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Alternative technology of constructing masonry structures designed for areas with increased seismic activity

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Abstract

The Czech Republic is a country which generally sees low seismic activity; however, this activity needs to be taken into account in ca 50% of the country's area with 10 districts being considered as having seismic activity higher than 0.08 g. In terms of masonry structures, this issue concerns mainly the execution of the head joints of the masonry and its reinforcement (both in the direction of the bed joint and in the perpendicular direction). All these technologies are rather difficult and expensive to implement. The research focuses on assessing the possibilities of constructing dry masonry and binding it with polyurethane foam. This method allows for significantly higher shear strength of the masonry and appears to be an interesting alternative in the area of constructing buildings in seismically active areas. The structure was stiffened by filling hollow masonry units with large cavities with polyurethane foam. The PUR foam was sprayed into the units during construction. The foam thus applied hardens perpendicularly to the bed joint of the masonry and, having expanded throughout the clay units, it functions as a binder and a stiffening component to the masonry as a whole. The initial shear and flexural strength of the masonry segments were determined. The newly developed method of filling the cavities of masonry units with PUR foam was compared with the conventional method of constructing masonry by means of bonding the blocks with mortar or PUR foam in the bed joints (with no cavities filled). The filling of the masonry unit cavities brought a significant increase in the shear and flexural strength of the masonry. This indicates the stiffness of the structure increased as well.

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Keywords: Clay masonry unit; masonry; seismicity; polyurethane foam; shear strength

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1. Introduction

Building design always emphasises the safety of building's users and inhabitants. Buildings are constructed so that they can resist (among others) damage by external factors that could endanger the function of the building as a whole. These factors include mainly weather effects but also random events, such as seismic activity. In areas, where such risks can occur, this factor must be taken into account during building design. If this threat is neglected, a possible earthquake could bring devastating consequences. This risk exists in the Czech Republic as well. There are areas where earthquakes occur [1], mainly in the Bohemian massif [2,3]. This is the reason why there is the effort to include seismic effect in the design of brick masonry composition in order to increase its resistance to mentioned events. This concerns mainly shear strength and sufficient stiffness of the walls as well as the whole structure.

Shear strength, being the main parameter connected with the earthquake resistance of masonry, was observed in masonry walls commonly used in the construction of civil and industrial structures. Increasing the shear strength of masonry concerns mainly the execution of bed and head joints as this provides stiffness to the structure [4,5].

2. Materials and methods

A way of improving the stiffness of a masonry structure is vertical and horizontal stiffening resulting in stiffer walls. These are the prerequisites for increasing the earthquake resistance. During construction with clay masonry units, other, new materials are used next to traditional mortar mixes (e.g. polyurethane foam (PUR), which is finding broad practical use).

The experiment was performed with clay masonry units with large cavities. These were clay masonry units with polished bed faces for precision wall construction. Their dimensions are 248/380/249 mm. These blocks are designed for both load-bearing and non-load-bearing exterior walls with the thickness of 380 mm.

These clay masonry units have large cavities, which offer possibilities for wall stiffening in the vertical direction. The stiffening was performed by means of a new method of filling the large-cavity clay masonry units with PUR foam with the result of binding the clay masonry units across several layers. The first stage involved determining the initial shear strength of the masonry according to EN 1052-3 [6] and in the second stage, the flexural strength test was performed according to EN 1052-2 [7].

The initial shear strength tests were performed on masonry fragments. This was a preliminary test for determining the performance of PUR foam in terms of vertical stiffening. Fig. 1 shows the placement of a specimen in the testing apparatus.

Fig. 1. The test sample for the determination of initial shear strength.