5
Final Considerations

5.1
Conclusion

Based on the results presented and analyzed previously, it was possible to reach the conclusions approached in this item.

The insertion of PET residue causes different behaviors in the three different soils used (sand, clayey soil and bentonite). Thus, the development of a new geotechnical material with PET residue had begun in this research; this new material has characteristics similar to pure soil, but improving or providing little change in the behavior and strength parameters.

The main conclusions towards the addition of the PET residue in the soils studied in this research were:

- **About the sand:**

- In the triaxial tests for the sand at higher confining stresses, the addition of fine crushed PET did not improve the bearing capacity of the soil, because the grains of the sand used are too rounded, and in higher confining stress the interaction between them and the particles of the sand are weak, decreasing the load capacity of the mixture. For lower confining stresses the behavior of the mixture has the tendency to equalize or overpass the behavior of the pure sand. This happened because there are less contact between the rounded particles of the sand and the fine crushed PET;
- The strength parameters of the mixture sand-PET had an improvement in terms of cohesion comparing with the pure sand, because the fine crushed PET works as a grain size improvement, it raises the value of cohesion, but the bad interaction among the particles affects the friction angle;
- The mixture S90P10 (sand-PET) has the best relation between the improvement of the parameter and the load capacity of the soil, where the cohesion increased from 0kPa to 7kPa and the friction angle has just decreased 1 degree;

- For mixture with sand, insertion of fine crushed is more effective for confining stress of 50kPa;

- **About the clayey soil:**

- The standard compaction test results on the clayey soil show that the insertion of the fine crushed PET acts directly in the values of dried weight and water content of the soil, decreasing both of them. This can be explained because the low value of dry weight of fine crushed PET, when mixtured with the soil, decreases the value of the dry weight of the mixture. However, for the PET flakes the moisture content increased and the dried weight suffered a slightly shrieked;
- For the mixture with the clayey soil in the triaxial test, it can be concluded that the influence of the confining stress is an important point. There is a limiting confining pressure where beneath this, the presence of the fine crushed PET degrades the strength of the clayey soil. It could be explained because the fine crushed PET does not react with the soil particles creating a cementation process, it acts like in the sand, as grain size improvement, at low confining stress it does not fill all the voids in the soil, and so, during the shear phase when the fine crushed PET is requested it is not interacting with the soil particles, minimizing the load capacity of the soil;
- The mixture C70P30 and C95F05 had the best results of load capacity and the best improvement in the parameters. The amount of fine crushed PET in the soil was able to fill better the voids, improving the interaction between the particles of PET and soil, causing an enrichment of the cohesion and also the friction angle;
- For mixture with clayey soil, insertion of fine crushed is more effective for confining stresses of 150 and 300kPa;

- **About the bentonite:**

- Based on the peak strength for the direct shear tests, the addition of PET raised the values of cohesion for all mixtures and a decrease in the friction angle;
- Through the residual strength, it is noticed that as the PET content increases the value of cohesion decreases and the friction angle increases, emphasizing that the PET changes the mechanical behavior of the

bentonite in terms of peak and post-peak strength. The only exception is the mixture B95F05, the amount of PET flakes reached a content where the interaction between the particles of bentonite and PET flakes were higher than the interaction of the particle of the pure bentonite, raising up the values of the strength parameters related with the peak and residual strength;

- **General Conclusions:**

- The chemical tests for the fine crushed PET and the mixture C70P30 did not highlight any hazard material with contents above the ones stablished by the Brazilians standard;
- The addition of the PET residue has a direct influence in the strength parameters. Adding the PET residue in the soil results in a decrease in one of the parameters, and an increase of the other, but for certain mixtures both strength parameters improved.

The proper disposal of urban residue, including PET, is one of the biggest problems of modern society, since the composition of this residue has changed a lot over the last few years and the generation of residue has grown considerably. In order to give a final destination to a residue that takes more than 400 years to degrade, this research evaluated the use of this material as a soil improvement and concluded that, these composites may have strength characteristics which could fulfill the requirements of certain geotechnical as, for example, layers of landfills embankments on soft soils and temporary landfills. Thus, allowing the lower consumption of natural material and thereby reducing transportation costs and the volume of mobilized material. The use of this material in geotechnical works, it may reduce the wrong disposal of the residue in nature, being a low cost and environmentally friendly option for soil reinforcement.

5.2
Recommendations for Future Work

Following, some suggestion to enlarge and better understand of the behavior of this material will be presented that could help to make possible the use of it in geotechnical project in the future.

- Analyze the mechanical behavior of the soils with other PET residue content, in order to find the optimum percentage of PET to be used;
- Study mixtures with different PET grain sizes, to understand the influence of it in the strength parameters of different soils;
- Study this soil with fibers of PET residue, to comprehend how the mixture will behave;
- To develop a prediction model of the stress-strain behavior of this new material soil-PET, which could be very important to the numerical simulation;