2nd International Civil Engineering Conference (ICEC 2020)
Department of Civil Engineering
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Development of a Smartphone Application for Classifying Soils Based on AASHTO Classification System

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ABSTRACT
Engineering soils are classified using charts and tables so as to have first-hand knowledge of their engineering properties. Majority of the mobile application used to classify soils are based on the USCS, USDA and ASTM system. Thus, this research is focused on the development of a mobile application for classifying soils based on AASHTO classification system. The mobile application was written in Java programming language using the android studio environment. Two cases of Liquid Limit (LL), Plasticity Index (PL) and percentage of soil passing sieve number 200 used to validate the mobile application was 39.45%, 26.52. and 38 % as well as 19%, 19%, and 35% termed case I and II respectively. Results obtained using AASHTO classification charts were the same as that obtained using the mobile application developed. The mobile application classified case I as A-6 soil consisting of clayey particles with a poor rating while case II was classified as A-2-4 silty or clayey gravel having a good rating. The study concluded that the mobile application can be used to classify soils based on the AASHTO classification system to save time.

Keywords: *AASHTO, Classification system, Mobile application, Soil.*

1. INTRODUCTION

Virtually all civil engineering and construction work require soil of different class and grade. Construction of concrete based infrastructures such as pavements, dams, abutments, tunnels, airports, canals, bridges and various types of building use different types of soils either as sub-base materials or concrete constituent. In the ancient times, soils were classified based on hydrologic characteristics as well as colour and texture (Gong, 1994). Properties which defines a soil for engineering purpose are far from this. Since soil formations and structure differ from region to region, however, engineering soils have been classified based on properties that govern their use. Soil classification, therefore, encompasses the cataloguing of soils according to groups in such a manner that soils in the same group exhibit identical properties (Arora, 2009; Roushan *et al.*, 2015; Rakesh *et al.*, 2019).

Majority of the soil classification systems available today were developed by American organisations. Notable among these systems are; The United States Department of Agriculture (USDA) Textural Classification System, the Unified Soil Classification System (USCS), American Society for Testing Materials (ASTM), and American Association of State Highway and Transportation Organisation (AASHTO) System (Roushan *et al*, 2015). The parameters used for classifying soils in each of these systems are given in Table 1. AASHTO classification system which is widely used in Nigeria employs particle size distribution and Atterberg indices to classify a soil. AASHTO classification system is presented as charts, tables and graphs that can be manually read to classify soils as shown in Figure 1. In the event where soil samples to be classified are enormous, soil samples can be wrongly placed especially when the soil samples exhibit different properties. This will ultimately lead to misjudgments in the engineering properties of such soils. Several researches built on computer programs and mobile device applications have been developed to solve this problem.

TABLE 1: CLASSIFICATION SYSTEMS

Classification Systems	Parameters Used	Remarks
AASHTO (1928)	Particle size distribution, liquid limit, plasticity index, GI	Does not include classification of organic soils
USDA (1938)	Grain size of sand, silt and clay	Provide only textural classification
USCS (1942)	Gradation, grain size, LL, PI	Provision of medium compressibility
ASTM D 2487-6 (2006)	Gradation, grain size, LL, PI, LLR	Classify all types of soils

Source: Roushan *et al*, (2015)

Arinze and Okafor (2015) developed a Matlab program for classifying soils according to the AASHTO classification system while Jase *et al.* (2017) developed an artificial neural network model for classifying soils. The program and model can only run on a Personal Computer (PC) or desktop computer. Major drawback in using these programs lies in the fact that the PC or desktop computer has to be handy and, in most cases, connected to a power supply. In a view to solve this problem, Okan (2007), developed a mobile soil classifier based on the USCS and ASTM system of classification using Microsoft Visual Basic. Similarly, Rakesh *et al.*, (2019) developed a soil classification mobile application based on modified classification systems. ASTM based mobile application was developed by Roushan *et al.*, (2015) for classifying soils. Findings from these researches confirm that time of classification is shortened and inaccurate classification can be avoided using the identified techniques. Mobile classification app for classifying engineering soils in Nigeria based on AASHTO classification system is therefore rare to find in literature. Based on substantial facts, there is clearly a research gap in this regard. Thus, this research is focused on developing a mobile app for classifying Nigerian soils based on AASHTO classification system.

Nigeria is reported to be the most populous country in Africa and by extension, the country with the biggest economy in the African continent. The number of smartphone users in Nigeria according to Statista (2019) is in excess of forty (40) million people. This figure is expected to rise beyond 140 million by the year 2025 largely due to the awareness of many consumers of the computing capabilities of smartphones available in the market (Yusuf *et al.*, 2017; Yusuf *et al.*, 2019). There is therefore a clear indication that majority of geotechnical engineers will own a smartphone or related gadget. As such, developing a mobile application for classifying soils is therefore necessary.

General Classification	Granular materials (35% or less passing No. 200 Sieve (0.075 mm))							Silt-clay Materials More than 35% passing No. 200 Sieve (0.075 mm)			
Group Classification	A—1		A—3	A—2				A—4	A—5	A—6	A—7
	A—1—a	A—1—b		A—2—4	A—2—5	A—2—6	A—2—7				A—7—5 A—7—6
(a) Sieve Analysis: Percent Passing											
(i) 2.00 mm (No. 10)	50 max										
(ii) 0.425 mm (No. 40)	30 max	50 max	51 min								
(iii) 0.075 mm (No. 200)	15 max	25 max	10 max	35 max	35 max	35 max	35 max	36 min	36 min	36 min	36 min
(b) Characteristics of fraction passing 0.425 mm (No. 40)											
(i) Liquid limit				40 max	41 min	40 max	41 min	40 max	41 min	40 max	41 min
(ii) Plasticity index	6 max		N.P.	10 max	10 max	11 min	11 min	10 max	10 max	11 min	11 min*
(c) Usual types of significant Constituent materials	Stone Fragments Gravel and sand		Fine Sand	Silty or Clayey Gravel Sand				Silty Soils		Clayey Soils	
(d) General rating as subgrade.	Excellent to Good							Fair to Poor			

* If plasticity index is equal to or less than (liquid Limit—30), the soil is A—7—5 (i.e. PL > 30%)
If plasticity index is greater than (Liquid Limit—30), the soil is A—7—6 (i.e. PL < 30%)

Figure 1: AASHTO Classification Table/Chart

2. METHODOLOGY

The percentage of soil passing sieve numbers 200 and 40, the liquid limit and plasticity index results obtained from Atterberg experiment are used in the AASHTO classification system to classify soils. As such the mobile application was designed according to these parameters.

Main components and system architecture

On launching the application, a welcome screen is displayed followed by an activity screen which permits the user to enter classification details as shown in Figure 2. On clicking the classify soil button, the soil group is displayed followed by a typical constituent material and rating of the soil. The flow chart depicted in Figure 3 shows the pseudocode of the mobile application written in Java programming language using the android studio environment.

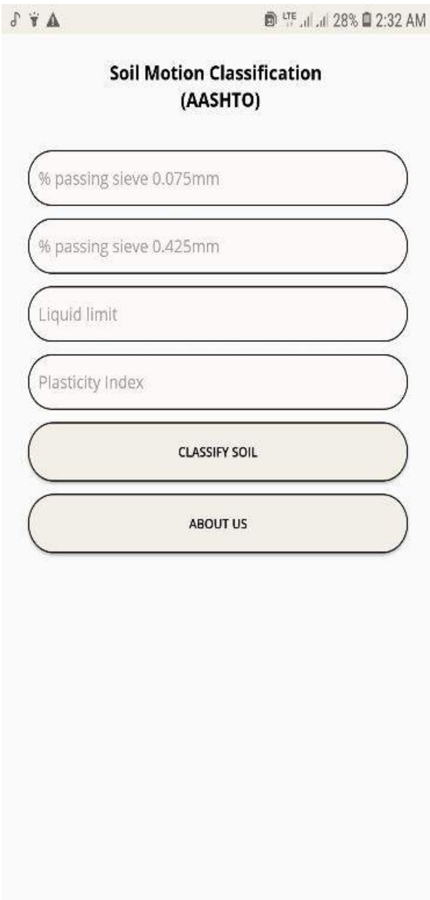

Figure 2: Activity screen of the mobile application

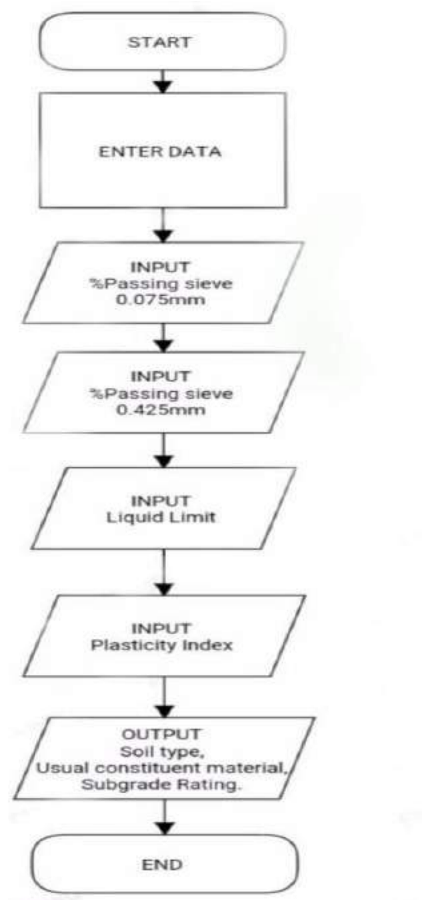

Figure 3: Flow chart of the mobile application

3. RESULTS AND DISCUSSION

The mobile application was developed to be user-friendly such that each input or output was guided with specific comments. The results reported by Ola (2013) and Ologun *et al*, (2017) for different soils classified based on AASHTO classification table/chart are presented in Table 2. The same parameters that were used to classify these soils were inputted in the mobile application developed.

Table 2: Results obtained using tables and charts by two authors

Constituents	Values (%) - Ola (2013)	Value (%) – Ologun *et al*, (2017)
LL	19	39.45
PI	19	26.52
%passing sieve, No 200	35	38
Classification	A-2-4	A-6

Results obtained from the mobile app is in agreement with what was obtained by Ola (2014) and Ologun *et al*, (2017) using the AASHTO classification chart as presented in Figures 4 and 5. In addition, the mobile app shows the significant constituent material and general subgrade rating of the soil. Essentially, ample time can be saved in reading AASHTO tables and chart for classification of soils.

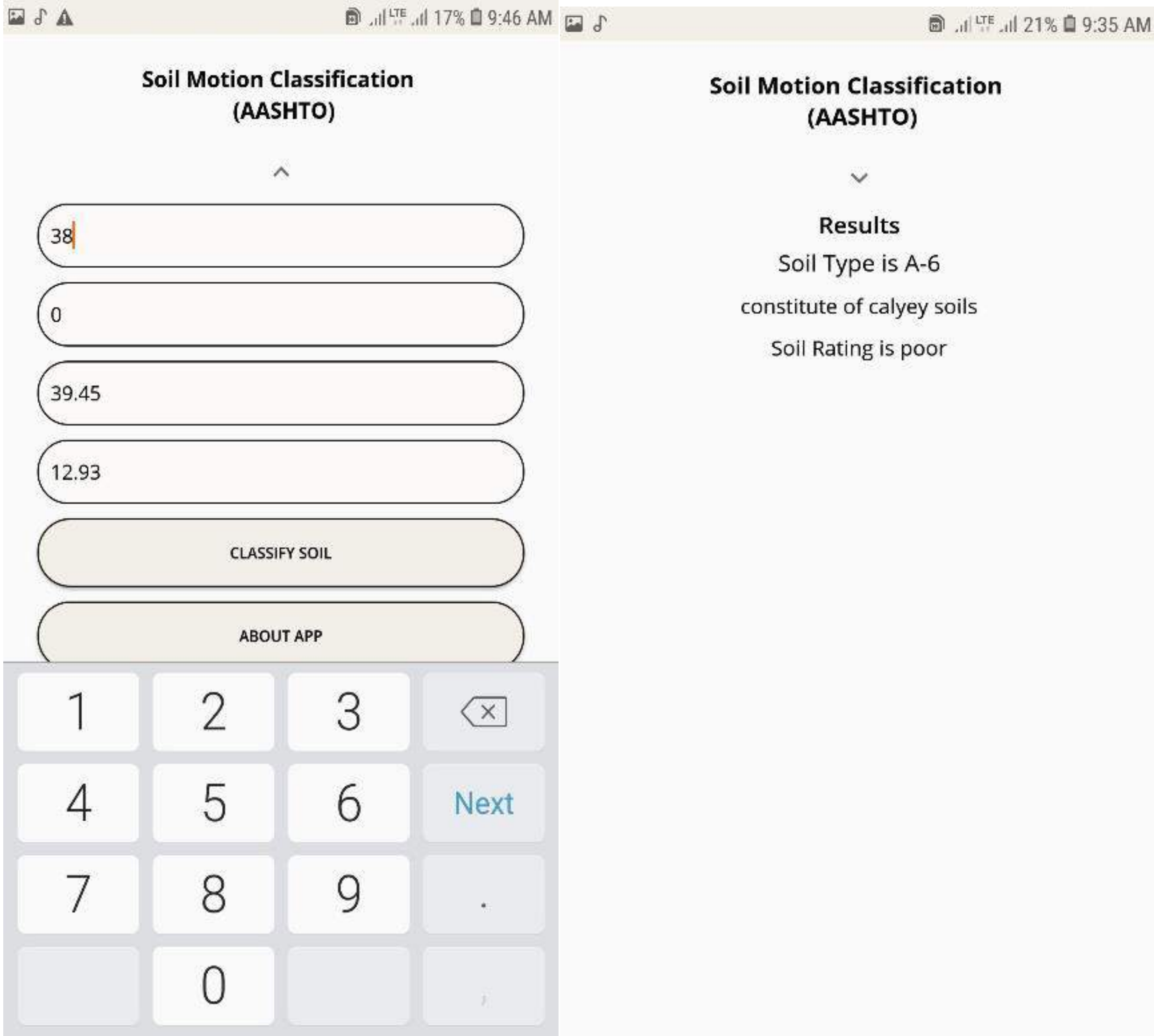

Figure 4: Results based on input parameters from Ologun *et al*, (2017).

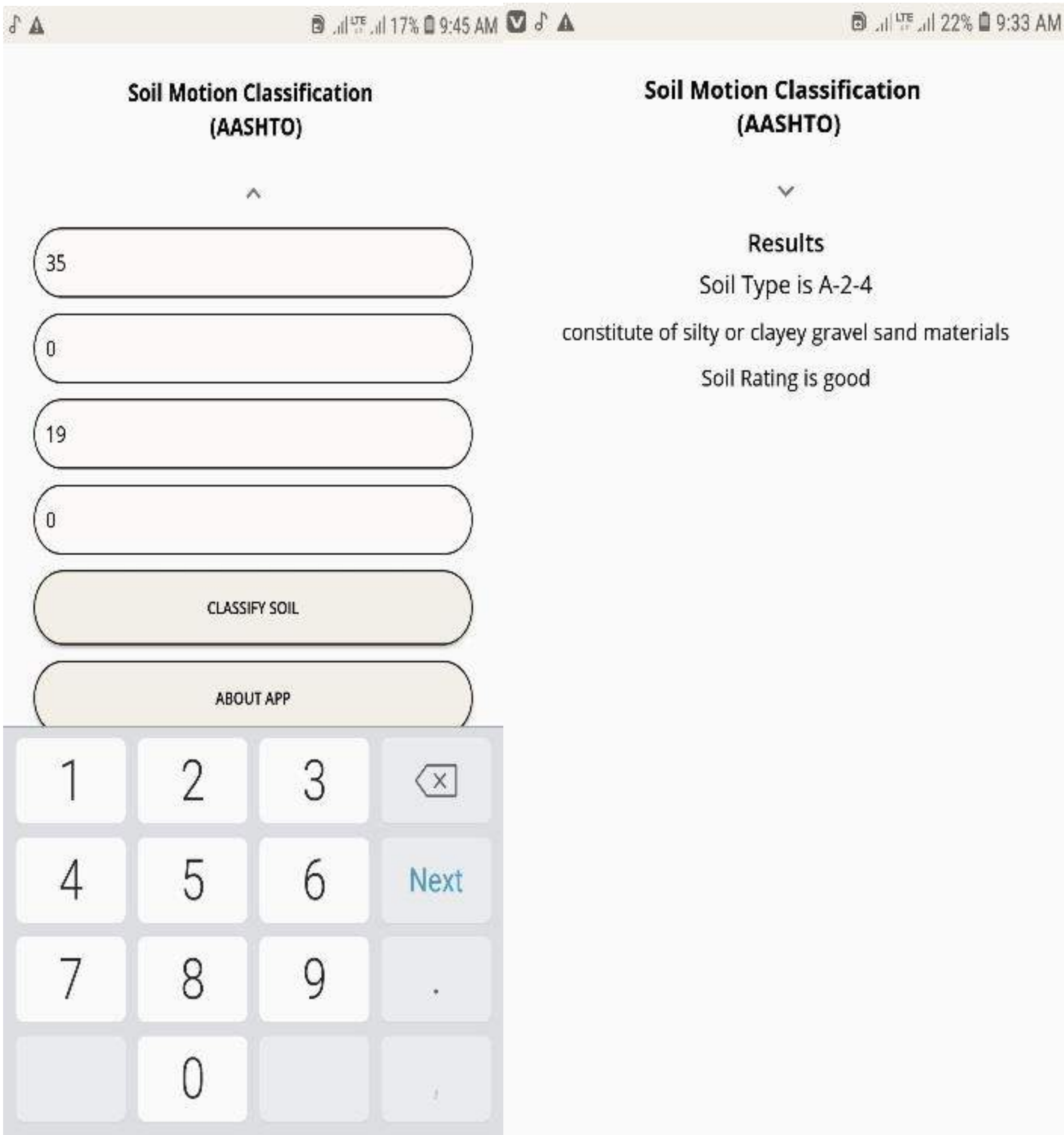

Figure 5: Results based on input parameters from Ola (2014)

4. CONCLUSION

Conclusion drawn from the outcome of the research include:

1. The soil classification app was designed using the android studio environment. The application can therefore run on android smartphones only.
2. The classification app can classify all engineering soils provided that percentage of particles passing sieve No 200 and 40 and the Atterberg indices of the soil is known.
3. The mobile app can provide the rating of soils as well as depict the constituent materials of classified soils.

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