ISSN 2347 - 3983
Volume 8. No. 4, April 2020
International Journal of Emerging Trends in Engineering Research
Available Online at http://www.warse.org/IJETER/static/pdf/file/ijeter54842020.pdf
https://doi.org/10.30534/ijeter/2020/54842020

# Compactive Energy Level Effect on Strength of Fiber-Bentonite-Sand Mixture

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**ABSTRACT**
Compaction is one of the preliminary stage of testing. The sample preparation is one of the effective measure in the outcome of the tests. Two methods of compaction (i.e standard and modified) were used in sample preparation. The mixture of soil was bentonite and different fiber percentages. The fiber dosage varied as 5%, 10% and 15%.The results showed that with increasing in compactive effort the UCS values increased.

**Key words:** Compaction, Fiber, Bentonite

## 1. INTRODUCTION
Soils including sand and clay due their existence in real life being studied by many research studies[1-6]. A new method way of modeling of soil proposed in [4,5]. Construction of foundation on clayey soils or other applications such a retaining walls etc caused need of improvement in bearing capacity and so forth to overcome failure. Agents such as slag,geogrid and flyash[7-27] increasingly being applied in geomechanics projects. Application of bentonite is an important measure in design of cut-off walls[8]. In the area with problem liquefaction also they came as handy solution to slow down disaster. Apart from those mentioned, usage of fiber caught interest and being studied in [28-42]. This study will further address the gap in the literature by considering combination of fiber and bentonite together with sand. Two methods of compaction were used to compare unconfined compressive strength (UCS) of mixes on these two cases. This paper is continuation of current research on soil stabilization in Curtin University.
The process of compaction is a laboratory testing in which the soil becomes denser and getting close to Maximum Dry Density (MDD). In this test, soil which its moisture content identified pour into mold and according to procedure of either standard or modified, the soil is compacted in 3 or 5 layers in the mold. Then whole stapes will be repeated for at least 4 different moisture contents, finally the graph of dry density versus moisture content will be plotted.

## 2. MATERIALS
This study aimed to consider the mixture of clay, fiber and cement. The following sections show the used materials:

### 2.1 Bentonite

Three soils with different PSD curves but all sandy type were selected to do this research. The PSD s are presented in Figure 1.

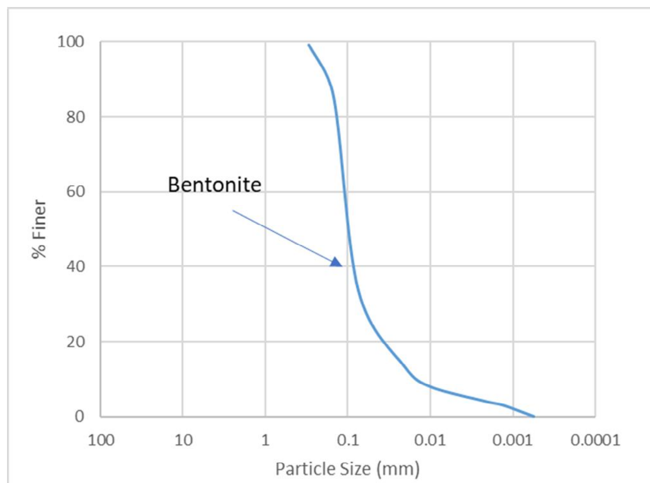

Figure 1: PSD curves of the employed soils

### 2.2 Fiber

The fiber properties can be seen in Table 1.

**Table 1:** Fiber properties

| Item | Characteristics/values |
|---|---|
| **Length** | 10mm |
| **Appearance** | Smooth/Grey |
| **Elongations at break** | Approx. 92%. |

### 2.3 Sand
The yellow sand was supplied with Gs 2.65. The PSD of sand can be seen in Figure 2.

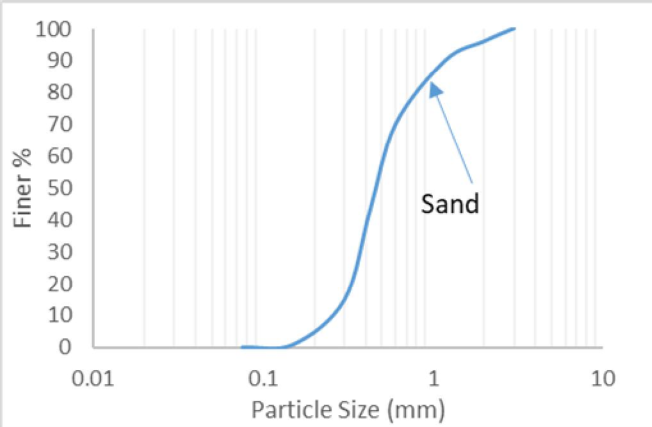


**Figure 2:** PSD of Sand

## 3. TESTING PLAN

The sample was mixed using the mixer as can be seen in Figure 3. Figure 4 shows the principle of UCS testing. The compressive strength of mixture was evaluated using the UCS device. First, the mixture were prepared as combination of soil A/Soil B/Soil C and slag and fiber. The slag percentage was varied from 5 to 15%. The fiber had dosage of 5%. The fiber kept constant to reduce the complexity of testing. The UCS testing were planned as presented in Table 2.

Figure 3 Used mixer

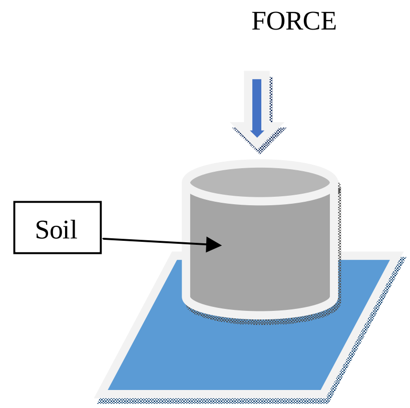


**Figure 4:** Principle of UCS testing

**Table 2:**Testing program utilized in this study

| Sample ID | Sand (%) | Compactive Enegery | Fiber (%) |
|---|---|---|---|
| B-5F | 5 | Standard,Modified | 5 |
| B-10F | 5 | Standard,Modified | 10 |
| B-15F- | 5 | Standard,Modified | 15 |

## 4. TEST RESULTS

### 4.1. Compaction Results

Table 3 displays the compaction features of the used mixes using standard compaction method. Table 4 presents the compaction results of mixes in modified method. Figure 5-8 show the compaction results with respect to both standard and modified compaction.

**Table 3:** Results of standard compaction tests

| Sample ID | Fiber (%) | OMC (%) | MDD(gr/cm3) |
|---|---|---|---|
| B-5F | 5 | 48 | 1.21 |
| B-10F | 10 | 49.2 | 1.19 |
| B-15F | 15 | 51 | 1.18 |

**Table 4:** Results of modified compaction tests

| Sample ID | Fiber (%) | OMC (%) | MDD(gr/cm3) |
|---|---|---|---|
| B-5F | 5 | 45 | 1.69 |
| B-10F | 10 | 47 | 1.61 |
| B-15F | 15 | 48 | 1.6 |

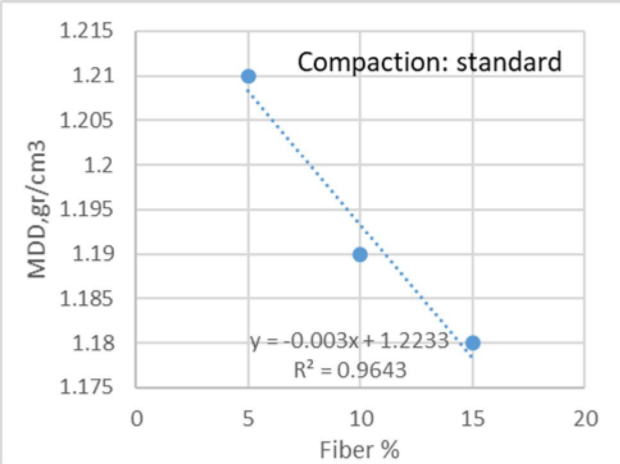


**Figure 5:** MDD against fiber percentage in standard compaction

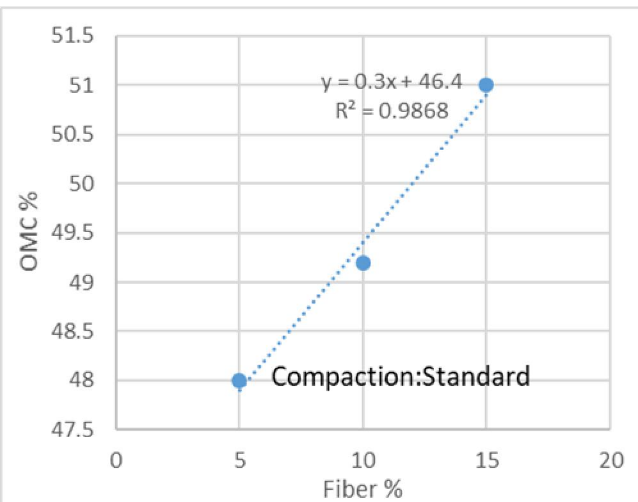


**Figure 6:** OMC against fiber percentage in standard compaction

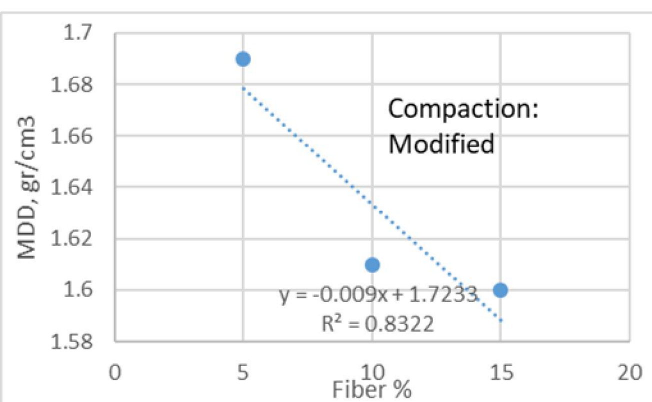


**Figure 7:** MDD against fiber percentage in modified compaction

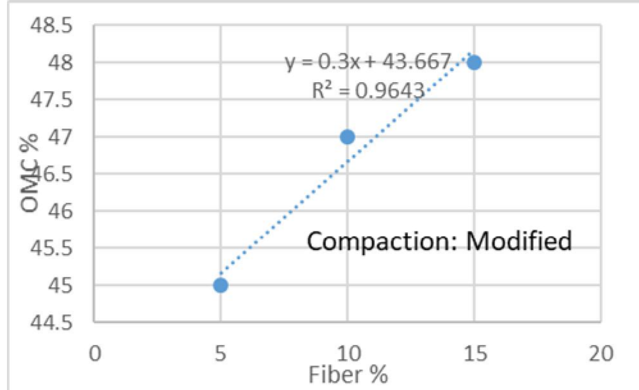


**Figure 8:** OMC against fiber percentage in modified compaction

### 4.2. Unconfined Compressive Strength

The results of UCS testing can be seen in Figure 9 and 10.

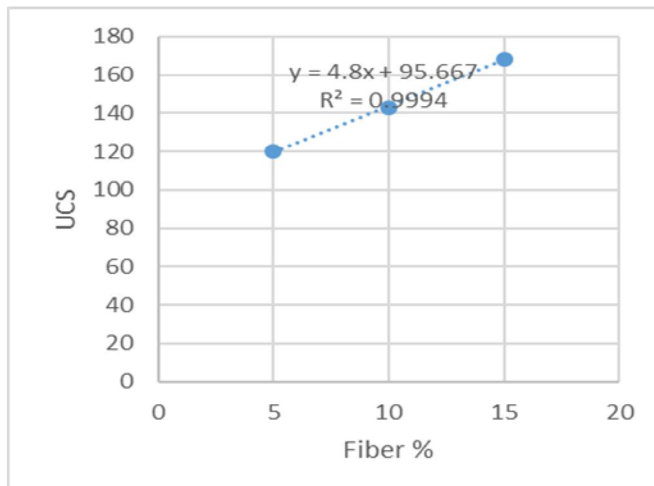


**Figure 9:** UCS values against fiber dosage in standard compaction

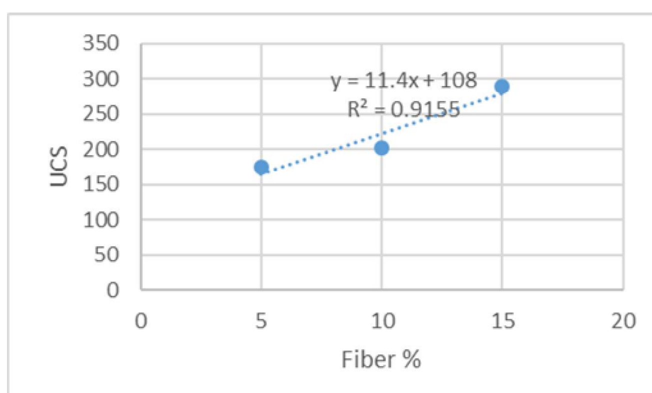


**Figure 10:** UCS values against fiber dosage in modified compaction

## 5. CONCLUSION

The results of compaction proved that OMC has been increased with addition of fiber dosage. At the same time, MDD was decreased. The UCS results proved that fiber inclusion in both standard and modified condition increased the UCS values.

## REFERENCES


[1]Wang, L., **Clay stabilization in sandstone reservoirs and the perspectives for shale reservoirs**. *Advances in Colloid and Interface Science*, 2020. 276: p. 102087. https://doi.org/10.1016/j.cis.2019.102087

[2] Al-rkaby, A.H.J., Chegenizadeh, A., Nikraz, H.R. 2017 **Cyclic behavior of reinforced sand under principal stress rotation** *Journal of Rock Mechanics and Geotechnical Engineering* 9(4), pp. 585-598

[3]Xu, B. and Y. Yi, **Soft clay stabilization using ladle slag-ground granulated blastfurnace slag blend**. *Applied Clay Science*, 2019. 178: p. 105136.

[4] Chegenizadeh A, Ghadimi B, Nikraz H, Simsek M. **A novel two-dimensional approach to modelling functionally graded beams resting on a soil medium.** *Structural Engineering and Mechanics*. 2014;51(5):727-41

[5]Tekeste MZ, Way TR, Syed Z, Schafer RL. **Modeling soil-bulldozer blade interaction using the discrete element method (DEM)**. *Journal of Terramechanics*. 2020;88:41-52. https://doi.org/10.1016/j.jterra.2019.12.003

[6]Wu, J., et al., **Hydraulic conductivity and strength of foamed cement-stabilized marine clay**. *Construction and Building Materials*, 2019. 222: p. 688-698.

[7] Montenegro-Cooper JM, Celemín-Matachana M, Cañizal J, González JJ. **Study of the expansive behavior of ladle furnace slag and its mixture with low quality natural soils.** *Construction and Building Materials*. 2019;203:201-9.

[8] Keramatikerman, M., Chegenizadeh, A., & Nikraz, H. **An investigation into effect of sawdust treatment on permeability and compressibility of soil-bentonite slurry cut-off wall.** *Journal of Cleaner Production*, 2017.162, 1-6. https://doi.org/10.1016/j.jclepro.2017.05.160

[9] Liu C, Yuan Y, He W, Zhang L. **Durability analysis of seashore saline soil bound with a slag compound binder.** *Soils and Foundations.* 2019;59(5):1456-67.

[10] Al-Rkaby AHJ, Chegenizadeh A, Nikraz H. **Anisotropic strength of large scale geogrid-reinforced sand:experimental study** *.Soils and foundations* 2017.57 (4), 557-574

[11]Li W, Yi Y, Puppala AJ. **Utilization of carbide slag-activated ground granulated blastfurnace slag to treat gypseous soil.** *Soils and Foundations*. 2019;59(5):1496-507.

[12] Al-Rkaby AHJ, Chegenizadeh A, Nikraz H. **Directional-dependence in the mechanical characteristics of sand: a Review** *International Journal of Geotechnical Engineering* 2016. 10 (5), 499-509

[13]He J, Shi X-k, Li Z-x, Zhang L, Feng X-y, Zhou L-r. **Strength properties of dredged soil at high water content treated with soda residue, carbide slag, and ground granulated blast furnace slag.** *Construction and Building Materials.* 2020;242:118126.

[14] Sabbar AS, Chegenizadeh A, Nikraz H. **Static liquefaction of very loose sand–slag–bentonite mixtures.** *Soils and Foundations.* 2017 Jun 1;57(3):341-56.

[15]Samara E, Matsi T, Balidakis A. **Soil application of sewage sludge stabilized with steelmaking slag and its effect on soil properties and wheat growth.** *Waste Management*. 2017;68:378-87.

[16] Chegenizadeh, A., Keramatikerman, M., Dalla Santa, G., & Nikraz, H. . **Influence of recycled tyre amendment on the mechanical behaviour of soil-bentonite cut-off walls.** *Journal of cleaner production*, 2018.177, 507-515 https://doi.org/10.1016/j.jclepro.2017.12.268

[17]Sudla P, Horpibulsuk S, Chinkulkijniwat A, Arulrajah A, Liu MD, Hoy M. **Marginal lateritic soil/crushed slag blends as an engineering fill material.** *Soils and Foundations*. 2018;58(3):786-95.

[18] Keramatikerman M, Chegenizadeh A. **Effect of particle shape on monotonic liquefaction: Natural and crushed sand.** *Experimental Mechanics*. 2017 Oct 1;57(8):1341-8.

[19]Larsson MA, Baken S, Smolders E, Cubadda F, Gustafsson JP. **Vanadium bioavailability in soils amended with blast furnace slag.** *Journal of Hazardous Materials*. 2015;296:158-65.

[20] Chegenizadeh A, Keramatikerman M, Panizza S, Nikraz H. **Effect of powdered recycled tire on sulfate resistance of cemented clay.** *Journal of Materials in Civil Engineering*. 2017 Oct 1;29(10):04017160.

[21]Shahbazi M, Rowshanzamir M, Abtahi SM, Hejazi SM. **Optimization of carpet waste fibers and steel slag particles to reinforce expansive soil using response surface methodology**. *Applied Clay Science*. 2017;142:185-92. https://doi.org/10.1016/j.clay.2016.11.027

[22] Keramatikerman M, Chegenizadeh A, Nikraz H. **Experimental study on effect of fly ash on liquefaction resistance of sand** *Soil Dynamics and Earthquake Engineering*,2017. 93, 1-6

[23] Maghool F, Arulrajah A, Suksiripattanapong C, Horpibulsuk S, Mohajerani A. **Geotechnical properties of steel slag aggregates: Shear strength and stiffness**. *Soils and Foundations.* 2019;59(5):1591-601.

[24]Celik E, Nalbantoglu Z. **Effects of ground granulated blastfurnace slag (GGBS) on the swelling properties**

**of lime-stabilized sulfate-bearing soils.** *Engineering Geology*. 2013;163:20-5.

[25] Phummiphan I, Horpibulsuk S, Rachan R, Arulrajah A, Shen S-L, Chindaprasirt P. **High calcium fly ash geopolymer stabilized lateritic soil and granulated blast furnace slag blends as a pavement base material.** *Journal of Hazardous Materials*. 2018;341:257-67.

[26] Ortega-López V, Manso JM, Cuesta II, González JJ. **The long-term accelerated expansion of various ladle-furnace basic slags and their soil-stabilization applications.** *Construction and Building Materials*. 2014;68:455-64.

[27] Mohd Fakri Muda, Saffuan Wan Ahmad, Fadhluhartini Muftah, Mohd Syahrul Hisyam Mohd Sani, **Mechanical Behaviour of Mortar Made with Washed Bottom Ash as Sand Replacement**, *International Journal of Emerging Trends in Engineering Research*,2019 7 (9).

[28] Chegenizadeh, A., Nikraz, H **Investigation on compaction characteristics of reinforced soil** . *Advanced Materials Research* 2011 261-263, pp. 964-968

[29] Tran KQ, Satomi T, Takahashi H. **Improvement of mechanical behavior of cemented soil reinforced with waste cornsilk fibers.** *Construction and Building Materials.* 2018;178:204-10.

[30] Chegenizadeh, A., Nikraz, H. **Shear test on reinforced clay** *Advanced Materials Research* 2011, 250-253, pp. 3223-3227

[31] Salih MM, Osofero AI, Imbabi MS**. Constitutive models for fibre reinforced soil bricks.** *Construction and Building Materials*. 2020;240:117806.

[32] Chegenizadeh, A., Nikraz, H. **Investigation on strength of fiber reinforced clay** *Advanced Materials Research* 2011.261-263, pp. 957-963.

[33]Ghadakpour M, Choobbasti AJ, Kutanaei SS. **Investigation of the Kenaf fiber hybrid length on the properties of the cement-treated sandy soil.** *Transportation Geotechnics.* 2020;22:100301.

[34] Chegenizadeh, A. and H. Nikraz, **Composite Soil: Fiber Inclusion and Strength,** *Journal of Advanced Materials Research* 2011.1646

[35]Narani SS, Abbaspour M, Mir Mohammad Hosseini SM, Aflaki E, Moghadas Nejad F. **Sustainable reuse of Waste Tire Textile Fibers (WTTFs) as reinforcement materials for expansive soils: With a special focus on landfill liners/covers**. *Journal of Cleaner Production*. 2020;247:119151.

[36] Kua T-A, Arulrajah A, Horpibulsuk S, Du Y-J, Shen S-L. **Strength assessment of spent coffee grounds-geopolymer cement utilizing slag and fly ash precursors.** *Construction and Building Materials.* 2016;115:565-75. https://doi.org/10.1016/j.conbuildmat.2016.04.021

[37]Kurugodu HV, Bordoloi S, Hong Y, Garg A, Garg A, Sreedeep S, et al. **Genetic programming for soil-fiber composite assessment.** *Advances in Engineering Software*. 2018;122:50-61.

[38] Chegenizadeh A, Nikraz H. **Permeability test on reinforced clayey sand.** *World Academy of Science, Engineering and Technology*. 2011;54:130-3.

[39] Chegenizadeh, A. and H. Nikraz, **Composite Clayey Sand and Short Fiber,** *Advanced Materials Research* 2012.383, 2764-2769

[40] Elkhebu A, Zainorabidin A, Asadi A, Bakar IH, Huat BBK, Abdeldjouad L, et al. **Effect of incorporating multifilament polypropylene fibers into alkaline activated fly ash soil mixtures**. *Soils and Foundations*. 2019;59(6):2144-54.

[41] Arulrajah A, Kua T-A, Suksiripattanapong C, Horpibulsuk S, Shen JS. **Compressive strength and microstructural properties of spent coffee grounds-bagasse ash based geopolymers with slag supplements**. *Journal of Cleaner Production.* 2017;162:1491-501.

[42]Cui H, Jin Z, Bao X, Tang W, Dong B. **Effect of carbon fiber and nanosilica on shear properties of silty soil and the mechanisms.** *Construction and Building Materials*. 2018;189:286-95. https://doi.org/10.1016/j.conbuildmat.2018.08.181