Use of construction materials to improve the properties of clay soil

Abeer Abduljabbar Al-Saeedi [1] ،Dalya h.Hameed [2]
[1, 2] Department of Ceramic Engineering and Building Materials
Faculty of Materials Engineering, University of Babylon

ABSTRACT

The demolition of old buildings, construction, and rebuilding processes leave a waste called the so-called construction waste. For the save the environment and its aesthetics, as well as for the economic and financial benefit from these wastes, as well as for the removal of all obstacles that may affect the continuity of work, so there was a joint responsibility of several parties, including the municipalities in addition to the party responsible for the construction process, which may be individuals or Construction companies contribute to the disposal and possible utilization of these wastes at the same time, and thus this has led to the joint responsibility of several parties and parties in recycling these wastes.

This research paper presents a study in the Use of construction waste to improve the properties of clay soil, by taking samples from the location of a building under construction in the city center of Hilla / Iraq. where we mixed it with ceramic powder.

Keywords: Waste ceramic dust, liquid limit, plastic index, plasticity index, California bearing ratio.

Corresponding Author:

Abeer Abduljabbar Al-Saeedi

Department of Ceramic Engineering and Building Materials
Faculty of Materials Engineering
Babylon university
Hilla, 51001, Babylon, Iraq
E-mail: abeerabduljabbar75@gmail.com

1. Introduction

With the development of engineering sciences, including civil engineering, and especially soil mechanics engineering, there has emerged a great interest by researchers and engineers in improving soil and its properties, and among these methods that were used first is to replace old soil by removing it with new soil.

Given the fact that this method requires a long period to be completed, which is reflected in the project completion period, which may take many months, as well as the need for a large workspace and specialized equipment for unloading and loading. Therefore, other solutions and treatments to improve the soil had to be researched.

By using additives as a solution. Therefore, we discussed in this research paper the use of the method of adding construction waste powder as a byproduct of demolishing buildings, especially ceramic powder, in addition to the improvement process through this addition, we will achieve another benefit, which is the disposal of waste and the preservation of the environment.

Clay soil, when flooded with water, has a tendency to swell as well as its ability to expand and withdrawal groundwater, and thus it will cause many problems, including soil erosion and collapse on one side, and consequently the occurrence of precipitation and cracks in buildings and many other problems on the other hand.

Soft clay soils are considered problematic soils that are highly compressed under the foundations, and their resistance to shearing is very little, which leads to failure to resist the loads on them, and collapses and unsettlement of the soil occur, which leads to total or partial collapses in the buildings built on it.

Since the lands available for construction have become very few as a result of the expansion of urbanization, but rather an extension of it or an extension to it, it has become imperative to exploit this land to build on it, which has prompted many researchers to try to find ways to strengthen and consolidate the soil to withstand the various forces that affect it, including what is chemical. Or thermally, mechanically, or any other way with the soil. This is our goal in this research paper [1][2].

2. Experimental part

2.1 Clay soil

Bentonite is a flexible mineral clay soil found in the crust of the Benton region. Bentonite clay is a clay of volcanic origin in the group montmorlite, consisting mainly of silica (60-70%), aluminum (15-20%), and a low percentage of iron (5%). Each particle of this clay consists of an octahedral aluminum plate Confined between two sheets of tetrahedral silica.

The nature of the bonding between the bentonite particles is very weak, which gives the opportunity for water to enter easily between these molecules, which leads to their Spacing from each other and hence the ability of bentonite high swelling that reaches (8) times its original size causing many problems [5] [9]. Table 1 below provides the characteristics of the soil used:

Table 1. The characteristics

Specification	Value
Granular soil	
	sand size%=2
	silt size %=25
	clay size %=73
Specific gravity	= 2.65
Atterberg's limits	liquid limit % = 73
	plastic limit % =33
	plasticity index % =44
Standard Proctor Test (SPT)	
Opt. Moisture content%	OMC = 22
Max. Dry Density KN/m^3	MDD = 15.3
Unconfined C.S KN/m^2	= 54
Color	Greyish Black
Unified classification system	CH
CBR %	1.7

2.2 Waste Ceramic Dust Additives:

For the purpose of making the most of building waste resulting from the demolition of buildings, especially ceramic dust in the process of improving the properties of clay soil, Table 2 below represents the mentioned characteristics [3][7].

Table 2. The physical characteristics of waste ceramic dust used

Specification	Value
Granular soil	
	sand size =46
	silt size =32
	clay size =22
Specific gravity	= 2.75
Standard Proctor Test	
Opt. Moisture content%	OMC = 15
Max. Dry Density KN/m^3	MDD = 19

2.3 Testing procedure

The Los Angeles device available to us in the soil laboratory dedicated to this purpose was used to grind ceramics from the construction site to be demolished and transformed into dust to be mixed with clay soil from 0-50%, an increase of 5% from the total of 11 samples to achieve the desired purpose.

3. Analysis of Test Results

The results were obtained by performing multiple experiments inside the laboratory.

3.1 Atterberg Limits

The Atterberg limits also called the (consistency limitation) of cohesive soil, it is the possibility for soil to exist in any of the four states depending on its moisture content. Which: (solid-state, semisolid state, plastic limit, liquid limit). These limits are also affected by the amount and nature of the clay mineral content. the general characteristics of both silt and clay will change with the addition of water by the following Fig.1:

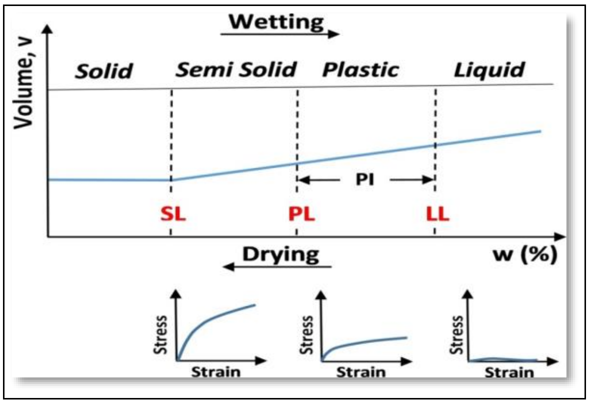

Figure 1. Atterberge limits

1)Liquid Limit Test: (L.L, WL)

It is defined as the moisture content of the soil in which it changes from a plastic to a liquid state, or it is defined as the minimum amount of moisture at which the soil will flow or flow only by its weight. The moisture content that causes this change is called the liquid limit. Which we will see in the two Fig.2.

2)Plastic Limit Test; (P.L, WP)

The plasticity limit is defined as the water content at which the soil changes from the plastic to the semi-solid state. If the water content of the soil falls between the plasticity limit and the natural water content of it, the soil will be plastic.

3)Plasticity Index (P.I)

It is defined as the numerical different between the liquid limit and the plastic limit of soil

$$P.I = W.l - W.p \quad (1)$$

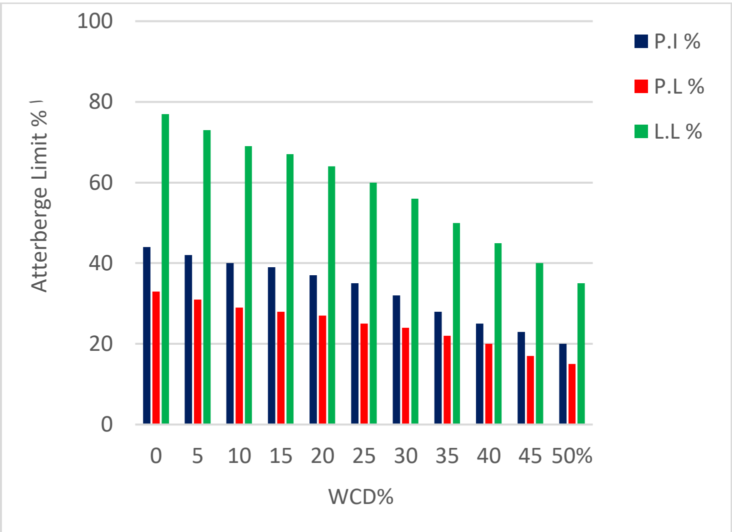

Figure 2. The relation between Atterberg Limits with the percentage of waste Ceramic dust

By adding the above ratios of WCD to the soil, the Atterberge limits were reduced, which improved the geotechnical properties of the soil clay.

It can be concluded that the WCD molecules fill the fine pores of the soil structure and allow less water to center and thus reduce the soil clay.

3.2 Standard proctor test SPT

The Proctor test was originally designed to simulate the compaction carried out with in situ machines. The purpose of performing the stacking test in the laboratory is to extract the maximum dry density (MDD) and determine the appropriate amount of water or as it is called the optimum moisture content (OMC) that is added to the soil to be stacked on site [10]. And determine the (degree of denseness) or (the compaction ratio) that can be expected from compaction of the soil at the optimum moisture content. Which we will see in the two Fig. (3,4).

Fig. 3. shows the Maximum Dry Density (MDD) variation with a percentage of WCD. From the chart, it is clear that the percentage of WCD Proportional to the MDD of soil goes on increasing.

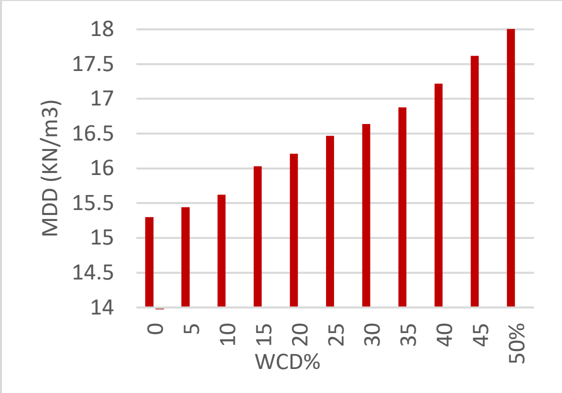

Figure 3. The relation between MDD and WCD%

The relationship in this figure 3 is a proportional relationship, as increasing the WCD from 0 to 50% leads to an increase in the MDD ratio from 15.3 KN/m^3 to 18.2 KN/m^3. This increase is due to the replacement of low-gravity soil particles (2.65) with higher particles (2.75) from ceramic dust particles. In other words, there will be a molecular exchange between the clay soil and the ceramic dust material, and this in turn leads to a decrease in the ratio of voids present as well, as we can see in the following equation:

$$\gamma d = \frac{Gs}{1+e}\gamma w \qquad (2)$$

Where:

γ_d = Dry density , γ_w = water density

Gs = specific gravity , e = voids ratio

The relationship is Proportional between the specific gravity (Gs) and the density, as well as the inverse relationship between the density and the ratio of voids [6].

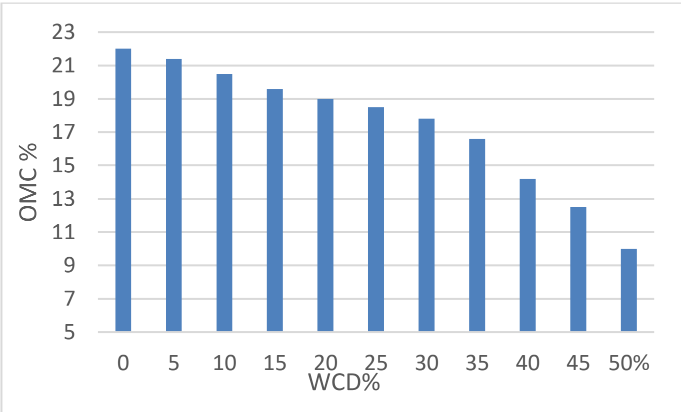

Figure 4. The relation between OMC and WCD%

We notice from the above a decrease in the value of OMC from 22 % to 10 % when the increase from 0 to 50% in the value of WCD due to the exchange occurring between WCD and soil particles and due to the decrease in the gravity of water molecules in the soil to be the main reason for the decrease in moisture content [8].

3.3 California Bearing Ratio (CBR)

The Soaked California bearing ratio test is considered one of the important tests that are conducted for the soil in soil engineering. This test aims to know the ability of the soil to be a base layer for a road or for all Buildings built on it or an auxiliary foundation or other layers.

The name of this examination came to the Department of Roads in the state of California who was the first to carry out this examination in 1929.

The Soaked CBR experiment depends so much on the Proctor's experience, and in many respects, it is similar to it, so that this experiment cannot be carried out until the Proctor's experiment is completed.

That Soaked CBR is a numerical value without a unit, expressed in percentage terms, and it represents the ratio between the stresses (loads) applied to the sample on the one hand and the pressures (loads) typical of a typical soil [9].

$$C.B.R = P_n / P_s \times 100 \quad (3)$$

Where:
Pn = It is the value of the stressors (loads) that cause penetration value from (2.5mm) and (5mm)

Ps = It is the ideal load value for an ideal soil.

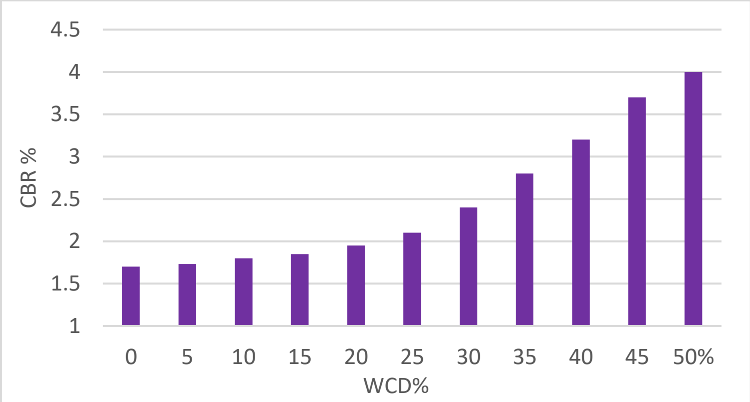

Figure 5. The relation between CBR and WCD

In Fig. 5. In the soaked CBR test for clay soil, we can see that the relationship is proportional between WCD and CBR soaked in clay soil and the increase is from 1.7 % to 4.0 % for WCD rates from 0 to 50%.

3.4. Unconfined compression strength (UCS)

The Uncompressed Compressive Strength (UCS) (q_u) is defined as the highest value of vertical stress (σ_v) or vertical stress corresponding to a certain axial strain (ε_a)[4].

This test is one of the important and basic tests in our research after adding the clay soil to the previously mentioned ratios of WCD which are from (0% -50%), which will improve the properties of clay soils. as we see in the figure below:

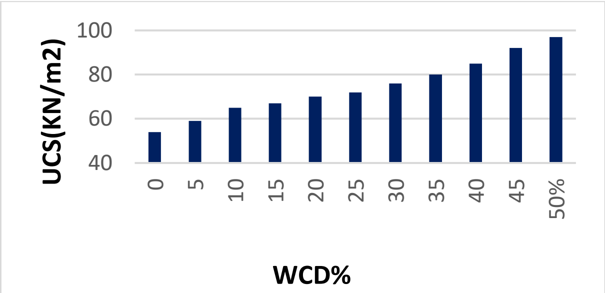

Figure 6. The relation between Unconfined compression and WCD%

In Fig. 6. we notice a clear proportional relationship between the WCD% and UCS for all ceramic dust values.

4. Conclusions

Construction, industrial and agricultural wastes are considered environmental pollutants, so the specialists' attention has focused on protecting the environment in disposing of these wastes, and to the extent that they occupy us as specialists in the field of civil engineering.
In our research paper and after completion we concluded the following, to have a good advantage when adding a percentage of WCD, and this led to a decrease in the liquid limit and an increase in the unconfined pressure resistance for all added ratios and a change in the type of failure from shear failure to bearing failure which may be caused by high pressure .
That happens after adding WCD. Using the same demolition waste, the environment was protected and preserved, and then the properties of the clay soil were improved.
We obtained through some tests that we conducted that the values of (MDD, CBR and UCS) increase with increasing the rate of WCD, and this is a good indicator for improving the properties of clay soil, as the percentage of soaked CBR increases by 250% when adding 50% of WCD to clay soil.

References

[1] Bakchan, A., Faust, K. M. (2019). Construction waste generation estimates of institutional building projects: Leveraging waste hauling tickets. Waste Management, 87, pp. 301–312.

[2] Cheng, Y. Wang, S. Li, J. Huang, X. Li, C. Wu, J. (2018). Engineering and mineralogical properties of stabilized expansive soil compositing lime and natural pozzolans. Constr. Build. Mater, 187, 1031–1038.

[3] Pathania, M., Soni, D.K. (2017). Combined Effect of Quarry Dust & Ceramic Dust on Stabilization of Clay. International journal advance research in science & engineering, 1, 297-302.

[4] Butt, WA. Gupta, K. Jha, JN. (2016). Strength behaviour of clay soil stabilized soil with saw dust ash. International Journal of Geo Engineering ,7:18. https://doi.org/10.1186/s40703-016-0032-9, 2016.

[5] Rehana, P., Kalita, U.C. (2017). Study on Liner Material Using Fly ash - Bentonite Mixture for Engineered Landfill. International Journal of Innovative Research in Science, Engineering and Technology, Vol.6, (Issue11), pp. 22072-22080.

[6] Menegaki, M., Damigos, D. (2018). A review on current situation and challenges of construction and demolition waste management. Current Opinion in Green and Sustainable Chemistry, Vol. 13, pp. 8–15.

[7] Koyuncu, M. Pathania, Soni, D.K. (2017). Combined Effect of Quarry Dust & Ceramic Dust on Stabilisation of Clay. International journal advance research in science & engineering. 1, 297-302.

[8] Hussan, Z. A., Al-Janabi, A. T. (2018). Studying Some Mechanical properties of soft soils Treated by CaCo3-Nano material. International Journal of Civil Engineering and Technology (IJCIET), Volume 9, Issue 11 .

[9] Al-Janabi, A. T., Al-saeedi, A. A. (2019). Evaluation the Swelling Soil Stabilized by Waste Corn Ash (WCA). Journal of Engineering and Applied Sciences, Vol:14 (No.15-16).

[10] Akhtar, A., Sarmah, A. K. (2018). Construction and demolition waste generation and properties of recycled aggregate concrete: A global per- sportive. Journal of Cleaner Production, Vol. 186, pp. 262–281.