines
	C	Plastic fines
	L	Low Plasticity
	H	High Plasticity

Primary notations show soil main types while the secondary notations show the subdivisions within a group. For instance, GW, GP, GM and GC indicate well-graded gravel, poorly-graded gravel, silty gravel and clayey gravel respectively while SW, SP, SM and SC indicate well-graded sand, poorly-graded sand, silty sand, clayey sand respectively. Clay that has liquid limit higher than 50 percent is CH while the one that has liquid limit smaller than 50% is CL.

Soils are regarded as well-graded or non-uniform when variety of the grain size distributions are present in the soil, that is the adequate representation of soil particles of every usual grade of sizes ranging from the maximum to minimum limits. On the other hand, soils are regarded as poorly-graded or uniform when the soil predominantly consists of the same particle size and the absence of some other grain sizes. A soil is classified to be coarse-grained in the USCS [21] when it is higher than 50 percent of the soil particles are bigger than the apertures on number 200 sieve. The soil would be referred to as gravel when higher than medium quantity of the coarse proportion are bigger than the apertures of sieve number 4 whereas the soil would be referred to as sand when higher than medium quantity of the coarse proportion fall within numbers 4 and 200 sieves. Also, if the soil particles are finer than the apertures of sieve number 200 are lower than or equal to 5 percent of the soil grains, then the soil can be referred to as any of GW, GP, SW or SP contingent upon the group that the soil satisfies. In the case a soil is rated to be coarse-grained but the soil particles finer than the aperture of sieve number 200 are higher than 12 percent of the soil grains, then the soil could be referred to as any of GM, GC, SM or SC also contingent upon the group that the soil satisfies the conditions. Conversely, in a case where higher than 50 percent of the soil particles are smaller than the apertures of sieve number 200, then the soil is regarded as fine-grained. Furthermore the plasticity or A-line chart would be required would be required for rating of fine-grained soils as shown in Figure 1 depending on the plots of the plasticity index and liquid limit. The fine-grained soils could be referred to as inorganic clays (C), silts (M) and organic soils (O).

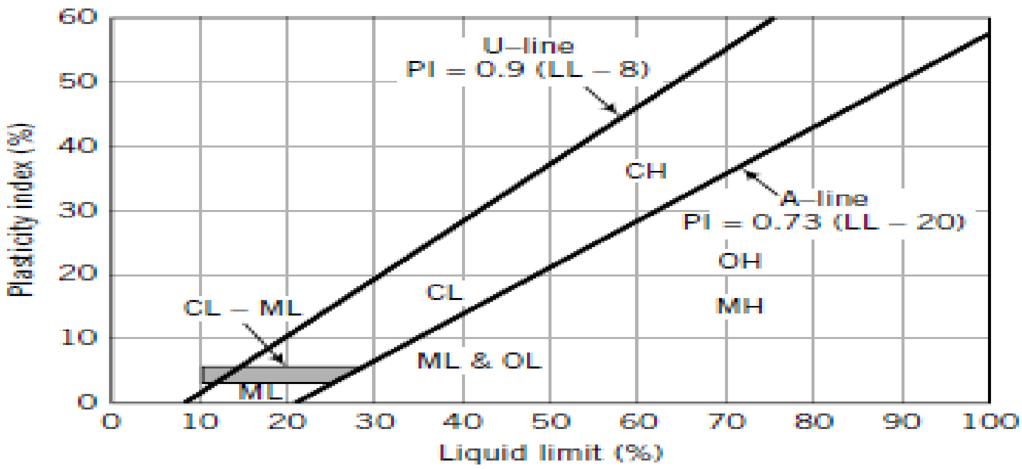


Figure 1 Plasticity or A-line Chart [21]

3.0 MATERIALS AND METHODS

The study was conducted on two soil samples which were adopted for the illustration. One (Sample A) was acquired from a soil deposit at Olokoro in Umuahia South Local Government Area of Abia State, (latitude 5.46^{0}N, longitude 7.52^0 E) while the other (Sample B) from Ihechiowa in Arochukwu Local Government Area of Abia State (latitude 5.38^{0}N, longitude 7.92^0 E) both in Nigeria. The required tests (Atterberg limits and particle size analysis) for the characterization of the soils were carried out in accordance with standard [24–26] for testing soils. The soils were further classified using usual charts and plots of the AASHTO [20] and USCS [21] classification systems. The idea was to compare the results from the manual approach with which was obtained from the Matlab program.

Matlab is a product of Math Works Inc. it is arithmetic based and has element of programming incorporated in it. Matlab is popular because of its simplicity in usage, interactive interface which can also involve very wide numerical computation and clear presentation abilities. Matlab also possesses logical, rational, conditional and loop structures which is similar to the various software or programming languages, like Pascal, C, Fortran etc, therefore

Matlab is programmable [27]. Since the program developed for the soil classification is a decision-making program the algorithm consists of the decision-making codes such as:

1. Rational Operators and logical variables
2. Logical operators and functions
3. Conditional statements
4. Loop structures

The Matlab program for soil classification is written in line with the tables, charts and graphs required for proper grouping of the soils based on the categories of the classification methods. The Matlab program in appendix was developed to classify soils based on input parameters of particle sizes and consistency indices. The soil classification programme comprises of four (4) different methods namely: AASHTO [20], Plasticity Chart, USCS [21] and ISCS [28]. Once the programme is run it displays the different soil classification methods which allow the user to select the soil classification method(s) of choice. After the method for the soil classification is selected, the programme allows the user to input the soil parameters. For the AASHTO [20]method of soil classification the input parameters are: percentage of soil samples passing the following sieve numbers 10, 40, 200; the liquid limit and plasticity index of the soil; grouping of soils under the plasticity chart requires only the liquid limit and plasticity index; the input parameter for the USCS [21] are percentage of the soil retained in BS sieve No. 4 and 200, the coefficient uniformity Cu, coefficient of curvature Cc, liquid limit, plasticity index; The input parameters for the USCS [21] method and Indian system [28] are the same. However, the sieve analysis should be performed using IS sieves. Rational operators such as less than (<), less than or equal to (<=), greater than (>), greater than or equal to (>=), equal to (==) and not equal (~=) and conditional statements (e.g., "if", "elseif") were used to quantitatively compare the soil properties with respect to the specifications provided by the soil classification codes. The loop statement which helps in executing a block of code repeatedly was used to ensure that the soil classification programme can be used to classify soil multiple number of times.

4.0 PRESENTATION OF SOIL TEST RESULTS, PROGRAM OUTPUTS AND DISCUSSIONS

Characteristics of the soils adopted for the study are summarized in Table 4 especially for grain size and consistency limits. Using the values of 63.2, 47% and 28% for proportion finer than the apertures of sieve No 200, liquid limit and plasticity index respectively and also evaluating the Group Index (GI) from Equation (1) for Sample A; which was rated to be in group A-7(15) in the AASHTO [20] classification system. From the AASHTO [20] Table 2, the soil could be referred to as clayey under group A-7 soils. As the soil groups moves from left to right of the AASHTO [20] Table 1 and 2 imply that the poorer the soil would be for road construction work. In this case, A-7 soil group is the farthest to the right of the AAASHTO [20] Table 2. This goes to show that the soil is poor for road construction work. Furthermore, the more the numerical value of GI, the worse the soil would be as a construction soil. The GI value of 15 is very high and also indicates poor construction soil. The soil would require to be treated with any good stabilizing agent before it could be suitable for construction works. With up to 63.2% of the soil grains finer than sieve No 200, it could be deduced that the rating of the soil would be fine-grained in USCS [21] Considering the region where the meeting point of liquid limit and plasticity index falls on the A-line chart shown as Figure 1, the soil could be referred to as CL (clayey soil of medium plasticity). On the other hand, Sample B which has 39% and 20% as percentages finer than Sieve Numbers 40 and 200 respectively, was rated to be in group A-1-b (0) in the AASHTO [20] classification system. It is very obvious that Sample B is a coarse-grained soil which is far to the left of AASHTO [20] Table 1 with a Group Index (GI) value of zero (0). It also implies that Sample B is a good soil for construction purposes. Sample B is non-plastic which has values of Coefficient of Uniformity (Cu), Coefficient of Curvature (Cc) and liquid limit to be 5.8, 1.53 and 17.2% respectively. Sample B was rated to be Silty Sand (SM) which is a coarse-grained soil in USCS [21].

Table 4 Soil Characteristics

Soil Properties	**Description**	
	Sample A	Sample B
Colour	Reddish-brown	Whitish-yellow
% Finer than aperture of Sieve No 4	100	100
% Finer than aperture of Sieve No 10	85.5	71.5
% Finer than aperture of Sieve No 40	70.2	39
% Finer than aperture Sieve No 200	63.2	20
Liquid Limit	47 %	17.2 %
Plastic Limit	19 %	Immeasurable
Plasticity Index	28 %	NP

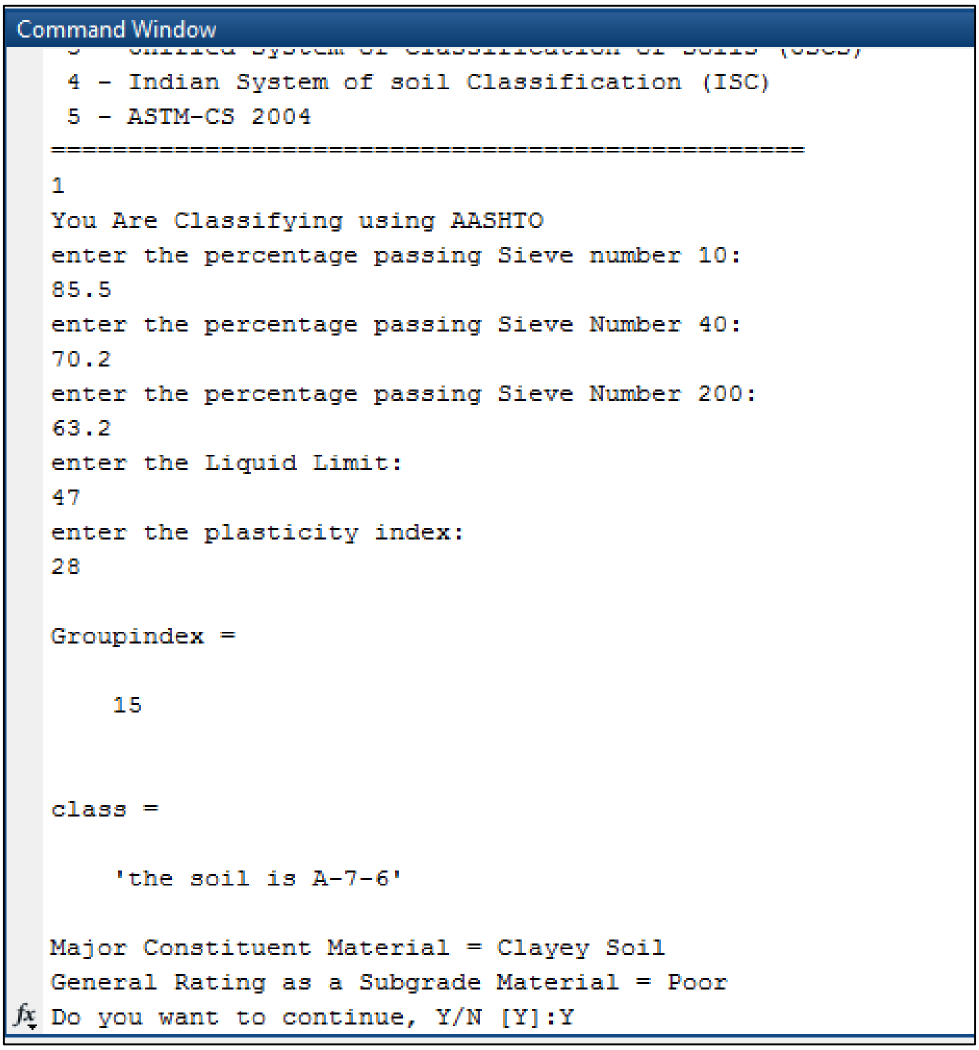
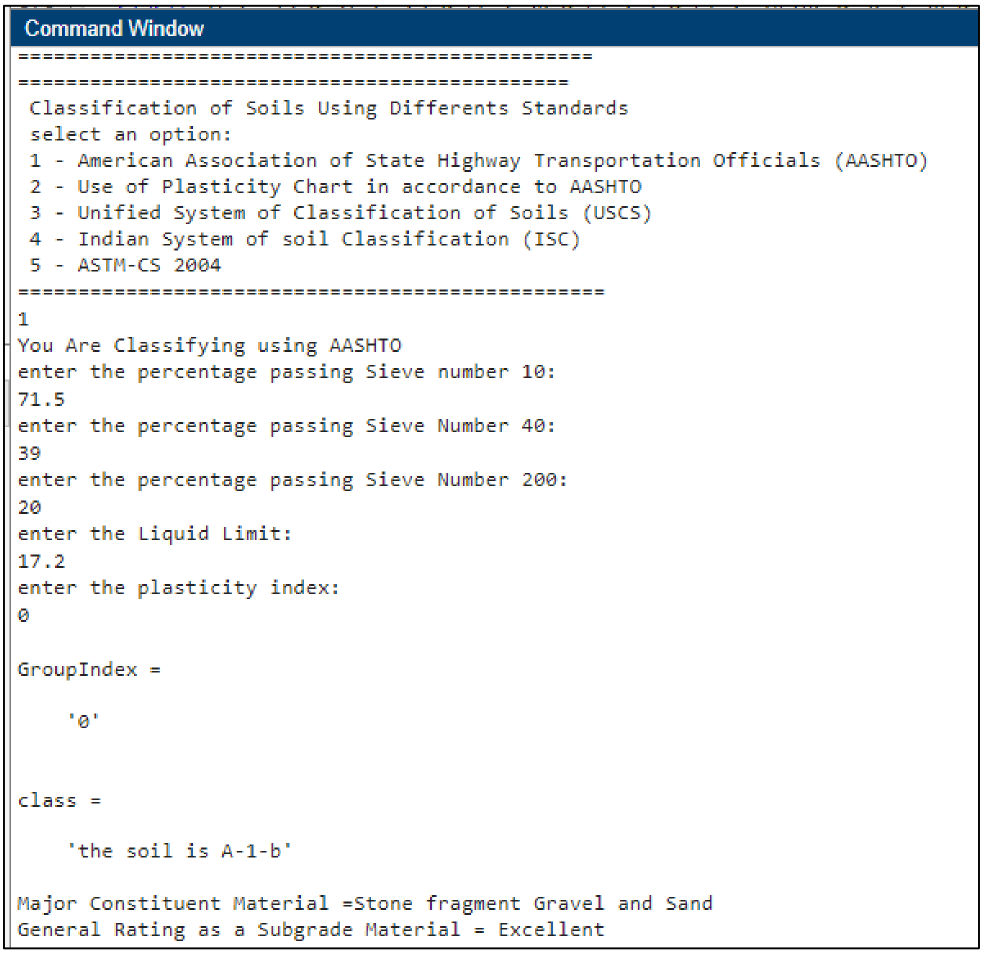


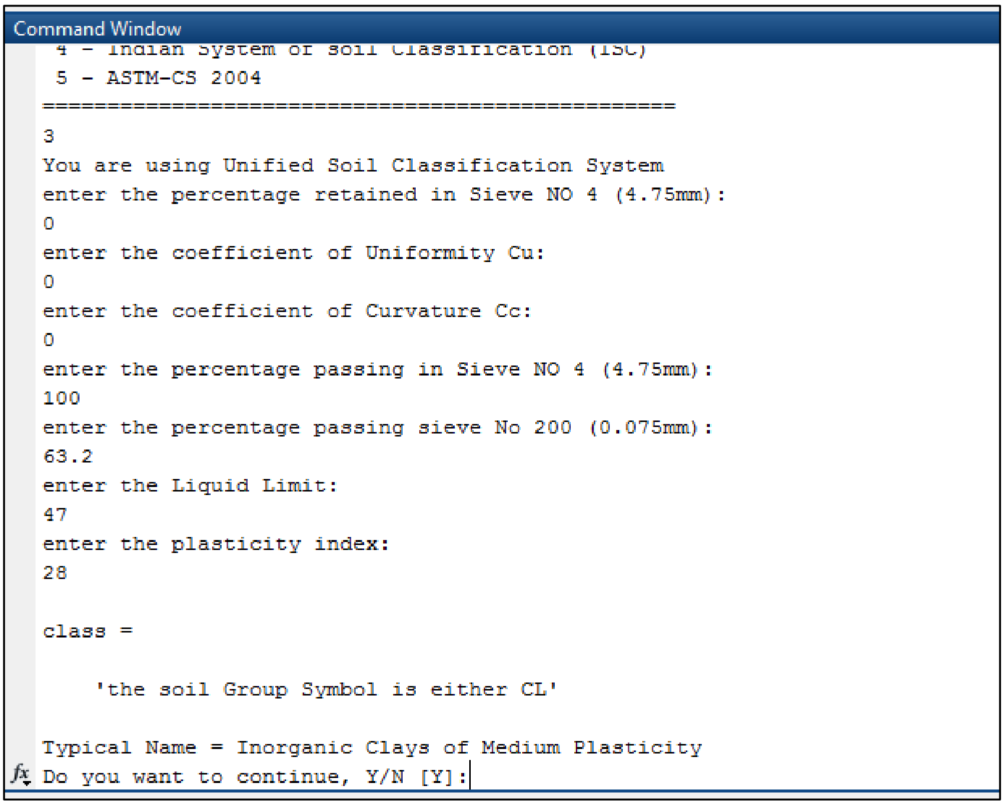
Figure 2 Matlab Program Output for Classifying the Soil Sample A using AASHTO [20]



```
Command Window
================================================
==============================================
 Classification of Soils Using Differents Standards
 select an option:
 1 - American Association of State Highway Transportation Officials (AASHTO)
 2 - Use of Plasticity Chart in accordance to AASHTO
 3 - Unified System of Classification of Soils (USCS)
 4 - Indian System of soil Classification (ISC)
 5 - ASTM-CS 2004
=================================================
1
You Are Classifying using AASHTO
enter the percentage passing Sieve number 10:
71.5
enter the percentage passing Sieve Number 40:
39
enter the percentage passing Sieve Number 200:
20
enter the Liquid Limit:
17.2
enter the plasticity index:
0

GroupIndex =

    '0'


class =

    'the soil is A-1-b'

Major Constituent Material =Stone fragment Gravel and Sand
General Rating as a Subgrade Material = Excellent
```

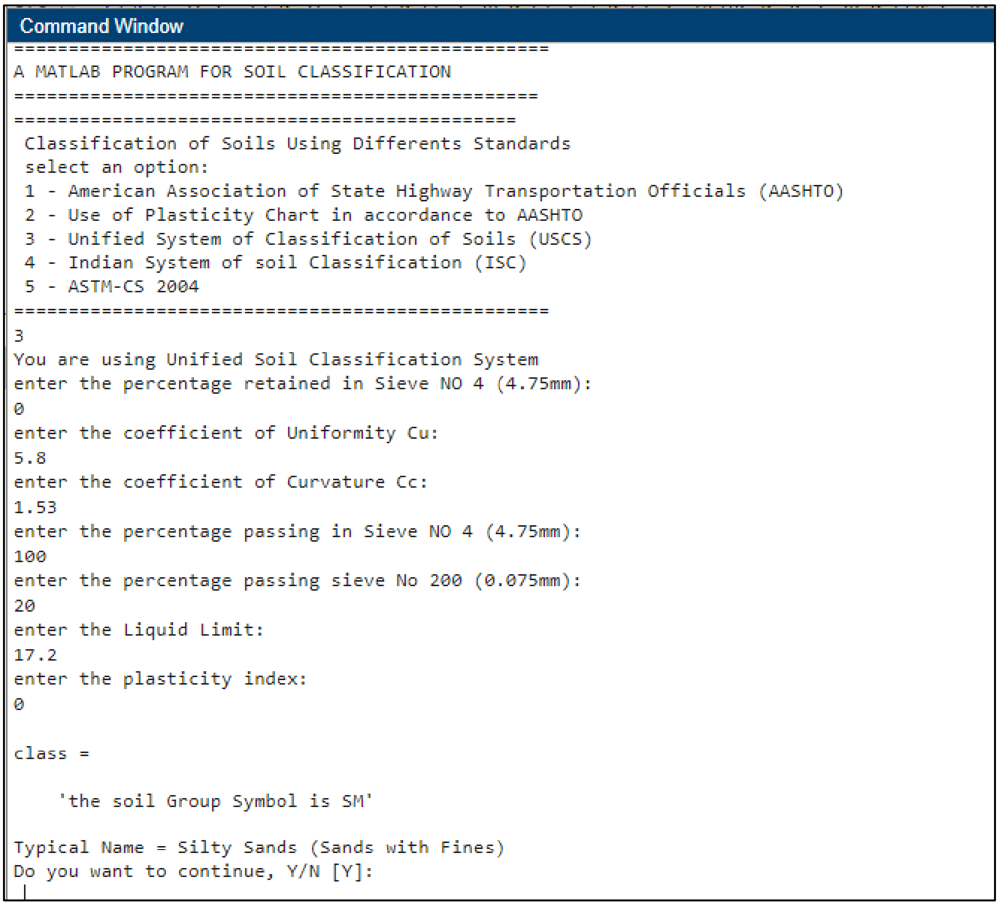
Figure 3 Matlab Program Output for Classifying the Soil Sample B using AASHTO [20]

Figure 2 shows the Matlab program output in grouping the soil Sample A on the scale of AASHTO [20]. Numerical values of the soil characteristics from Table 4 such as the liquid limit, plasticity index as well as soil percentages finer than the apertures on sieve numbers 10, 40 and 200 as 47%, 28%, 85.5, 70.2 and 63.2 respectively were put in the Matlab program. The Matlab program classified the soil to be A-7-6 group on the scale of AASHTO [20] and the GI value is 15. Major constituent of the soil was found to be clayey soil and it was rated to be a poor construction soil. Figure 3 also shows the Matlab Program output in grouping the soil Sample B on the scale of AASHTO [20]. The numerical values of the characteristics of soil sample B from Table 4 like liquid limit, plasticity index, percentage passing sieve numbers 10, 40 and 200 as 17.2%, 0, 71.5%, 39% and 20% respectively were put in the Matlab program. The Matlab program classified the soil to be A-1-b with GI value of zero (0). The Matlab program also referred Soil Sample B to be largely constituted of stone fragment of gravel and sand which is an excellent material for subgrade soil. The results of the two soils from the Matlab program completely conformed to that which was obtained using manual approach. This has shown that the Matlab program could be dependable for soil classification in the AASHTO [20] classification system.



```
Command Window
 4 - Indian System of soil Classification (ISC)
 5 - ASTM-CS 2004
==================================================
3
You are using Unified Soil Classification System
enter the percentage retained in Sieve NO 4 (4.75mm):
0
enter the coefficient of Uniformity Cu:
0
enter the coefficient of Curvature Cc:
0
enter the percentage passing in Sieve NO 4 (4.75mm):
100
enter the percentage passing sieve No 200 (0.075mm):
63.2
enter the Liquid Limit:
47
enter the plasticity index:
28

class =

    'the soil Group Symbol is either CL'

Typical Name = Inorganic Clays of Medium Plasticity
Do you want to continue, Y/N [Y]:
```

Figure 4 Matlab Program Output for Classifying the Soil Sample A using USCS [21]



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Command Window
==================================================
A MATLAB PROGRAM FOR SOIL CLASSIFICATION
================================================
==============================================
 Classification of Soils Using Differents Standards
 select an option:
 1 - American Association of State Highway Transportation Officials (AASHTO)
 2 - Use of Plasticity Chart in accordance to AASHTO
 3 - Unified System of Classification of Soils (USCS)
 4 - Indian System of soil Classification (ISC)
 5 - ASTM-CS 2004
==================================================
3
You are using Unified Soil Classification System
enter the percentage retained in Sieve NO 4 (4.75mm):
0
enter the coefficient of Uniformity Cu:
5.8
enter the coefficient of Curvature Cc:
1.53
enter the percentage passing in Sieve NO 4 (4.75mm):
100
enter the percentage passing sieve No 200 (0.075mm):
20
enter the Liquid Limit:
17.2
enter the plasticity index:
0

class =

    'the soil Group Symbol is SM'

Typical Name = Silty Sands (Sands with Fines)
Do you want to continue, Y/N [Y]:
```

Figure 5 Matlab Program Output for Classifying the Soil Sample B using USCS [21]

Figure 4 shows the Matlab program output for classifying the Soil Sample A using USCS [21]. The values of the soil characteristics from Table 4 such as the liquid limit, plasticity index as well as the soil proportions finer than the apertures of sieve numbers 4 and 200 as 47%, 28%, 100 and 63.2 respectively were put in the Matlab program. The value of zero '0' was put for the coefficient of uniformity and coefficient of curvature because the soil is fine-grained (63.2 percent of soil grains passing sieve number 200). Coefficient of uniformity and coefficient of curvature are only relevant for granular soils. Percentage retained on sieve number 4 was also put at zero because 100 percent of the soil grains were finer than sieve number 4. The Matlab program classified the soil to be CL (inorganic clay of medium plasticity). Figure 5 shows the Matlab program output for classifying Soil Sample B using USCS [21]. The numerical values of the characteristics of Soil Sample B such as 17.2%, 0, 5.8, 1.53, 100% and 20% for liquid limit, plasticity index, coefficient of uniformity, coefficient of curvature, percentages passing sieve numbers 4 and 200 respectively were put in the Matlab program. The Matlab program classified the soil to be SM (Silty Sand). These results are absolutely in agreement with the manual classification approach which has a very high level of accuracy of almost 100%. Previous studies [16] could only achieve 84% degree of accuracy using deep learning approach. In view of the foregoing, it would appear that Matlab program somewhat achieved higher level of accuracy than Artificial Intelligence. The reason for this would not be far from the fact that the steps for the Matlab program is similar to the manual approach the only difference is that the former is computerized while Artificial Intelligence involves training the software using series of outputs of datasets to then predict for other soils behaviour.

```
Command Window
==============================================
 Classification of Soils Using Differents Standards
 select an option:
 1 - American Association of State Highway Transportation Officials (AASHTO)
 2 - Use of Plasticity Chart in accordance to AASHTO
 3 - Unified System of Classification of Soils (USCS)
 4 - Indian System of soil Classification (ISC)
 5 - ASTM-CS 2004
=================================================
4
You are Using the Indian System of Soil Classification
please enter the percentage retained in sieve 4.75mm IS Sieve:
0
Please enter the coefficient of Uniformity Cu:
0
Please enter the coefficient of Curvature Cc:
0
please enter the percentage passing in sieve 4.75mm IS Sieve:
100
please enter the percentage passing 75microns IS Sieve (0.075mm):
63.2
enter the Liquid Limit:
47
enter the plasticity index:
fx 28

class =

    'the soil Group Symbol According to ISC Standard is MI or OI'

Typical Name = Inorganic Silt of Medium Plasticity or Organic Silt of Medium Plasticity
 REMARK = Organic and inorganic soils plotted in the same zone in plasticity chart
are distinguished by odour and colour or liquid limit test after oven-drying.
A reduction in liquid limit after oven-drying to a value less than three-fourth of liquid
limit before oven drying is positive indentification of organic soils
fx Do you want to continue, Y/N [Y]:
```

Figure 6 Matlab Program Output for Classifying Soil Sample A using ISCS [21]

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Command Window
==================================================
A MATLAB PROGRAM FOR SOIL CLASSIFICATION
=================================================
===============================================
 Classification of Soils Using Differents Standards
 select an option:
 1 - American Association of State Highway Transportation Officials (AASHTO)
 2 - Use of Plasticity Chart in accordance to AASHTO
 3 - Unified System of Classification of Soils (USCS)
 4 - Indian System of soil Classification (ISC)
 5 - ASTM-CS 2004
==================================================
4
You are Using the Indian System of Soil Classification
please enter the percentage retained in sieve 4.75mm IS Sieve:
0
Please enter the coefficient of Uniformity Cu:
5.8
Please enter the coefficient of Curvature Cc:
1.53
please enter the percentage passing in sieve 4.75mm IS Sieve:
100
please enter the percentage passing 75microns IS Sieve (0.075mm):
20
enter the Liquid Limit:
17.2
enter the plasticity index:
0

class =

    'the soil Group Symbol According to ISC Standard is SM'

Typical Name = Silty Sands (Sands with Fines)
Do you want to continue, Y/N [Y]:
```

Figure 7 Matlab Program Output for Classifying Soil Sample B using ISCS [28]

Figure 6 shows the Matlab Program Worksheet for Classifying the Soil using ISCS [28]. The values of the soil characteristics from Table 4 were put in the Matlab program just as in the case of USCS [21]. The Matlab program classified the soil to be MI or OI (inorganic silt of medium plasticity or organic silt of medium plasticity) in the ISCS [28] standard. Similarly, Figure 7 presents Matlab Program Output for Classifying Soil Sample B using ISCS [28]. The ISCS [28] classified Soil Sample B to be Silty Sand (SM). These were to demonstrate that the Matlab program is not limited to soil classification in the AASHTO [20] and USCS [21] classification systems only but could also successfully classify soils in other classification systems like ISCS [28].

5.0 CONCLUSION

This study successfully developed by MATLAB is used for classifying soils in different classification systems. At the end of the study, the following were observed:

1. The MATLAB program is capable of classifying soils in different classification systems.

2. The MATLAB program found the Soil Sample A to be fine-grained, which belongs to group A-7-6(15), CL (inorganic clay of medium plasticity) and MI or OI (inorganic silt of medium plasticity or organic silt of medium plasticity while Sample B to be coarse-grained belonging to A-1-b (0), SM (Silty Sand) and SM (Silty Sand) in the AASHTO [20], USCS [21] and ISCS [28] classification systems, respectively.

3. The soil classification results from the MATLAB program were completely in conformity with results obtained from the manual approach, which could be referred to almost 100% level of accuracy.

Conflicts of Interest

The authors categorically state that this article is originally from them and there is no conflict of interest by any individual or institution.

Data Availability Statement

The authors hereby confirm that raw datasets presented in this article can be supplied through the corresponding author. Also, all the materials or documents that were used to support the findings of this article are available on demand.

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