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Dynamic characterization of EPS geofoam

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ABSTRACT

This paper attempts to describe the dynamic behavior of expanded polystyrene EPS geofoam, and shows the dependence of shear modulus, G, and damping ratio, λ, on shear strain, γ, density, ρ, and confining stress, σ_3, through the results of a series of resonant column and strain- and stress-controlled cyclic compression tests. Shear modulus and damping ratio versus shear strain curves were obtained and a series of equations were developed to model the dynamic behavior of EPS. From stress-controlled cyclic compression tests the effect of the number of cyclic load applications, N, on the maximum axial strain ε_{max} (for a specific static deviator stress, σ_e, plus the amplitude of the loading cyclic stress, σ_c) and on the dynamic modulus of elasticity E_{dyn} was evaluated as a function of the EPS density, confining stress, and the applied cyclic stress amplitude σ_c.

1. Introduction

Expanded polystyrene EPS is a polymeric foam, the internal structure of which is integrated by beads tangentially fused and formed by a tridimensional arrangement of closed cells that are developed by the beads expansion during the manufacturing process (Gibson and Ashby, 1999). The components of the EPS structure are shown in Fig. 1. Within the cellular structure of EPS a great amount of air is encapsulated, which represents about 95% of the total volume of this material. When the EPS is compressed the cell walls bend and buckle; also the walls and hinges that form the cellular structure fracture, allowing the air within the closed cells leak out.

EPS blocks are widely used in geotechnical projects. Due to its lightweight properties this material has been used as a partial or total replacement fill in embankments on soft compressible soils to minimize settlements and avoid stability problems. Also EPS blocks have been used by geotechnical engineers in the reduction of lateral loads on walls and bridge abutments, in this case blocks act like a deformable inclusion that improve the stability of these structures by attenuating the loads imposed by the backfill, seismic forces or surcharges. Further applications of EPS blocks are used in shallow foundations placed over expansive soils, and as a protection of water, gas and oil pipes. In general, due to the easiness in transportation and installation, EPS blocks have been used in projects where the time-schedule is a key issue.

The use of EPS blocks in geotechnical structures to specifically mitigate the intensity of loads caused by seismic events has been limited perhaps mainly due to the rather restricted knowledge the profession has on the dynamic behavior of this material.

Duškov (1997) estimated the degradation of the dynamic modulus of elasticity E_{dyn} carrying out cyclic unconfined stress-controlled compression tests on cylindrical samples with an average density of 19 kg/m^3 applying different stress levels and up to 270,000 load repetitions at frequencies between 3 and 6 Hz. Test results showed an evident influence of number of load repetitions on E_{dyn} and permanent deformations when the deformation induced by the static deviator stress applied exceeded the elastic range.

Athanasopoulos et al. (1999) carried out unconfined resonant column and cyclic unconfined compression strain-controlled tests on EPS specimens with average densities of 12.4 and 17.1 kg/m^3 to estimate shear moduli and damping ratios under varying load frequency conditions (0.01–2 Hz). Test results indicated that the shear modulus increased with density but the damping ratio was not influenced by this parameter. On the other hand, cyclic test results showed that there was not a significant effect of load frequency on the shear modulus; however the damping ratio increased with load frequency evidencing the viscous behavior of EPS.

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