

A Matlab[®] Program for Soil Classification Using Aashto Classification

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Abstract: *This research work involve the use of Matlab program in classification of soil according to AASHTO. The programme does not only classify soil but also give the group index, the general sub-grade rating as well as possible material a particular sample is made of. It also helps in reducing the tedious work of having to go through the chart over and over again. The program has indicated that Matlab is not only for calculation and analysis but also can be used in analysis involving numerics and word problems simultaneously.*

Keywords: *soil classification, Matlab[®] program, AASHTO classification system, Atterberg Limits, Sieve Analysis, coding, loop statements, input/output based.*

I. Introduction

Matlab is an arithmetic-based computer software with elements of programming incorporated in it to that enables user friendly programming for solution of specified problems in various disciplines. Matlab was developed by the Math Works Inc. Matlab is a computer software for advanced performance visualization and computation. Matlab is the short form of Matrix Laboratory. This powerful system package provides a user friendly environment with lots of built in mathematical functions for accurate and reliable mathematical operations. These functions provide solutions to a diverse range of mathematical tasks such as;

- Matrix Algebra
- Signal Processing
- Complex arithmetic
- Linear Systems
- Optimization
- Non-linear system of equations
- Statistical Analysis
- System modeling and solutions
- Differential equations, and other types of scientific computations

The most interesting and important features of Matlab is its programming ability via written Matlab codes for specific uses which allows user developed functions to perform user intended purposes. The interesting thing about programming with Matlab is that a program of 100 lines in other programming packages like Q-Basic might take just 10 lines in Matlab as Matlab has many in-built functions that reduces tedious coding to just a call-up function. As leverage over other conventional programming packages, Matlab provide a flexible way of manipulating inputs, outputs, and conditions via its vast use of loop statements.

Soil classification is the arrangement of soils into different groups such that the soils in a particular group have similar behavior. It is a sort of labeling of soils with different labels. As there is a wide variety of soil covering the earth, it is desirable to systemize or classify soils into broad groups of similar behavior.

Every now and then, geotechnical engineers find the need to classify various soil samples from diverse sources for the purpose of analysis and determination of the engineering properties of a particular soil sample from a particular area.

One of the conventional systems of soil classification is the American Association of State Highway Transportation Officials (**AASHTO**) soil classification systems. In this system of classification, the particle size analysis and the plasticity characteristics are required to classify a soil. The classification system is a complete system which classifies both coarse-grained and fine-grained soils. In this system, the soils are divided into 7 types designated as A-1 to A7. The soils A-1 and A-7 are further subdivided into two categories, and the soil A-2, into four categories (Das B.M, 2005).

Classification using this system involves a series of comparison based on the properties of the soil sample in question. This could be tedious when one has to classify numerous soil samples with different soil characteristics. Hence there is the need for a program to make this easier which is what promoted the urge for this work.

Holger(2014) published a series of codes for a program on soil classification using the USDA classification system which had a lot of constraints hence limiting the user-friendly property as it needed definition of the parameters and variables necessary for the execution of the program. Due to these difficulties the program was unable to be easily used for its intended purpose.

II. Materials And Methods

The major source of materials that aided the success of the discussed program was obtained from online and e-resources majorly the video tutorials. Keen observation, watching, listening and understanding was paid to the video tutorials which aided in the understanding of how to manipulate loop statements to carry out intended purposes. The YouTube online video portal provided a comfortable platform for watching and learning from a vast range of video tutorials provided by many authors.

A series of video tutorials titled “Matlab Tutorials” which basically entailed guidelines in operating Matlab was obtained from the YouTube portal which aided in the understanding of loop statements.

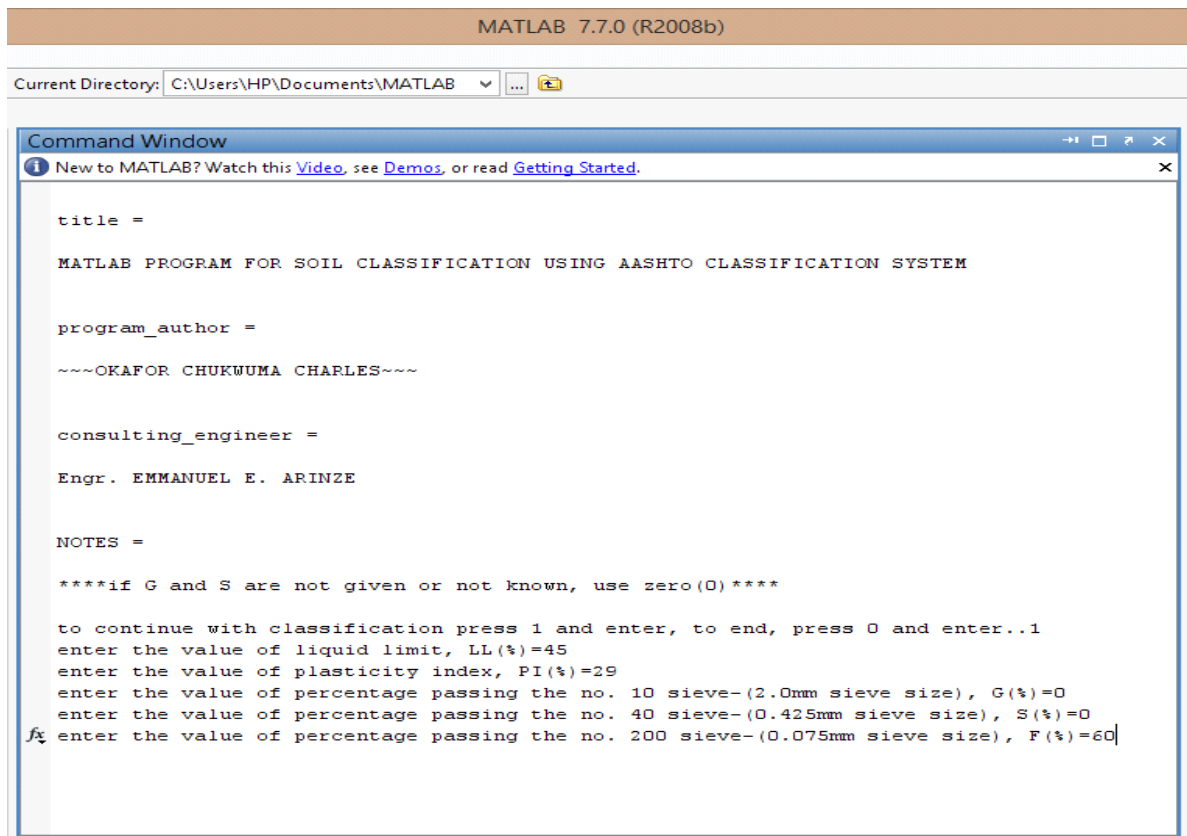
Also a video tutorial titled “An Introduction to Coding in Matlab” which was published by MathWorks Inc. also helped in the development of the basic functions upon which the program discussed in this work was based. The series of codes upon which the program is based is simply the input-output system and the conditional loop statements. These statements help in defining a particular set of properties that is assigned to each group in the classification system. After the completion of the coding, it was discovered that group A-1-b and A-2-4 accommodated similar properties as some classification had A-1-b as well as A-2-4 as the output. It was sorted out using AASHTO direction on the use of classification chart.

III. Results And Discussion

As already stated, the program is user-friendly and is input-output based with lots of comments and description and warning messages to guide users. A lot of results has been discussed and compared with already noted results to check the efficacy of the program and it has proved effective during the last phase of test-running. An example was picked from the textbook of Soil Mechanics and Foundation Engineering (Geotechnical Engineering) by **Dr. K. R. Arora**. A soil sample having the following properties was classified; Liquid limit=45%

Plasticity index=29%

F=60%, The soil was manually classified as A-7-6(14)



```
MATLAB 7.7.0 (R2008b)

Current Directory: C:\Users\HP\Documents\MATLAB

Command Window
New to MATLAB? Watch this Video, see Demos, or read Getting Started.

title =
MATLAB PROGRAM FOR SOIL CLASSIFICATION USING AASHTO CLASSIFICATION SYSTEM

program_author =
~~~OKAFOR CHUKWUMA CHARLES~~~

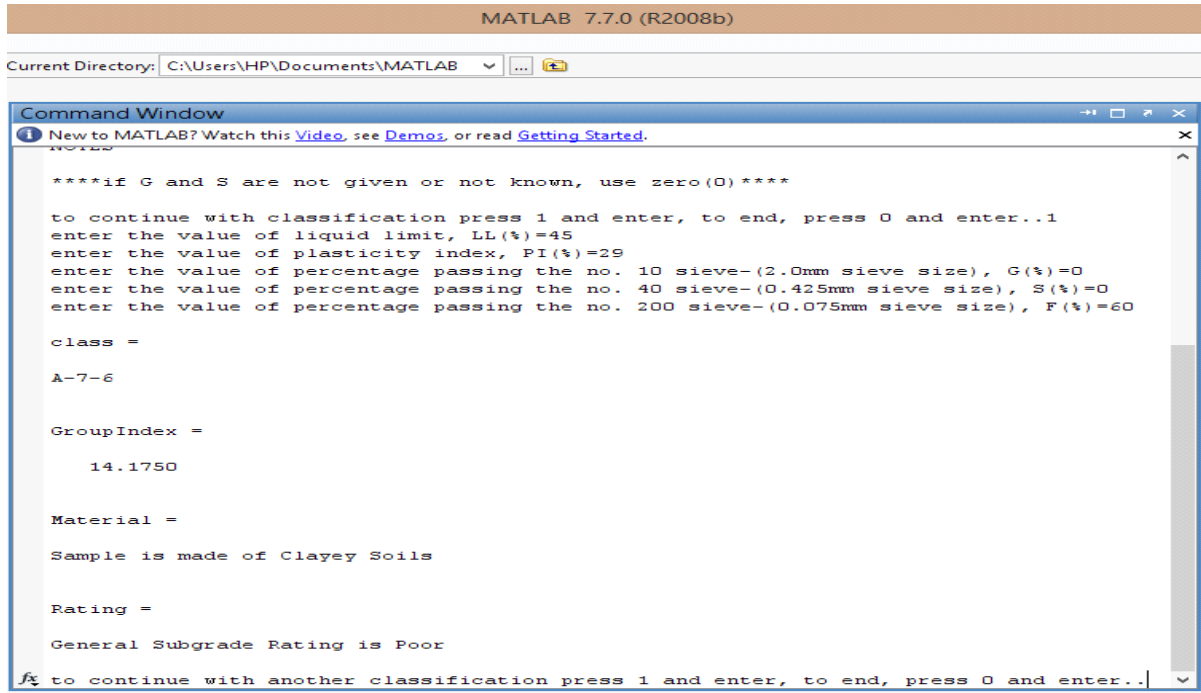
consulting_engineer =
Engr. EMMANUEL E. ARINZE

NOTES =
****if G and S are not given or not known, use zero(0)****

to continue with classification press 1 and enter, to end, press 0 and enter..1
enter the value of liquid limit, LL(%)=45
enter the value of plasticity index, PI(%)=29
enter the value of percentage passing the no. 10 sieve-(2.0mm sieve size), G(%)=0
enter the value of percentage passing the no. 40 sieve-(0.425mm sieve size), S(%)=0
fx enter the value of percentage passing the no. 200 sieve-(0.075mm sieve size), F(%)=60
```

Fig. 1: the input stage of the already mentioned example.

As obvious as it is, the program is easy to use due to its user-friendliness; it does not stop with just the symbols but goes ahead to describe the parameter all so to make sure that each parameter is keyed in where it is supposed to be. This property of the program does not only make it easy to use but also reduces the propensity of it being misused. The soil sample with the already stated classification properties was analyzed and classified by the program and the figure below was obtained from the output.



```
MATLAB 7.7.0 (R2008b)
Current Directory: C:\Users\HP\Documents\MATLAB
Command Window
New to MATLAB? Watch this Video, see Demos, or read Getting Started.
****if G and S are not given or not known, use zero(0)****
to continue with classification press 1 and enter, to end, press 0 and enter..1
enter the value of liquid limit, LL(%)=45
enter the value of plasticity index, PI(%)=29
enter the value of percentage passing the no. 10 sieve-(2.0mm sieve size), G(%)=0
enter the value of percentage passing the no. 40 sieve-(0.425mm sieve size), S(%)=0
enter the value of percentage passing the no. 200 sieve-(0.075mm sieve size), F(%)=60

class =
A-7-6

GroupIndex =
    14.1750

Material =
Sample is made of Clayey Soils

Rating =
General Subgrade Rating is Poor

to continue with another classification press 1 and enter, to end, press 0 and enter..1
```

Fig. 2: the output stage of the already mentioned example.

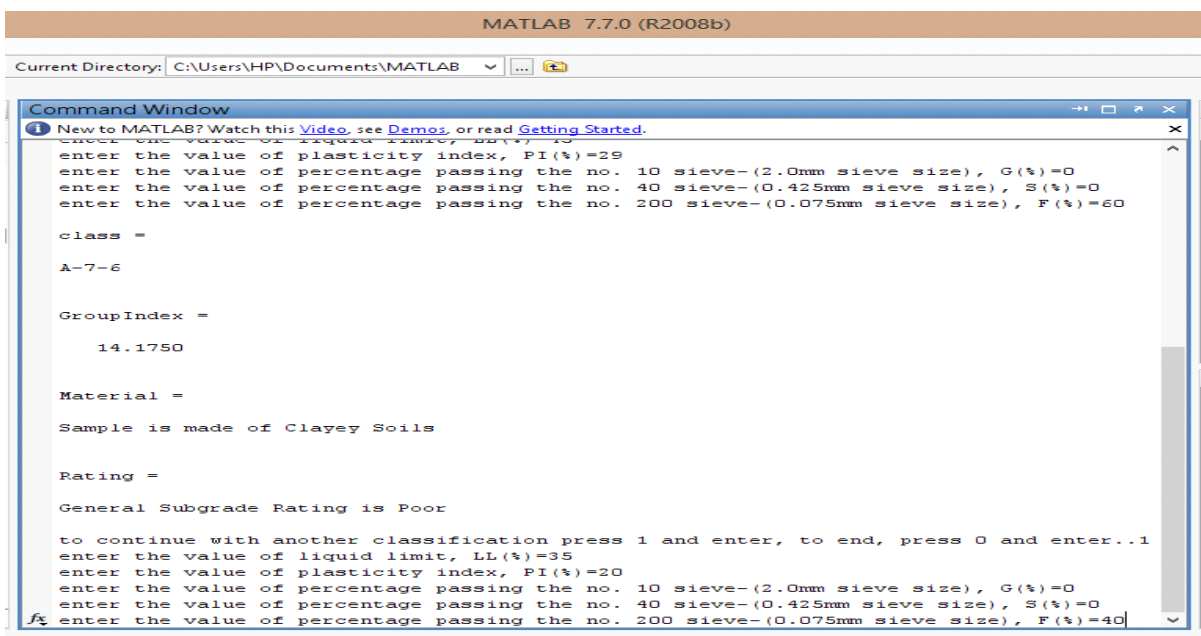
A comparison of the two results clearly shows that the two approaches both yielded the same result but that of the program is definitely faster and saves time as well as minimizes error.

Another example was picked from the same textbook and analyzed. The soil properties are as follows.

Liquid limit=35%

Plasticity index=20%

F=40% The soil was manually classified as A-6(4).



```
MATLAB 7.7.0 (R2008b)
Current Directory: C:\Users\HP\Documents\MATLAB
Command Window
New to MATLAB? Watch this Video, see Demos, or read Getting Started.
enter the value of liquid limit, LL(%)=35
enter the value of plasticity index, PI(%)=29
enter the value of percentage passing the no. 10 sieve-(2.0mm sieve size), G(%)=0
enter the value of percentage passing the no. 40 sieve-(0.425mm sieve size), S(%)=0
enter the value of percentage passing the no. 200 sieve-(0.075mm sieve size), F(%)=60

class =
A-7-6

GroupIndex =
    14.1750

Material =
Sample is made of Clayey Soils

Rating =
General Subgrade Rating is Poor

to continue with another classification press 1 and enter, to end, press 0 and enter..1
enter the value of liquid limit, LL(%)=35
enter the value of plasticity index, PI(%)=20
enter the value of percentage passing the no. 10 sieve-(2.0mm sieve size), G(%)=0
enter the value of percentage passing the no. 40 sieve-(0.425mm sieve size), S(%)=0
enter the value of percentage passing the no. 200 sieve-(0.075mm sieve size), F(%)=40
```

Fig. 3: input stage of the above example.

The main purpose of the above figure is to exercise the consistency of this program and to emphasize on its ability to run numerous classifications continually.

```
MATLAB 7.7.0 (R2008b)
Current Directory: C:\Users\HP\Documents\MATLAB
Command Window
New to MATLAB? Watch this Video, see Demos, or read Getting Started.
General Subgrade Rating is Poor
to continue with another classification press 1 and enter, to end, press 0 and enter..1
enter the value of liquid limit, LL(%)=35
enter the value of plasticity index, PI(%)=20
enter the value of percentage passing the no. 10 sieve-(2.0mm sieve size), G(%)=0
enter the value of percentage passing the no. 40 sieve-(0.425mm sieve size), S(%)=0
enter the value of percentage passing the no. 200 sieve-(0.075mm sieve size), F(%)=40
class =
A-6
GroupIndex =
3.5000
Material =
Sample is made of Clayey Soils
Rating =
General Subgrade Rating is Poor
to continue with another classification press 1 and enter, to end, press 0 and enter..1
```

Fig. 4: output stage of the above example.

A comparison of the two results clearly shows that the two approaches both yielded the same result but the group index calculated by the program is 3.5 which can be easily rounded to the nearest whole number as 4. One can continue with classification for as many soil samples as possible. This is easily done by the input or the number 1 after each successive classification.

The figure below is to exercise the intelligence of the program by using an input that is out of range.

```
MATLAB 7.7.0 (R2008b)
Current Directory: C:\Users\HP\Documents\MATLAB
Command Window
New to MATLAB? Watch this Video, see Demos, or read Getting Started.
enter the value of percentage passing the no. 10 sieve-(2.0mm sieve size), G(%)=0
enter the value of percentage passing the no. 40 sieve-(0.425mm sieve size), S(%)=0
enter the value of percentage passing the no. 200 sieve-(0.075mm sieve size), F(%)=40
class =
A-6
GroupIndex =
3.5000
Material =
Sample is made of Clayey Soils
Rating =
General Subgrade Rating is Poor
to continue with another classification press 1 and enter, to end, press 0 and enter..1
enter the value of liquid limit, LL(%)=45
enter the value of plasticity index, PI(%)=29
enter the value of percentage passing the no. 10 sieve-(2.0mm sieve size), G(%)=0
enter the value of percentage passing the no. 40 sieve-(0.425mm sieve size), S(%)=0
enter the value of percentage passing the no. 200 sieve-(0.075mm sieve size), F(%)=605
Warning: AN ERROR HAS BEEN ENCOUNTERED, ONE OR MORE INPUTS ARE OUT OF RANGE
```

Fig. 5: illustration of the warning message.

Notice that the value of percentage passing the no. 200 sieve-(0.075mm sieve size), $F(\%)=605$ which of course is greater than 100 and is out of range, also notice that the program terminated with a warning message. This warning message has been highlighted for purpose of clarity in this report. The only limitation to the effectiveness of this program is its inability to round of the calculated group index value to nearest whole numbers. This is currently being considered in the next version of the program.

IV. Conclusion

In conclusion, it is pertinent to say that the conception of such idea to alleviate the work incorporated with soil classification and limit chances of error while classifying is a good academical venture as it helps to attain a level of certainty of one's understanding of the AASHTO soil classification system. It does not only classify the soil but also gives the group index, the general sub-grade rating as well as the possible material a particular sample is made of. It also helps in reducing the tedious work of having to go through the charts over and over again as one could get tired of the routine check which then is a favorable condition for mistakes. Also this program has shown that Matlab is not only for calculation and numerical analysis but can as well be used in analysis involving numeric and word problems concomitantly. Finally, like every other program, this program is open to comments and remarks and suggestions which will help improve a later version

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