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Journal Articles

1. **Rawat, P.** and Mohanty, S., 2021. Experimental investigation on MSW fine mixed with fibers: Fiber reinforced waste. **Journal of Hazardous, Toxic, and Radioactive Waste**, 25(3), p.04021009. DOI: 10.1061/(ASCE)HZ.2153-5515.0000609. (Published)
2. **Rawat, P.** and Mohanty, S., 2022. Parametric Study on Dynamic Characterization of Municipal Solid Waste Fine Fractions for Geotechnical Purpose. **Journal of Hazardous, Toxic, and Radioactive Waste**, 26(1), p.04021047. DOI: 10.1061/(ASCE)HZ.2153-5515.0000659. (Published)
3. **Rawat, P**. and Mohanty, S., 2022. One-Dimensional Compressibility Study on Fiber-Reinforced Municipal Solid Waste (MSW Fines). **Indian Geotechnical Journal**, pp.1-8. DOI: 10.1007/s40098-022-00679-z. (Published)
4. **Rawat, P.** and Mohanty, S., 2023. Study on Cyclic Strength and Pore Water Pressure response of Fiber-reinforced Municipal Solid Waste (MSW Fines). **Acta geotechnica**, pp.1-15. DOI: 10.1007/s11440-023-01818-3. (Published)
5. Ram, A.K., **Rawat, P.** and Mohanty, S., 2023. Strength performance of soil-fly ash-MSW fine layered system under different controlled loading conditions: A comparative study. **Construction and Building Materials**, 369, p.130524. DOI: 10.1016/j.conbuildmat.2023.130524. (Published)
6. **Rawat, P**. and Mohanty, S. (**Under review**) Mini-State of the Art Review on Engineering Perspective of Municipal Solid Waste (Fine Fractions) and its applications. **Critical Reviews in Environmental Science and Technology.**

7. **Rawat, P**. and Mohanty, S. (**Under review**) Experimental Study on Shear Wave Velocity Determination and Correlation Between Normalized Small Strain Shear Modulus and Shear Strength of Fiber-Induced MSW Fines. **Bulletin of Engineering Geology and the Environment.**
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9. **Rawat, P.** and Mohanty, S., (**Under review**). Static and Dynamic Loading Effects on the Strength Characteristic of Municipal Solid Waste (MSW) Fines Reinforced with Geosynthetics. **Sadhana**.

Conference Proceedings

1. **Rawat, P.,** Kumar, P. and Mohanty, S., 2020.Study on Permeation Grouting with Cement to Improve Load Carrying Capacity of Sandy Soil" Proceedings of **Indian Geotechnical Conference** 2020, December 17-19, 2020, Andhra University, Visakhapatnam.

Lecture Note

1. **Rawat, P.,** and Mohanty, S., 2021. 1D and 2D dynamic site response of landfill site through numerical analysis. In **Local Site Effects and Ground Failures** (pp. 91-103). Springer, Singapore.

2. **Rawat, P.,** and Mohanty, S., 2021. Utilization of municipal solid waste as backfill material. In Proceedings of the Indian **Geotechnical Conference 2019** (pp. 49-62), Lecture Note in Civil Engineering. Springer, Singapore.
3. **Rawat, P.,** and Mohanty, S., 2022. Study of Municipal Solid Waste in Road Embankment. In Proceedings of the **7th Indian Young Geotechnical Engineers Conference** (pp. 195-207). Springer, Singapore.
4. **Rawat, P.,** Mohanty, S. 2023. Potential Use of Fine Fraction of Municipal Solid Waste as Replacement of Soil in Embankment. In: Muthukkumaran, K., Ayothiraman, R., Kolathayar, S. (eds) **Soil Dynamics, Earthquake and Computational Geotechnical Engineering**. IGC 2021. Lecture Notes in Civil Engineering, vol 300. Springer, Singapore.

APPENDIX-A

GEOSYNTHETIC REINFORCED MSW FINES

A.1 INTRODUCTION

The study investigates the influence of geonet and non-woven geotextile reinforcement on the strength performance of municipal solid waste (MSW fines). A set of unconsolidated undrained (UU) static and cyclic triaxial tests were conducted on the reinforced MSW fines samples by a varying number of reinforcement layers (0, 1, 2, and 3) to investigate the stress-strain and strength behaviour of the composite material. The MSW fines (particle size < 4.75mm) itself is a weak material and require additional ground improvement techniques for their field applications. The laboratory experiments show improvement in the static strength of the considered composite material with reinforcements.

A.2 MATERIAL PROPERTIES

The two types of geosynthetics were considered for the study, i.e., geonets and geotextile. The material properties of these geosynthetics are provided in the Table. A.1 as provided by the manufacturers. The geosynthetics used are shown in Figure A.1

The geonet used in this study was a polymer grid made of high-density polyethylene (HDPE) with high dimensional stability and junction strength with integrally fused joints. They are resistant to environmental and UV degradation. Geonets are used to control slope erosion, landscape, retaining wall and toe wall gabions, drainage, and to protect pipeline layers. Needle-punched and thermally bonded polypropylene non-woven geotextile was used in the study. Non-woven geotextiles have higher permeability and smaller characteristic opening size, making them suitable for subsurface drainage, erosion control, and road stabilization over wet moisture sensitive soils.

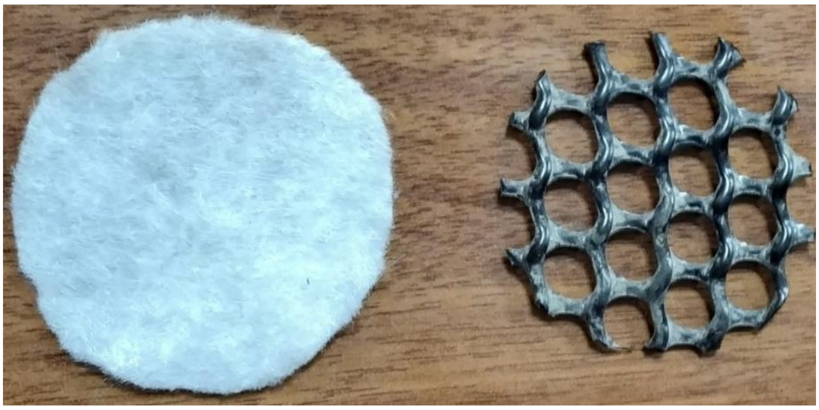

(a) **(b)**

Figure A.1 Geosynthetics used in the study **(a)** Geotextile, and **(b)** Geonet

Table A.1 Properties of the reinforcing material used.

Properties	Geotextile (non-woven)	Geonet
Thickness (mm)	1.2	3
Tensile strength (kN/m)	10	-
Elongation at break (%)	50	-
CBR puncture resistance (N)	1600	-
Dynamic cone drop (mm)	28	-
Permeability (m/s)	$115*10^{-3}$	-
Mass per unit area (g/m^2)	120	730
Aperture shape and size (mm)	-	Diamond 8*6 (±0.25)
Thickness at joint (mm)	-	3.1(±0.25)
Max. strength kN/m	-	7.68
*As per the manufacturer specifications (TUFLEX geosynthetics)		

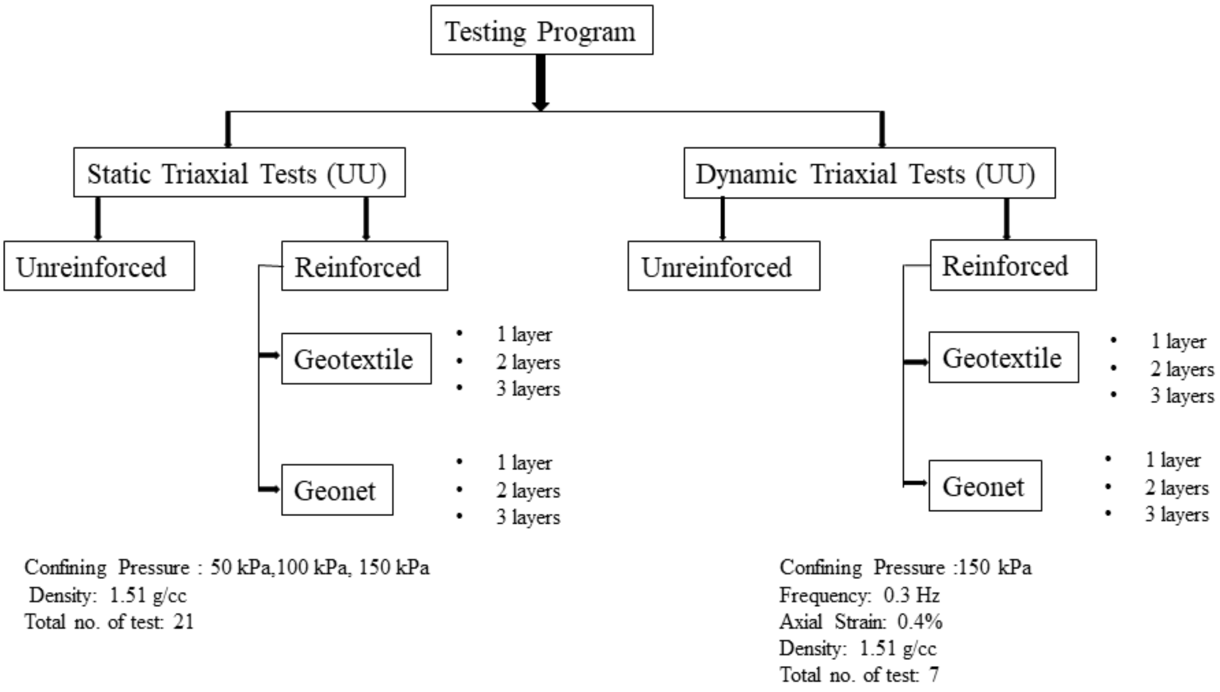
A.3 EXPERIMENTAL STUDY

A.3.1 Testing Program

Here, two sets of triaxial tests were conducted for the unreinforced and reinforced (geotextile and geonet) MSW fine samples under unconsolidated undrained (static and cyclic) conditions. The testing program of the present study is shown through a flowchart in Figure A.2. The considered MSW fines were reinforced (geotextile and geonet) in 1, 2, and 3 layers, and other parameters were maintained constant for both static and cyclic triaxial tests. A series of strain-controlled static and cyclic unconsolidated undrained (UU) triaxial tests were performed at a maximum dry density of the specimen. The specimens for the static tests were tested under a strain rate of 1.2 mm/min and for three confining pressures (σ_c: 50, 100, and 150 kPa) according to IS: 2720 part 11 (1993). The cyclic triaxial tests were conducted on the reinforced samples as per the ASTM D3999 (2013) by keeping all other parameters constant (confining pressure: 150 kPa, axial strain: 0.4%, and loading frequency: 0.3 Hz). The static (cohesion: c and angle of friction: ϕ) and dynamic (shear modulus: G and damping ratio: D) strength parameters for different reinforcements were computed and analyzed through the above-mentioned tests.

A.3.2 Sample Preparation

The samples were prepared with 0, 1, 2, and 3 layers of reinforcement (geotextile and geonet) embedded in the MSW fines with uniform spacing (Figure A.3). All the reinforcements were arranged in a planar manner, i.e., reinforcements are placed horizontally with no inclination. The samples of the considered MSW fines were prepared at MDD (maximum dry density) and OMC (optimum moisture content), i.e., 1.51 g/cc and 18.40%, respectively. The size of the samples was fixed, i.e., height of the sample (h): 76 mm and diameter of the sample (d): 38 mm for the static triaxial test and (h):100 mm and (d): 50 mm for the cyclic triaxial test. The samples were prepared by the moist tamping technique of specimen preparation (Silver et al. 1976). The unreinforced sample was compacted in four equal layers in a split mould. Each layer was tamped 25 times and density was ensured after every layer. Similarly, the reinforced samples were prepared for 1, 2, and 3 layers of geotextile and geonet reinforcement. In the first case, the reinforcement was placed in the middle of the sample by dividing the split mould into four equal parts and compacting the first two layers as mentioned above for unreinforced sample preparation, and then after placing the reinforcement, another two layers were compacted. For the 2 layers reinforcement, the sample was compacted in equal layers, and after each layer reinforcement was placed ensuring the height after each compaction. In 3-layer reinforcement, the sample was compacted in four layers as mentioned above by placing the reinforcement after each layer of compaction.



Confining Pressure : 50 kPa,100 kPa, 150 kPa
Density: 1.51 g/cc
Total no. of test: 21

Confining Pressure :150 kPa
Frequency: 0.3 Hz
Axial Strain: 0.4%
Density: 1.51 g/cc
Total no. of test: 7

Figure A.2 Flow chart of the testing program considered for the present study

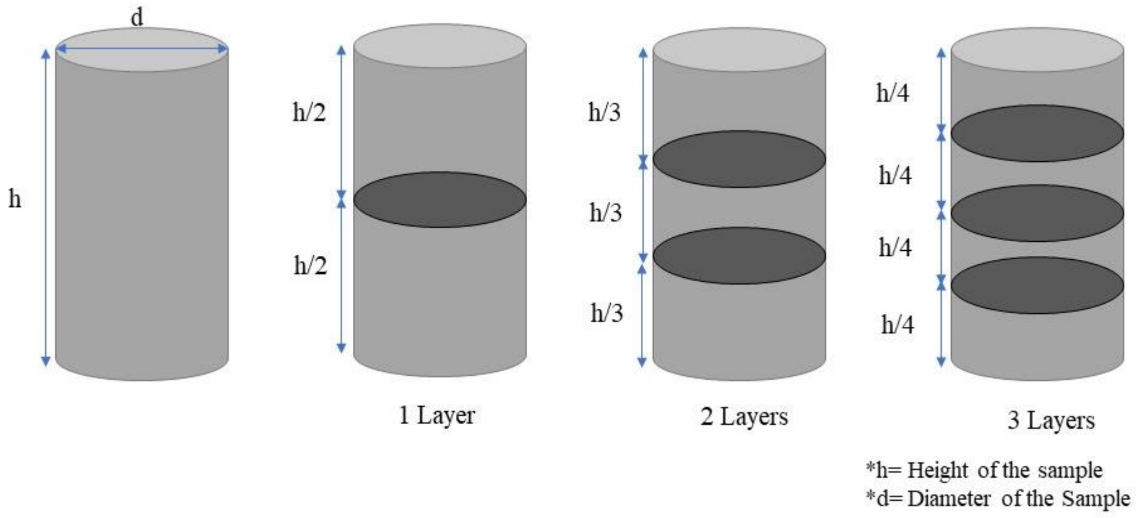


Figure A.3 Geosynthetics arrangements considered for the study

A.4 EXPERIMENTAL RESULTS AND DISCUSSION

A.4.1 Strength Performance of Reinforced MSW Fines under Static Loading Condition

The reinforcement improves the mechanical properties of the soil by providing tensile strength to the material and hence preventing deformation. The samples for this study have been prepared as mentioned above in section A.3.2 and the strength behaviour was analyzed under the static loading condition. The failure patterns of the specimens were compared before and after the testing (Figure A.4). It can be observed that for both the reinforcements in the case of the single layer (Figure A.4(d and g)) top bulging is predominant whereas in the double layers (Figure A.4(e and h)) the maximum bulging can be seen in the middle portion of the specimen. A similar kind of bulging failure was observed in the case of reinforced coarse soil and fly ash specimens (Ram Rathan Lal and Mandal 2013; Chen et al. 2014). In the case of three-layered reinforcement, the maximum bulging can be seen in the top layer for geotextile (Figure A.4(f)), whereas for geonet the maximum bulging was seen in the middle section of the specimen (Figure A.4(i)).

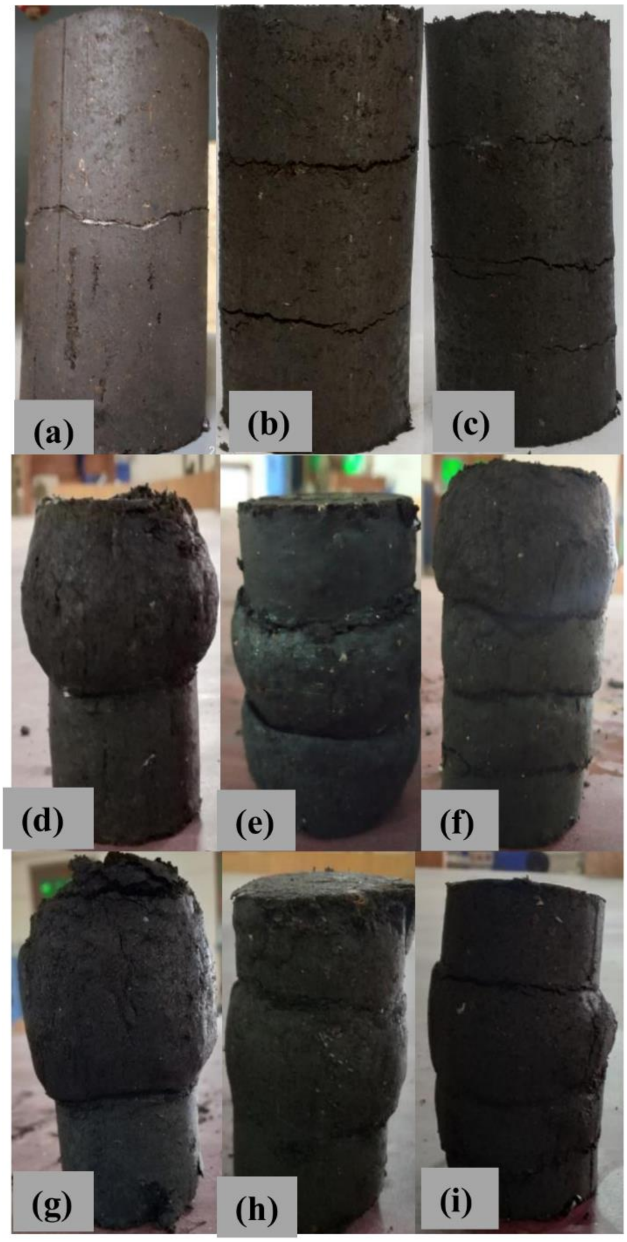


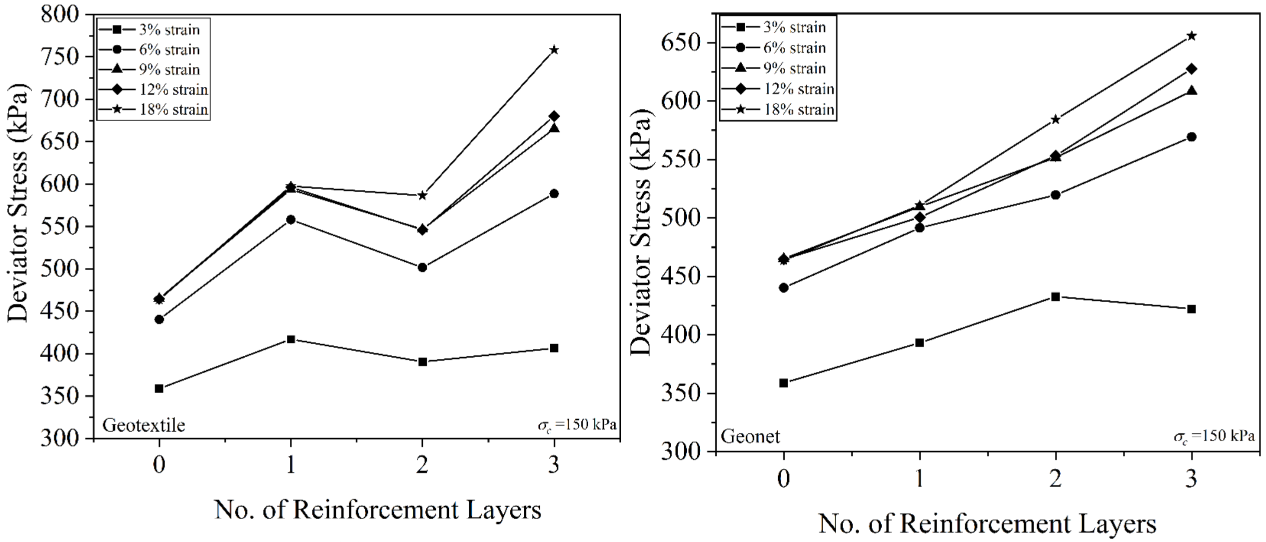
Figure A.4 Sample images **(a)** 1-layer reinforcement, **(b)** 2-layers reinforcement, and **(c)** 3-layers reinforcement before failure, and failure pattern images of sample for **(d)** 1-layer geotextile reinforcement, **(e)** 2-layers geotextile reinforcement, **(f)** 3-layers geotextile reinforcement, **(g)** 1-layer geonet reinforcement, **(h)** 2-layers geonet reinforcement, and **(i)** 3-layers geonet reinforcement at confining pressure of 150 kPa

A.4.2 Shear Strength Behaviour of Geotextile Reinforced MSW Fines

The stress-strain behaviour of the MSW fines with and without geotextile reinforcement is shown in Figure A.5(a), where the confining pressure (σ_c) was kept constant at 150 kPa. At a lower strain of 3%, there is little improvement with the increasing number of reinforcement layers. For one-layer reinforcement, the maximum strain increment is 16.17%. Above 3% strain, 3-layer reinforcement increases the stress from 33.72% (6% strain) to 63.46% (18% strain) over the unreinforced MSW fine samples. When comparing 2-layer reinforcement to 1-layer reinforcement, the percentage decrement decreases from 45.45% to 8.33% as the strain increases. At higher strain, there was no improvement in stress levels for the unreinforced and 1-layer reinforcement, indicating yielding after 6% strain. For 2 and 3-layered reinforced MSW fine samples, stain hardening can be seen at higher strains. Shukla reported on the reinforcing mechanism of geosynthetics (Shukla 2002). The deformed geosynthetic provides vertical support to the overlying material because the samples are only subjected to normal load. The membrane effect refers to this mechanism of stress transfer from soil to geosynthetics (Shukla et al. 2009).

In the case of reinforced sand with geotextile, reinforcement greatly increases the deviator stress, especially at low confining pressure, due to the geotextile's poor tensile strength at high elongation (Denine et al. 2016), whereas in the current study reinforcement increases the deviator stress but also improves with increasing confining pressure.

Figure A.6(a) shows the improvement in strength with confining pressure, which is also justified in the case of reinforced or unreinforced soils. At each confining pressure, 3-layered reinforced MSW fine samples show the greatest shear strength improvement. The average shear strength plot (Figure A.8) also showed that 3-layered reinforced MSW fine samples improved the most. For the unreinforced MSW fine samples, the improvement in the average shear strength is more than 100%. The same improvement in strength can be seen from the Mohr circle representation at failure (at σ_c =150 kPa) (Figure A.7(a)).

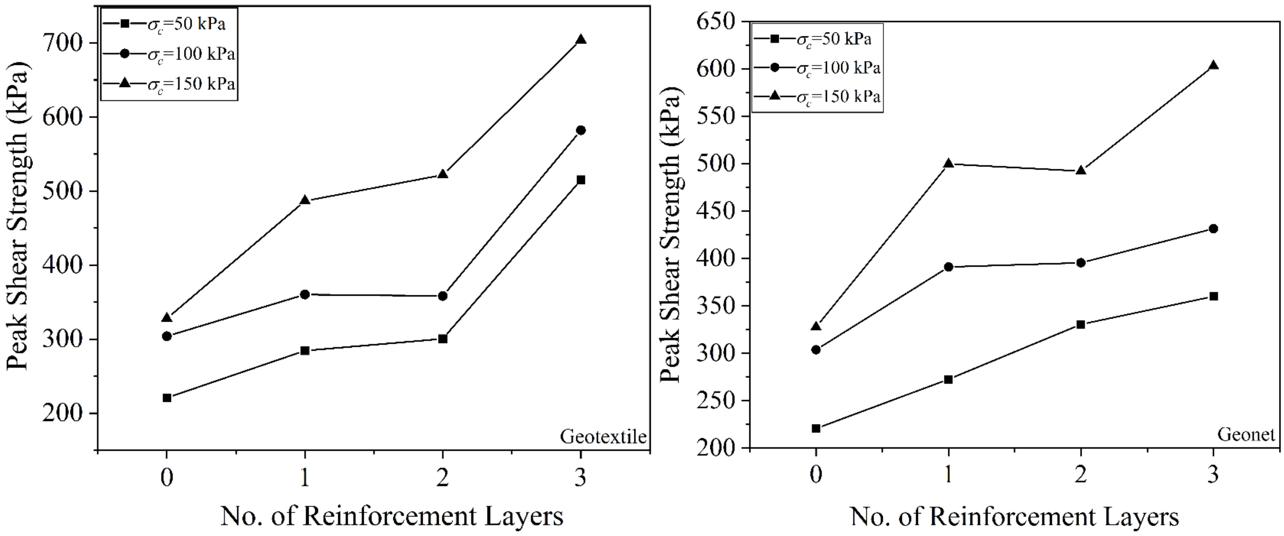


(a) **(b)**

Figure A.5 Deviator stress variation with number of reinforcement layers for **(a)** Geotextile, and **(b)** Geonet at confining pressure of 150 kPa

A.4.3 Shear Strength Behaviour of Geonet Reinforced MSW Fines

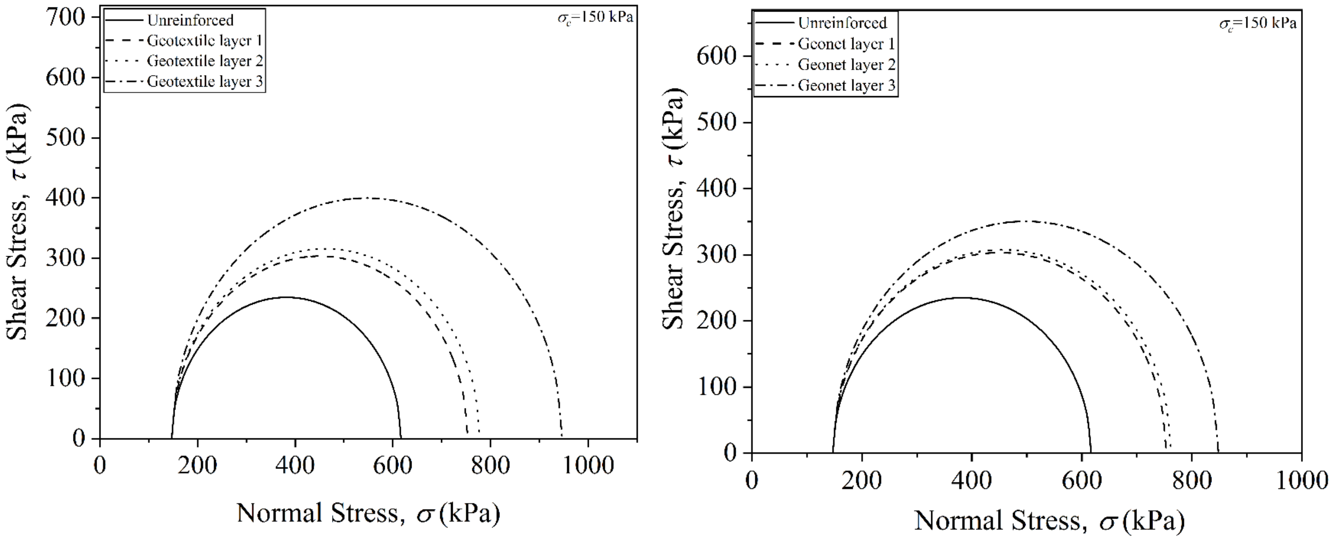
The stress-strain behaviour of the MSW fines with and without geonet reinforcement (Figure A.5(b)) shows that at a lower strain of 3%, there is no change in stress by increasing the reinforcement layers from 2 to 3, but at higher strains, the increments are very linear with the increase in reinforcement layers. At 18% strain, the increment in deviator stress is about 10, 25, and 41% for 1, 2, and 3-layer reinforcement respectively as compared to the unreinforced MSW fines. Similar trends of stain hardening can be seen for 2 and 3-layer reinforcements in this case also. The variation of strength with the number of reinforcement layers and confining pressure is shown in Figure A.6(b) which verified the strength improvement with both increasing confining pressure and the number of reinforcement layers. Although the percentage improvement in the peak shear strength is comparatively lower than that of the MSW fines reinforced with geotextiles. This can be validated by Figure A.8 where the average shear strength of both the reinforced cases is compared. For 1 and 2-layer reinforcements, the difference is very less but the percentage improvement in the average strength is about 111% and 63% in the case of geotextile and geonet reinforcement respectively compared to the unreinforced MSW fines. The increment in Mohr circle diameter (Figure A.7(b)) with the reinforcement also shows an improvement in shear strength.



(a)

(b)

Figure A.6 Peak shear strength variation with number of reinforcement layers for **(a)** Geotextile, and **(b)** Geonet for varying confining pressures (50,100 and 150 kPa)



(a) **(b)**

Figure A.7 Mohr circles for unreinforced and reinforced **(a)** Geotextile, and **(b)** Geonet at confining pressure of 150 kPa

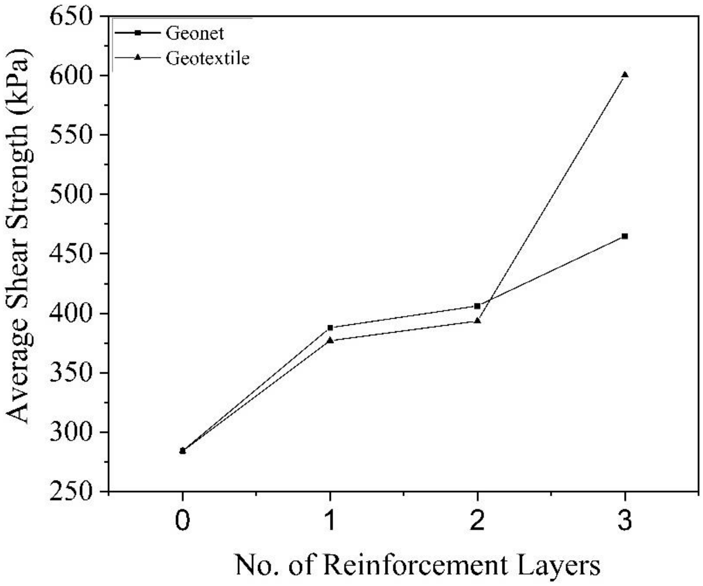
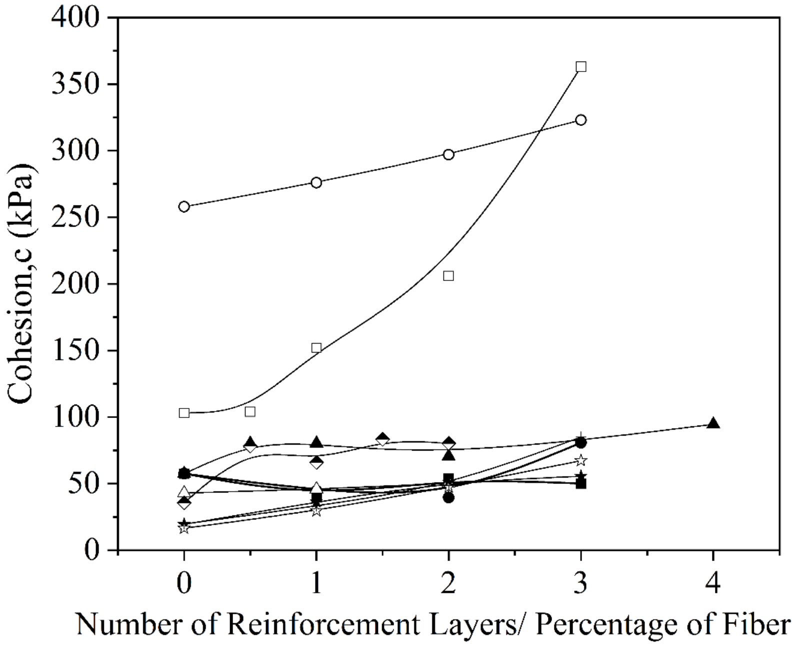
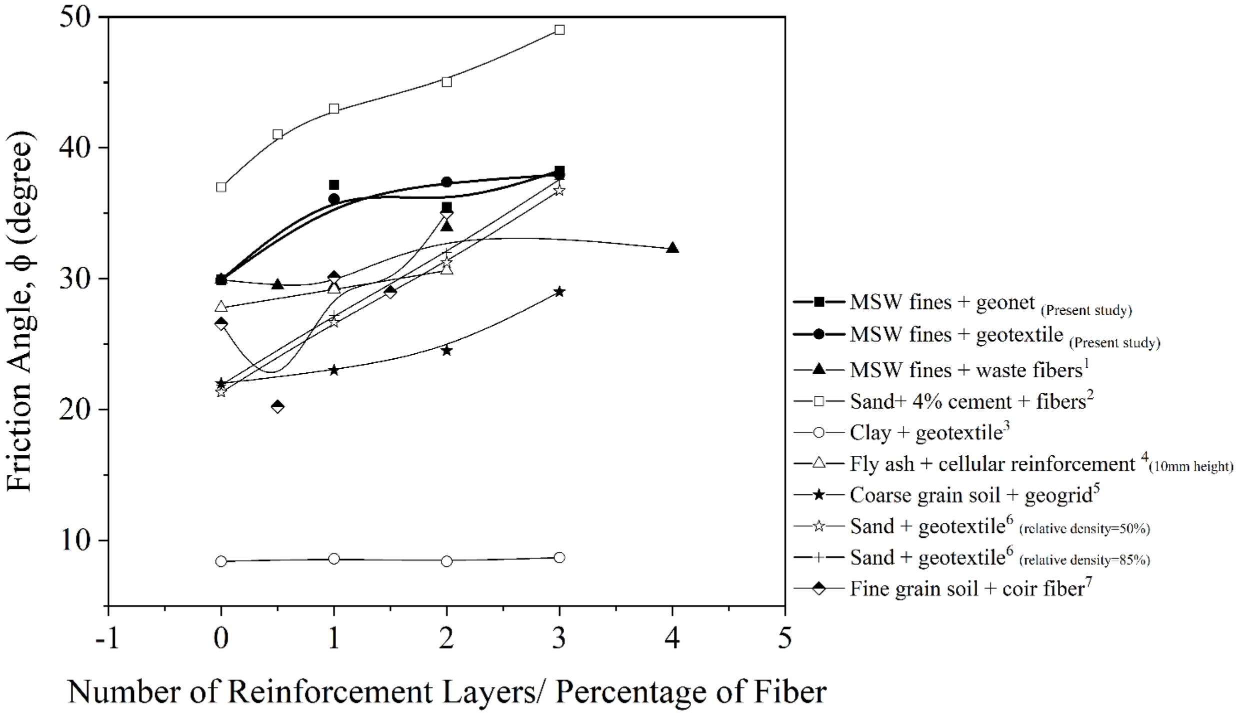


Figure A.8 Average shear strength comparison of geotextile and geonet

The comparison of cohesion and friction angle of the present study with other composite reinforcement materials (randomly distributed (natural and artificial) fibers and layered geosynthetics) have been shown in Figure A.9 (a, and b). It can be noticed that the friction angle obtained from the present study is in good alignment with the other studies. However, there is very little difference in friction angle values of the two reinforcements (geonet and geotextile) used in the present study. Similarly, by comparing the cohesion value obtained from the present study with the other reinforced materials or soils, it can be observed that the cohesion values are in a similar range of reinforced sand (coarse grain) or fly ash.



(a)



(b)

Figure A.9 Comparison of present study **(a)** cohesion (c), and **(b)** friction angle (ϕ) with other composite reinforced studies. (Note: [1](Fiber reinforced MSW fines (Present study); [2](Maher and Ho 1993); [3](Noorzad and Mirmoradi 2010); [4](Ram Rathan Lal and Mandal 2013); [5](Chen et al. 2014); [6](Benessalah et al. 2016); [7](Dasaka and Sumesh 2011))

A.4.4 MSW Fines–Geosynthetic Strength Ratio

The strength ratio parameter (SR) is defined as the maximum deviator stress in the case of reinforced soil ($q^{\mathrm{R}}{}_{\mathrm{max}}$) to maximum deviator stress of unreinforced ($q^{\mathrm{UR}}{}_{\mathrm{max}}$) one, shown in Equation A.1 (Latha and Murthy 2007; Denine et al. 2016).

$$SR = q^{R}_{max}/q^{UR}_{max} \tag{A.1}$$

Table A.2 summarizes the maximum deviator stress and strength ratio (SR) obtained for different reinforcing layers and confining pressure. It is indicated that SR increases with the number of layers of the reinforcements (geotextile and geonet) for any particular confining pressure, which is also true for the reinforced sand cases (Zhang et al. 2006; Chen et al. 2014; Denine et al. 2016). The results in the present case are a little contrary to the sand case where geosynthetics improves the shear strength of sand under low confining pressure whereas here improvements can be seen at higher confining pressure (150 kPa).

Table A.2 Strength ratio values obtained from the experimental study.

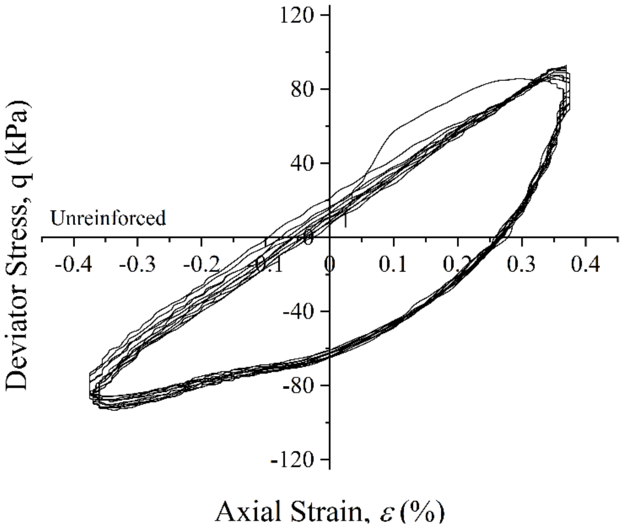
No. of layers	σ_c (kPa)	Geotextile		Geonet	
		$q_{\max}$ (kPa)	SR	$q_{\max}$ (kPa)	SR
0 (UR)	50	283.72	1	283.72	1
	100	428.00	1	428.00	1
	150	469.59	1	469.59	1
1 (R)	50	328.89	1.16	307.21	1.08
	100	433.00	1.01	463.40	1.08
	150	606.40	1.29	606.44	1.29
2 (R)	50	341.31	1.20	388.53	1.37
	100	416.80	0.97	479.51	1.12
	150	631.10	1.34	615.20	1.31
3 (R)	50	557.48	1.96	392.79	1.38
	100	643.20	1.50	483.40	1.13
	150	799.64	1.70	701.01	1.49
*UR= unreinforced; R= reinforced; σ_c= confining pressure; $q_{\max}$= maximum deviator stress; SR= strength ratio					

A.4.5 Strength Performance of Geosynthetic Reinforced MSW Fines under Cyclic Loading Condition

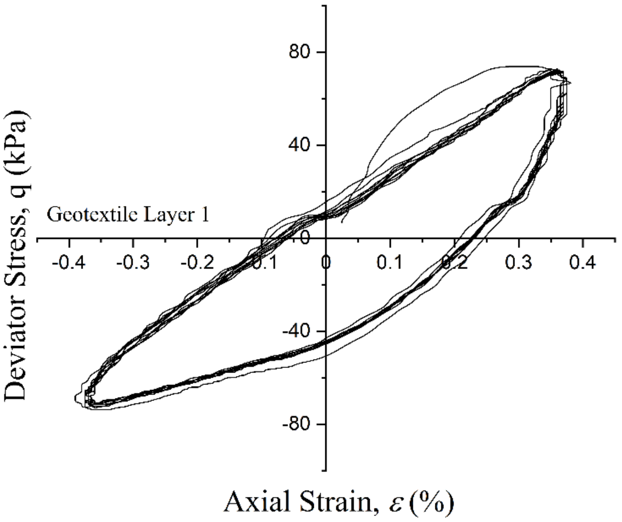
The unconsolidated undrained (UU) cyclic triaxial tests were performed on the unreinforced and reinforced samples of MSW fines to check the improvement in dynamic strength parameters (dynamic shear modulus (G) and damping ratio (D)) with the applied reinforcement layers. The deviator stress and axial strain variation for 10 cycles for the unreinforced (Figure A.10(a)) and reinforced MSW fines with geotextile (Figure10 (b, c, and d)) and geonet (Figure A.10(e), A.10(f), and A.10(g)) shows that there is no improvement of deviator stress with any number of reinforcement layers or reinforcement type. The same can be concluded from Figure A.11(a) and A.11(b) where the area enclosed by the hysteresis loop for the 1st cycles has been compared for both the reinforcement types and the unreinforced MSW fines have the largest loop area as compared to the reinforced ones. The stress-controlled cyclic tests on dry sand and silty sand show a decrease in the cyclic ductility (area of hysteresis loop) with an increase in the geotextile layers from 1 to 3 which is due to an increase in the soil strength and reduction in the strain at constant stress as the distance between geotextile layers decreases (Naeini and Gholampoor 2014). In the present case, which is a strain-controlled cyclic triaxial test, the inclusion of geosynthetic layers decreases the area of the loop which is due to the decrease in soil strength and reduction in stress at a constant strain.

By comparing the dynamic strength parameters (G_{avg} and D_{avg} values are averages of the first 10 cycles) of the reinforced and unreinforced MSW fine samples presented in Table A.3, it can be noticed that there is a decrease or no improvement in G value with the increase in the number of reinforcement layers in both the cases and D value has no significant variation. However, pond ash (categorized as inorganic silts of low plasticity with a specific gravity of 2.18) reinforced with geotextile (1 and 3 layers) shows improvement in the secant shear modulus, friction angle, and liquefaction resistance with reinforcement (Vijayasri et al. 2016). The results are not aligned with the past studies but there are various parameters on which the performance of MSW fines depends, i.e., type of test, sample preparation, geosynthetic type and properties, material properties, loading parameters, etc. This concluded that the addition of reinforcement to the MSW fines does not improve the cyclic strength of the material, this may be because the reinforcements are horizontally placed in the sample and create a discontinuity in the sample. In the case of static loading, the load is applied vertically in one direction, i.e., compressive load and reinforcement layers can distribute that load. However, in the case of cyclic loading, the sample must go through a series of compressive and expansive loading cycles and these discontinuities (reinforcement layers) divide the sample into different parts which act separately during the cyclic loading. The reinforced samples work excellently in compressive loading but fail in tension.

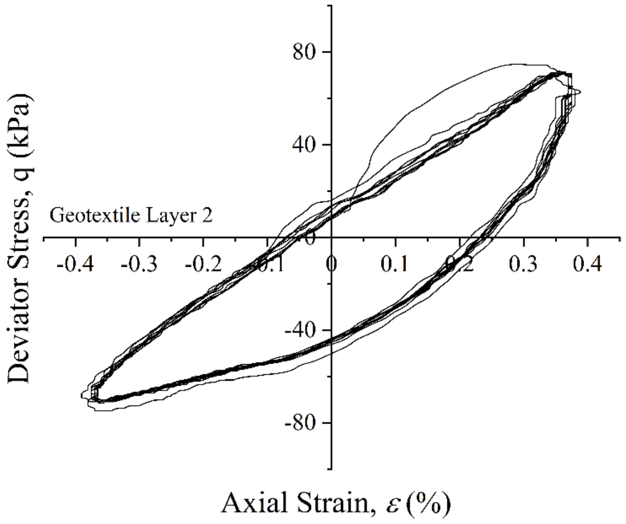
Although there is no improvement of dynamic shear modulus (G) with reinforcement, G shows improvement with the number of cycles, this improvement is not significant for the reinforced MSW fines but in the unreinforced cases, there is a continuous improvement from 7500 kPa to 9000 kPa (Figure A.12(a) and A.12(b)). The tests were conducted under unconsolidated undrained conditions and when the cyclic loading was applied, the sample gets compacted and does not rebound as in the case of the reinforced case and hence improving its cyclic shear strength after every cycle for unreinforced MSW fines. The damping ratio shows a downfall with the number of loading cycles irrespective of the reinforcement type and number of layers, but the maximum damping ratio was recorded for 2-layered reinforcement for both cases (Figure A.12(c) and A.12(d)).


Unreinforced
Deviator Stress, q (kPa)
Axial Strain, ε (%)
120
80
40
0
-40
-80
-120
-0.4
-0.3
-0.2
-0.1
0
0.1
0.2
0.3
0.4

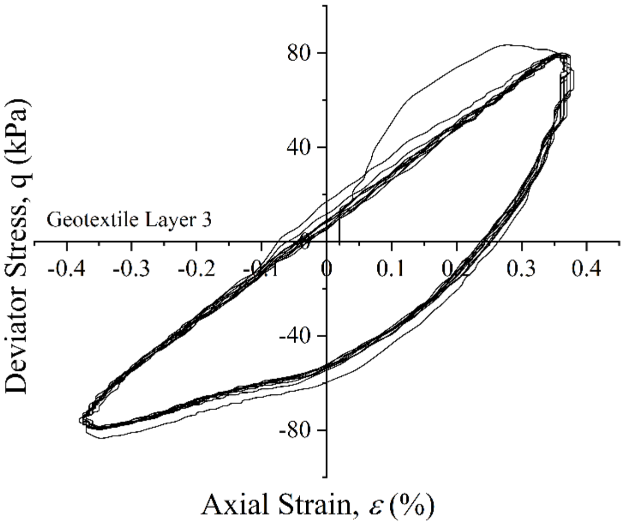
(a)


Geotextile Layer 1
Deviator Stress, q (kPa)
Axial Strain, ε (%)
80
40
0
-40
-80
-0.4
-0.3
-0.2
-0.1
0
0.1
0.2
0.3
0.4

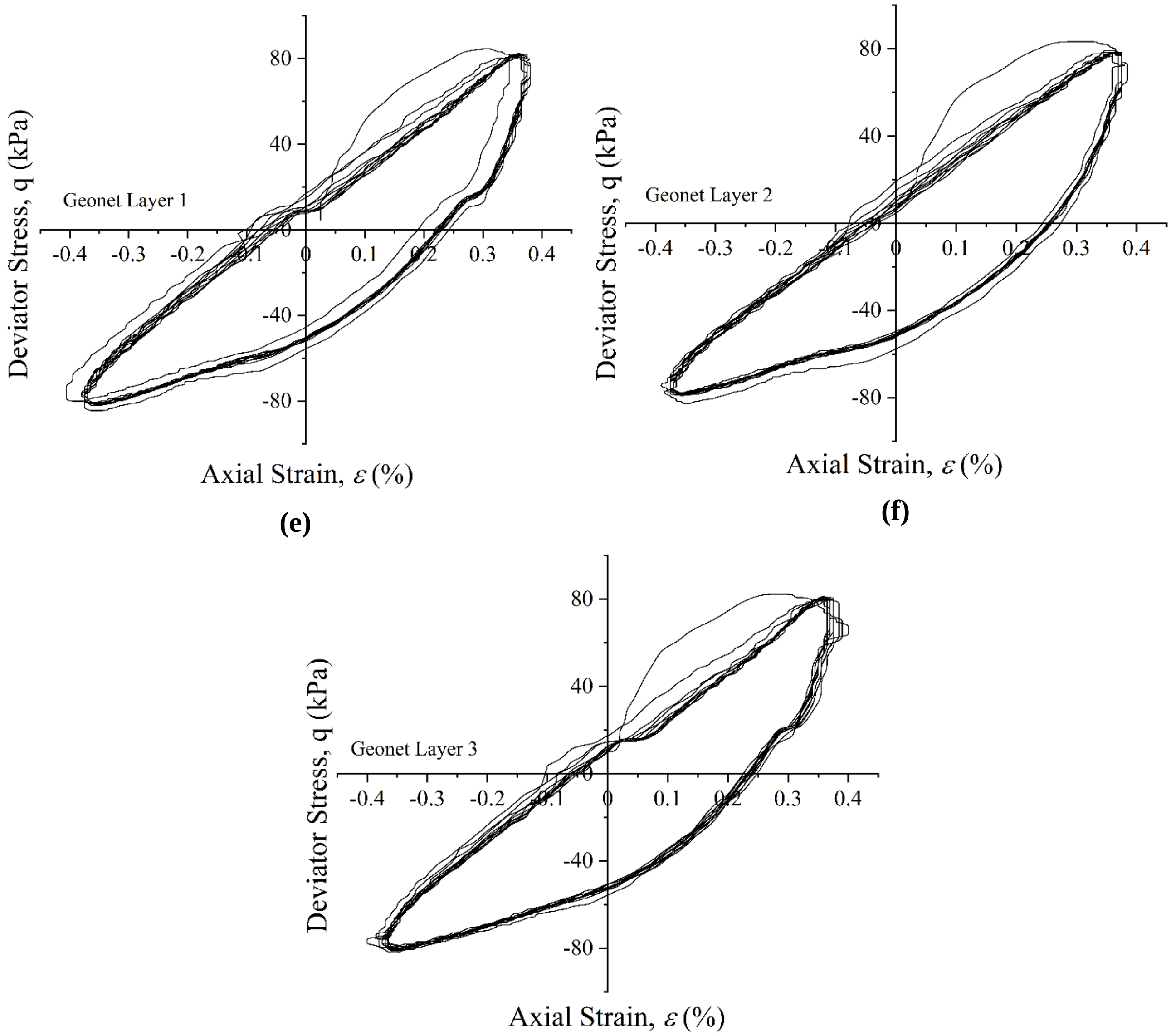
(b)


Geotextile Layer 2
Deviator Stress, q (kPa)
Axial Strain, ε (%)
80
40
0
-40
-80
-0.4
-0.3
-0.2
-0.1
0
0.1
0.2
0.3
0.4

(c)


Geotextile Layer 3
Deviator Stress, q (kPa)
Axial Strain, ε (%)
80
40
0
-40
-80
-0.4
-0.3
-0.2
-0.1
0
0.1
0.2
0.3
0.4

(d)

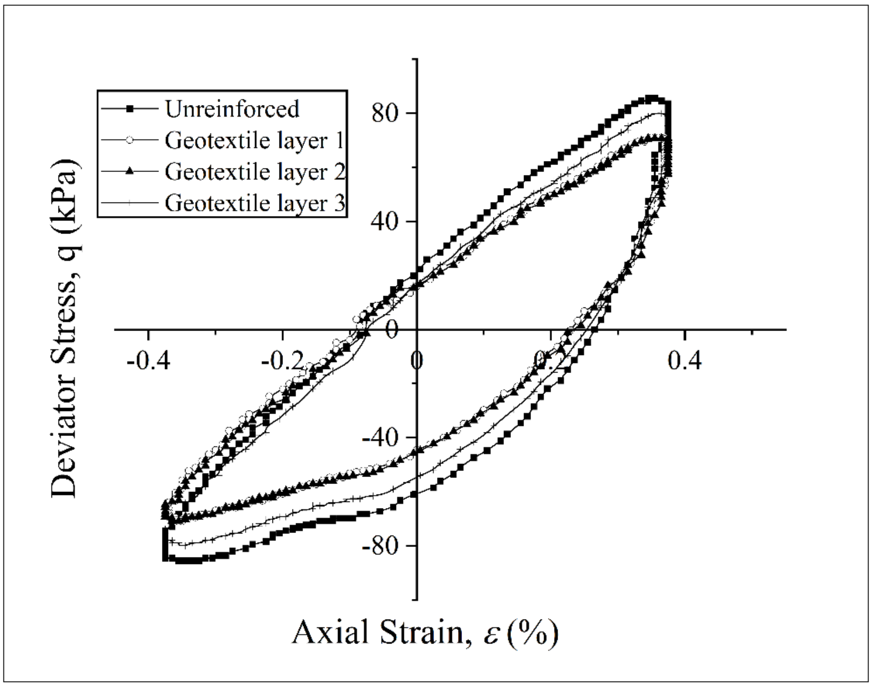


(e)

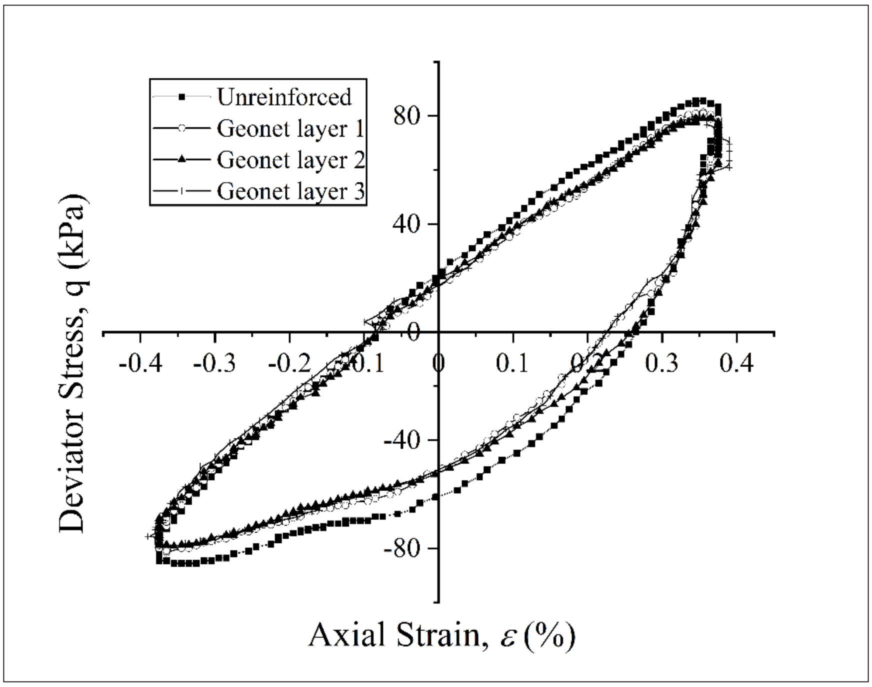
(f)

(g)

Figure A.10 Deviator stress vs axial strain plot (10 cycles) for **(a)** unreinforced **(b)** 1-layer geotextile **(c)** 2-layers geotextile **(d)** 3-layers geotextile **(e)** 1-layer geonet (f) 2-layers geonet, and **(g)** 3-layers geonet

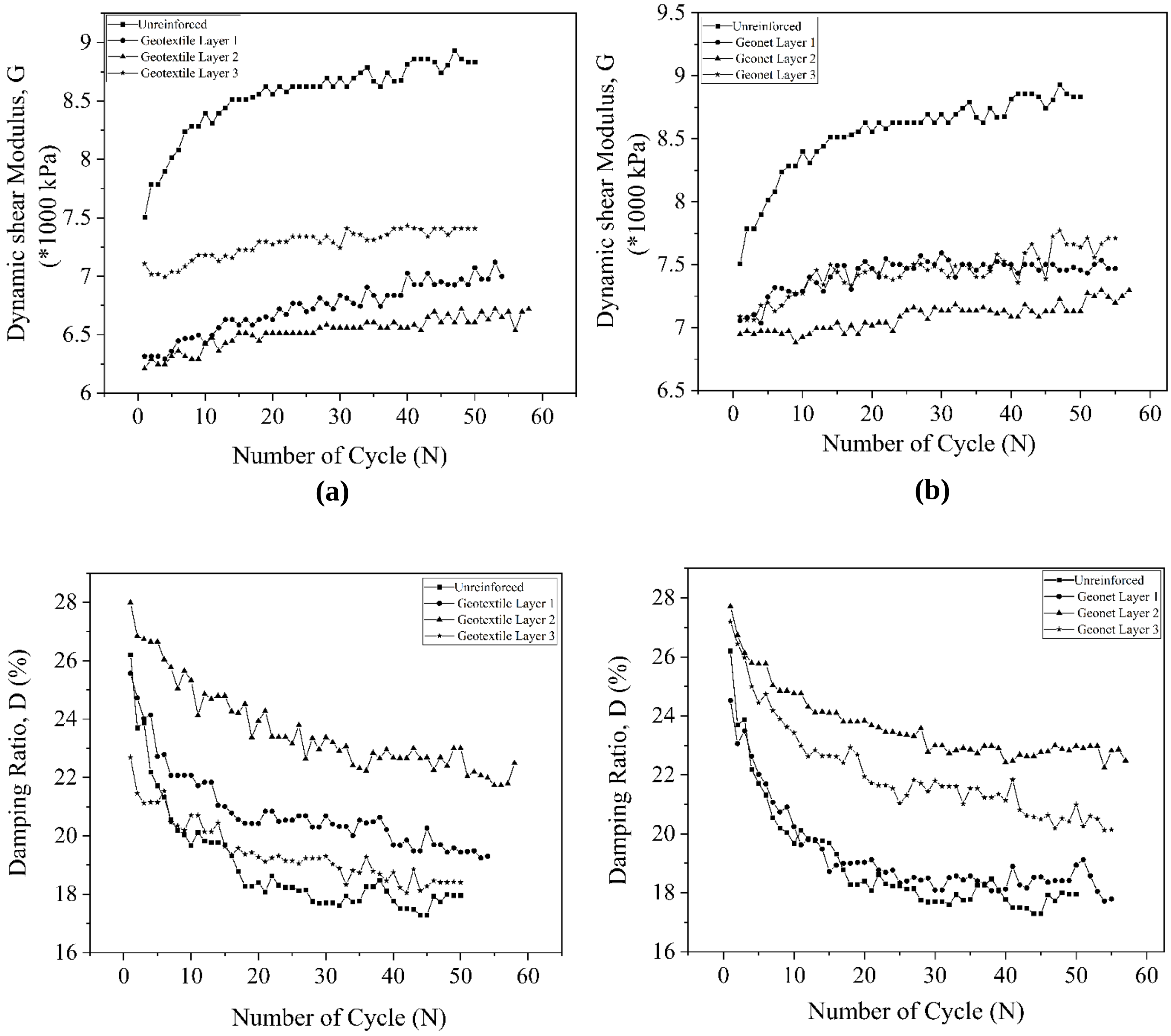


(a)



(b)

Figure A.11 Comparison of hysteresis loop (1st cycle) for unreinforced and **(a)** geotextile reinforced, and **(b)** geonet reinforced MSW fines



(a) **(b)**

(c) **(d)**

Figure A.12 Dynamic shear modulus (G) variation with number of cycle (N) for unreinforced and **(a)** geotextile reinforced, and **(b)** geonet reinforced MSW fines, and Damping ratio (D) variation with number of cycle (N) for unreinforced and **(c)** geotextile reinforced, and **(d)** geonet reinforced MSW fines

Table A.3 Variation of dynamic shear strength parameter with the number of reinforcement layers.

	Geotextile		Geonet	
No. of Layers	Dynamic shear modulus (G_{avg}) kPa	Damping ratio (D_{avg})	Dynamic shear modulus (G_{avg}) kPa	Damping ratio (D_{avg})
0	80.27	26.20	80.26	26.20
1	63.15	25.57	71.99	24.52
2	62.09	27.98	69.50	27.71
3	71.08	22.69	71.68	27.19
*G_{avg} and D_{avg} values are averages of the first 10 cycles				

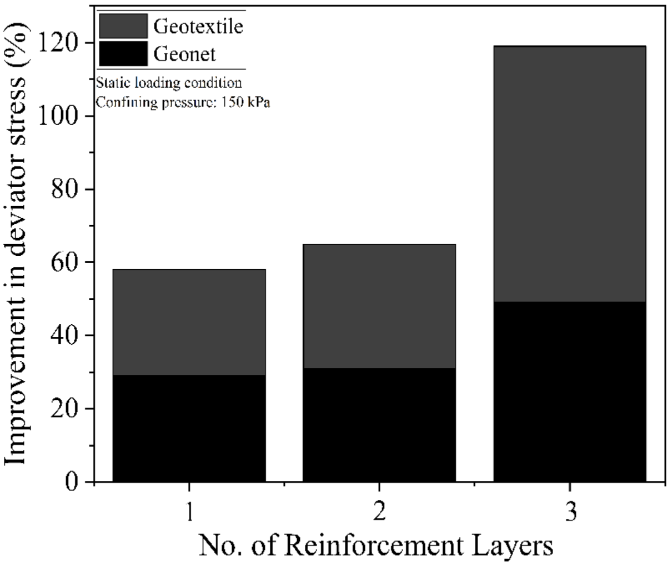
A.4.6 Comparative Analysis of Strength Under Static and Cyclic Loading Conditions

The improvement in the static strength performance of the considered waste material was noticed due to the introduction of geosynthetics in the MSW fines. This has been already confirmed through the discussion in the above sections and through Figure A.13(a), where at confining pressure of 150 kPa geotextile reinforced MSW fines show maximum deviator stress improvement of 70% for the unreinforced ones for 3-layers reinforcement whereas in the case of geonets it is limited to 45%. Comparing the results for cyclic loading under similar conditions the strength performance reduces drastically and is confirmed in Figure A.13(b), where the maximum deviator stress reduction can be seen at around 34% for 2-layered geotextile reinforcement and 26% in the case of 1-layer geonet reinforcement.

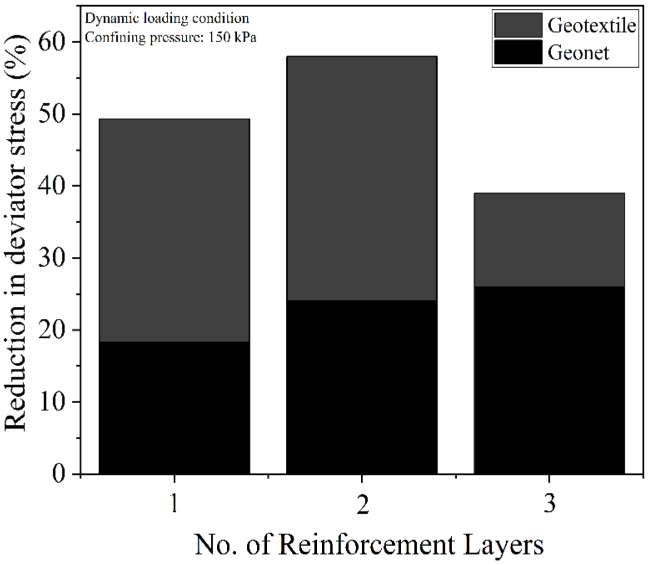
A new strength ratio parameter ($SR_{S/D}$) is evaluated which is defined as the maximum deviator stress in the case of static loading condition (q^{S}_{max}) to maximum deviator stress in cyclic loading condition (q^{D}_{max}), shown in Equation A.2

$$SR_{S/D} = q^{S}_{max}/q^{D}_{max} \tag{A.2}$$

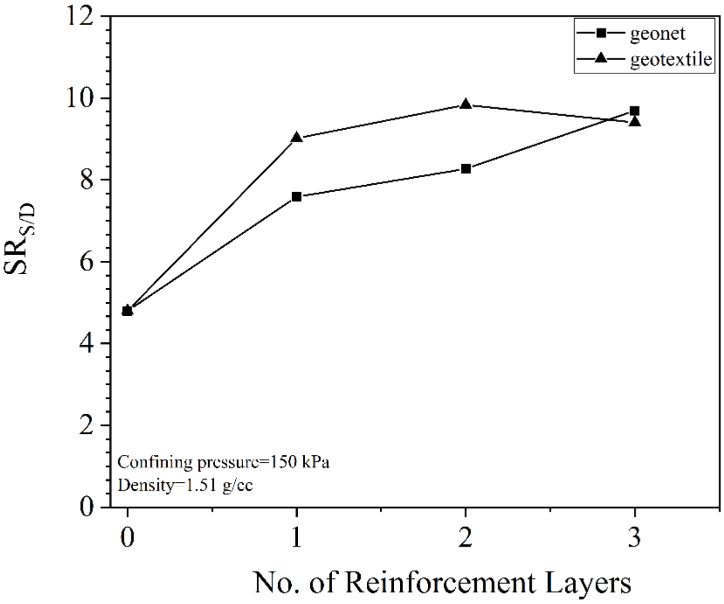
Figure A.13(c) shows the plot of $SR_{S/D}$ of the two considered reinforcements with the number of included layers. The ratio defines that 2-layered geotextile reinforcement provides better results and is comparable to the 3-layered geonet reinforced MSW fines.



(a)



(b)



(c)

Figure A.13(a) Deviator stress improvement with reinforcement layers (static loading conditions) **(b)** Deviator stress reduction with reinforcement layers (cyclic loading conditions), and **(c)** strength ratio (SR$_{S/D}$) with number of reinforcement layers

A.5 SUMMARY

The study focuses on the laboratory investigation of the MSW fines reinforced with two types of geosynthetics (geotextile and geonet) with a different number of reinforcement layers (1, 2, and 3) and investigated under static and cyclic loading conditions to predict the strength performance of the considered composite material. Based on the results obtained from the extensive experimental investigations, the study can be summarized as follows:

- The MSW fines reinforced with geosynthetics behave like soil reinforced with geosynthetics for the static case but no evidence for the improvement in strength for the dynamic case can be seen in the present study.
- In the static triaxial test case, there is no remarkable improvement in strength parameters with the increment of reinforcement layers can be seen but the overall

average shear strength shows improvement with the increased layers of reinforcement. Geotextile gives better improvement results over the geonet for 3-layered reinforcement.

- The shear strength improves with the confining pressure and shows maximum results for a 3-layered reinforcement system. The same results are validated by the strength ratio evaluation.
- The dynamic study on the reinforced MSW fines does not show any improvements in the dynamic strength parameters and the cyclic strength and hence limits this study. Although the $SR_{S/D}$ (strength ratio) gives an idea that 2-layered reinforced MSW fines with geotextile can work better for the given conditions and loadings.

The improvement in static strength of the considered MSW fines with reinforcement makes it suitable for geotechnical applications, like backfilling applied to static loading but not for high seismic zones as no enhancement in strength can be seen in the case of dynamic study. This laboratory study has limitations like sample size and preparation methods, machine dimensions, limited parameters study, etc. To overcome these limitations large-scale tests under in-situ conditions or field implementation and monitoring are required to have a realistic idea of the strength performance of the composite material.