LOADING CAPACITY OF A THICK EPS LAYER

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ABSTRACT

The EPStress-programme, carried out in Finland in 1999-2002, aimed to specify design procedure to activate application of EPS products and to improve the technical and economical competitiveness compared to other subsoil improvement methods.
In the EPStress programme, mechanical characteristics like compressive strength, creep and cyclic compression were determined in laboratory tests on an EPS100 product, and mechanical properties and deformations were tested in a full scale in accelerated pavement testing facility (Heavy Vehicle Simulator). Deformations and stresses in the structures containing EPS products were calculated applying finite element methods and programs used in the mechanical design of earth structures. If the deformations of EPS material were less than 0.4-0.5%, then EPS behaved elastically, with no significant, permanent creep or cyclic deformations due to the static overburden pressure and the standard wheel load of 50kN.
An old EPS lightweight fill at Vammala, Pesurinkatu, was found to be in original dimensions and well functioning. Test embankments were constructed at street repair sites in Helsinki and Espoo and on a highway pavement a Muurla. According to the site measurements, pavement service-life was comparable with the results of a multilayer analysis assuming the highway traffic of M9, even without a protective concrete slab.
As a conclusion, structures containing thick EPS layers should be planned and mechanically designed so that the service-life of the structure can be estimated. Laboratory testing should be modified so that tested parameters can also be applied in design calculations. Applications of structures containing EPS should be further developed to ensure the service-life. Further, an EPS-lightweight fill can be constructed without a concrete slab, if the overlay material and layer thicknesses are designed applying mechanistic multilayer calculations.

GENERAL

EPS-products are used in frost and thermal insulation of structures, and in lightweight fills to reduce settlements on soft subsoils. EPS products are softer materials compared to conventional mineral aggregates. One of significant problems has been the lack of information concerning mechanical design properties and on the mechanical design methods. The EPStress-program aimed to specify design procedure to activate application of EPS products and to improve the competitiveness (Fig. 1). Thus, lightweight filling should be developed to an application, technically and economically comparable with other subsoil improvement methods.

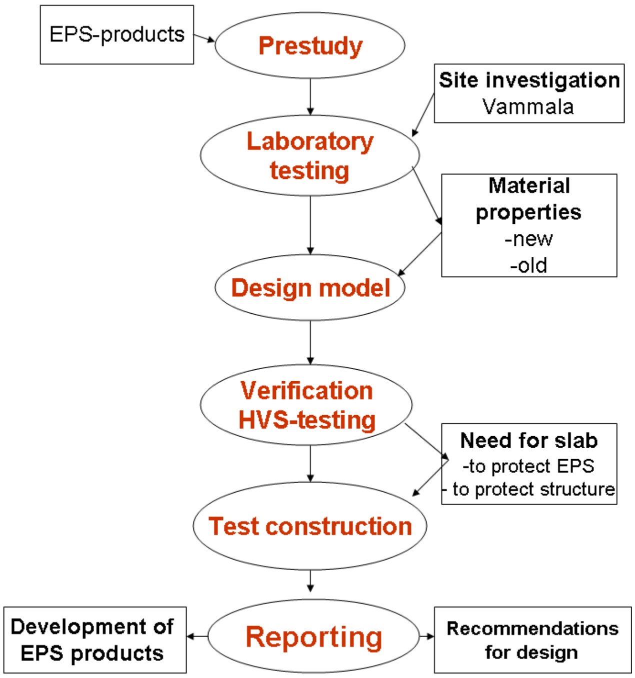


Fig. 1. The research plan for the EPStress programme.

LABORATORY TESTING

In the EPStress programme, mechanical characteristics like compressive strength, creep and cyclic compression were determined in laboratory tests on an EPS product. The compressive strength of the product (compressive stress at 5 a' 10% compression) was practically independent on laboratory testing procedure. Instead, the specimen size and procedure influenced on the determined elastic modulus. When the compression was measured in the middle part of the specimen with a diameter of 100mm, the determined modulus values were comparable to those, back-calculated from the full-scale structures. The modulus values determined from the total compression of the specimen were lower, even in the very same specimen and compression test (Fig 2). Thus, the standard compression testing procedure should be modified so that also the elastic modulus can be determined reliably. The long term compression (creep) of the tested EPS-product under static loading as well as permanent compression under cyclic loading began significantly increase after the compressive stress exceeded a value, corresponding to about 40% of the compressive strength

σ_{10} (Fig 3). This limit value corresponded to a compressive stress, resulting from a compression of 0.5%.

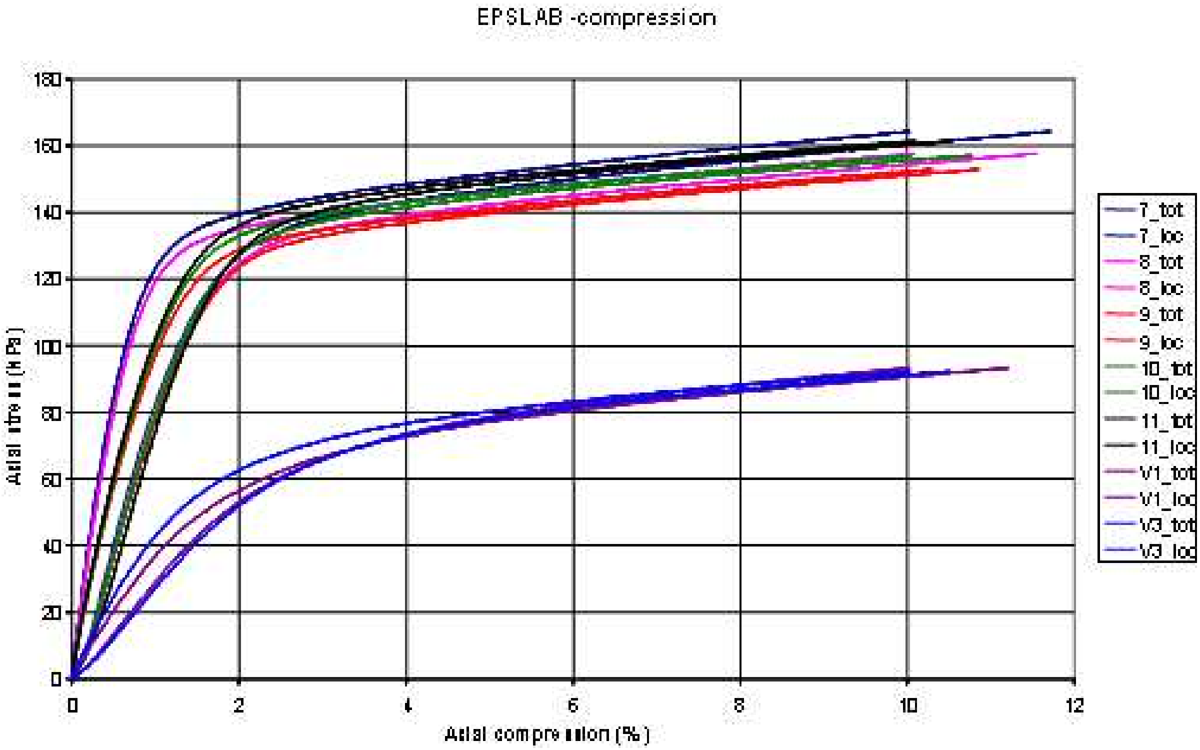
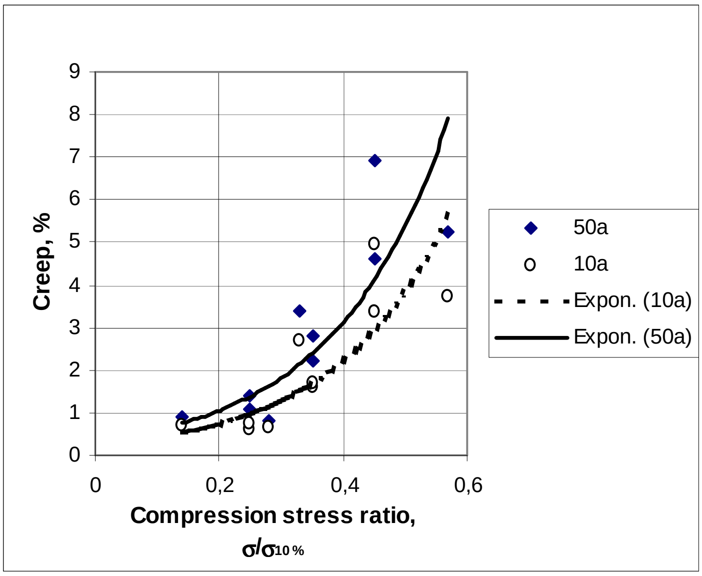


Fig 2 Compression curves of tested EPS materials. Upper set of curves: new EPS; lower sets of curves: old EPS from Pesurinkatu site. Marking of curves: "7 tot/loc" – specimen 7, compression measured between ends (tot)/between inner third points (loc).



Kuva 3. Compression creep in 10 a' 50 years vs. compression stress ratio. (10a – 10 years; 50a – 50 years)

TEST CONSTRUCTION

The mechanical properties and deformations of this EPS100-product were tested in a full scale in an accelerated pavement tasting facility (Heavy Vehicle Simulator, [1]). Test embankments were also constructed at street repair sites in Helsinki and Espoo, and at the construction site of the connecting road to Highway M9 at Muurla, located about 100km west from Helsinki ([2]). Earlier had been investigated an old lightweight fill on Pesurinkatu street in Vammala, western Finland ([7]).

DESIGN PROCEDURE

Deformations and stresses in the structures containing EPS products can be calculated applying finite element methods and programs used in the mechanical design of earth structures. If the deformations of EPS material are less than 0.4-0.5%, which correspond to about 40% of the compressive strength σ_{10}, then EPS behaved elastically, with no significant, permanent creep or cyclic deformations due to the static overburden pressure or the standard wheel load of 50kN.

EXPERIENCE FROM THE TEST CONSTRUCTION

The old EPS lightweight fill at Vammala, Pesurinkatu, was found to be in original dimensions and well functioning. At Muurla site, from the multilayer design analysis based on pavement measurements after construction, one could conclude that the service life of the bound pavement layers would be about 15 years under the highway traffic of M9 even without a protective concrete slab ([4]). In this case, the lightweight fill of EPS was overlain with a pavement with the thickness of 0.7m, strengthened with a bitumen-stabilised base layer. The test site was a temporary new road, connecting the highway to the old main road, and it was intended to be under traffic for less than 10 years ([3], [2]).

LESSONS TO LEARN

The permanent compression of EPS100 and higher strength products is not a significant issue in the design of road pavements in Finland, because on the thermally insulating EPS layer, a more than 0.5m thick layer of mineral soil is needed to mitigate the icing in wintertime. Further, an EPS-lightweight fill can be constructed without a concrete slab, if the overlay material and layer thickness are designed applying mechanistic multilayer calculations, and also controlling the strains of the bound surface. The protection of the EPS-fill against oil and solutive spills may not demand a concrete slab on the top of the fill. The protection can be carried out with an oil-resistant plastic foil that is protected against mechanical damage from above using a geotextile. If a lightweight fill is installed beneath a heavily loaded floor or foundation, one should control that the stress on the EPS-fill does not exceed the long-term compressive strength of the product to be applied.

FINALLY

It could be concluded that structures containing thick EPS layers could be planned and mechanically designed so that the service-life of the structure can be estimated ([5]).

Laboratory testing should be modified so that tested parameters can also be applied in design calculations. Applications of structures containing EPS should be further developed to ensure the service-life and economical feasibility in construction.

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