Light-weight fibre-cement cladding elements

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Abstract. By the means of various kinds of light-weight aggregates or aerating agents it is possible to achieve light-weighing of thin-walled fibre-cement composite elements. Even if these are not structural elements, it is necessary to evaluate also strength characteristics and resistance to environment for their durability in certain applications. In one part of our research light-weighing possibilities of standard composition were evaluated by the means of porous structure creation. In the second part the standard aggregate was substituted with available kinds of light-weight porous aggregates in a certain part or in a whole volume. As the limit criterion there was maximal particle size 1 mm for spraying of fibre-cement mixture by the means of special air pressure equipment. This paper brings not only a summary of laboratory experiments but also examples of successful realizations such as balcony panelboards, façade elements, bridge structure claddings or bulk flower pots.

1 Introduction

Thin-walled elements with a matrix set on a base of high-valuable Portland cement with dispersed reinforcement from alkali-resistant glass fibres are used in a range of applications as claddings of buildings and infrastructure constructions as well as various architectural elements of residential buildings. Even if their elementary thickness and therefore total weight is quite low, architects and building companies demand on even further decreasing of the bulk density of these fibre-cement elements for the reason of loading elimination of connected superstructures and easier assembling in demand conditions.

2 Mixture components

Fibre-cement composite consists of approximately 53% binder, 40% filler, 3% fine filler, 3% fibre reinforcement, 1% plasticizer (in weight percents). Light-weight aggregates are added to substitute 50, 75 or 100% of the silicate sand volume in the whole matrix according to density of particular aggregates. As exception to the rule there were so called microspheres, which are very specific in their appearance. Even a small addition to the mixture caused increasing of fresh concrete mass up to two times larger volume. As suitable amount of these micro-balls approximately 2 – 3% of filler weight was proven good.

For light-weighing of fibre-cement composites there were used components as follows:

1) Polymer microspheres Expancel
2) ceramic aggregate Liapor 0-2/575
3) expanded vermiculite Medium and Superfine
4) aerating agent Sika Lightcrete I-500

3Production technologies

The aim of all laboratory experiments was to design a fibre-cement mixture suitable for production technology premix, which is used in a production department of the Research Institute of Building Materials. This technology demands on high flowable mixtures without bleeding and sedimentation of heavier mixture components.

Due to co-operation with the company DAKO Brno it was necessary to prepare compositions for the spraying technology. The key parameter for the spraying equipment is maximal particle size only 1 mm.

4Evaluation of technological properties

Basic physical-mechanical properties were evaluated on test samples 250x50x10 mm prepared with the technology premix after 28 days curing in water. Firstly bulk density, followed with absorptivity, flexural strength and impact resistance were evaluated for various mixture compositions.

Table 1. Properties of light-weight compositions - laboratory.

Composition	Bulk density [kg/m^3]	Flexural strength [MPa]	Absorptivity [%]	Impact resistance [kJ/m^2]
Standard	2 050	11.0	< 10.0	7.0
Microspheres	1 430	7.5	15.0	7.0
Liapor	1 650	10.5	13.0	5.0
Vermiculite 75	1 620	10.0	14.0	5.0
Vermiculite 100	1 500	11.0	17.0	6.0
Aerating agent	1 760	9.0	13.0	7.5

Bulk density and strength of the composites are properties in relation to each other. The better is the first one the poorer is the second one and vice versa. It is evident with flexural strength values, which are influenced by not only low strength of individual particles of the light-weight component, but also by higher level of water/cement ratio in the range of 0.32 to 0.56.

5Evaluation in production conditions

5.1. First stage

For the first stage two compositions of light-weighed fibre-cement composite were selected for the evaluation in real production conditions in the company DAKO Brno. The first one was with microspheres and the second one with aerating agent Sika. Three thin-walled balcony panelboards were casted in dimension 1000x900x20 mm. For impact resistance improvement two panelboards were reinforced with PVA mesh situated in most exposed part, the last panelboard was reinforced with glass fabric.

Table 2. Properties of light-weight compositions - first stage.

Composition	Bulk density [kg/m^3]	Flexural strength [MPa]	Absorptivity [%]	Impact resistance [kJ/m^2]
Standard	2 050	11.0	< 10.0	7.0
Microspheres	1 460	6.0	15.0	4.5
Aerating agent	1 620	11.0	11.0	4.5

Impact resistance of the completed panelboards according to Czech standards was examined and all the panelboards fulfilled the required impact energy 150 J without failure.

5.2 Second stage

In the next stage the compositions with ceramic aggregate Liapor, expanded vermiculite and again with the aerating agent were evaluated in production of fibre-cement composites. For evaluation of both the technologies, i.e. premix and spraying, planar balcony panelboards, façade cladding elements and shaped bridge structure claddings were prepared.

Table 3. Properties of light-weight compositions - second stage.

Composition	Bulk density [kg/m^3]	Flexural strength [MPa]	Absorptivity [%]	Impact resistance [kJ/m^2]
Standard	2 050	11.0	< 10.0	7.0
Liapor	1 290	6.5	15.0	5.0
Vermiculite 100	1 550	10.5	17.5	7.5
Aerating agent - spraying	1 570	8.0	9.0	6.5
Vermiculite 75 - spraying	1 630	17.5	19.5	18.0
Aerating agent - spraying	1 850	18.5	13.5	19.0

Casted bridge structure cladding element made of air-void fibre-cement composite will be examined in the laboratory of Brno University of Technology for evaluation of resistance to wind loading. Selected balcony panelboards will be evaluated in resistance to impact loading in the same way as the previous variants. Façade panels made of both compositions by the means of the spraying technology are currently under durability examinations in the weather equipment in the Research Institute for Building Materials.

5.3 Third stage

The last stage of evaluation was carried out in May 2012. It covers both optimizationofthecomposition with vermiculite for better workability achievement and optimization of the composition with aerating agent for lower bulk density achievement.

Again both the technologies were used for the production of balcony panelboards, façade cladding elements, bridge cladding elements and bulk flower pot as well. Despite the variant with utilization of aerating agent was not much successful, the elements with vermiculite weigh approximately 20% lower in comparison to standard fibre-cement elements.

Table 4. Properties of light-weight compositions - third stage.

Composition	Bulk density [kg/m^3]	Flexural strength [MPa]	Absorptivity [%]	Impact resistance [kJ/m^2]
Standard	2 050	11.0	< 10.0	7.0
Vermiculite	1 485	10.2	16.2	5.6
Aerating agent	1 722	8.4	11.9	5.6
Vermiculite - spraying	1 566	11.8	17.3	14.8
Aerating agent - spraying	1 886	12.7	12.1	12.9

From this stage of production several products were chosen for the forthcoming experiments. Casted balcony panelboard with vermiculite will be examined in the Technical and Test Institute for Construction Prague, Branch Brno. Very perspective bridge cladding element with vermiculite will be examined in the laboratory of Brno University of Technology. Bulk flower pot is a prototype for the planned production in the company DAKO Brno as well for a small-scale production in the Research Institute for Building Materials.

Static evaluation of the planar façade panel and the shaped bridge cladding element made of light-weight composition with vermiculite was carried out. All the variants fulfilled the requirements according to the I. as well as the II. ultimate state.

Fig. 1. Spraying of bridge cladding element.

6 Conclusions

The aim of our research is design of the fibre-cement composite with minimal bulk density and adequate flexural and impact strength. According to our experiments we can conclude, that after optimization process of light-weight fibre-cement composites we can meet better technological properties of these products.

Material costs are expected to be higher, but this disadvantage will be compensated with decreasing of production, transport and assembly costs. With utilization of both the production technologies it will be possible to produce this assortment: balcony panelboards, façade cladding elements and various architectural elements with distinctive lower weight.

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