Websites:
http://www.lifesciencesite.com
http://www.sciencepub.net

Emails:
editor@sciencepub.net
sciencepub@gmail.com

Life Science Journal

MARSLAND PRESS
Multidisciplinary Academic Journal Publisher

IMPROVEMENT OF SWELLING SOIL PROPERTIES USING CRUSHED GLASS WASTES AND LIME

Shehab Nasr Abdelmoneim Mohamed [1]
Mostafa Abdou Abdel Naiem Mahmoud [2]
Ahmed Rushdy Towfeek [3]

[1] M.Sc. Student, Civil Engineering Department, Faculty of Engineering, Assiut University, Assiut 71516, Egypt; E-mail: eng_shehab2017@yahoo.com.
[2] Professor, Civil Engineering Department, Faculty of Engineering, Assiut University, Assiut 71516, Egypt; E-mail: mostafaabdo@yahoo.com.
[3] Associate professor, Civil Engineering Department, Faculty of Engineering, Al-Azhar University, Qena, Egypt; E-mail: ahmed_78_eng@yahoo.com.

ABSTRACT: Expansive soil is a soil that has large changes in volume when there is a change in its water content, and it is found in many areas in Egyptian valleys. This research aims to study the effect of using locally low cost materials such as crushed glass wastes and lime to improve the engineering properties of expansive soil. The expansive soil that has been studied is taken from Al-Kawamil city (New Sohag city), Sohag region is considered unsuitable soil for civil engineering project such as roads and buildings, as it was classified according to the AASHTO classification A-7-6. The percentage of soft materials passing through sieve No. 200 (0.075 mm) was more than 90%. This soil was treated with different ratios of crushed glass wastes (0-5-10-15-20)% by weight , as well as the soil was treated with different ratios of lime (0-2-4-6-8)% by weight. Atterberg limits (liquid limit, plastic limit and plasticity index), standard proctor test (optimum moisture content, maximum dry density) and swelling test were carried out. The results shown an improvement in the engineering properties of the expansive soil such as Atterberg limits and swelling pressure by increasing added percentage. This helps to make use of the local materials available at low cost, make the environment clean from glass wastes and recycle these wastes so they can utilized at the environmental, economical, and engineering levels. This matches the sustainable development strategy of Egypt's vision 2030 in both the environmental and economical dimensions.
[*Shehab Nasr Abdelmoneim Mohamed, Mostafa Abdou Abdel Naiem Mahmoud, Ahmed Rushdy Towfeek*. **IMPROVEMENT OF SWELLING SOIL PROPERTIES USING CRUSHED GLASS WASTES AND LIME**. Life Sci J 2023;20 (1):1-12]. ISSN 1097-8135 (print); ISSN 2372-613X (online). http://www.lifesciencesite.com.01.doi:10.7537/marslsj200623.01.

KEY WORDS: Expansive soil, crushed glass wastes, lime, Atterberg limits, compaction, swelling pressure, engineering properties, soil improvement.

1. Introduction

The improvement of the properties of the soil is the change of some physical, chemical or mechanical properties, or all of them to a specific geometric application. Expansive soil is the soil with large changes in volume when there is a change in its water content. It was found in many areas in the Egyptian valleys, which were chosen for their expansive areas for the construction of new cities and roads for example, New Sohag city and New Akhmeem city. **[1], [2], [3], [4].**

When an increase in the moisture content of this soil, its granule size increases, which leads to reduce the shear forces and increase their susceptibility to compression. These properties are undesirable geometrically. When soil dries, it shrinks due to loss of water. The presence of this type of soil has serious consequences for planning of the civil engineering projects such as roads and buildings. This happens when there is a large change in moisture content. **[1], [2], [3], [4], [5].**

In the sites of expansive soil, it is often required to construct engineering project. In this case, we need to improve its properties before constructing. This is because the replacement of the soil with other suitable soil for constructing will be non-economic (expensive). Thus, it is necesary to find economic ways to improve the properties of expansive soild. **[2], [6], [7], [8].**

There are many ways to improve the engineering properties of the expansive soil such as thermal, mechanical, chemical methods, and improvement with additions such as cement, lime and metal additives or adding inert materials to increase soil density, cohesion and friction resistance**. [2], [4], [6], [7] , [9].**

Some previous research has shown that it is possible to use glass wastes easily in the fields of geotechnical engineering. When lime is added to the expansive soil in the presence of water, many reactions are

occurred to improve its geometrical properties. Due to the local availability and cheapness of glass wastes and lime, we try in this paper to study the effect of adding crushed glass wastes and lime to the expansive soil to improve their engineering properties**. [1], [2], [4], [6], [10], [11], [12].**

2. Objectives and importance of the study

The main objectives of this study:

1- This research studies if it is possible to use local and available materials which is cost-effective such as crushed glass wastes and lime to improve the engineering properties of the expansive soil in a way that makes it ergonomically fit for the construction of buildings without the need to replace it.

2- This study aims to compare the effect of adding solely the crushed glass wastes to the expansive soil and the effect of adding solely lime to the expansive soil in order to improve the engineering properties of the expansive soil.

3- This study also aims to recycling glass waste, which is disposed randomly because the recycling of crushed glass wastes to be used in improving the swelling soil engineering properties has a great economic, environmental and engineering value.

3. Methodology

The research mainly depends on laboratory tests to reach an acceptable amount of crushed glass wastes by adding these percentage of crushed glass wastes (5-10-15-20)% by weight to expansive soil as well as to reach an acceptable amount of lime by adding these percentage of lime (2-4-6-8)% by weight to expansive soil. Experiment of Atterberg limits, standard Procter test and swelling pressure were carried out on expansive soil taken from Al-Kawamil city, Sohag region before being treated as well as those tests were performed on expansive soil after treating with crushed glass wastes solely, and on expansive soil after treating with lime solely, aims to studying the effects of adding solely the crushed glass wastes to the expansive soil and the effect of adding solely lime to the expansive soil on preventing swelling, consistency properties and compaction characteristics of the studied soil.

4. Previous investigations

The research and studies carried out to investigate the effect of the crushed glass wastes additions on the engineering properties of expansive soil or the possibility of using these wastes in stabilizing and improving the engineering properties of expansive soil are very scarce. We present some research that carried out to investigate the effect of adding solely the crushed glass wastes to the expansive soil and the effect of adding solely lime to the expansive soil on the engineering properties of expansive soil.

In 2020 "Javed and Chakraborty "studied Effects of Waste Glass Powder on Subgrade Soil Improvement. They investigate that by adding glass powder to the natural soil the liquid limit (LL), plastic limit (PL) and plasticity index (PI) continuously decreased. Maximum dry density (MDD) was increasing and found constant and optimum moisture content (OMC) was decreasing when added glass powder. Both unsoaked and soaked California bearing ratio (CBR) was increasing with the addition of glass powder. Unconfined compressive strength (UCS) was increasing and then decreased. Shear strength parameter also increases with the increase of glass powder **[12].**

In 2018 " Attom" studied the use of waste glass material to control soil swelling pressure. He concluded that the increasing the percentage of cement and the glass in the mix will reduce both the swelling pressure and the swell potential of the soil. Additionally, it was found the larger sizes of the glass is more effective than smaller sizes in reducing the swelling pressure of the soil and reduce both the swelling pressure and the swell potential significantly **[10].**

In 2018 " Lingwanda" studied use of waste glass in improving subgrade soil properties. He investigates that by adding crushed glass to the natural soil has resulted to an increase in CBR and a decrease in PI thus achieving the required quality as stipulated in the relevant standard **[11].**

In 2019" Farghaly", et.al were studied the effect of lime on expansive soil in Al-Kawamil city, Sohag region .They investigate that the liquid limit, plasticity index and maximum dry density decreased while the plastic limit and optimum moisture content increased **[2].**

In 2017 "Emarah and Seleem" were studied the effect of lime mixed with sea water on treating the swelling properties for the road projects. They investigate that the liquid limit, plasticity index and maximum dry density decreased while the plastic limit and optimum moisture content increased**[4].**

In 2013" Afaf ",et.al were studied the effect of adding lime on improving the expansive soil properties of the subgarde at the Qena - Sfaga road. They investigate that the California bearing ratio and optimum moisture content were increased while the maximum dry density, plasticity index, and swelling pressure were reduced **[1].**

5. Materials used

5.1. soil

Sieve analysis test and hydrometer test were performed to identify some of the properties of the expansive soil.

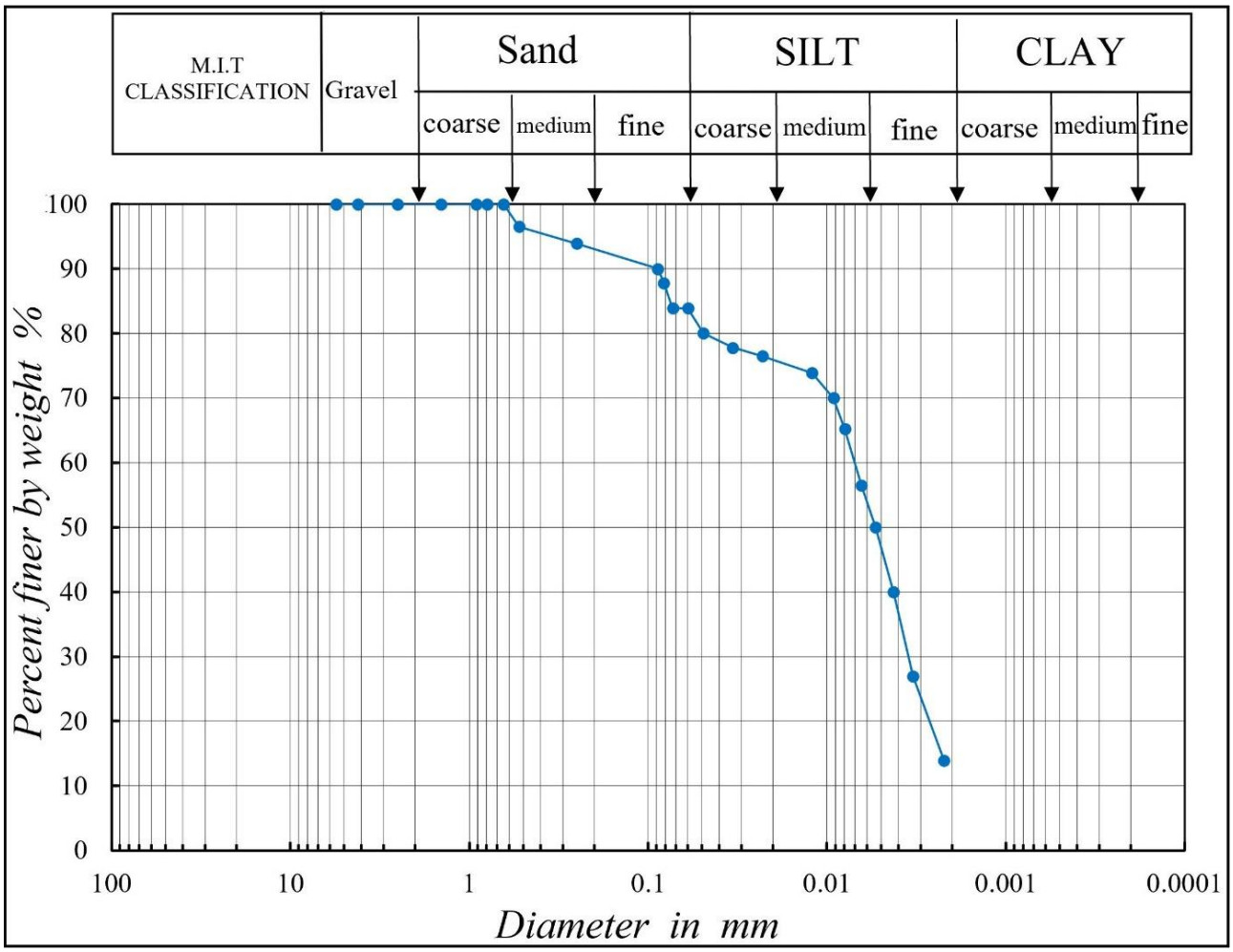

Figure 1: Grain size distribution for expansive soil.

Table (1): Shows the results of laboratory experiments on expansive soil without addition.

experiments	results
Passing from the sieve No. 200 % (0.075 mm) Natural	more than 90
Natural moisture content (%)	3.35
Field dry unit weight (gm/cm^3)	2.06
Specific gravity	2.69
L.L (%)	70.75
P.L (%)	30.70
P.I (%)	40.05
M.D.D (gm/cm^3)	1.53
O.M.C (%)	15.75
Swelling pressure(kg/cm^2)	3.92
Soil classification according to the AASHTO classification	A-7-6

5.2. Glass wastes.

To identify some of the properties of the glass wastes, the sieve analysis test was performed.

The glass wastes were brought, ground, and then put in sieve No. 4 (4.75 mm) to do the test of standard compaction and sieve No. 40 (0.425 mm) to do the tests of liquidity limit and plasticity.

Life Science Journal

Websites:
http://www.lifesciencesite.com
http://www.sciencepub.net

Emails:
editor@sciencepub.net
sciencepub@gmail.com

MARSLAND PRESS
Multidisciplinary Academic Journal Publisher

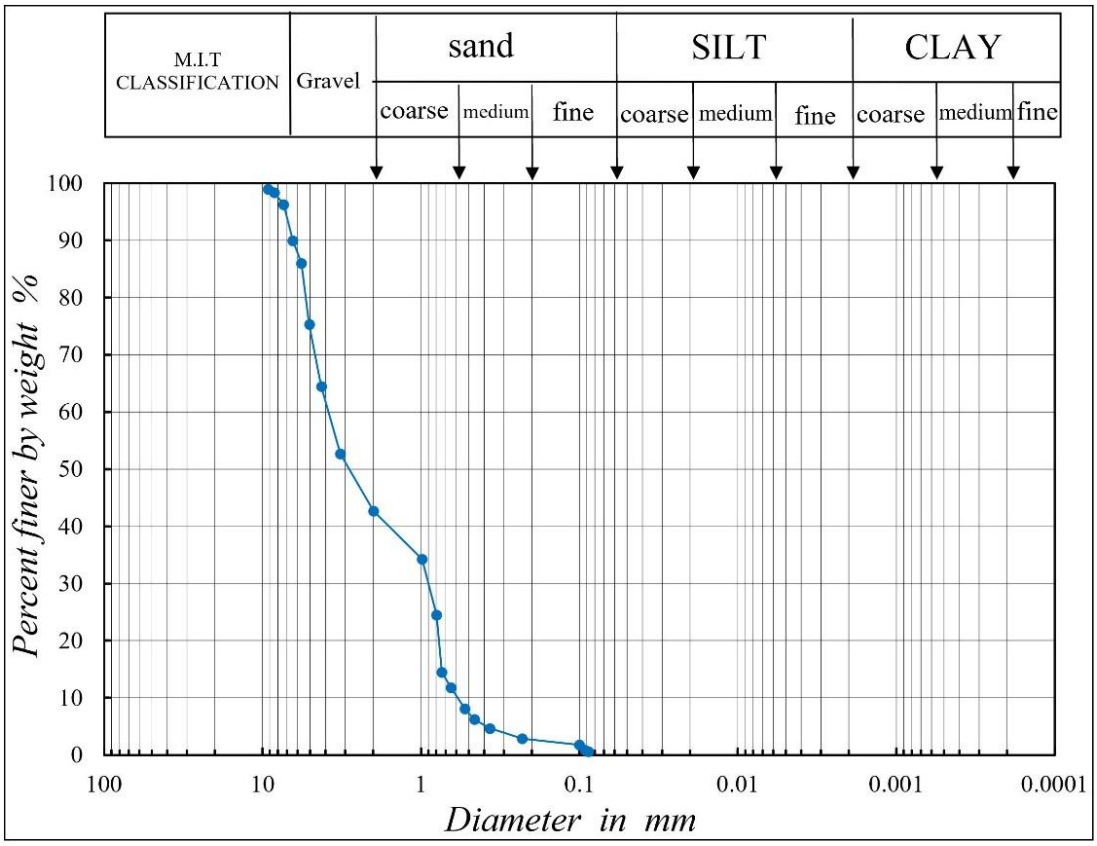

Figure 2: Grain size distribution for crushed glass wastes.

Table (2): Shows the chemical analysis of glass wastes.

SiO2	**74%**
Na2O	13%
CaO	10.5%
SO3	0.2%
Al2O3	1.3%
K2O	0.3%
MgO	0.2%
Fe2O3	0.04%

5.3. Lime.

The chemical analysis of lime are shown in table (3).

Table (3): Shows the chemical analysis of lime.

Mg	1.9
Al	0.1
Si	1.1
Cl	---
K	0.27
Ta	62.6
Ti	0.01
Mn	---
Fe	1.4
P	0.01
Na	0.55
L.O.I	32

6. Result

6.1. Consistency Properties (Atterberg limits)

The Consistency properties of soil without any addition and soil with the addition of crushed glass wastes are shown in table (4). While the Consistency properties of soil without any addition and soil with the addition of lime are shown in table (5).

Table (4): The effect of adding crushed glass wastes on the consistency properties (Atterberg limits).

Added percentage%	L.L %	P.L %	P.I %
0	70.75	30.7	40.05
5	69.25	29.66	39.59
10	64.1	24.75	39.35
15	53.33	23.78	29.55
20	52.51	21.87	30.64

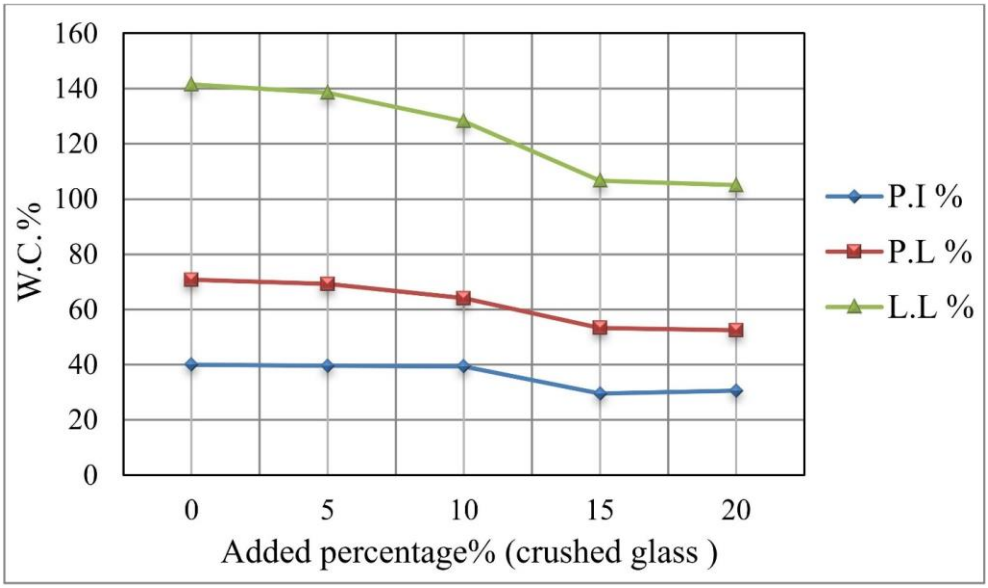

Figure 3: Graph of Atterberg limits against percentage of crushed glass wastes.

Table (5): The effect of adding lime on the consistency properties (Atterberg limits).

Added percentage%	L.L %	P.L %	P.I %
0	70.75	30.7	40.05
2	62.95	42.55	20.4
4	60.75	43.55	17.2
6	58.65	45.45	13.2
8	43.65	----	N.P.

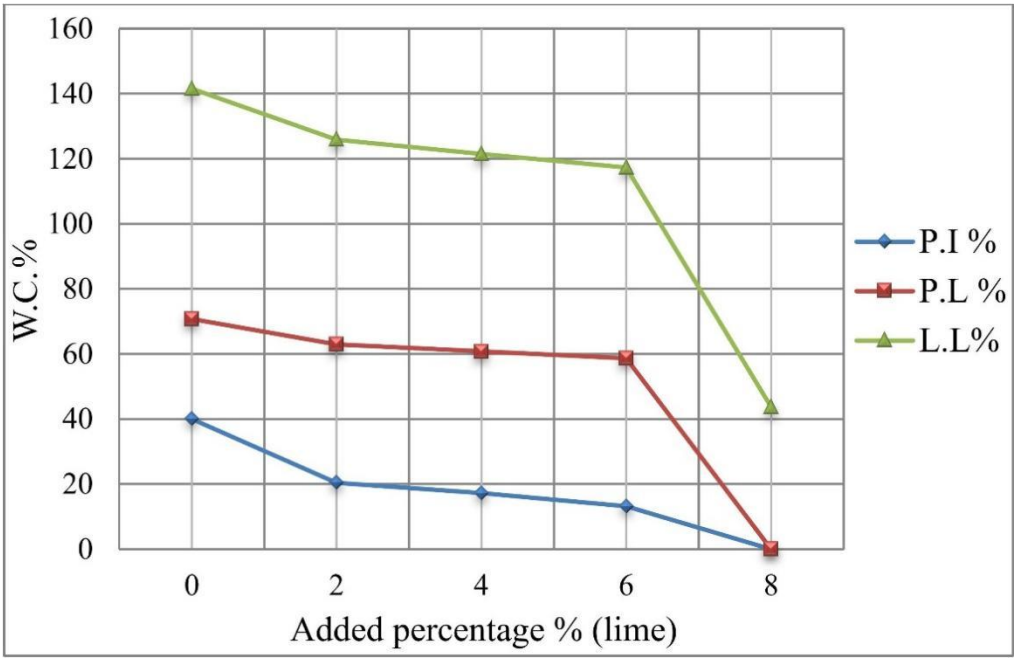

Figure 4: Graph of Atterberg limits against percentage of lime**.**

By adding the crushed glass wastes to the expansive soil, the liquid limit and the plastic limit decreased from 70.75 to 52.51 (%) and from30.7 to 21.87 (%) respectively, the decrease in the liquid limit was greater than the decrease in the plastic limit, which led to a decrease in the plasticity index from 40.05to30.64 (%). The decrease in the liquid limit can be attributed to the fact that the ability of the crushed glass wastes to retain water is much less than the ability of the expansive soil to retain it. The decrease in plastic limit can be attributed to the fact that the crushed glass wastes is a non-plastic or low plastic material, which led to a decrease in the plastic limit of the expansive soil to which the crushed glass wastes were added to it.

By adding lime to the expansive soil, the liquid limit decreased from70.75 to 43.65(%) but the plastic limit increased slightly. The decrease in the liquid limit was much greater than the increase in plastic limit, which led to a decrease in the plasticity index making it none plastic. The decrease in the liquid limit can be attributed to the interaction of the lime with the expansive soil, which leads to the merging and agglomeration of soil particles. This results in the thickness of the water layer known as the double electrode layer, and, consequently, the swelling ability of the expansive soil decrease by the addition of water to it. The slight increase in the plastic limit can be attributed to the fact that lime is a plastic material, which led to a slight increase in the plastic limit of the expansive soil to which the lime was added to it.

6.2. compaction characteristics (standard proctor test)

The compaction characteristics of soil without any addition and soil with the addition of crushed glass wastes are shown in table (6). While the compaction characteristics of soil without any addition and soil with the addition of lime are shown in table (7).

Life Science Journal

Websites:
http://www.lifesciencesite.com
http://www.sciencepub.net

Emails:
editor@sciencepub.net
sciencepub@gmail.com

MARSLAND PRESS
Multidisciplinary Academic Journal Publisher

Table (6): The effect of adding crushed glass wastes on compaction characteristics of expansive soil

Added percentage%	M.D.D gm/cm^3	O.M.C (%)
0	1.53	15.75
5	1.55	12.95
10	1.59	11.55
15	1.63	9.15
20	1.64	8.25

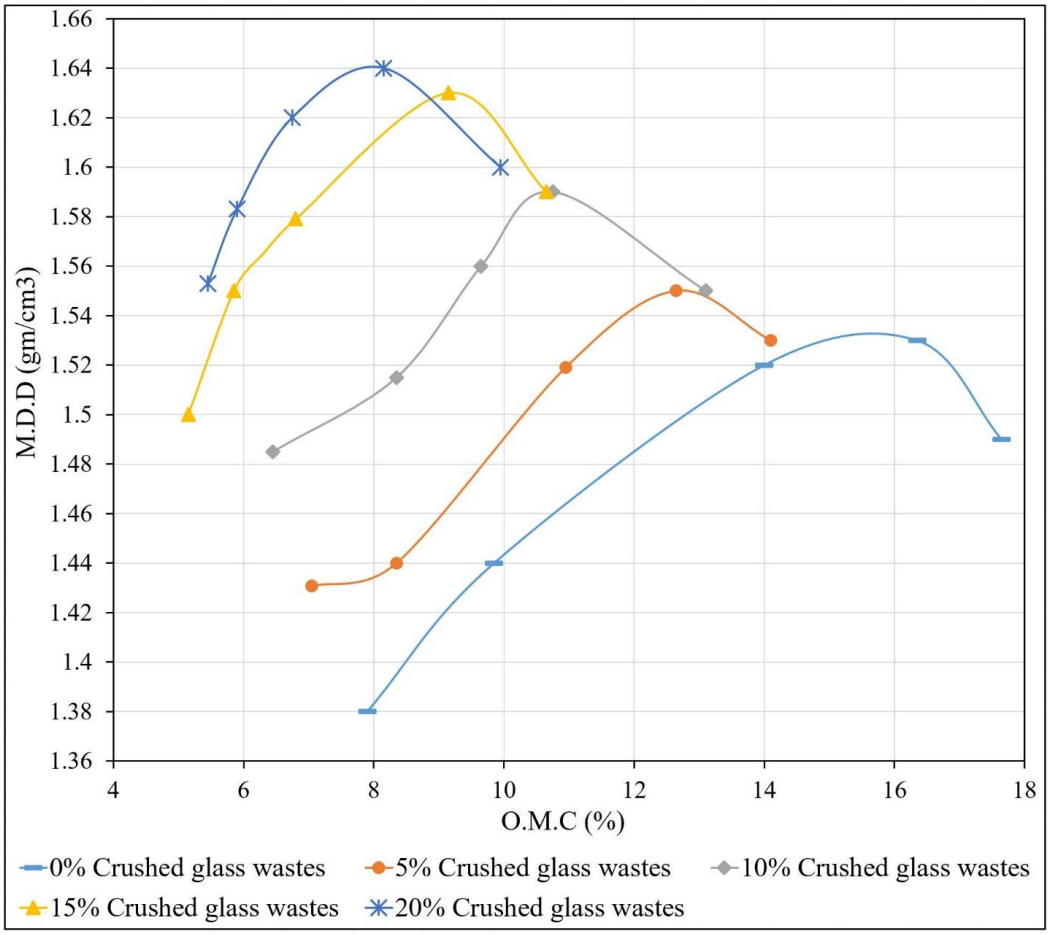

Figure 5: Compaction tests curves of the expansive soil-crushed glass mixtures.

Table (7): The effect of adding lime on compaction characteristics of expansive soil

Added percentage%	M.D.D gm/cm^3	O.M.C (%)
0	1.53	15.75
2	1.49	16.7
4	1.46	17.6
6	1.43	18.55
8	1.4	19.4

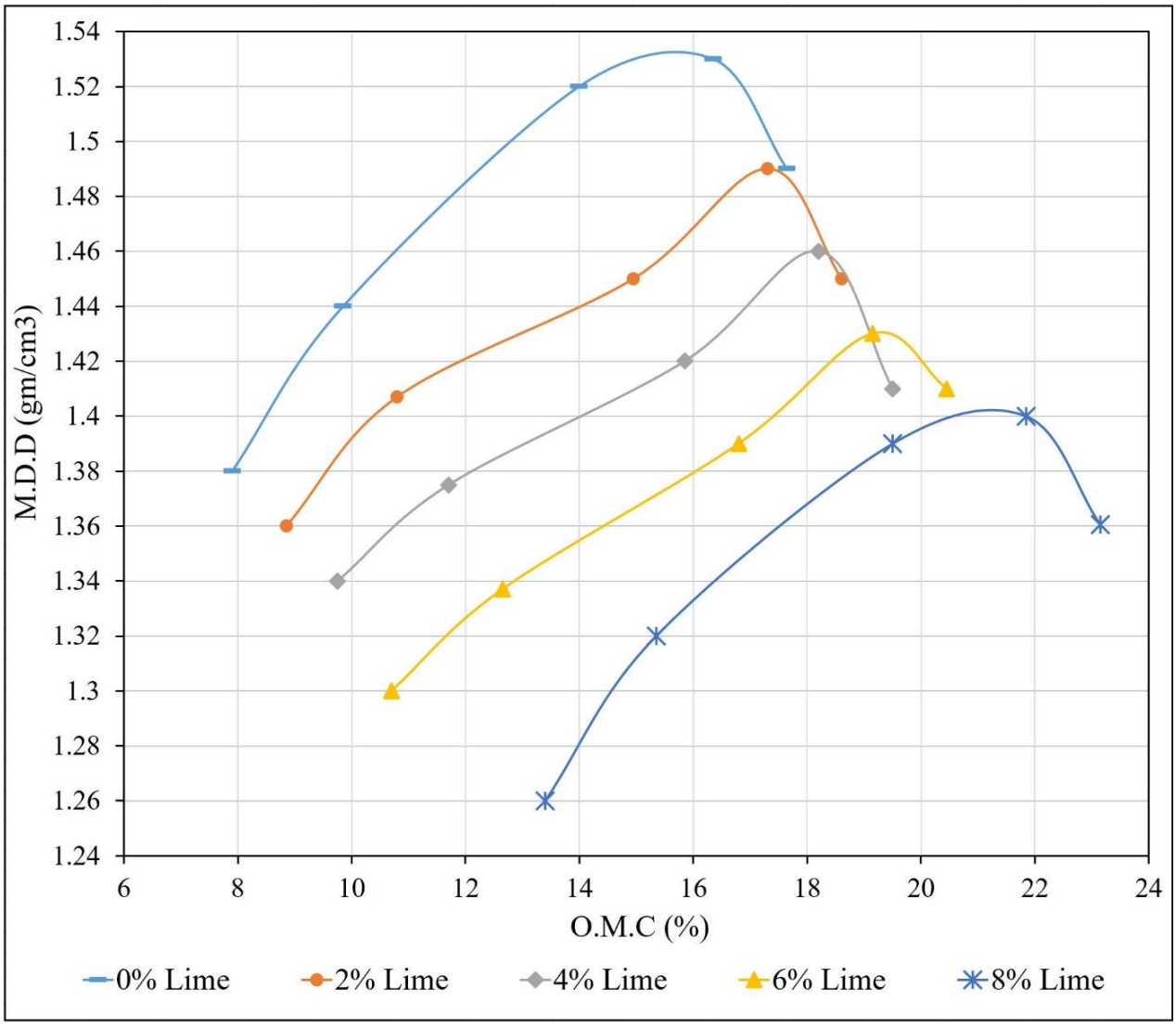

Figure 6: Compaction tests curves of the expansive soil-lime mixtures.

By adding crushed glass wastes to the expansive soil, the optimum moisture content was reduced from 15.75 to 8.25 (%) and the maximum dry density increased by increasing the percentage of addition from 1.53 to 1.64 (gm / cm^3). We can attribute the decrease in optimum moisture content of the expansive soil to which the crushed glass wastes were added to the fact that glass is an inert material that does not absorb water. We can attribute

the increase in the maximum dry density of the expansive soil to which the crushed glass wastes were added to the fact that the specific weight of the glass is higher than the specific weight of the expansive soil.

By adding of lime to the expansive soil, the optimum moisture content increased from 15.75 to 19.4(%) and the maximum dry density of the soil was decreased from 1.53 to 1.4(gm / cm^3). The increase in the optimum moisture content of the expansive soil with added lime can be attributed to the fact that the lime requires additional water for the hydrolysis process. We can attribute the decrease in the maximum dry density of the expansive soil to which lime is added to the occurrence of clumping and accumulation of soil particles, which leads to the difficulty of compaction.

6.3. The swelling properties of the expansive soil

The swelling pressure of soil without any addition and soil with the addition of crushed glass wastes are shown in table (8). While the swelling pressure of soil without any addition and soil with the addition of lime are shown in table (9).

Table (8): The effect of adding crushed glass wastes on the swelling pressure of the expansive soil.

Added percentage%	Swelling pressure kg/cm^2	The decrease in swelling pressure (%)
0	3.92	0
5	3.45	12
10	2.96	24.5
15	2.48	36.73
20	2	49

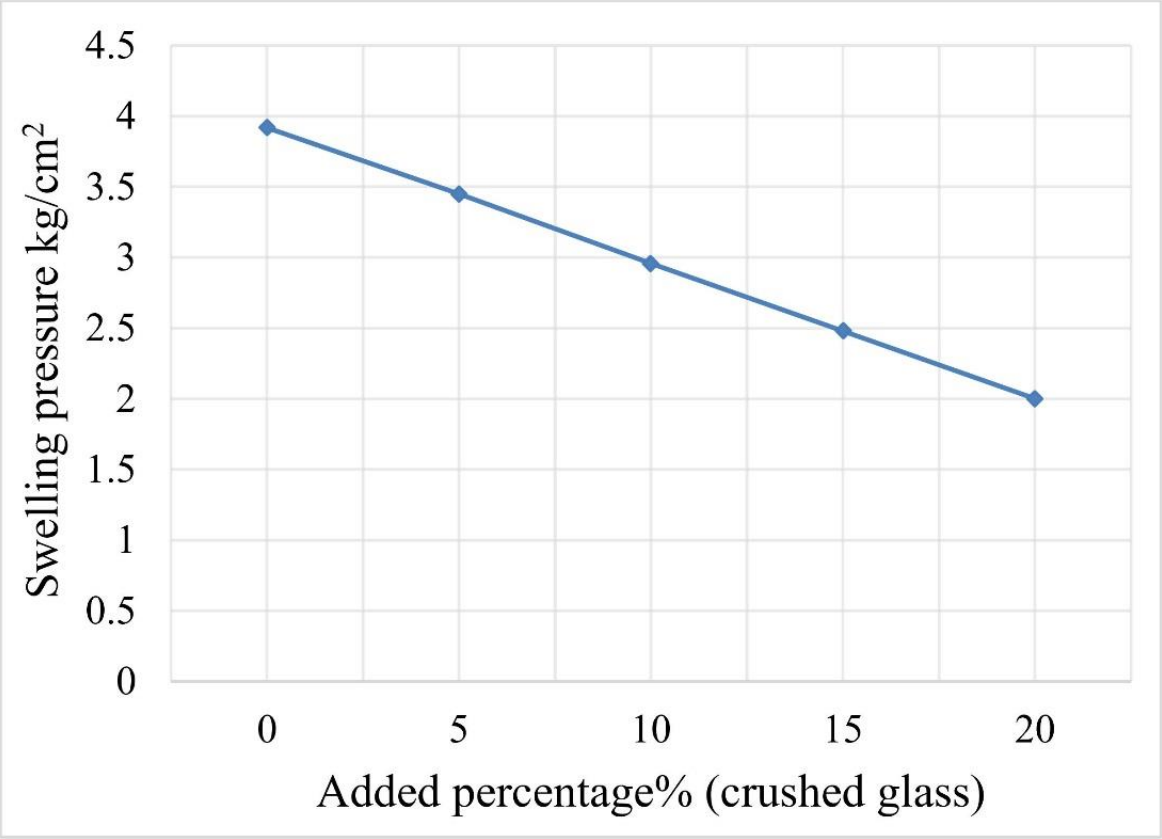

Figure 7: Graph of swelling pressure against percentage of crushed glass wastes.

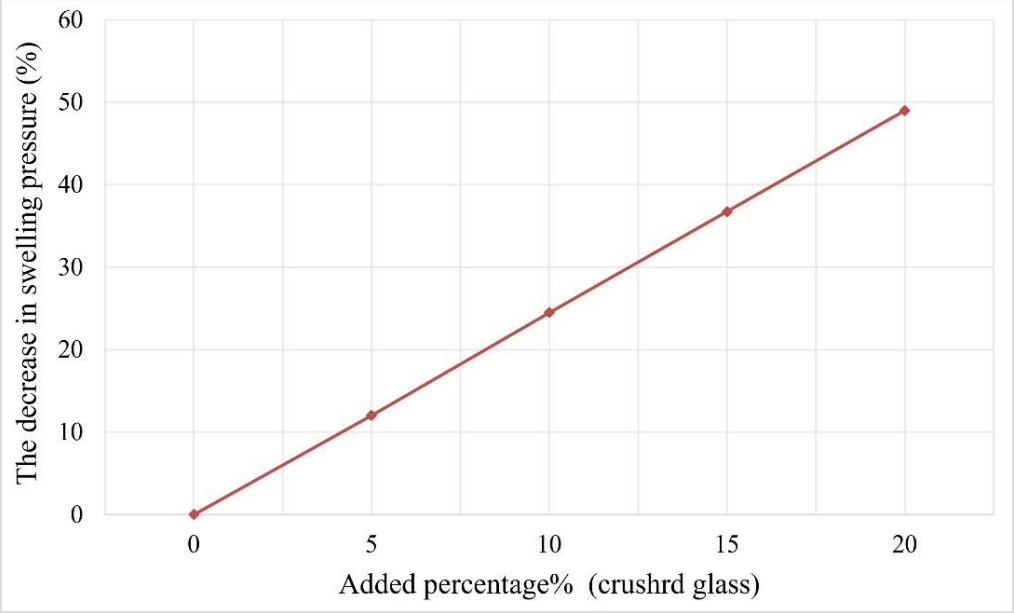

Figure 8: The percentage of decrease in swelling pressure against percentage of crushed glass wastes.

Table (9): The effect of adding lime on the swelling properties of expansive soil.

Added percentage%	Swelling pressure kg/cm^2	The decrease in swelling pressure (%)
0	3.92	0
2	2.93	25.25
4	1.9	51.53
6	0.79	79.85
8	0	100

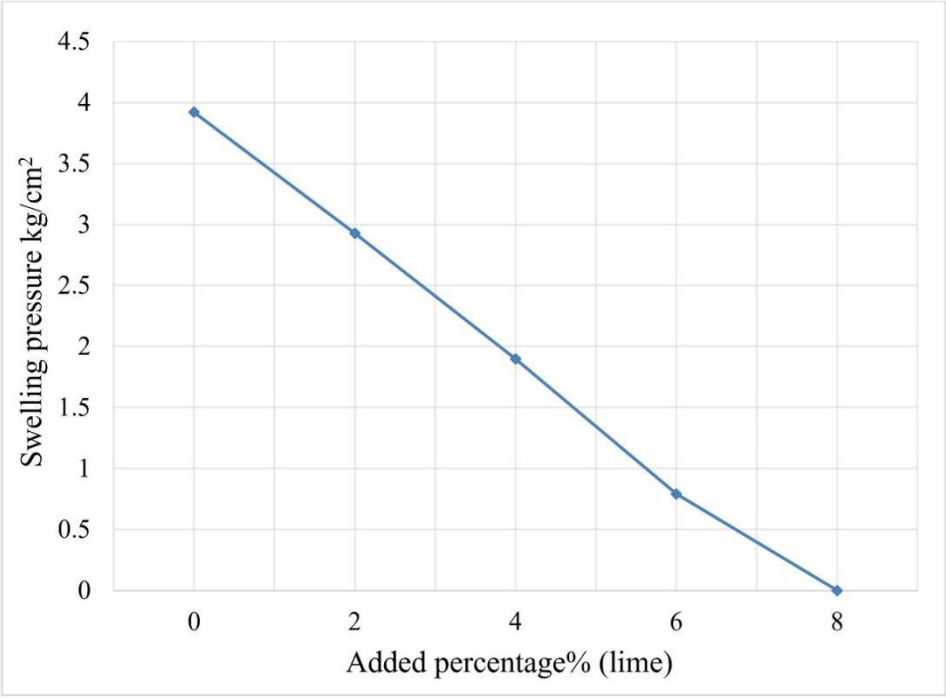

Figure 9: Graph of swelling pressure against percentage of lime.

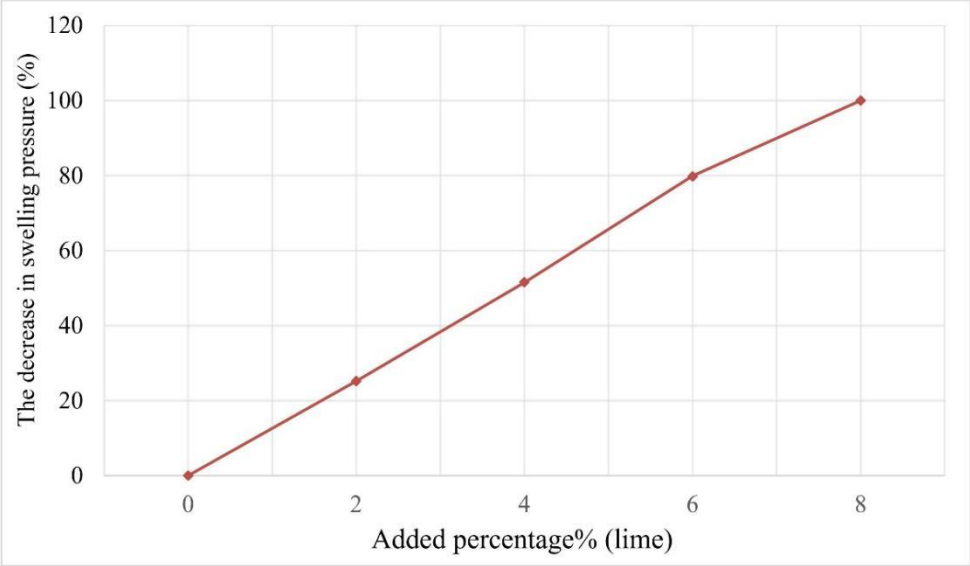

Figure 10: The percentage of decrease in swelling pressure against percentage of lime.

By adding of crushed glass wastes to the expansive soil, the swelling pressure was reduced from 3.92 to 2(kg/ cm^2) by increasing the percentage of addition. We can attribute the decrease in the swelling pressure of the soil to which the crushed glass wastes was added to decrease in the thickness of the swelling soil due to the interaction between crushed glass wastes and soil.

By adding lime to the expansive soil, the swelling pressure was reduced from 3.92(kg/ cm^2) to zero by increasing the percentage of addition. The decrease in the swelling pressure of the soil to which lime is added to can be attributed to a decrease in the thickness of the ion double layer due to the decrease in the capacity of the ion exchange (hydrolysis of ions), as a result of the solidification and agglomeration of the soil particles, and this in turn leads to the reduction of the swelling properties of the expansive soil.

7. Comparison between the effect of adding both solely crushed glass waste and solely lime on the geotechnical properties of the expansive soil.

Geotechnical properties of expansive soil	Using crushed glass wastes	Using lime
Consistency properties (Atterburg limits)	By adding the crushed glass wastes to the expansive soil, the liquid limit and the plastic limit decreased, the decrease in the liquid limit was greater than the decrease in the plastic limit, which led to a decrease in the plasticity index.	By adding lime to the expansive soil, the liquid limit decreased, but the plastic limit increased slightly, the decrease in the liquid limit was much greater than the increased in plastic limit, which led to a decrease in the plasticity index that make it none plastic.
Compaction characteristics (standard proctor test)	By adding crushed glass wastes to the expansive soil, the optimum moisture content was reduced and the maximum dry density increased by increasing the percentage of addition.	By adding lime to the expansive soil, the optimum moisture content was increased and the maximum dry density of the soil was decreased.
The swelling properties of the expansive soil	By adding crushed glass wastes to the expansive soil, the swelling pressure of the expansive soil was reduced by increasing the percentage of addition.	By adding lime to the expansive soil, the swelling pressure of the expansive soil was reduced to zero by increasing the percentage of addition.

8. Notation

L.L=liquid limit , P.L=plastic limit , P.I=plastic limit , W.C= water content , M.M.D=maximum dry density, O.M.C=optimum moisture content.

9. Conclusions

The Consistency properties of the expansive soil, improved by adding solely the crushed glass wastes to the soil and by adding solely lime to the soil. By adding crushed glass wastes to the expansive soil, it led to a decrease in the liquid limit and the plastic limit, the decrease in the liquid limit was much greater than the plastic limit decrease, which led to a decrease in the plasticity index while by adding lime to the expansive soil, the liquid limit decreased, but the plastic limit increased slightly, the decrease in the liquid limit was much greater than the increased in plastic limit, which led to a decrease in the plasticity index that make it none plastic.

The compaction characteristics of the expansive soil were affected by adding crushed glass wastes to it through a decrease in the optimum moisture content and an increase in the maximum dry density by an increase in the percentage of addition, but by adding lime to the expansive soil, led to an increase in the optimum moisture content and a decrease in the dry maximum density of the expansive soil.

The swelling properties of the expansive soil, improved by adding solely the crushed glass wastes to the soil and by adding solely lime to the soil. By adding solely crushed glass wastes to the soil and by adding solely lime to the soil caused the swelling pressure of the expansive soil to be reduced by the increase in percentage of addition**.**

References:

[1]. Afaf, A.; Hesham, A.; Atef, A., Elh, M. (2013) **Improvement of expansive subgrade by lime addition ;** Journal of Engineering Sciences, Assiut University, Faculty of Engineering, Vol 41, No. 5, pp. 1778 – 1795.

[2]. Farghaly , A. A.; El-Shater ,A.; Abdel Naiem, M. A. ; Hamdy ,F. **(** 2020**) Lime addition chemical stabilization of expansive soil at Al- Kawamil city, Sohag region, Egypt**. international journals and conference proceedings. Vol 5, No 1, PP 1-11.

[3]. Elsharief, A. M.; Elhassan, A. A. M.; Mohamed ,A. E. M**. (** 2013**) Lime Stabilization of Tropical Soils From Sudan For Road Construction**. International Journal of GEOMATE, Vol 4, No 2. PP 533-538.

[4]. Emarah ,D. A.; Seleem ,S. A. (2018) **Swelling soils treatment using lime and sea water for roads construction**. Alexandria Engineering Journal, Vol. 57, No 4 . PP 2357-2365.

[5]. Abu zeid ,M. M. (2016) **Improve Swelling Soil Properties by Mixing With Lime for Road Projects**. European Journal of Academic Essays Vol 3, No 2 , PP 94-99.

[6]. Moghal ,A. A. B.; Elkady, T. Y. (2012) **Durability Studies on Expansive Soils Treated with Lime.** International Conference on Ground Improvement & Ground Control. PP 1187- 1192.

[7]. Baglari ,D.; Dash ,S. K. **(**2013**) Improvement of expansive soil by lime and reinforcement**. IGC RoorkeeAt: Roorkee, India, , Vol 4, No 2 (Sl. No. 8), pp. 22-24.

[8]. Kechouane ,Z.; Nechnech, A. (2015) **Characterization of an expansive clay treated with lime: effect of compaction on the swelling pressure**; AIP conference proceedings 4th international congress in advances in applied physics and materials science (APMAS 2014) – on line https://aip.scitation.org/doi/abs/10.1063/1.4914248

[9]. Abdulaziz ,E.S. M.; Taha ,Y. K.; Kenawi ,M. A. ; Kamel, A. O. (2013) **Treatment of expansive soil with chemical additives**, Journal of Engineering Sciences, Assiut University, Faculty of Engineering, Vol 41, No 5, pp 1765 – 1777.

[10]. Attom ,M. (2018) **The use of waste glass material to control soil swelling pressure**. Proceedings of International Conference on Technological Challenges for Better World. Arab Emirates.

[11]. Lingwanda ,M.I. (2018) **Use of waste glass in improving subgrade soil properties**. International Journal of Research in Engineering and Technology. Vol 7 , No 04

[12]. Javed ,S. A.; Chakraborty ,S. (2020) **Effects of Waste Glass Powder on Subgrade Soil Improvement.** International Journal of Civil Engineering and Technology (IJCIET) Vol 9, No 10, pp. 12–21.

6/20/2023