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Thermal and Dynamic Numerical Analysis of a Prefabricated Wall Construction Composite Element Made of Concrete-polyurethane

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Abstract

In this paper an innovative prefabricated composite wall construction blocks made of concrete with polyurethane inserts was investigated. Two different and separate numerical analyzes were performed i.e. thermal and dynamic analysis, respectively. At first the dynamic numerical analysis was performed to estimate the damping ability of disturbance wave propagation in the composite block in relation to the solid concrete model. Such disturbance propagation was assumed as a result of an explosion blast located at certain distance from the considered wall. Secondly the thermal conductivity analysis for both models was performed. In order to perform such numerical analyzes the ADINA program was chosen. All computations were performed on three dimensional space models. Performed analyzes allowed to observe if and how much the polyurethane inserts diminish both the heat flow and wave disturbance propagation.

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Keywords: Thermal conductivity; wave propagation; damping; composite; concrete; polyurethane;

1. Introduction

Composites are a special group of materials with two or more desirable mechanical properties combined resulting in more desirable structure element from the engineering and designing point of view. Such composite materials are frequently used in civil engineering, which for example provide enhanced buckling capacity, increased tensile stress capacity, increased mechanical wave damping properties, etc. The most popular composites are concrete with steel,

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but there are also other types of composites utilized, dependently on destination of structure element. As the simplest example of concrete-steel composite may be treated the reinforced concrete. Steel rods allow to transfer tensile forces, whereas compressive forces are transferred via concrete. Other example of composites are laminated wood structures utilized as beams supporting long spanned roofs, steel-rubber bearings utilized in bridge constructions to reduce vibrations from vehicle and pedestrians movement, etc. However there are many different composites utilized in civil engineering, research concerning combining concrete with polyurethane inserts to reduce both the heat flow and mechanical wave propagation is still in an early state.

Nowadays, due to the rapid technological progress, expensive experimental tests are frequently postponed after the end of numerical analysis based on finite element method. Analysis with FEM software not only allow reduce costs of normally performed experiments but also allow significantly reduce time of performed tests [1-4]. There can be found numerous publications of different phenomena analysis with the use of FEM method. For example numerical analysis of mechanical wave propagation in different materials with FEM utilization was performed in [5, 6].

In this paper thermal and dynamical analysis of an innovative composite wall block element made of concrete-polyurethane was performed. Two different numerical models were taken into considerations i.e. composite concrete block with polyurethane inserts and solid concrete block as a reference model, respectively. Due to the fact that composite model can be easily implemented in the production process and can be further utilized as a wall construction element for the analysis purposes it was assumed that concrete blocks are covered with plaster on the interior and exterior surface. In thermal analysis the main purpose was to observe and estimate if and how much polyurethane inserts reduce the thermal conductivity from the warmer interior to the colder exterior environment. For the dynamic analysis of mechanical wave propagation it was assumed that both composite and solid concrete block were subjected to the impact pressure load resulted from an explosion blast initiated in certain distance from the wall. Moreover it was preliminarily assumed that the energy transferred via pressure impact load is not destructive. As the numerical solutions had to cover two areas (thermal conductivity and disturbance wave propagation) ADINA program fully based on finite element method was chosen.

2. Numerical models

In this paper two different numerical models in three dimensional space were investigated. As a first numerical model proposition of an innovative construction material made of concrete block with polyurethane inserts was adopted, whereas as a second, reference model solid concrete block was adopted, respectively. Each numerical model had exactly the same dimension relations, which were presented in Fig. 1.

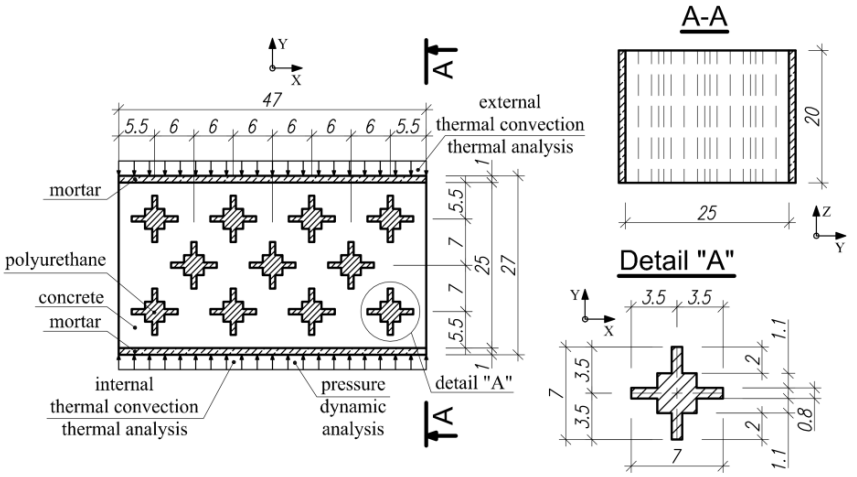

Fig. 1. Dimensions of analyzed composites [cm].