Study on the strength characteristics of MSW in Sri Lanka

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ABSTRACT

Proper engineering landfills have not been practiced by Sri Lanka. Most of the open dumps in the country are located in the city centers. Due to rapid development and urbanization, these dump sites are abandoned and now they are used for critical construction works. Strength characteristics are very important for general foundation designs, however, due to the heterogeneity, it is very difficult to evaluate those parameters in dump waste sites. Dump waste samples were collected from Bloemendhal dumpsite. Direct shear test and unconsolidated undrained triaxial tests were conducted to obtain the shear strength properties such as cohesion and angle of friction for different moisture contents obtained during Proctor compaction test. Direct shear tests have proven that the angle of internal friction does not vary much with moisture content. However, the experimental results of cohesion of dump wastes have shown that the cohesion of dump waste varies with moisture content and the shape of the cohesion vs moisture content graph is similar to the shape of the Proctor compaction test. These results indicate that the behavior of the dump wastes is similar to silty soil. Further tests were done with the addition of cement to observe the strength gain. Several cement contents were tested and unconfined compression tests were carried out on the wetted (cured) samples with time until 28 days. Samples were tested at certain time intervals and observed the strength gain with time. Age of the solid waste could change the properties of MSW. However, in this study it has to be noted that the age could not be used as an external parameter as the open dumps had been operated without proper records.

Keywords: Dump waste, cohesion, angle of internal friction, optimum moisture content

1. INTRODUCTION

One of the major issues in Sri Lanka is the collection and disposal of dump waste in urban areas. Especially in Colombo city due to the rapid population growth, the amount of waste added to the dump sites has been increased.

It is essential to acquire a better understanding of the properties of municipal solid waste to maximize the amount of waste that can be placed in existing and future landfills. So optimization of waste will increase the waste density as well as it will increase the landfill operational life. In addition, it will be useful to determine that whether this dump waste site can be used as a construction site or the dump waste can be used as a filing material.

The scope of this research is to find out the strength characteristics of the dump waste in Sri Lanka. For that purpose Bloemendhal dump waste site was selected. Bloemendhal dump waste area is the biggest garbage dump area in Sri Lanka. Bloemendhal dump waste area is a desegregated garbage mountain from all sources collected by the Colombo Municipal Council. There are an estimated 58 unmanaged waste dumps in the Western Province, most of which are almost filled to their capacity. As these dumps continue burning it creates many health problems too (www.ejustice.lk).

2 OBJECTIVES AND METHODOLOGY

The purpose of this study is to determine strength characteristics and the level of improvement using cement as a soil stabilizer. The selected cement was Ordinary Portland cement (OPC). Following procedure was adopted.

1. Characterizing the soil by performing the following tests: particle size distribution (Wet sieve and dry sieve), Atterberg limit tests, moisture-density relationship using standard Proctor Compaction test, Specific gravity, Sulfate content, Chloride content and pH value

2. Identifying the waste/soil characteristics and dose rate and strength characteristics using the laboratory procedures.

3 EXPERIMENTAL WORK

A series of experiments were conducted according to appropriate guidelines such as BS 1377 and ASTM volume 04.08. Classification of sample and determination of the shear strength characteristics are two identified objectives. Particle size distribution and consistency limit tests were done to classify the dump waste soil sample. Classification of the dump waste is
done according to Unified Soil Classification Method.

Chemical parameters of the soil or a fill material will have adverse impacts on structure in that soil such as foundations. Since, dump waste has a high potential to have an influence of chemically activated ingredients, it was decided to perform some general chemical tests such as pH test, sulfite test and chloride test.

The proctor compaction test was done to obtain the maximum dry density and optimum moisture content. Then direct shear tests were done to find out the relationship between moisture content and shear strength parameters. Then Unconsolidated Undrained triaxial tests were done to find out the relationship between moisture content and short term shear strength parameters.

4 RESULTS AND DISCUSSION

4.1 Particle size distribution

Four methods were adopted to analyze the particle size distribution. They are; air dry-dry sieve, air dry-wet sieve, oven dry-dry sieve and oven dry-wet sieve. From the above results, for the air dried- dry sieved sample the percentage of clays and silts were 7% and for the air dried –wet sieved sample the percentage of clays and silts were 10%. It means 3% of particles in the sample could not be removed by dry sieving and when air dried wet sieve analysis were done they were separated into small particles.

4.2 Chemical Tests

Chemical parameters of the sample such as pH, chloride content and sulfite content were evaluated according to BS 1377: part 3.

Table 1 – Chemical test results

| Parameters        | Values |
|-------------------|--------|
| pH                | 7      |
| Chloride content  | 0.02%  |
| Sulfite content   | 0.086% |

Chemical tests reveal that, considered sample is almost neutral with pH 7 and does not have significant chloride or sulfite content. pH value indicates the unavailability of significant amount of other adverse chemical compounds. This could be possible as Bloemendhal site has been abandoned for some time and recently no waste dumping had been done.

4.3 Consistency limit tests

Liquid limit was found by using the penetration method.

Table 2 – Plastic and Liquid limits

| Type                    | LL  | PL  | PI  |
|-------------------------|-----|-----|-----|
| Air dry and wet sieve   | 44.5| 26.2| 18.3|
| Air dry and dry sieve   | 34.5| 27.9| 6.6 |
| Oven dry and wet sieve  | 38  | 27.4| 10.6|
| Oven dry and dry sieve  | 30  | 26.6| 3.4 |

From the above results, it can be observed that, Atterberg limit test changes according to the method of drying and subsequently the behavior of the dump waste varies significantly. For example in air dried- wet sieved condition, the soil sample behaves as a highly plastic soil (PI 17-35%). However, in air dried- dry sieved condition the soil behaves as a slightly plastic soil (PI 1-7%).

This is because when the soil sample is wet sieved the clay particles, which were bonded, with larger particles are separated into small pieces and increases the plasticity of the dump waste soil.

4.4 Proctor compaction test

Standard proctor compaction test was conducted...
Maximum dry unit weight is 1418 kg/m$^3$ obtained at moisture content of 24.5%.

### 3.5 Specific Gravity

Specific gravity value of sample was evaluated according to BS 1377: part 1, Pyknometer method. Average specific gravity of sample was found to be 1.96.

### 3.6 Direct shear tests

Samples were extracted for direct shear tests from the standard Proctor compaction for different moisture contents. At every moisture content value, direct shear test was conducted to find out the variation of strength parameters such as cohesion and internal friction angle with different moisture contents.

From the above two graphs, it can be said that the angle of internal friction does not vary much with moisture content (between 14-17). In addition, behavior of the dump wastes is very similar to a silty soil. However, the experimental results of cohesion of dump wastes have proven that the cohesion of dump waste varies with moisture content significantly (16.6 - 24.5 kPa).

The below description will be the possible reason for the shape of the above two graphs.

As Cocka et al (2004) clearly expressed, when the dump waste soil is dry of optimum, the soil tends to behave more like cohesionless soil, with a relatively high angle of friction and low cohesion as potentially angular, flocculated structures dominate the shear strength behaviour. As the dump waste soil approaches optimum moisture content the internal angle of friction decreases and the cohesion increases to maximum cohesion at optimum moisture content. This response is due to the breakdown of the flocculated structures, which decreases frictional resistance to shearing and to increasing moisture content, which lubricates the movement of soil particles past each other.

### 3.7 Unconsolidated undrained tests

Unconsolidated Undrained tests were conducted to find out the relationship between moisture content and short term shear strength parameters of the dump waste.

The plot between the cohesion and moisture content follows the same shape of Proctor compaction test. In addition, at the optimum moisture content the highest cohesion value of 48.35kPa was observed. Obviously it indicates that at the optimum moisture content, the shear strength of the dump waste soil sample is at its maximum.
3.8 Strength gain after adding some cement
Some percentage of cement was added to observe the strength gain and Fig. 6 provides such information between unconfined compression strength and days of curing.

4 CONCLUSIONS
Geotechnical properties of Bloemendhal dump waste soil were determined through laboratory testing. In particular, particle size distribution, Atterberg limits, chemical properties of soil, specific gravity, and shear strength parameters (friction angle and cohesion) of dump waste were studied. Direct shear tests have shown that the angle of internal friction does not vary much with moisture content. However, the experimental results of cohesion of dump wastes have shown that the cohesion of dump waste varies with moisture content and the shape of the cohesion vs moisture content graph is same as the shape of the Proctor compaction test.

Chemical tests on the dump waste show that Bloemendhal dump waste area is suitable for the construction activities according to those three chemical properties of soil.

For low dosage rates, treatment with the Portland cement stabilizer achieved comparable strength.

Overall, this study discusses that the shear strength parameters significantly vary with the change in moisture content. Further, there is a high possibility of gain in strength with some addition of cement. The variation in shear strength characteristics with moisture content should be properly accounted in the analysis and design of landfills or for the construction activities in existing dump sites.

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