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Foamed Concrete Layer as Sub-Structure of Industrial Concrete Floor

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Abstract

Nowadays, the development of building industry and the increasing demand for building materials together compose the emergence of new warehouse centers. This trend enables building materials to be delivered more efficiently and within shorter time, thus making them more cost-attractive. At the same time, the sustainable development policy causes new materials and solutions to become more favorable by decreasing the amount of materials applied and reducing the energy consumption in industrial buildings. Concrete industrial floors must meet a number of requirements such as limited cracking, flatness and sufficient load-bearing capacity. Besides redundancy and visual aspects, the industrial floors are also required to show good thermal performance. The development and application of foamed concrete layer, due to its mechanical performance and thermal properties seem to be an adequate solution as substructure layer for industrial floors. The article shows results of numerical simulations of concrete industrial floor with foam concrete layer as substructure. It also includes a comparison of numerical results with a simplified analytical approach which is commonly used by structural engineers. Mechanical properties of foamed concrete, used in the analyses, were based on tests performed within the research project. The numerical simulations were performed with the use of ZSoil finite element software. This work was supported by the on-going research project "Stabilization of weak soil by application of layer of foamed concrete used in contact with subsoil" (LIDER/022/537/L-4/NCBR/2013), financed by The National Centre for Research and Development within the LIDER Programme.

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Nomenclature

b_p	equivalent contact radius of a load [m]
d_p	diameter of contact area [m]
E_{cm}	secant modulus of elasticity of concrete [GPa]
f_{ctk}	characteristic flexural strength of concrete [MPa]
h	thickness of slab [m]
k	modulus of subgrade reaction [kN/m^3]
P_k	characteristic value of point load [kN]
P_d	design value of point load [kN]
β	dynamic coefficient for loads [-]
γ_f	partial safety factor for loads [-]
γ_M	partial safety factor for concrete [-]
ν	Poisson's ratio of concrete [-]

1. Introduction

All forms of activity in buildings demand a solid platform to operate on - from manufacturing, storage and distribution, to retail and leisure facilities. In most cases a concrete floor makes the base on which such activities are carried out. In the recent years there has been a steady growth in distribution, warehousing and retail operations to serve the needs of industry and society. Furthermore, the scale of such facilities and the speed in which they are constructed has also resulted in higher and heavier racking systems and in storage capacity. All these factors initiate an increased demand for industrial concrete floor.

A typical build-up of a ground-supported floor consists of several layers of materials and components: concrete slab, slip membrane, subbase and subsoil. Industrial floors in cold stores or floors with high thermal requirements incorporate additionally an insulation layer between the slab and the subbase. This insulation layer is usually made of hard extruded polystyrene boards, while the subbase is formed with lean concrete or compacted gravel. Alternative materials are investigated due to the limit of natural resources. A good example of such material is lightweight foamed concrete (LFC). It is a material with excellent acoustic and thermal properties [1-4]. For many years it has been used worldwide for backfill to retaining walls, insulation to foundations and roof tiles, sound insulation, etc. However, in the last few years foamed concrete has become a promising material also for structural purposes [1,2,5-7]. Fig. 1 presents an example of such application, where pavement construction was reconstructed with subbase layer of foamed concrete. This experimental application was carried out in Trencin, Slovakia [1].

Fig. 1. Experimental application of LFC in pavements of access roads and car parks (view on top and side) in Trencin, Slovakia [1].

Improved thermal insulation requirements of building also require thermal protection of floors constructed directly on the ground. This problem occurs in both housing and different types of warehouses. Excellent insulating properties of foam concrete raises the discussion on the possibilities of new applications of foam concrete, such as subbase of