Evaluation Curves SWCC for Tropical Peruvian Soils

Évaluation des courbes de rétention d'eau SWCC pour les sols tropicaux péruviens

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ABSTRACT: The geotechnical analysis of this research shows the results of a program conducted in tropical soils of the Peruvian Amazon plain for over 20 years. With this information a database has been developed. It has collected samples and tests that establish the characteristics of these unsaturated soils in all watersheds that shape the Peruvian tropical region, using alternative means of obtaining the characteristic curves and laboratory tests. The results in this paper show geotechnical occurrences that indicate substantial similarity and differences of stress and deformation behavior of Peruvian tropical soils. The presence of these unsaturated soils in this region, where unique features of climate and difficult geological formation are present, makes this information very valuable for engineering design and construction development due to its models applicability to different stress patterns.

RÉSUMÉ : Cet article présente une base de données mise en place avec les résultats d'un programme d'analyse géotechnique mené sur les sols tropicaux de la plaine amazonienne du Pérou depuis plus de 20 ans. Des essais de laboratoire ont permis d'obtenir les SWCC qui établissant les caractéristiques des sols non saturés dans les bassins versants qui forment la région tropicale péruvienne. Les résultats présentés ici montrent les événements géotechniques qui indiquent une similarité substantielle et les différences de contrainte et de déformation des sols tropicaux du Pérou. La présence de ces sols non saturés dans cette région, où les caractéristiques uniques du climat et formation géologique complexes sont présents, rend cette information très précieuse pour la conception technique et le développement de la construction en raison de son applicabilité des modèles pour différents schémas de contrainte.

KEYWORDS: tropical unsaturated soils, suction, soil-water curves.

1 INTRODUCTION

Based on recognized and user-friendly models, SWCC have been determined with field tests results and lab soil tropical sampling gathered in the Peruvian Amazonian region for more than 20 years (Carrillo-Gil, 1983). With that feedback, it was possible to elaborate SWCC ranges that represent probable tropical soil behavior as non-saturated geotechnical material. The results from the considered samples for this study were taken from engineering projects and consulting works developed in the Peruvian Amazon region. This area is difficult to access because of its environmental conditions and geomorphology. For those reasons is very important to come out with Peruvian tropical soils SWCC grouped with distributed ranges for each of the five hydrographic watersheds. This information is very valuable for future relevant projects that are going to be developing in the study region.

2 SITE CONDITIONS IN AMAZON PLAIN

The general geology considers that a large part of the Amazon region has stayed covered during the interglacial periods of the quaternary by an interior sea of shallow water when the level of the oceans had 100 meters above of the existing now (330,000 years ago). It also to fluctuate during several glacial and interglacial periods forming terraces throughout the water courses, dropping to 100 meters below of the original level during the last Glacial Era (17,000 years ago) and remaining in these deep channels the large rivers, between them the Amazon river, raising afterwards to the current level (6,000 years ago).
The accomplished studies establish that in the high jungle and in the limits of the low jungle are found many igneous rocks as sedimentary, while in the low jungle prevail residual soils originated by the sedimentary rocks of the tertiary and quaternary and mainly sandstones, shales and clays form them (Fig 1).

Figure 1. High and low jungle location in the Peruvian Map.

The general description of the geomorphology of the Amazon region indicates that the low jungle is substantially flat and as said remains, its height varies between 80 to 400 meters above mean sea level. Due to this small difference of elevation, the rivers flow slowly, getting in the dry station the appearance of lakes. This region of the Amazon plain can be indicated as advanced erosion type. The Amazon Plain is characterize by its great humidity and soil covered by a dense tropical vegetation (Carrillo-Gil & Dominguez , 1996).

3 SOIL FORMATION

In this study, many researches and recollections of punctual data from the Amazon Plain were validated. The main watersheds from the most important rivers (Amazonas, Marañón Huallaga, Ucayali and Madre de Dios) were considered in order to establish their behavior characteristics in detail (Fig 2). According to the gathered database that consists of 1,318 samples tested in Peruvian tropical soils, forty typical samples were chosen to verify the original rocks that originate residual material. It was found some differences with the mother rock that is generally mention for another regions in South America.

Figure 2. Main jungle watershed located in the Peruvian Map.

4 CLIMATE CONDITIONS

The regional pluviometric level, where in some cases reach until 4,000 mm annually, depends in the temperature, density, absolute moisture, and other air mass characteristics. The climate acts in the decomposition of the soil and its original material throughout many agents that act in variable conditions and determine a wide quality range of soils. This complexity can be seen in how much different are their properties even though they are located very close among them. However, each of these tropical soils can be very similar to others located at thousands of kilometers of distance (Carrillo-Gil, Carrillo D & Cardenas, 1995).

5 MEASUREMENT

It was necessary to establish measurements conditions as non-saturated soils to evaluate SWCC for each hydrographic determined watershed. Curves were obtained using alternatives methods based on the soil property index and some direct measures by a suction cell prepared especially for these soils. The method for the adjusted estimate is performed using Fredlund & Xing models (1994) and Van Genuchten (1980) because they provide with better adjustment for the available data (Carrillo-Gil, 2008). The suction measurements in the Peruvian Amazon Plain are shown figures 3, 4, 5, 6, and 7.

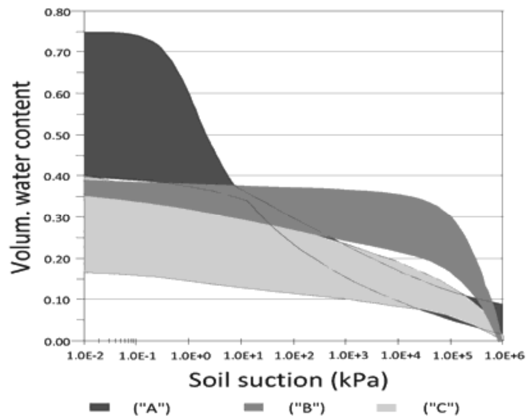

Figure 3. SWCC ranges for the Maranon River Watershed.

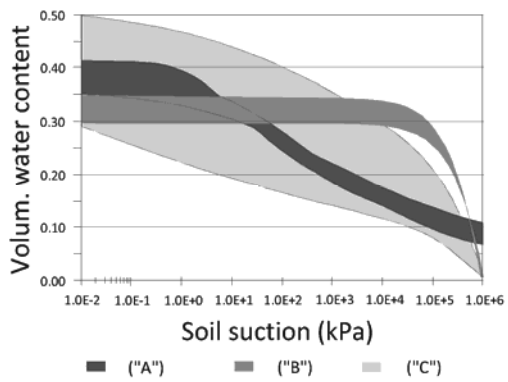

Figure 4. SWCC ranges for the Huallaga River Watershed.

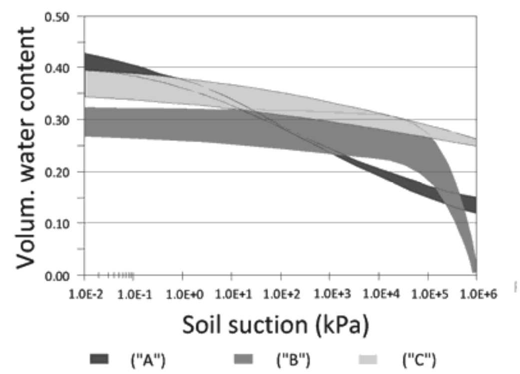

Figure 5. SWCC ranges for the Amazon River Watershed.

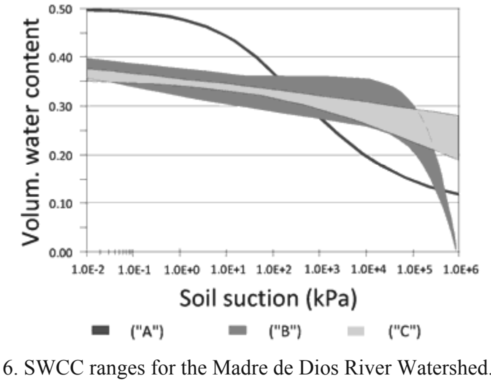

Figure 6. SWCC ranges for the Madre de Dios River Watershed.

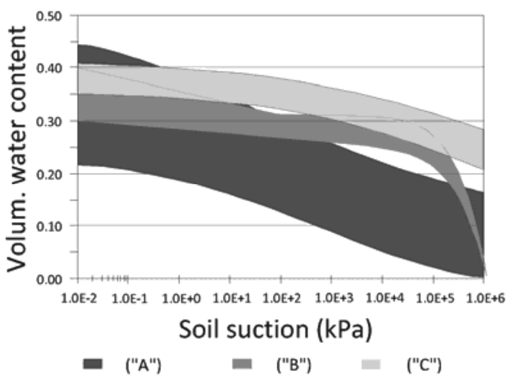

Figure 7. SWCC ranges for the Ucayali River Watershed.

6 RESULTS ANALYSIS

In general, the considered tropical soils in all Peruvian Amazon plain were clays, limes, and sands that show mixes that generate combine soils in each of the five hydrographic watersheds. For this reason, generalization of the resulted curves is establish only in its format and tendency adopting type A (Clay), B (Clay-Lime), and C (Sand) nomenclature.

The comparison made for each watershed, quality of research soils, geologic origin with respect to the mother rock, and structural heritage evaluated at site have established similarities of SWCC that are shown in figures 8, 9, and 10 for type A, B, and C respectively. These graphs allow the professional to evaluate behavior predictions that in many cases will be used for conceptual projects where suction measurements are difficult to practice (Carrillo-Gil, 2012).

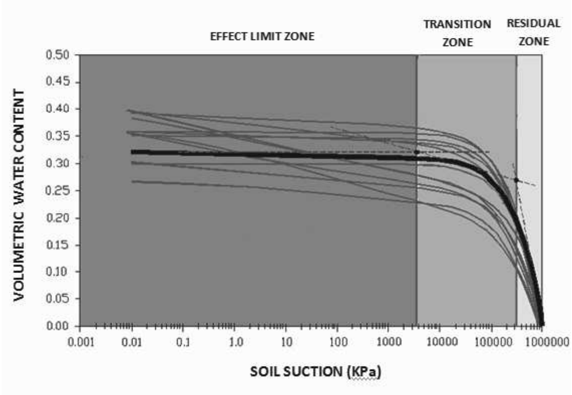

Figure 8. Typical SWCC for Clays (Type A).

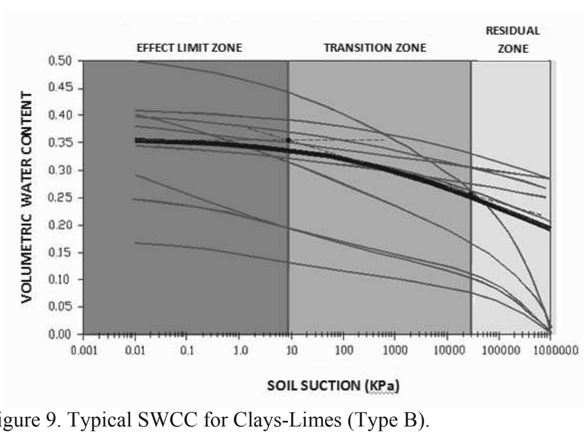

Figure 9. Typical SWCC for Clays-Limes (Type B).

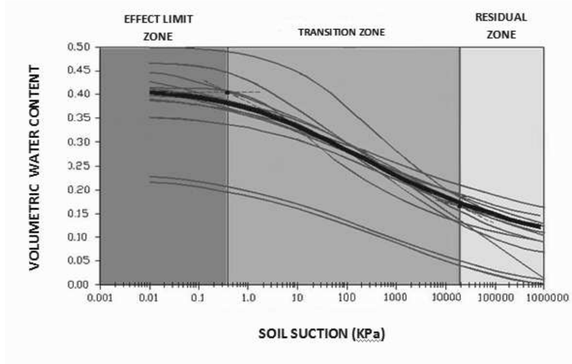

Figure 10. Typical SWCC for Sands (Type C).

7 CONCLUSIONS

The results analysis from the SWCC showed that Peruvian tropical soils not necessarily show uniformity but a variation and dispersion in accordance with its geological origin and positioning within the great Amazonian rivers. However, considering soil type variations that show wide range, it is found certain similarity of mechanic behavior in accordance with the establish watersheds for this study.

The data of 1,318 samples was review in order to choose 40 tropical soils used in this study to obtain SWCC of similar trends for type A, B, and C evaluated for all watersheds. For type A (clays), it was found the following characteristics: (1) significant water retention (2) high plasticity (3) air entrance value occurs in large suctions (4) suction uncertainty for certain maximum permissible moist content (5) rapid decrease from air entrance value (6) it does not show inflection point, and (7) nule transition zone. For type B (clays-limes), it was found the following characteristics: (1) less plasticity (2) less sudden rupture (3) constant desorption (4) it does not show inflection point (5) easy suction determination for the permissible moist contents, and (6) the air entrance value ranges between values of curves type A & B. For type C (sands), it was found the following characteristics: (1) less water retention (2) sudden rupture until reaching the residual zone (3) it shows inflection point (4) equal suctions for certain moist contents that belong to the transition zone, and (5) the limit effect zone can be very small in some cases, due to the early rupture or air entrance.

It is concluded that the results provide a global vision of the geotechnical characteristics of non-saturated soils from the Peruvian tropic humid. These results will allow in the future the development of new patterns of behavior considering an adequate evaluation and treatment in order to achieve more accurate SWCC. This will concede more numerous and better practical applications for rationalizing special geotechnical materials in many construction projects through out the entire Peruvian Amazon region.

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