GEOLAB

Transnational Access User Project

LIWEMAT: deformation characterisation of LIghtWEight foundation MATerials

LIWEMAT investigates deformation characteristics of two types of lightweight materials - foamed glass aggregates and expanded clay aggregates to be used in infrastructure projects.

ZAG/UM Large-scale Triaxial Apparatus

Ljubljana, Slovenia 09-04-2022 to 22-04-2022

Organization	Country	Industry	Total No. Users	M/F Ratio	SME
Ss. Cyril and Methodius University of Skopje Faculty of Civil Engineering	North Macedonia	Academia	3	1/2	N

DESCRIPTION OF THE EXPERIMENTS

Proper use of lightweight materials as construction material for various types of infrastructure brings a lot of advantages to European critical infrastructure related to weight reduction and prevention of progressive heating or freezing of its structural elements.

Large-scale Triaxial Apparatus was used to perform the loading tests, which enables the characterization of materials at very small strain ranges with a very high accuracy level of load-displacement control. The apparatus has rigid confining aluminum frames with a height of 3 cm and cross-section of 40 x 40 cm, enabling prismatic specimens with a height of up to 80 cm to be tested.

This research aims to determine the characteristics of expanded clay and foamed glass aggregates through laboratory testing, performing cyclic loading for the stiffness and damping evaluation, which would be beneficial parameters for numerical simulations.

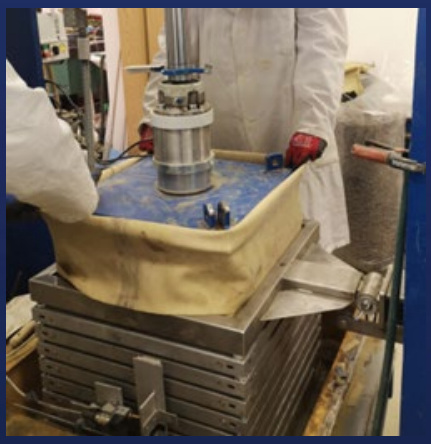
Testing material

The foam glass aggregate has a homogeneous microstructure with approximate uniform shape and sizes. Foam glass aggregate is considered one of the best solid isolation materials with several unique properties. It can be widely used in many applications such as basement walls, foundations, floors and roofs, terrace and garden covers, rooftops, and parking areas.

The expanded clay aggregate is round shape with different sizes with small, air-filled cavities, with dark brown, reddish, brown-red or gray colors, which depends on the chemical composition of the expanded clay. The lightweight expanded clay aggregate has bulk density from 250kg/m^3 to 710kg/m^3, mostly dependent on the size of the aggregate.

INNOVATIVE ASPECTS

What makes these lightweight aggregates a research worth material is the lack of data for specification in the literature. Therefore, this paper gives an overview of the detailed large-scale laboratory tests of the expanded clay aggregate. Both expanded clay aggregates and foamed glass aggregates were exposed to simultaneous vertical and horizontal loading as a resemblance to the consequences of traffic loading. The very small and large strains were measured during the cyclic shear loading. The purpose of obtaining these data is to define the stiffness and damping characteristics of these materials and the impact of the traffic loading and the long-term damage it leaves behind.



MAIN RESULTS

The examinations were conducted at ZAG, Slovenia, for two weeks. During this period, both materials were tested in a Large-scale Triaxial Apparatus.

A Large-scale Triaxial Apparatus was utilized to perform the loading tests, which enables characterization of materials at very small strain ranges as the result of the very high accuracy level of load-displacement control. It is consisted of rigid confining aluminium frames with a height of 3 cm and cross section of 40 x 40 cm, enabling prismatic specimens with a height of up to 80 cm.

For both materials, three consecutive direct shear tests were performed. Each of the samples was embedded into a rubber membrane within the rigid aluminum frames of the large triaxial apparatus. Prismatic samples with a cross-section of 40 x 40 cm, and a height up to 40 cm, were prepared with light compaction in a dry state. The weight of the specimens for the expanded clay aggregate is about 18.5-20 kg per single test.

Three tests were performed for each material, meaning three samples per material are taken into consideration. The test begins with a careful lowering of the plate for the vertical load accordingly. Thus, constant vertical stress is applied, equal to 50kPa, 100kPa, and 200kPa. After that, cyclic loading is applied with a gradually increasing strain with a range between 10^{-5} and 10^{-1} mm.

EXPECTED IMPACT

According to the European Container Glass Federation (FEVE), glass recycling has reached 35.9 million tons in 2020. Global production is about 195 million per year, of which 46% is container glass.

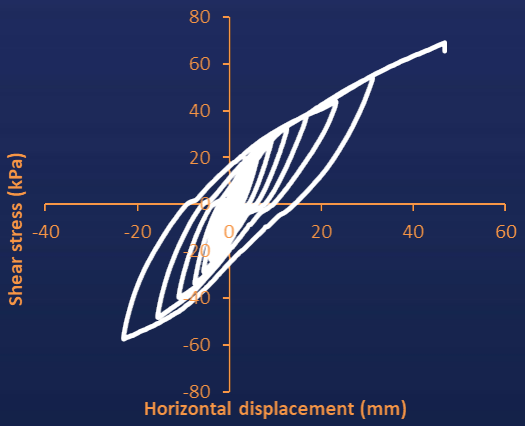
Project investigates the feasibility of testing samples of lightweight foundation materials at the Large-scale Triaxial Apparatus at ZAG and explores optimising the use of lightweight materials in the construction and reconstruction of critical infrastructure affected by climate change.

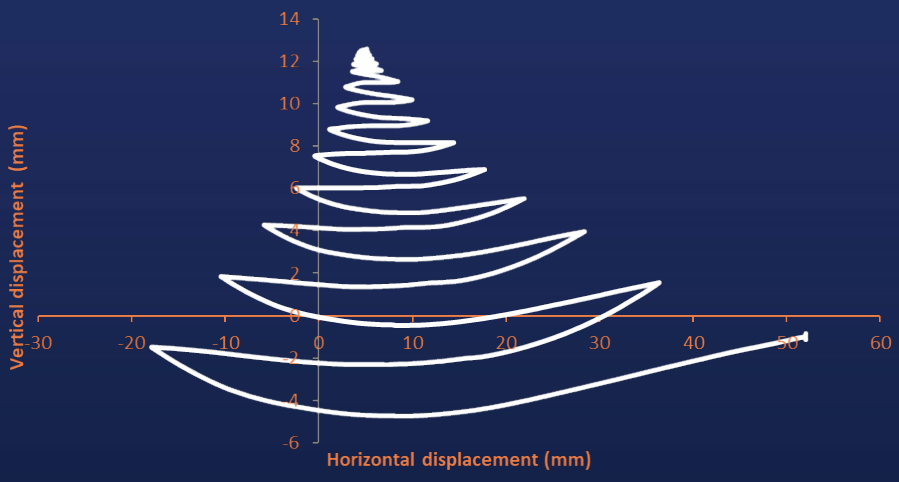
In addition, they could also support the implementation of another proposed transnational access project (PEDLER /CEDEX Facility) on the use of lightweight filling in railroad embankments.

The lightweight materials due to their stable mechanical properties with relatively lightweight and small compressive deformation, have great potential to be used in the construction sector as a base layer for the construction of roads, railroads, airports, buildings, etc.

Another important contribution of the project is the dynamic aspect of the investigations which are contributing to the definition of their dynamic properties such as the damping, dynamic shear modulus, fatigue as a properties as well as the long-term dynamic behavior. Hence, they can be quite beneficial if used as base isolation layer under the buildings or infrastructure constructed in seismically active areas.

Moreover, they have low thermal conductivity, making them a safe choice for improving the fire safety protection of buildings. Lightweight materials are often used to insulate roofs and water pipes and even as partition walls inside buildings. Thus, in the next period a continuation of the project is planned to define the thermal properties of this lightweight materials.





CONCLUSION

Lightweight materials are used for infrastructure construction purposes (roads, railroads, airports, buildings and industrial plants, etc.) in areas with low-bearing capacity subgrade soils for settlement mitigation and load reduction measures as well as thermal insulation in cases sensitive to temperature gradients. Critical infrastructure of Europe, particularly in the urban and transport sectors is facing challenges related to the low-bearing capacity of sub-grade, which requires a reduction of infrastructure weight, and on the other hand, climate change challenges with extreme temperatures bring requirements for additional thermal insulation of infrastructure. Due to those reasons, lightweight materials become an important construction material for the construction and reconstruction of critical infrastructure in Europe in near future.

LIWEMAT investigated the use of expanded clay aggregate and foamed glass aggregate exposed to cycling loading using large-scale simple shear apparatus which eventually was used to define the deformation characteristic of the material. The obtained data will be further analyzed to study numerical simulations of the use of lightweight material in critical infrastructure and its consequences in comparison to conventional natural aggregates.