The Effect of Local Waste Aluminium Material on the Geotechnical Properties of Soft Soil

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***Abstract*:- Due to the growth of industrial sectors in the world, the production of the waste materials is increased significantly at daily bases. This would increase the cost of landfilling and the transportation of the waste materials. The reuse of waste materials in construction field represents a promising solution. This research represents the results of the experimental works of the soft soil treated with local waste aluminium (WA) produced from aluminium furniture manufacturing. Different percentages of WA percentages (0, 5, 10, and 15%) were used and the effect of WA on different geotechnical properties of a soft soil was investigated in terms of Atterberg limits, compaction parameters, and unconfined compressive strength.**

The resulted indicated a significant modification in the plasticity index of the soil after using WA, while the density and compressive strength were decreased with the increase of WA percentage.

Keywords:- Local aluminium waste, soft soil, Atterberg limits, compaction parameters, unconfined compressive strength.

1 INTRODUCTION

It is common that new established engineering projects located in areas with a soft soil. Soft soils are the most problematic soils in civil engineering because of their high compressibility, tendency to swell when the water content increases and low compressive strength (Consoli et al., 2015). The accepted usual method of soft soil mitigation is to replace the soft soil with stronger materials. Due to the high cost of this method, researchers have been driven to look for alternative methods and one of these methods is the process of soil stabilisation (Harichane et al., 2011, Cristelo et al., 2013, Sol-Sánchez et al., 2016). Soil stabilisation is recommended to aid the engineer in being able to employ the natural soil of a project's site as an engineering material with specific properties, especially strength, volume stability, permeability and durability (Kolias et al., 2005, Venda Oliveira et al., 2011).

Soil stabilization Is a way to treat soft soil to eliminate or mitigate problems associated with this type of soil by mixing and mixing materials with soil to improve certain soil characteristics. The process may include mixing soil to achieve desirable gradation or mixing commercially available additives that may change gradient, texture or Plasticity, or as a link to strengthen the soil (Akbulut et al., 2007). The use of the stabilizing factor improves the strength factor such as cohesion, and the improvement in cohesion leads to reinforcing dams (Patel & Patel, 2012). Endless materials can be used to stabilize soil such as cement, lime, fly ash, bitumen or a combination of these materials. Stable soil materials are characterized by higher strength, lower permeability and lower pressure than virgin soil (Makusa, 2012).

On the other hand, many researchers have used waste materials as SCM in soil stabilization to reduce the use of OPC and lime and to boost the hydration reactivity dependent on the pozzolanic reaction of these materials. RHA, palm oil fuel ash (POFA), ladle furnace slag (LFS), SF, and coal waste have been used as SCM in recent research projects (Brooks, 2010; Ahmed et al.,2011; Mans ,et al., 2013; Fattah et al., 2014; and Modarres and Nosoudy , 2015).

Aluminium is a very expensive nonferrous metal and can therefore produce high incomes for recycling schemes. Aluminium waste is produced primarily from two main streams, the production lines of aluminium industry and the aluminium as an end-of-life product, after its use by the consumers. In both cases the option of recycling is favourable and widely implemented in many parts of the developed world.

In our current study we used aluminium waste to know how it affects the physical properties of the soil and its stability.

2 MATERIALS AND METHODS

2.1 Soil samples

The soft soil used in this study was collected from a site of university of Babylon located to the south of Babylon province. The soil samples were extracted from a depth about 0.3 to 0.5 meter below ground level, then transferring to the laboratory. When the soil was moved to the laboratory, minor soil samples was tested immediately to calculate the natural moisture content. While the majority of the soil was left in the laboratory to be aerated and prepared for the laboratory works. Figure 1 shows the photo of the soil at the laboratory.

Figure 1: The samples of the collected soil.

The soil was air dried inside the lab to be prepared for other classification testing. The physical and geotechnical characteristics of the soft soil were determined in accordance to BS EN ISO 17892-4:2014 for particle size distribution and in accordance to BS 1377-2 and 4:1990 (British Standard, 1990) for Atterberg limits and compaction parameters respectively. The results are shown in Table 1, and Figure 2 shows the particle size distribution of the soft soil used in this study.

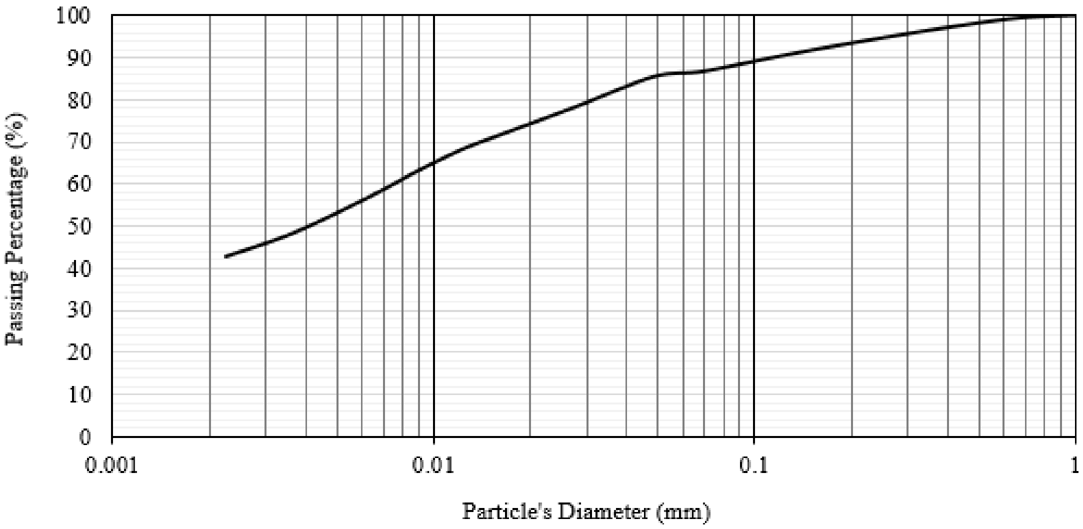

Figure 2: Particle size distribution of soil.

Table 1: Physical and geotechnical properties of soft soil.

Property	Value
Liquid Limit LL %	47
Plastic Limit PL %	25
Plasticity index PI	22
Sand %	7.5
Silt %	48.5
Clay %	44
Specific Gravity (Gs)	2.65
γ_{dmax} **g/cm^3**	1.58
Optimum moisture content OMC %	24.5
pH	7.78
Organic Matter Content %	7.95
qu (kPa)	175

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2.2 Waste Aluminium

A local waste aluminium (WA) material produced from the local factories of furniture manufacturing was collected. WA was found to contain large grains of aluminium fibre as shown in Figure 3, therefore; it was sieved on sieve size 1mm in which the passed material was used as an additive to the soft soil in this study. WA was mixed with the soil at 5, 10 and 15% by the dry mass of the treated soil.

Figure 3: The waste aluminium used in this study.

2.3 Laboratory tests

Three fundamental tests were conducted to investigate the effect of the WA on the physical and engineering properties of the soft soil in this study. These tests were:

- Atterberg limits test - (Liquid Limit (LL), Plastic Limit (PL), and Index of Plasticity (IP)). These limits were determined in accordance to BS 1377-2:1990 (British Standard, 1990). A Cone Penetrometer device was used to find the LL.
- Standard Proctor compaction test - conducted in accordance to BS 1377-4:1990 (British Standard, 2002), 2000g of dry powdered soil was mixed with five different water contents. For each value of water content, soil paste was compacted in a standard mould using a 2.5kg rammer with three layers; each layer was subjected to 25 blows.
- Unconfined compressive strength test - carried out according to BS 1377-7:1990 (British Standard, 1998) for each corresponding percentage of WA.

3 RESULTS AND DISCUSSION

3.1 Atterberg Limits

Figure 4. shows the relationship between the atterberg limit and the waste aluminium used in the study for the soft soil. Soft soil treated with 5%, 10% and 15% of the waste aluminium by the dry weight of the soft soil. From this figure, it can be seen that the aluminium wastes has the positive effect in reducing. The Index of plasticity from 22 to below 14 and that L.L values decrease with increase the waste aluminium percentage.

This reduction in soil plasticity is due to the difference between L.L and P.L. Liquid limit decreases because aluminium wastes dose not absorb water so that L.L will decrease, also at plastic limit the soil begins to crack early , it is need more water to adhesion thus the P.L will increase (Gharib , et. al, 2012). Since Atterberg limits play an important role in soil identification and classification and give an indication about soil behaviour in the presence of water such as the workability and expansion problem, the aluminium waste used in this study can increase the workability by decrease the L.L, swelling and shrinkage potential by decreasing I.P as shown in Table 2.

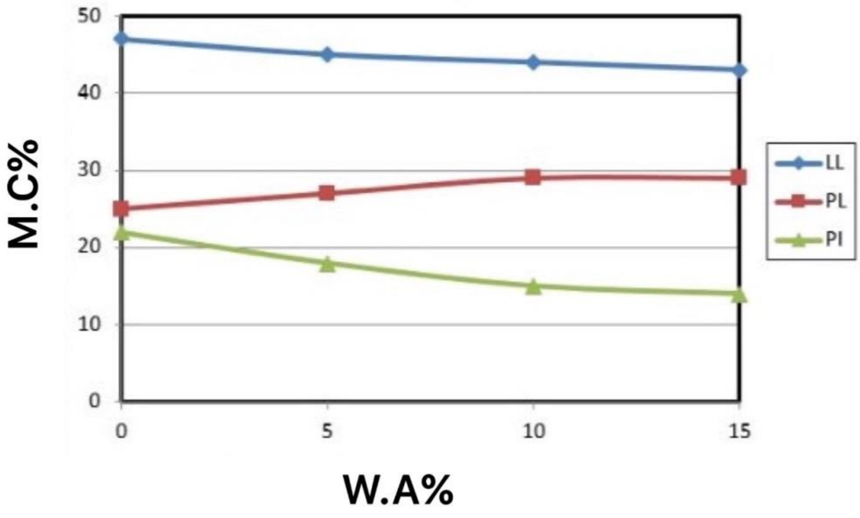

Figure 4: Effect of the WA on the Atterberg limits of the soft soil.

Table 2: Atterberg limits values for soil with WA

MIX	L.L	P.L	P.I
Virgin soil	47	25	22
5% W.A	45	27	18
10% W.A	44	29	15
15% WA	43	29	14

3.2 Compaction parameters

The aim of this test is to find the maximum dry density and optimum moisture content for untreated soil and soil stabilized with different percentage of stabilizer material. The values obtained from this test are very important and they are considered to prepare the required specimens for several geotechnical experiments such as UCS, CBR, Compressibility, and swelling potential. Standard proctor compaction test were carried out on the soft soil using different percentage of the aluminium wastes (5%, 10% and 15%). The results of compaction test are shown in figure 5.

It can be observed easily that MDD decrease and OMC increase with the continuous increase in aluminium waste percentage because of high water absorption of the aluminium waste.

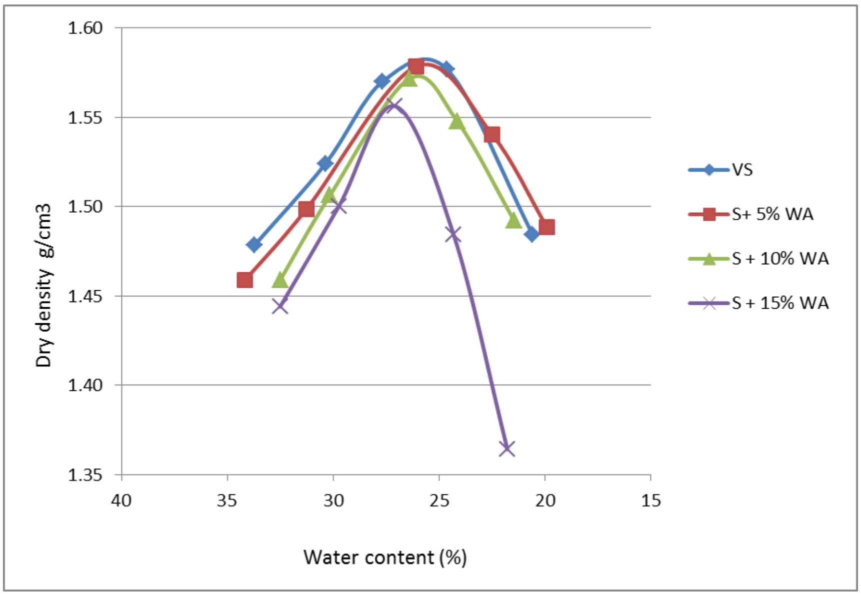

Figure 5: Effect of WA on the compaction parameters of the soft soil

3.3 Unconfined compressive strength test (UCS)

Figures 6 shows the laboratory results in the form of stress-strain diagrams from unconfined compressive strength tests for the soft soil treated with different percentages of the WA (5, 10 and 15%) for zero days of curing. It should be noted here that since no hydration reaction was expected, the curing effect was not taking in the account in this study. The results indicated slight reductions in soil compressive strength with the continuous increase in the WA used. This reduction maybe due to the reduction occurred in the soil density. The value of UCS was decreased from 175 kPa for the untreated soil to 140 kPa for the soil treated with 15% WA. However, this reduction represents 20% of the total compressive strength of the untreated soil.

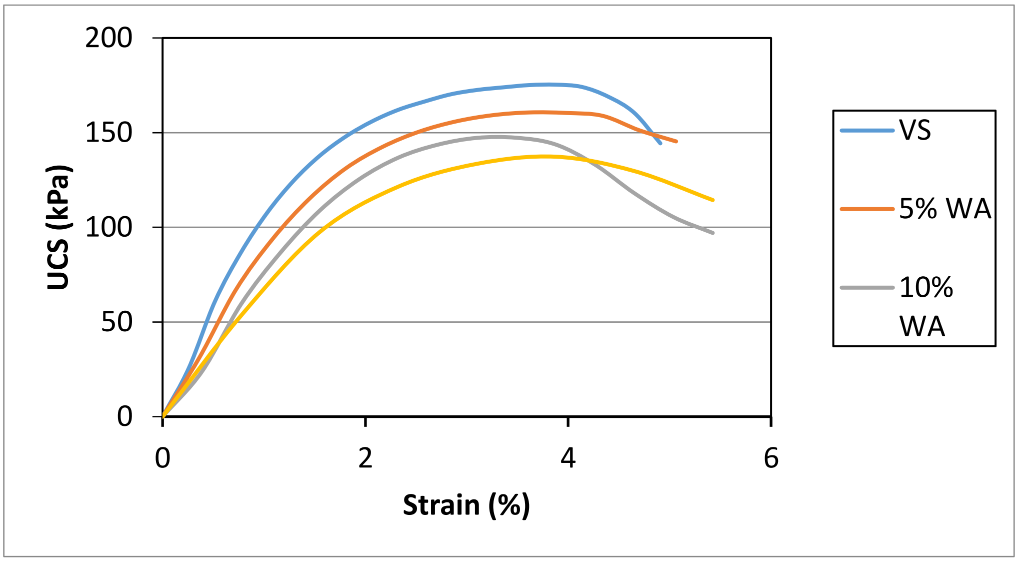

Figure 6: Stress-strain relationship for soil treated with different contents of WA.

4 CONCLUSIONS

Based on the results obtained from this study, the following conclusion can be drawn:

Waste aluminium produced from the furniture manufacturing can be effectively used as soil stabilizer particularly in terms of enhancing the soil water resistivity. The results of atterberg limits tests showed that the plasticity index decreased noticeably with the increase of WA percentage which indicates a reduction in soil swelling property. However, the use of WA led to decrease the MDD and increase OMC. Due to the reduction occurred in MDD after the use of WA, the soil strength decreased significantly.

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