A Study on Light Expended Clay Aggregate (LECA) in a Geotechnical View and its Application on Greenhouse and Greenroof Cultivation

Siamak Boudaghpour, and Shervin Hashemi

***Abstract*—** Increasing population in the world increases the demand of housing and it causes destroying pasture lands and jungles immethodically. It also causes soil attrition in every country of the world. In this way, the demand of making flowerbeds in the inner and outer parts of the building increases. But expending method of making these flowerbeds as they need an environment to keep the plant and also not to be harmful for the plant and environment and also they are needed to be light and economical.

According to our studies, LECA has some specific properties which can be apply as a suitable material. In this study, first the LECA and its suitable properties has been introduced in a geological and geotechnical view. Then the LECA application on greenhouse cultivation has been reviewed and a new method of making green roof by using LECA.

***Keywords*—**Geological and Geotechnical Properties, Greenhouse Cultivation, Greenroofs Technology, Light Expanded Clay Aggregate (LECA).

I. Introduction

LECA is the abbreviation for Light Expanded Clay Aggregate. LECA is a will known material which is used in concrete technology. (Fig. 1)

LECA is a special type of clay that has been pelletized and fired in a rotary kiln at a very high temperature. As it is fired, the organic compounds in the clay burn off forcing the pellets to expand and become honeycombed while the outside surface of each granule melts and is sintered. The resulting ceramic pellets are lightweight, porous and have a high crushing resistance.

LECA is a natural product containing no harmful substances. It is inert with a neutral pH value, resistant to frost and chemicals, will not break down in water, is non-biodegradable, non combustible and has excellent sound and thermal insulation properties.

This material is an incredibly versatile material, and is utilized in an ever-increasing number of applications.

In the construction industry, it is used extensively in the production of lightweight concrete blocks as well as both a sound and thermal insulation material, and flue & chimney lining material.

LECA used in structural backfill against foundations, retaining walls, bridge abutments etc., can reduce earth pressure by 75% compared with conventional materials, and also increases stability while reducing settlement and land deformation.

LECA is also used in water treatment facilities for the filtration and purification of municipal wastewater and drinking water as well as in other filtering processes, including those for dealing with industrial wastewater and fish farms.

It also has superb water-draining properties, and because it is much lighter than alternatives such as gravel, is far easier to transport and handle.

This is why it is increasingly the preferred aggregate for sports field drainage contractors.

It is also used as a growing medium in Hydroponics systems, and blended with other growing mediums such as soil and peat to improve drainage, retain water during periods of drought, insulate roots during frost and provide roots with increased oxygen levels promoting very vigorous growth.

To produce LECA, first clay will be delivered form mine to the LECA mill. Then after sampling and accurate controlling for not to have any chemical or calcareous material the dry clay will be watering and will be delivered to the spinning kiln. So inside the kiln, in 1200 degrees of centigrade temperature, released gases will expand the beads and lots of tiny cells of air will be appear inside them and after cooling the surface become firm.[1]

II. Categorizing LECA

After the manufacturing process, the size categorizing process will be done.

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The categorizing process will be done by the application of LECA. Table 1 is mentioning the categorizing LECA by its constructional application.[1]

Leca Wide Applicability	Leca Gradation (mm)	Density (kg.m-3)
Leca Light Weight Concrete,Light Weight Block, Prefabricated Panels & Slabs.Light Filler.	0-4	610
Light Weight Concrete, Light Weight Block.	4-10	430
Light Weight Filler Concrete, Sewage System Landscaping.	10-25	380
Floor & Roof Sloping, Road Construction.	0-25	430

Table1. Common Size Categorizing of LECA

Also it is possible to categorize LECA by the density grade. This kind of categorizing is mentioned in table 2.

Type	Density grade	Packing density ($kg.m^{-3}$)	Compression strength (MPa)	Water absorption rate (%)
Light Weight LECA	400	310 – 400	2.0	16.5
	500	410 – 500	3.6	13.0
High Strength LECA	600	510 – 600	4.2	7.50
	700	610 – 700	5.6	6.00
	800	710 – 800	6.4	4.50
	900	810 – 900	6.8	4.20

Table1. Common Density Categorizing of LECA

Fig. 1. The Appearance of LECA

III. A Review on Geotechnical Application of LECA

LECA have a variety application in construction because of many geotechnical applications. Here is a quick view of some of these common applications:[2]

- Reduction of earth thrust on retaining walls (Fig. 2)
- Load compensation on low bearing resistance soils (Fig. 3)
- Lightweight embankment on slopes (Fig. 4)
- Lightweight embankment to reduce settlement (Fig. 5)

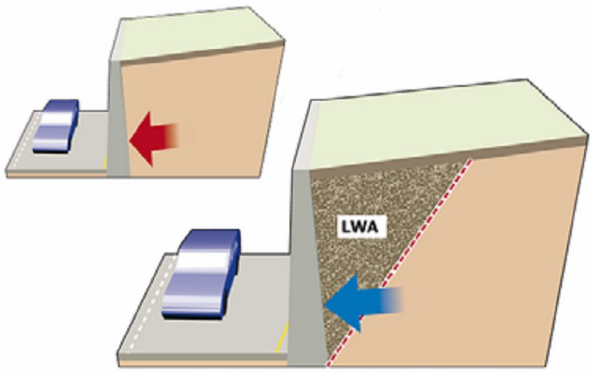

Fig. 2. A Schematic Plan of Application of LECA on Reduction of Earth Thrust on Retaining Walls

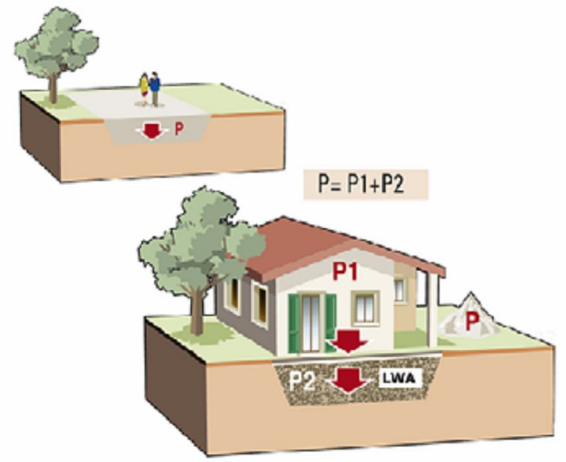

Fig. 3. A Schematic Plan of Application of LECA on Load Compensation on Low Bearing Resistance Soils

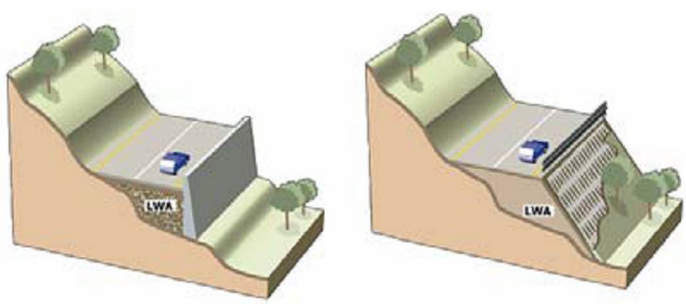

Fig. 4. A Schematic Plan of Application of LECA on Lightweight Embankment on Slopes

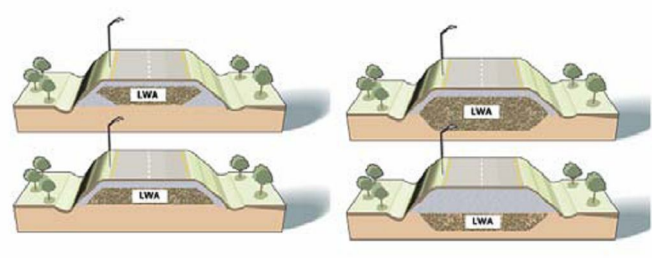

Fig. 5. A Schematic Plan of Application of LECA on Lightweight Embankment to Reduce the Settlement

IV. Mechanical Properties of LECA

The laboratory testing of the mechanical properties includes initial tests for preparation and compaction, triaxial tests, cyclic triaxial tests, and large scale oedometer tests. The results have been verified through large scale model tests and instrumented field tests.[2],[3]

Results from oedometer test in terms of idealized modulus curves are given in Fig. 6.

In Fig. 7 results from cyclic triaxial test in terms of E-modulus are presented.[2]

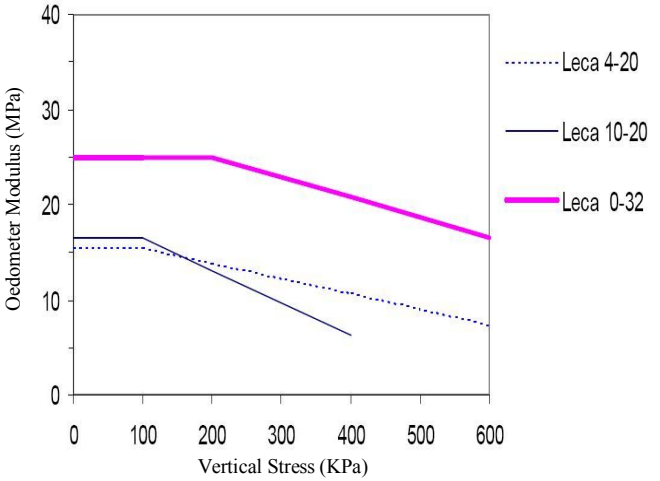

Fig. 6. Idealized Modulus Curves for LECA

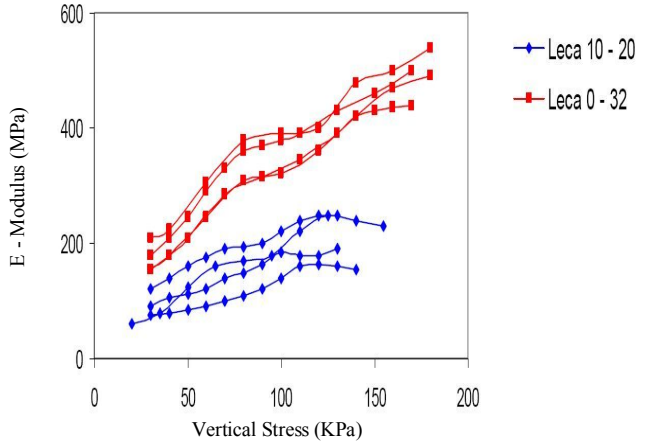

Fig. 7. E-modulus as Found from Cyclic Triaxial Tests

V. LECA Application on Greenhouse Cultivation

Today, LECA has an effective application in agriculture and greenhouse cultivation which some of them will be reviewed here:

A. LECA and Loam

LECA is a high quality material in chemical and biological views.[4]

LECA has a very nice resistance against fungus. So that it is quite possible to be applied in hydro cultural cultivation in flowerbeds and flowerboxes.

B. Hydro cultural cultivation

It is possible to use LECA in Hydro cultural cultivation. It is possible to implant the root of plants so that the root can use the nutrition of LECA.[4]

C. Plant Calamities

LECA is a mineral material so that it prevents increasing abundance of bacteria, fungus and harmful worms. So that by applying LECA it is possible to prepare a suitable environment for plant.[5]

VI. Advantages of Applying LECA in Greenhouse Cultivation

According to our studies, applying LECA in greenhouse cultivation has several benefits. Here is a review of two important of these benefits.

A. Invigoration of Roots

Trees and bushes are in improper environment especially when they were planted in crowded streets and roads. The most important problems are lack of Oxygen and water.

As there are species of bacteria and other micro organisms that can prepare minerals that the plant demands, this process needs enough Oxygen and water.

The water reservation properties can be suitable to prepare demanded water. Also because of porosity of LECA, it is possible for the plant to have access to enough Oxygen.[4]

B. Soil Improvement

Hard soils of the flowerbeds are needed to be improved. By applying LECA it is possible to synchronize the air and moisture inside the soil.

The process is to scatter a 5 centimeters layer of LECA in the part which contains the unsuitable soil. Then the soil should be mixed.

The other method is to putting out a layer of the unsuitable soil and put a layer of LECA and the return back the layer of the soil.

Also by furrowing the layer with 2 up to 3 cm width and 15 cm depth and putting LECA balls inside these strias. So that it is possible to invigorate the quality of plant growth by absorbing enough air and water.[5]

VII. Introducing Greenroofs Technology

Greenroof is a habitable construction that whole or a part of it may covered by flowerbeds. A schematic plan of a green roof is showing by Fig. 8.

Current Greenroofs are built by "multi layers" system and they have been invented in Germany on 1960 and have been developed to all over Europe. Around 10 percent of the roofs in Germany are based on green roof technology. This technology is developing in United States but the usage is not still as much as Europe.[4]

Greenroofs can be categorized by the depth of planting and foundations which is needed to be built. Classic greenroofs are demanding a common depth of soil for planting. In the other hand in vast greenroofs the minimum amount of foundations and installations and it is just needed to be watered less than the traditional ones.

In another categorizing, greenroofs will be categorized by the steep of the roof. The more steep of the roof, the easier designing is needed as the load of watering will be decreased.[5]

Fig. 8. A Schematic Plan of a Greenroof

VIII. Advantages of Greenroofs in Habitable Buildings

By using green roof technology it is possible to make a better environment for residents of the building by making yard and making a better view. Also it is possible to grow up vegetables, fruits or flowers.

Also the amount of Carbon Dioxide (CO_2) and also the amount of noise pollution will be decreased in a large amount.

By using this technology it is possible to longevity the usage of the roof by protecting the layers of the roof against UV ray.

And even more, it is possible to make a suitable environment to grow pets.[6]

IX. Disadvantages of Applying Greenroof Technology

By using this technology, it is needed to fortify the construction in order to built a green roof because it may cause overloading the construction and in some cases it is difficult to design a suitable green roof because of the regional situations.[6]

X. Applying LECA as a New Material and Method in Constructing Greenroofs

According to our studies, by applying LECA, it is possible to redressing parts of disadvantages of green roof technology. By using LECA it is possible to increase the dead load of the soil up to 300 percents. Fig. 9 is showing the comparing diagram for reducing the load of greenroofs by applying common soil, reformed soil and LECA.

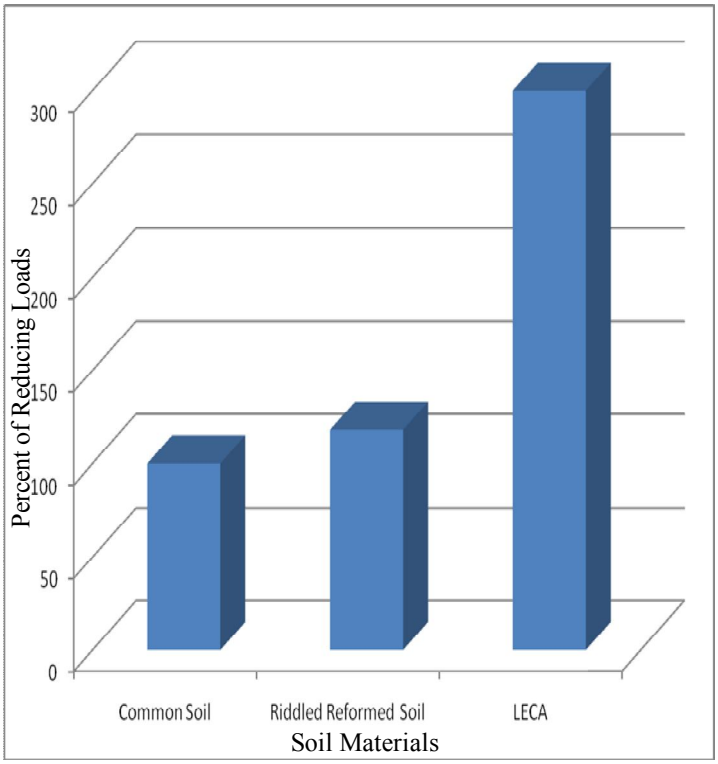

Fig. 9. Comparing Diagram for Reducing the Load of Greenroofs

As LECA can reserve water, it is possible to decrease the demand of watering.

LECA can hold the roots better and it also can reduce the amount of vermin and make a light and better situation and environment for the Greenroofs.

Also by applying LECA it is possible to increase the heat and noise insulation of the roof.

In the other hand it is possible to decrease the depth of the soil, and because of lack of hazardous materials, it prevents the corrosion of layers of the roof and the protection of the roof will be increasing.

XI. Conclusion

- LECA has many specific properties which can be applied in Geology, Civil and Environmental Engineering, Agricultural and Greenhouse issues.
- LECA shows a high resistance as a mechanical property. Which can be applied so many proposes.
- LECA is a high quality material in chemical and biological view. Therefore it is possible to apply it in classic and hydroponic cultivation for flowerboxes and flowerbeds.
- By using LECA instead of regular soil, it is possible to increase the synchronizing gas and moisture inside the environment.
- It is possible to decrease the energy wasting by building greenroofs for the habitable constructions.
- By using LECA it is possible to build lighter greenroofs so that it is possible to prevent overloading the construction.
- Also by decreasing the load of the roof by applying LECA up to three times, it is possible to use this technology in every kind of buildings
- It is possible to protect the insulator layers and preventing the corrosion by applying LECA in greenroof technologies.

References

[1] Jones, Hirsch, and Stephenson, "The Physical Properties of Structural Quality Lightweight Aggregate Concrete", Texas Transportation institute, August 1959.

[2] Arnstein, Want, et al. Expanded Clay Lightweight Aggregates for Geotechnical Applications, Geo LECA Conference, 2009, Portugal.

[3] Länsivaara, T. (2000): "Quality requirements for Light Weight Clay Aggregates. Present status in Finland". Report from SCC VIATEK as part of this project. May, 2000.

[4] Collette, Timothy W., Williams, Ted L., "Analysis of hydroponic fertilizer matrixes for perchlorate: Comparison of analytical techniques, Analyst (London), 2003.

[5] Jones, J. Benton, "Hydroponics: A particular guidance for the soilless grower", CRC Press, 2005.

[6] Resh, Howard M., "Hydroponic food productions: A Definitive Guide Book for Advanced Home Gardner and the Commercial Hydroponic Grower", 6th edition, Lawrence Erlbaum Associates, 2002.