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Effect of Shear Rate Shear Strength of Sand Mixed with Fibre-Pine Shaving

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ABSTRACT
Shear rate is an important parameter in analysis of the shear strength of the soil. Whilst many studies conducted to investigate efficacy of the different materials on peak shear strength of the soil, importance of shear rate has been ignored. This study aims to investigate effect of three different shear rate (i.e., 0.2, 0.3, 0.4mm/min) on peak shear strength of the sand mixed with 2% fiber (F) when mixed with different pine shaving (PS) contents (i.e., 5, 10, 15%) by performing a series of experimental direct shear testing. The results of analysis showed that increasing the shear rate increased the peak shear strength and may cause less accurate result.

Key words: Soil Mechanics; Direct Shear; Experimental Analysis; Shear Strength; Sand; Fiber, Pine Shaving

1. INTRODUCTION
Soil and its complex behaviore should be studied due to stress distribution effect on the designs and also the effective parameters on stresses itself.[1,2,3] Application of different additives to improve mechanical behavior of soil is a common approach in soil stabilization. This method not only is a cost-effective method, helps to reduce the carbon footprint in the environment whilst the outcome has not been compromised. Different by-product materials have been investigated in this light. The by-products such as fly ash [4-6], slag [7-10], and fiber [12-18] widely has been considered. Lime as a cementitious agent widely has been used in soil stabilization projects [19,20]. Recycled tyre in form of crumbled or powdered has been widely utilized [21-23]. Sawdust [24] is another by-product that widely has been used to investigate shear strength behavior of soil. Improvement of the shear strength of contaminated soil is another venue for implementation of the by-products [25,26]. Investigation effect of parameters and by-products on liquefaction resistance of soil has been widely investigated [27-29]. Geo-grid also being applied in soil and different behavior was observed.[30,31]. While the compressive strength of materials important [32], from the reviewed literature, however there has been attempt to consider shear strength by inclusion of by product/fiber [33-42], it can be clearly seen that the shear rate impacts on peak shear strength of soils have been considered to less extent .In particular, pine shaving that has not considered in previous studies when mixed with fiber and sand. Therefore, this study designed to investigate effect of different shear rates on peak shear strength of sand mixed with fiber and pine shaving. This study of researches in Curtin University on soil stabilsation techniques.

2. MATERIALS
As indicated, this study investigates shear strength behavior of sand mixed with fiber and shaving pine. Therefore, the main materials used to perform this study includes sand, fiber, and pine shaving. The following sections provide more details regarding used materials.

2.1 Sand
The main material used in this study was sand. To perform the tests, Perth sand was employed. This sand had a specific gravity (*Gs*) of 2.65 and uniformity coefficient (*Cu*) equal to 0.6.

2.2 Pine Shaving
Pine shaving was sourced from a local source in Perth, Western Australia. The average size of PS was 0.5mm.

2.3. Fibre
Propylene fibre (PF) was used in this study with characteristics such as tensile moduli of 0.6 GPa and a elongations at break in the range 92%.

2. SHEAR TEST PROGRAM
The direct shear test was utilized to perform the tests. This is common testing device in evaluating shear strength of the soil, and more information can be found in soil mechanics books in this regard. Testing was performed at three different normal stresses of 100, 150, and 200 kPa. Also, three shear rates of 0.2, 0.3, and 0.4mm/min were utilized to perform the tests. Also, prior to perform the tests, a series of compaction

testing performed to investigate the optimum moisture content (OMC) and the maximum dry density (MDD). This information will be utilized at the time of sample mixture and preparation. Table 1 shows the testing programs used to utilize the tests.

Table 1: Testing program utilized in this study

Sample ID	PS (%)	Shear Rate (mm/min)	Fiber (%)
S-2F-5PS	5	0.2, 0.3, 0.4	2
S-2F-10PS	10	0.2, 0.3, 0.4	2
S-2F-15PS	15	0.2, 0.3, 0.4	2

3. TEST RESULTS

3.1. Compaction Results

Table 2 shows the compaction characteristics of the used mixtures. As seen, addition of PS increased the OMC and reduced MDD value of the mixtures. In fact, when pine shaving mixed with the soil, the mixture would need more moisture to have a similar performance and workability with mixtures with no pine shaving. Therefore, an increase in OMC and a reduction in MDD has been recorded.

Table 2: Results of compaction tests

Sample ID	PS (%)	OMC (%)	MDD
S-2F-5PS	5	12	1.61
S-2F-10PS	10	14	1.58
S-2F-15PS	15	15.2	1.51

3.2. Direct Shear Tests

Figure 1 to 3 shows the results of shear strength for specimens with 5, 10, and 15% pine shaving when the test run at 0.2mm/min. As can be seen, addition of PS increased the peak shear strength at all three tested normal stresses. Similarly, an increasing trend can be seen when the tests were run at a shearing rate of 0.3mm/min. This fact can be seen in Figure 4 to 6. Likewise, the specimens showed a similar behavior at 0.4mm/min when 5, 10, and 15% PS were added into the specimens. Figure 7 to 9 shows this behavior. This behaviour can be attributed to the formed bonds amongst sand, fiber and the pine shaving that increasing the pine shaving increases these bonds amongst soil particles.

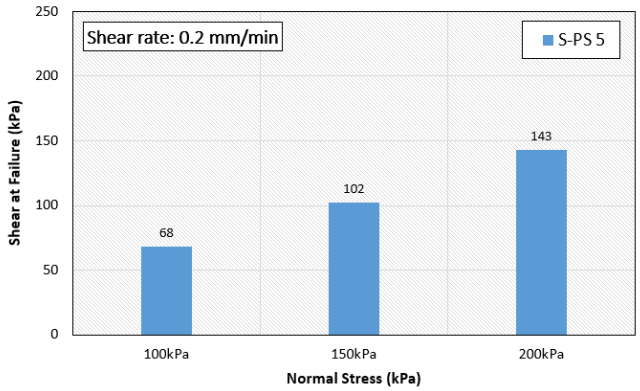

Figure 1: Shear at failure at 0.2 mm/min, 5% PS, 2% F.

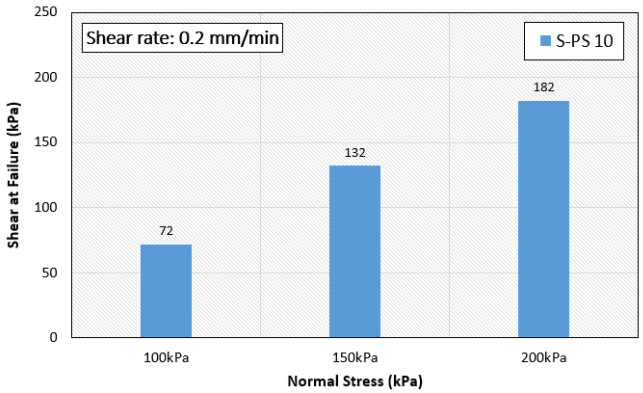

Figure 2: Shear at failure at 0.2 mm/min, 10% PS, 2% F.

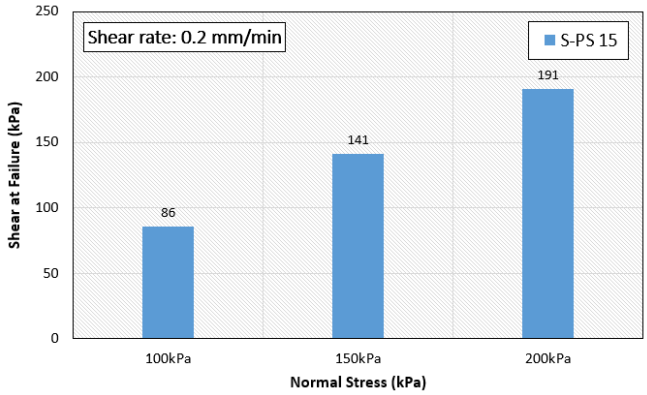

Figure 3: Shear at failure at 0.2 mm/min, 15% PS, 2% F.

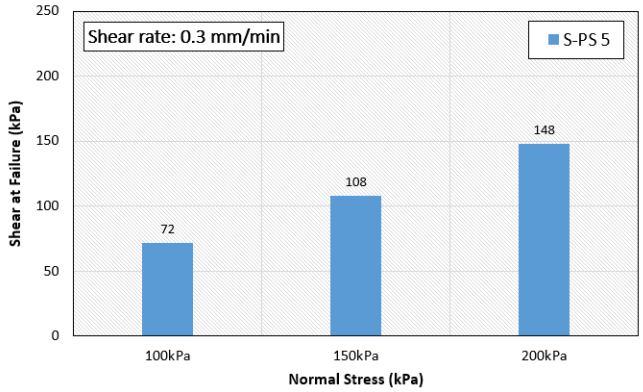

Figure 4: Shear at failure at 0.3 mm/min, 5% PS, 2% F.

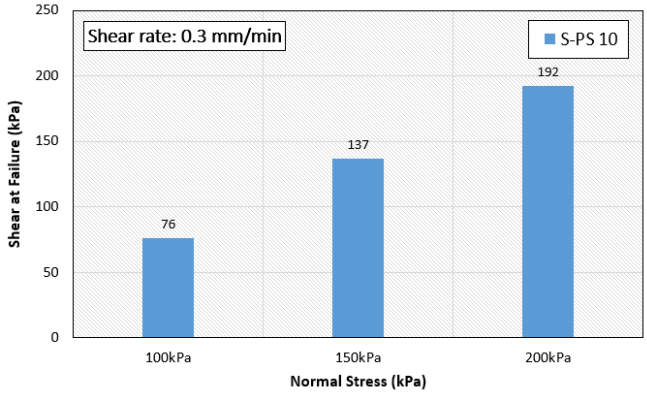

Figure 5: Shear at failure at 0.3 mm/min, 10% PS, 2% F.

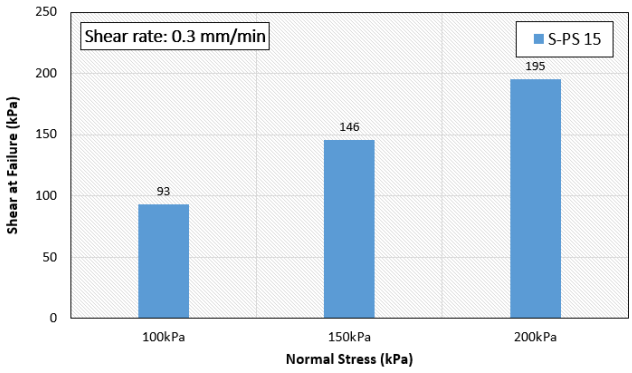

Figure 6: Shear at failure at 0.3 mm/min, 15% PS, 2% F.

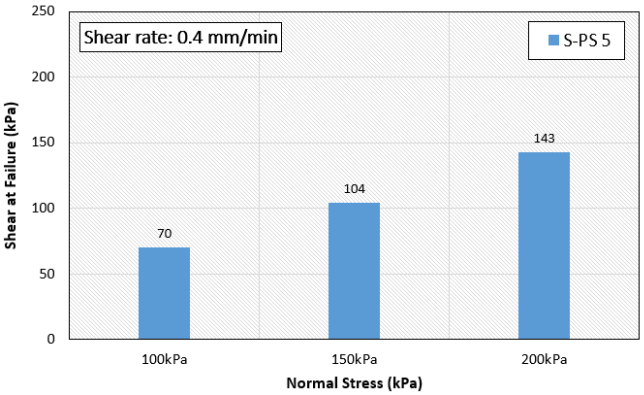

Figure 7: Shear at failure at 0.4 mm/min, 5% PS, 2% F.

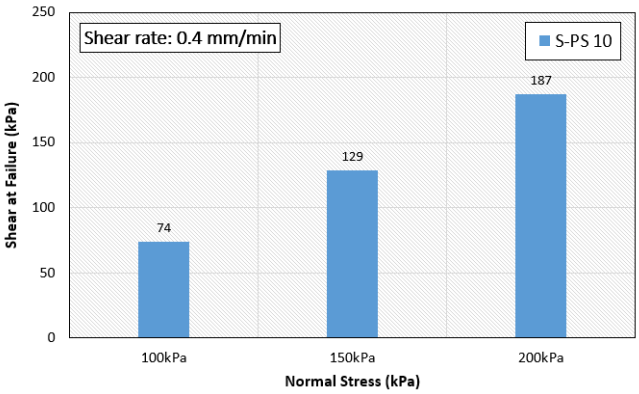

Figure 8: Shear at failure at 0.4 mm/min, 10% PS, 2% F.

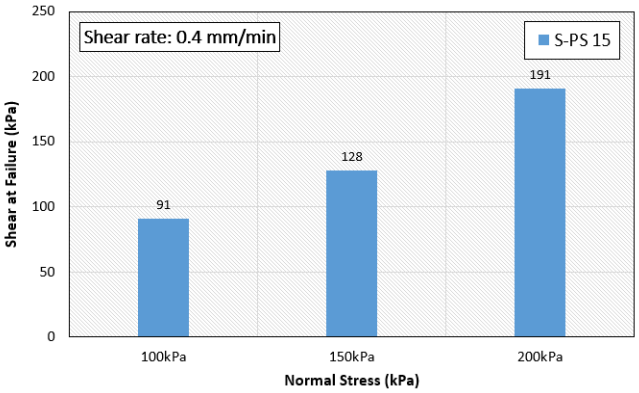

Figure 9: Shear at failure at 0.4 mm/min, 15% PS, 2% F.

5. CONCLUSION

Shear rate is an important parameter that has been considered to less extent to dat. This study investigated effect of three shearing rates of 0.2, 0.3, 0.4mm/min by performing a series of direct shear tests on mixtures of sand, fiber, and pine shaving. At the first stage, compaction testing was conducted on the mixtures and the optimum moisture content (OMC) and maximum dry density (MDD) values were calculated. In the next stage, the direct shear testing was conducted. Three pine shaving were considered (i.e., 5, 10, 15%). The results showed that increasing the pine shaving increased the shear strength under all three tested normal stresses of 100, 150, and 200 kPa. However, the results showed that increasing the shearing rate increased the shear strength which might be led to inaccurate results.

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