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Research into the structure and technologies of the building envelope

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Abstract

The article examines technological and structural solutions for walls, roofs, floors in order to find the most effective barriers for each material and its thickness. Selected alternative materials are mineral wool, polystyrene and polyurethane foam. Thermal parameters, economic and technological indicators are compared within the envelope. The optimal thickness of the envelope component is found by calculating every envelope option by means of test utility method. The most efficient insulation material is determined by the simple additive weighting (SAW) method. The optimal thickness of insulation materials: 400 mm for the roof, 300 mm for walls and 300 mm for floors. The most effective materials are as follows: polyurethane foam for the roof, polyurethane foam for walls and polystyrene for floors.

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Keywords: Envelope components; Technological solutions; Multiple criteria evaluation

1. Introduction

Efficient energy use is important in modern buildings because of high energy costs and CO_2 emissions. These reasons have led to the development of energy efficient buildings. The key factors in energy efficient building are insulation of partitions, their tightness and absence of thermal bridges [1].

A modern building must be economical and use energy resources efficiently by means of modern technologies. Energy efficient buildings have numerous environmental, economic, and social advantages versus traditional buildings. At the same time there are a lot of options in the choice of insulation materials, insulation layer thickness, glazing and other structural elements of the building.

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The article compares the alternative options for wall, roof and floor structures. Rock wool, polystyrene foam and spray-applied polyurethane foam can be alternatively used for thermal insulation. Thermal insulation materials are the key factor to be considered in energy efficient buildings.

2. Applied methodology and methods

The present paper compares envelope insulation materials used in modern buildings.

2.1. Structural solutions for envelopes

The paper analyses the thermal insulation solutions for a flat roof constructed on reinforced concrete slab (Figure 1). The aim is to find the most efficient insulation material and the insulation layer thickness. The following alternatives were selected for the analysis: rock wool, polystyrene foam sheets and spray-applied polyurethane foam.

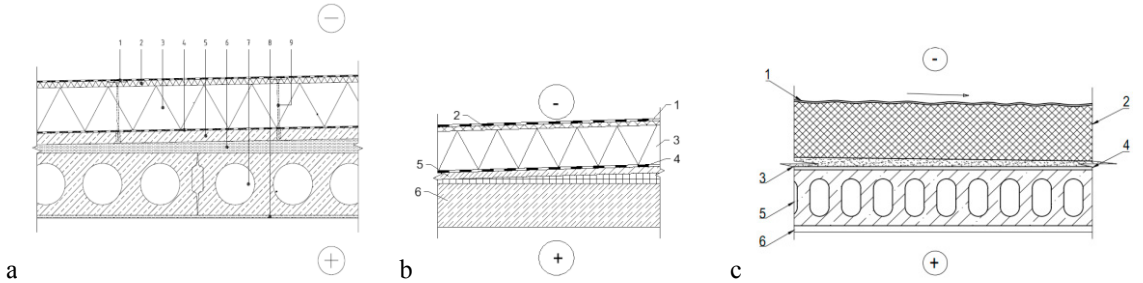

Fig. 1. Structural solutions for flat roofs: (a) rock wool; (b) polystyrene foam sheets; (c) spray-applied polyurethane foam: (a) 1 - Waterproofing roof coating; 2 - PAROC ROB 60, d=20 mm; 3 - PAROC ROS 30; 4 - Vapour and moisture control layer PAROC WMV 020 bas; 5 - Levelling layer, d>50 mm; 6 - Fall creating layer; 7 - Reinforced concrete slab; 8 - Finishing layer – plaster, d<10mm; 9 - Fixture [2]; (b) 1 - Waterproofing roof coating; 2 - Top layer from laminated polystyrene sheets; 3 - Bottom layer from laminated polystyrene sheets; 4 - Vapour and moisture control; 5 - Fall forming and levelling layer; 6 - Reinforced concrete slab [3]; (c) 1 - UV membrane; 2 - Polyurethane foam POLIURETAN SPRAY S-403E-W; 3 - Pitch forming layer; 4 – Interlayer; 5 - Reinforced concrete slab; 6 - Finishing layer [4].

Thermal insulation of flat roofs poses high requirements for insulating material because the roof surface must have resistance to various impacts such as extreme temperatures, snow, rain and wind loads. The foam sprayed on the roof hardens after several minutes and becomes resilient to foot traffic. Now it has to be covered with UV control layer [5].

Brick wall insulation alternatives are also analysed in order to find the most effective material and insulation layer thickness. The following insulation alternatives were selected: rock wool, polystyrene foam sheets and spray-applied polyurethane foam (Figure 2).

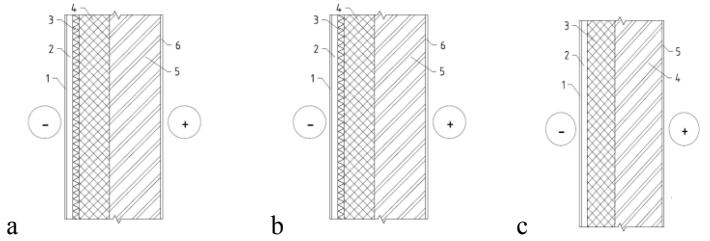

Fig. 2. Structural solutions for walls: (a) rock wool; (b) polystyrene foam sheets; (c) spray-applied polyurethane foam: (a) 1 - External finishing layer; 2 - Ventilated air gap, 30 mm; 3 - Wind barrier; 4 - Thermal insulation with PAROC FAS B; 5 - Brick wall; 6 - Finishing layer [4]; (b) 1 - External finishing layer; 2 - Ventilated air gap, 30 mm; 3 - Wind barrier; 4 - Thermal insulation with EPS 70; 5 - Brick wall; 6 - Internal finishing layer [2, 3]; (c) 1 - External finishing layer; 2 - Ventilated air gap, 30 mm; 3 - Polyurethane foam POLIURETAN SPRAY S-303E-W; 4 - Brick wall; 5 - Internal finishing layer [4].