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Repeated Loading Triaxial Test on Bentonite-Slag-Tire Mixture

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***Abstract:** A road may be built on expansive soil. Therefore, it is important to know the behavior of soil in the presence of other additives such as slag and tire; which in these days research wants to use them in geotechnical and pavement projects. One of the potential way to investigate the issue is application of by-products. Among all by-product/waste, slag and tire were selected in this study. This study investigates the effect of tire and slag into the behavior of bentonite under repeated triaxial loading. For the purpose of this research, RLTT was employed. The RLTT device represents real pavement condition in laboratory scale. Three percentage of slag along with three percentage of tire were employed. The results proved that a sample with up to 15% tire behaves better against permanent deformation which the effect of slag was limited against permanent deformation.*

***Keywords:** Bentonite, Slag, RLTT*

I. INTRODUCTION

The expansive soil is one of the major problem in construction in geotechnical and pavement project [1,2]. Application of many materials such as such as asphalt and bitumen as stated by [3]. Apart from those, new approach also was being employed such as short fibre which being investigated in recent years such as [4-7]. Problematic soil is one of real concern in construction project. The strange behaviour of problematic soils once absorb water is one of the reasons that push researchers and industry to look very precisely into problematic soils issues. Tire-soil connection model and compared with laboratory results and FEM displaying results for yield parameters, for example, the contact zone, contact volume demonstrated close agreement. Once the moisture of soil was increased the contact pressure dropped [8] A study on the tire construction techniques can also have an effect on compaction risk which was studied by [9,10]. On the other side, research suggested using waste tire into soils. Coffee grounds mixed rice husk and slag to create a green development subgrade material.

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The coffee ground and rice husk were natural from farming items. CG is the buildup from coffee grounds. RHA is a material from the consuming rice husk used to produce power. Slag (S) came out of steel generation. RHA and S were utilized as geopolymeric precursors (P). This examination gives an understanding on the long term strength.[11]

There has been interest into rectify the issue of problematic soils while they are present in a field. Application of by-product is a benefit due to firstly usage of waste and secondly gaining benefit from them rather than landfills. Previous studies [12,13,14,15] considered slag application into soil. Other studies [16, 17,18] studied application of tire into soil. This study investigates the effect of slag and tire in bentonite (as an expansive soil).

RLTT (Repeated Tiaxial Loading test) was proved to be very effective way to simulate real loading condition as used by [18, 19, 20]. Therefore, the RLTT testing has been employed to consider the effect of repeated loading on stabilized soil. This paper is continuation of second author research thesis.

II. SIGNIFICANCE OF THIS STUDY

This study will aim to provide information which builds up stabilizers to the significant level that tire and slag can attain an acceptable degree of improvement in Bentonite under repeated loading condition. It is vital to know the effectiveness of slag and tire needed to stabilize the expansive soil.

III. OBJECTIVE OF THIS STUDY

The objective of this research is to determine the impact of a blend of tire chips and slag on the performance of bentonite soil against permanent deformation. The research is basically concentrated on the deviatoric stress and permanent deformation. The objectives are:

- Create blends of bentonite with various extents of tire chips and GGBS,
- Determine the effect of GGBS and tire chips on permanent deformation of the samples

IV. MATERIAL

A. Bentonite

The characteristic of bentonite can be found in Table 1.

Table1 Bentonite properties [21]

Item	Values
Liquid limit	320%
Plastic Limit	60%
Plasticity index	260%
Specific Gravity	3.3
pH	8-10

B. Slag

The GGBS (slag) was fine off-white to grey powder in color and pH was alkaline. Ground blast furnace slag forms more than 90% of the used slag. The specific gravity was reported to be 2.8-3.1[22] Figure 1 (b) shows the slag which was used in this research. .

Figure 1 (a) Tire Chips, (b) Used Slag

C. Tire

Figure 1 (a) shows the used tire. The characteristics of tire were: The average particle size of 0.6 mm diameter was recorded for the used tire.

V. METHODOLOGY

A. Soil Sample Preparation

Mixture of bentonite-slag and tire prepared as outlined in Table1. The Figure 2 shows the three mixes with different percentages of tire chips. The prepared mixes varied at slag from 3, 4 and 5% while tire varied from 10, 15 and 20%. The sample was then mixed using the Hobart mixer as can be seen in Figure 3(a). Figure 3(b) shows the used compaction mould. Figure 3 (c) represent the used hydraulic jack in sample preparation process.

Figure2 Visionary difference in a) Mix1 b) Mix2 c) Mix3

Table 1 Designed mixes

Mix Number	Bentonite Proportion (%)	GGBS Proportion (%)	Ground Tyre Rubber Proportion (%)
0	100	0	0
1	87	3	10
2	82	3	15
3	77	3	20
4	86	4	10
5	81	4	15
6	76	4	20
7	85	5	10
8	80	5	15
9	75	5	20

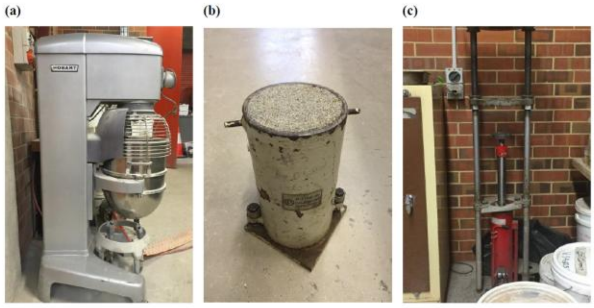

Figure 3 (a) Hobart blender, (b) Compacted mixture in mould (c) Hydraulic Jack

VI. RESULTS AND DISCUSSION

As outlined before, the RLTT test is set to be used to simulate the actual cyclic loading condition. The test stress combination can be seen in Table 2. Figure 4 shows the RLTT testing machine. Figure 5 shows the sample assembly into the RLTT apparatus.

Table 2 Stress combination of tests

Stress Path	Confining Pressure (kPa)	Deviator Stress (kPa)	Number of Load Cycles
1	20	20	1000
2	20	35	1000
3	20	50	1000
4	20	70	1000
5	35	35	1000
6	35	50	1000
7	35	70	1000
8	35	90	1000
9	35	120	1000
10	50	50	1000
11	50	70	1000
12	50	90	1000
13	50	120	1000
14	50	160	1000

A. RLTT

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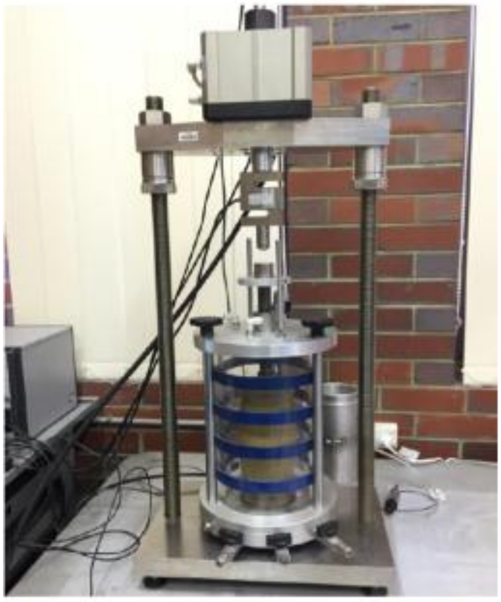

Figure 4 RLTT machine

Figure 5 sample preparation steps

Table 3 shows the failure cycle for each mix. The results show that with 3% of slag, tire inclusion of 10% records 7001 while the tire inclusion of 15% is 7199 and increasing the tire to 20% results in a decrease of up to 3041. That can be seen to be a trend in other mixtures. Therefore, tire inclusion of 15 % based on this study looks to be more effective.

Table 3 Stress Cycle to fail for mixes

Mix Number	GGBS Proportion (%)	Ground Tyre Rubber Proportion (%)	Stress Cycle Number that Failure Occurred
0	0	0	>8000
1	3	10	7001
2	3	15	7199
3	3	20	3041
4	4	10	7191
5	4	15	7191
6	4	20	3141
7	5	10	6491
8	5	15	7002
9	5	20	3991

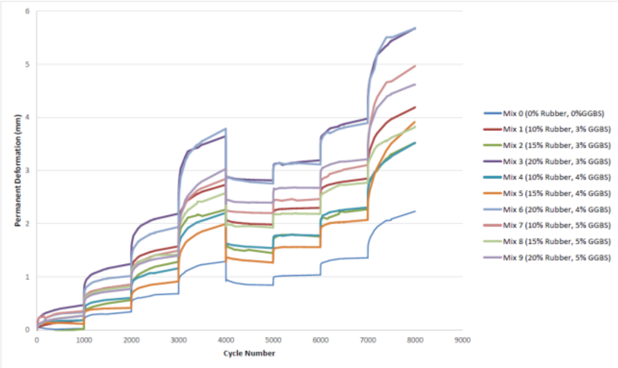

Figure 6 Permanent Deformation of mixes

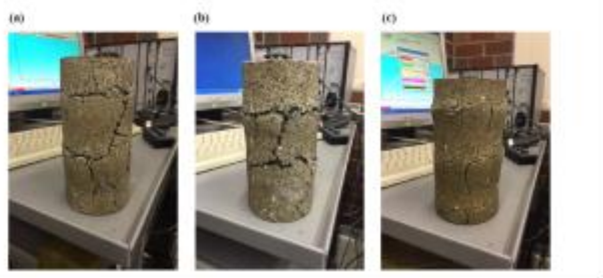

Figure 7 Cracks in a) mix1 b) mix 2 c) mix 3

A blend of swelling and fine crack was seen on the outside of the mixes [Figure 7]. By playing out a brisk examination of the three diverse blends, one can contend that while breaks are less noticeable as the substance of tire, the swelling of the mixes is increasingly perceptible. The bulging is characteristic of lower shear strength in this manner showing that the grip estimation of the strengthened soil diminishes with increasing in extent of the tire.

Figure 6 shows the permanent deformation behavior of mixes. Despite the fact that the outcomes show little changeability between specific mixes, to be specific Mix 7, 8 and 9, general patterns is evident. In the analyses, zero strains were practically recognized until the 3000th pressure cycle. From that point forward, enormous changes creates abruptly and in a couple of cycles, the strains in Mix 3, 6 and 9 surpass 3 mm, and therefore fails. From the curves, it's obvious that a tire of 20% is generally unfavorable to the strength of bentonite with no slag content. Then again, Mix 2, 5 and 8 (15% of tire) end up being unrivaled by falling flat at higher pressure cycles than the examples with a tire of 10% and 20%. Figure 6 portrays the methods of setbacks of Mix 1, 2 and 3 in the wake of being exposed to repeated loading.

From Figure 6, it is obvious that the mix showed slight changes in permanent deformation under continued loading with a variation of 3% to 5% of GGBS. The permanent deformation remained flat, just fluctuating by a couple of micrometers by increasing the number of cycles. It may be inferred that an increase of 3% to 5% has a slight effect on the improvement of bentonite.

VII. CONCLUSION

A series of RLTT testing was conducted on the stabilized expansive soil mixed with slag and tire. The sample prepared with extensive care in terms of homogeneity. Three different percentage of slag (i.e. 3,4,5 %) and three tire percentage (i.e. 10,15,20%) were used. The results of this research confirmed that:

-Tire percentage up to certain percentage (in this study 15%) helped the permanent deformation resistance.

-Slag inclusion of 4% was found to be the most effective percentage of this study.

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AUTHORS PROFILE

Amin Chegenizadeh, is senior lecturer in civil and mechanical engineering schools in Curtin University, Australia. His area of expertise is soil stabilization along with other geotechnical Cooperated in industry and engineering teams for 10 years to pursuit the goals of projects, collaborated and shared the progress of works in regular construction meetings, worked with the different discipline of engineers. Extensive knowledge of local geotechnical challenges of pavements and mine infrastructures in WA throughout and Australia my career. Knowledgeable and skilled at standard laboratory tests and operation of delicate and advanced laboratory equipment. Developing the hands on practice in geomechanics lab in Curtin University.

Mathew Tay, is a graduate student in Curtin University. His research project was on stabilsation with Lime Kiln Dust.

Hamid Nikraz, is an emeritus professor in civil and mechanical engineering schools in Curtin University, Australia. He is well known for his research on geotechnical and pavement engineering. He has delivered research excellence of high international standing and is a leading international authority in the field of geotechnical and pavement engineering, with particular interest to the sustainable use of industrial by-products in soil stabilisation, a study area that is applicable to the proposed research project. Several waste products are now finding alternative uses and are becoming more acceptable and commercially attractive as a result of his efforts.

Mahdi Keramati, is civil engineer working in Arup. He hols PhD in civil engineering. He has published many journal paper and is very active in research.