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Mobile App using ASTM System of Soil Classification

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ABSTRACT: Soil classification is one of the important aspects of Geotechnical engineering. There are various soil classification systems available in the literature. The classification of soil is based on a set of variable which can be determined experimentally. Different system uses a different set of variables as the basis for the classification of soil. The classification systems available in literature are usually represented in the form of a tables or graphs or flow charts. Further, to classify the soil one has to refer to these tables and graphs manually leading erroneous classification of soils. In order to eliminate human error in classifying the soil and referring to tables or graphs, a mobile app (an application) has been developed and demonstrated for the soil classification in this paper.

Keywords: Soil classification; mobile app; JAVA programming and soil classification systems;

INTRODUCTION: Soil classification is the arrangement of soils into different groups such that soil in particular group have similar behaviour. There is a need of soil classification because it is easy to study behaviour of group than single soil. Different system uses a different set of variables as the basis for the classification of soil. The classification systems available in literature are usually represented in the form of a tables or graphs or flow charts. Further, to classify the soil one has to refer to these tables and graphs manually leading erroneous classification of soils. In order to eliminate human error in classifying the soil and referring to flow charts and graphs, a mobile **app** (an application) has been developed and demonstrated for the soil classification using ASTM system of classification in this paper.

BACKGROUND: A large number of classification systems are available in the literature for classifying soil. These classification systems are also dependent on the purpose for which they are going to be used. For example, for road construction, AASHTO system is used, USDA is used for agricultural purpose and ASTM and USCS is generally used for determination of general engineering behaviour. Some of the classification systems are shown in the T**able 1.**

Table 1 indicates that AASHTO and USCS classification system do not include classification of organic soils and thus require improvement. Further, the AASHTO system of soil classification does not classify the black cotton soil also. In order to improve these classification systems, a corrective approach was introduced in AASHTO and USCS classification system by **Huang et al. (2009)** in classifying the organic soils. **Holger** (2014) reported a code for the USDA classification system.

Table 1: Classification systems.

Classification Systems	Parameters Used	Remarks
AASHTO (1928)	Particle size distribution,	Does not include classification of
USDA (1938)	Grain size of	Provide only tex-
USCS (1942)	Gradation, grain	No provision for
IS: 1498-(1970)	Gradation, grain size, LL, PI	Provision of medium compressibility
ASTM D 2487-6	Gradation, grain	Classify all types

This code had a lot of constraints and cannot be used easily for the intended purpose. **Arinze (2015)** reported a MATLAB code for the AASHTO classification system. This code can run on a desktop or on laptop computer only. Further, a web based commercial **Geosystem** software is also available which can classify the soil based on a classification system and runs on a desktop computer. ASTM classification system classifies all types of soils including organics soils. This system identifies three major soil divisions such as coarse-grained, fine-grained and highly organic soils. These divisions are further subdivided into a total of 15 basic soil groups and each soil group have number of group names. Soils are classified using ASTM system of classification by group symbols and group names. ASTM system of soil classification can identify about hundred types of soil and provides a better classification for mixed soils consisting of mixtures of sand, gravel, clay as well as organic soils.

A mobile application is a computer program which runs on mobile devices such as smartphones and tablets. Most of the mobile devices available in the market have several pre-installed application software's such as web browser, email client, calendar, application software for purchasing music etc. Apps that are not preinstalled are usually available through application distribution platforms such as Apple App Store, Play store, Windows Phone Store, and BlackBerry App World, which began appearing in 2008 and are typically operated by the owner of the mobile operating system. Some apps are free, while others must be purchased. Usually, they are downloaded from the platform to a target device, but sometimes they can be downloaded to laptops or desktop computers. Further, mobile applications for classifying the soils using USCS, AASHTO, and USDA are also available on the play store (application distribution platform) but cannot be used to classify all types of soils. The above literature indicates that no mobile application is available using ASTM classification. Therefore, an attempt has been made in this paper to develop and demonstrate a mobile **app** for the soil classification using ASTM classification system.

Algorithm and application development: It is evident from Table 1 that the ASTM classification system is able to classify all types of soils. Hence an algorithm for the ASTM classification system was developed in JAVA. A sample algorithm for classifying the sand is shown in Table 2.

Table 2: Algorithm for classifying the sand.

<table>
<tr><td rowspan="18">Sand
If
(%S>%G)</td><td rowspan="4">If F <5%</td><td rowspan="2">If (Cu>=4 and 1<=Cc<=3)</td><td rowspan="2">SW</td><td>If (G<15%)</td><td colspan="2">Well graded sand</td></tr>
<tr><td>Else</td><td colspan="2">Well graded sand with gravel</td></tr>
<tr><td rowspan="2">Else</td><td rowspan="2">SP</td><td>If (G<15%)</td><td colspan="2">Poorly graded sand</td></tr>
<tr><td>Else</td><td colspan="2">Poorly graded sand with gravel</td></tr>
<tr><td rowspan="8">If F (5%-12%)</td><td rowspan="4">If (Cu>=4 and 1<=Cc<=3)</td><td rowspan="2">If (M>C)</td><td rowspan="2">SW-SM</td><td>If (G<15%)</td><td>Well graded sand with silt</td></tr>
<tr><td>Else</td><td>Well graded sand with silt and gravel</td></tr>
<tr><td rowspan="2">Else</td><td rowspan="2">SW-SC</td><td>If (G<15%)</td><td>Well graded sand with clay</td></tr>
<tr><td>Else</td><td>Well graded sand with clay and gravel</td></tr>
<tr><td rowspan="4">Else</td><td rowspan="2">If (M>C)</td><td rowspan="2">SP-SM</td><td>If (G<15%)</td><td>Poorly graded sand with silt</td></tr>
<tr><td>Else</td><td>Poorly graded sand with silt and gravel</td></tr>
<tr><td rowspan="2">Else</td><td rowspan="2">SP-SC</td><td>If (G<15%)</td><td>Poorly graded sand with clay</td></tr>
<tr><td>Else</td><td>Poorly graded sand with clay and gravel</td></tr>
<tr><td rowspan="6">If F>12%</td><td rowspan="2">If (M>C)</td><td rowspan="2">SM</td><td>If (G<15%)</td><td colspan="2">Silty sand</td></tr>
<tr><td>Else</td><td colspan="2">Silty sand with gravel</td></tr>
<tr><td rowspan="2">If (M<C)</td><td rowspan="2">SC</td><td>If (G<15%)</td><td colspan="2">Clayey sand</td></tr>
<tr><td>Else</td><td colspan="2">Clayey sand with gravel</td></tr>
<tr><td rowspan="2">If (4<=PI<=7)</td><td rowspan="2">SC-SM</td><td>If (G<15%)</td><td colspan="2">Silty clayey sand</td></tr>
<tr><td>Else</td><td colspan="2">Silty clayey sand with gravel</td></tr>
</table>

A similar approach was adopted for gravelly soil and merged with the main code. For fine grained soil, additional coding for the plasticity chart was prepared and included in the main code for classification. The series of codes upon which the program was based was simply conditional loop statements. These statements help in defining a particular set of properties that is assigned to each group in the classification system. Further, to develop the mobile application, open source **android studio** software was used. This software is used to design pages of mobile app, space for entering the numeric input, output, font and color of the output. The mobile app will require some input variables in order to classify the soils. If the entered values of the input variables are not valid or not in range or non-numeric, a warning message will pop up on the screen and the mobile app will terminate. Further, if the user does not have the values of any input variable, zero can be entered for that input variable to run the mobile app.

RESULTS AND DISCUSSION: The mobile application developed is user-friendly and each input-output is guided with specific comment. The results reported in literature has been discussed and compared to check the accuracy of mobile application in classifying the soils. The results for the classification (based on the ASTM system of classification) of two soils (designated as soil A and soil B) reported by Budhu et al. (2011) has been presented in Table 3.

Table 3: Properties of soils (After Budhu et al. 2011).

Constituent	Soil A	Soil B
LL	26	-
PL	18	-
PI	(26-18)=8	Non plastic
% retained on 0.075mm (no. 200 sieve)	12	80
Fines (%) **F**	(100-12)=88	(100-80)=20
Gravel fraction (%) **G**	0	16
Sand fraction (%) **S**	12	64
Silt fraction (%) **M**	59	20
Clay fraction (%) **C**	29	0
Classification	**ML, sandy silt**	**SM, Silty sand with gravel**

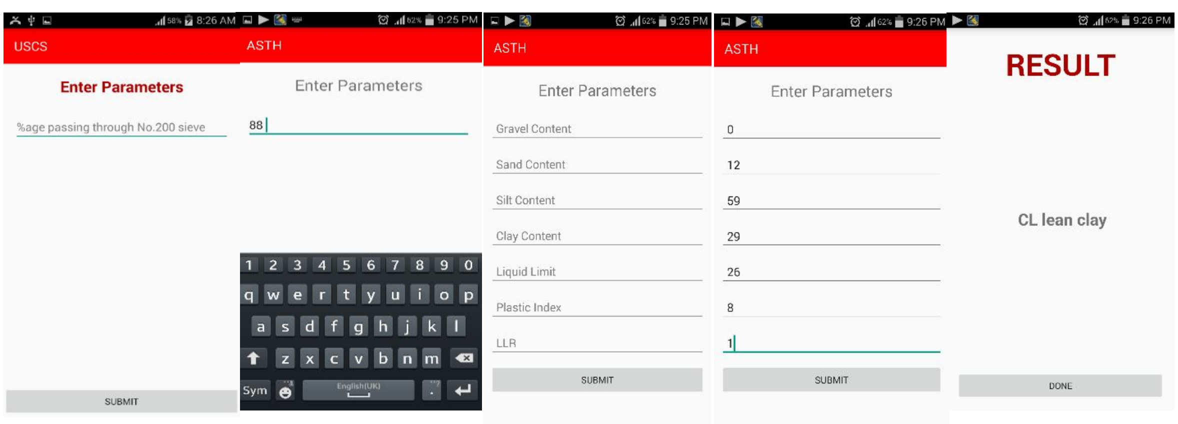

Fig. 1: Soil classification for soil A using mobile app.

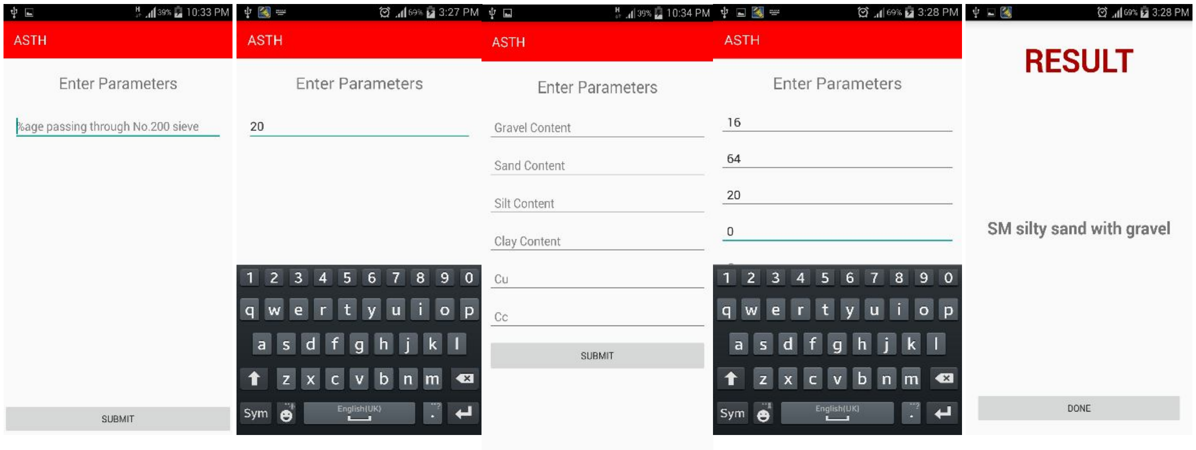

Fig. 2: Soil classification for soil B using mobile app.

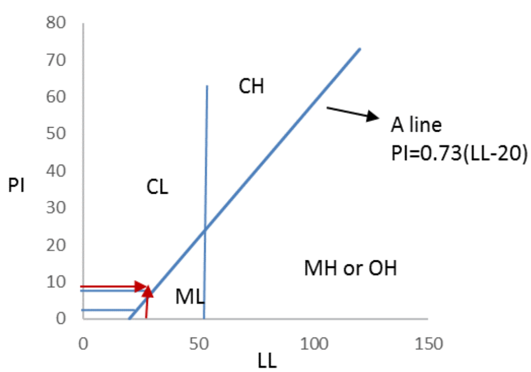

Fig. 3: Plasticity chart.

As evident from Table 3, soil A is classified as fine grained soil, whereas soil B is classified as coarse grained soil. Further, the classification of these soils is carried out using the mobile app and the results of the classification are shown in Fig. 1 and 2 respectively for the soil A and soil B. Study of Table 3 and Fig. 1 reveals that the classification of the soil A is reported as ML, sandy silt whereas the result shown by the mobile app is CL, lean clay. This difference in classification of soil A is due the human error in gathering the information from the plasticity charts and flow chart reported in ASTM D 2487-6 (2006). The term sandy used by Budhu et al. (2011) in classifying the soil A should not be there as the sand content was less than 15%. The liquid limit and the plasticity index as evident from Table 3, for the soil A was 26 % and 8% respectively which indicates that the soil A was of low compressibility. Further, to decide whether the soil A is silt or clay, the explanation is presented through the plasticity chart as shown in Fig. 3. As evident from Fig. 3, the point having coordinates (26 %, 8 %) are above the A- line. Hence the soil A is definitely a clay (CL) rather than silt (ML) as reported wrongly by Budhu et al. (2011). Further study of Table 3 and Fig. 2 reveals that the classification reported for soil B is in agreement with the classification reported for the soil B by Buddha et al. (2011). The fine content as well as gravel content in soil B was greater than 12 % and 15 % respectively as evident from Table 3. Soil B is also shown as non-plastic in Table 3. Hence the classification reported in Table 3 and the one with mobile app are in agreement. Hence, from the above discussion, it is concluded that human error may lead to the wrong classification of the soils, whereas the same could be eliminated with the use of mobile app reported in this paper.

CONCLUSION: Soil classification is one of the important aspects of Geotechnical engineering. The classification of soil is based on a set of input variable which can be determined experimentally. The classification systems available in literature are usually represented in the form of a graphs, tables and flow charts. Further, to classify the soil one has to refer to these graphs, tables and flow charts manually leading erroneous classification of soils. To eliminate human error in classifying the soil and referring to graphs, tables and flow charts, the superiority of the mobile **app** developed has been demonstrated for the soil classification. This mobile app would be useful for correctly classifying large number of soils and reducing the tedious work of referring graphs, tables and flow charts manually which otherwise leads to erroneous classification of soils. Further, improvement in the mobile app developed can be made for the missing input properties affecting the soil classification.

NOTATIONS

G = gravel contents

S = sand contents

M = silt contents

C = clay contents

F = fine contents

PI = plasticity index

LL = liquid limit

Cu = coefficient of uniformity

Cc = coefficient of curvature

GI = group index

LLR= liquid limit ratio

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