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Glass-Fibre-Concrete Applied for Building Façade Panels Subjected to Wind Loading Actions

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Abstract. In the period of several years, the research oriented to the development of particular type of glass-fibre-concrete (GFC) and to its application in buildings is continuously realized on the authors' workplace in co-operation with the Research Institute of Building Materials (VUSTAH). The first type of glass-fibre-concrete developed by VUSTAH has been determined and produced for the utilization in façade panels especially, but currently the GFC technology and quality is developed and aimed to use it also as parts of load-carrying civil engineering structures. To investigate the actual behaviour of GFC structural components subjected to loading actions and to obtain information of their load-carrying capacities, within the frame of this research the experimental verification is realized. This paper is focused on the partial problem of the design and realization of glass-fibre-concrete façade cassette panels, that means the results of experimental verification of their actual behaviour and load-carrying capacity, if subjected to the wind loading actions, are presented.

Introduction

External surface areas of façade claddings of multistory administrative and modern multifunction buildings – excluding transparent glass wall parts – are often realized using components represented by aluminum or glass-fibre-concrete cassette panels. The structural design of the wall cassette of building façade claddings is needed to solve with regards to many criteria and requirements, that means mainly simple installation and substitution, financial costs, durability and, significantly, ensuring the reliability in the case of affecting loading actions and temperature effects. Glass-fibre-concrete can be produced using two technologies: (i) premix and (ii) splashing [3], [5], [6], [7], [8]. Within the research part described here, test specimens produced by premix method have been verified.

Experimental Verification of GFC Material Properties

At the first phase of the experimental verification, tests of material properties of two types of glass-fibre-concrete determined for the façade claddings have been realized [7], [8], [9]. Material tests have been oriented to the strength in bending tension and corresponding modulus of elasticity.

Mechanical properties have been obtained from the set of 77 material test specimens and subsequently, test results have been elaborated and statistically evaluated. The basic values of GFC strength and modulus of elasticity including their statistic parameters are listed in Table 1.

Table 1 GFC physical-mechanical parameters in bending tension.

Strength in bending tension f_{tb} [MPa]				Modulus of elasticity E [GPa]	
mean value	var. coefficient	charact. value	design value	mean value	var. coefficient
21.06	0.231	12.78	4.50	14.95	0.438

a) b)

Fig. 1 Glass-fibre-concrete: a) GFC panels on building façade, b) GFC specimens for material tests.

Experimental Verification of Load-Carrying Capacity of GFC Façade Panels

Ultimate load-carrying capacity and behaviour of glass-fibre-concrete facade cassettes subjected to wind loading actions has been verified using loading tests of the real test specimens developed and produced in the Research Institute of Building Material, Inc. at Brno city, Czech Republic.

Investigated facade panels have special structural detailing with the stiffness on the edges of the panel and with the continuous longitudinal groove along the entire panel length, which has been given by architectonic requirements. It was expected, that the groove will be the weak element of the panel structure, but the results of the performed theoretical analyses gave unsatisfactory conclusions. Thus, the loading tests have been chosen as the most suitable tool to investigate the actual behaviour and objective ultimate load-carrying capacity of these panels influenced by the groove. The aim of the tests was to find out the influence of the groove on the edge stiffness, and subsequently, on the decreasing in load-carrying capacity of entire panel, and on the other side, to verify the possibility of reinforcing of the panel edge to eliminate the groove influence. Based on the results obtained, the potential aim was to design the modification of structural detailing, to align the requirements for the static behaviour and load-carrying capacity, and together, for the architectural expression.

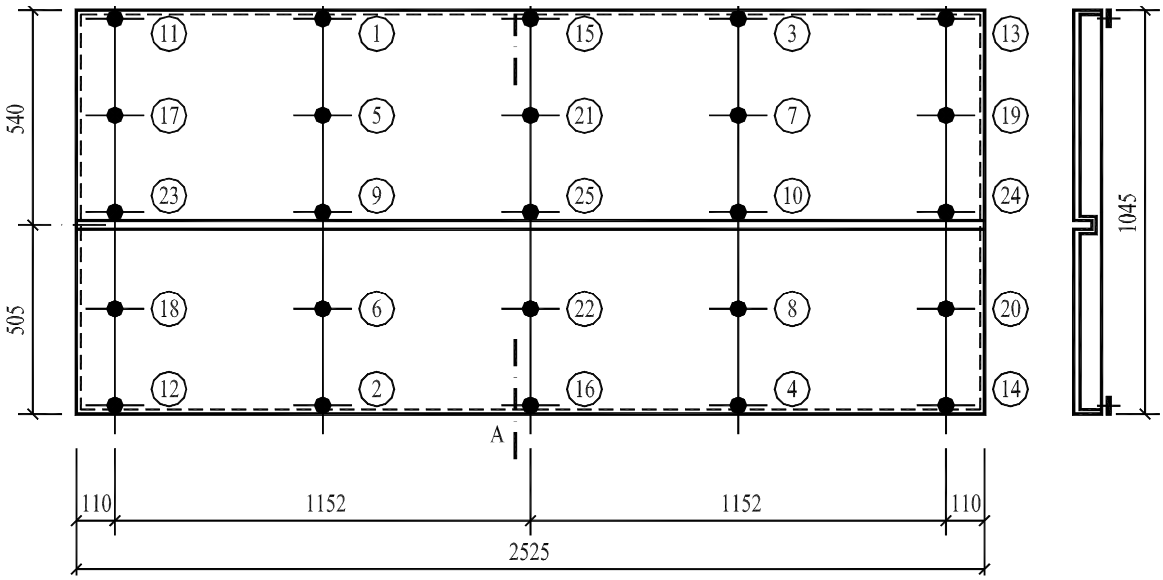


Fig. 2 GFC facade cassette panel: configuration, dimensions, static supporting

Test Specimens. In total, 5 specimens have been tested; 3 specimens (T1, T2 and T3) have been subjected to the loading actions simulating wind pressure and 2 specimens (T4 and T5) subjected to the actions simulating wind sucking. Hereto, the results of loading tests simulating wind pressure only are presented. The scheme of the configuration of the panel is drawn in Fig. 2.

The panel is statically a plate component locally supported in the points 11-12, 15-16 and 13-14. In the real structure, the supporting is represented by metal hanging hooks connected to the stiffening structure of the panel.

Test Arrangement and Realization. During the loading tests, the effect of the uniform load has been realized using the vacuum loading test method [2], [4], [6], [7], [9]. The test specimen is located in the box, from which air is sucked out, so that the surround air overpressure causes the continuous uniform load affecting the top surface of the tested specimen. Illustrative shots demonstrating vacuum test arrangement and the test realization in the testing room of authors' workplace are shown in Fig. 3.

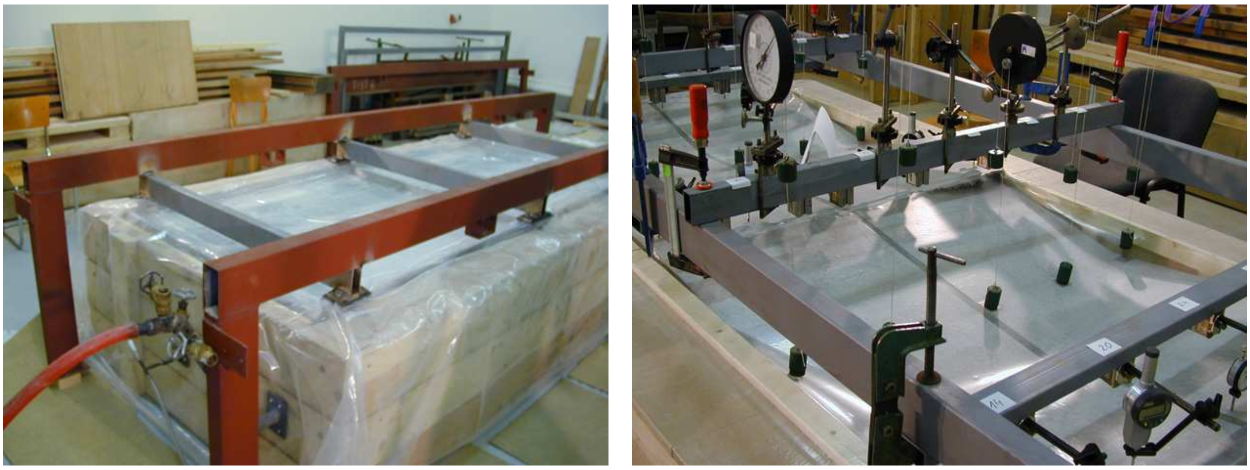


Fig. 3 Illustration of arrangement of vacuum loading test method and test realization

Test Results. The results of the loading test of the first panel (specimen T1) loaded by simulating wind pressure demonstrated that the longitudinal groove (see Figs. 4 and 5) significantly weakens the stiffening edge rib on the shorter panel side. The groove causes the failure of the edge rib, already if the load is about 1.5 kPa and the weakened edge rib as a critical detail adversely determines the resulting load-carrying capacity of the entire panel.

In the case of next test panels (specimens T2 and T3) the critical detail mentioned above has been eliminated by reinforcing the edge using thin-walled metal U-profile (see Fig. 6), which is a substitute equivalent of the modification of the edge rib, which must be realized. The test results of the specimens T2 and T3 indicate the significant influence of this modification manifesting about up to 6 times increasing in the ultimate load of the test specimen T1.

Fig. 4 Illustration of failed test specimen T1

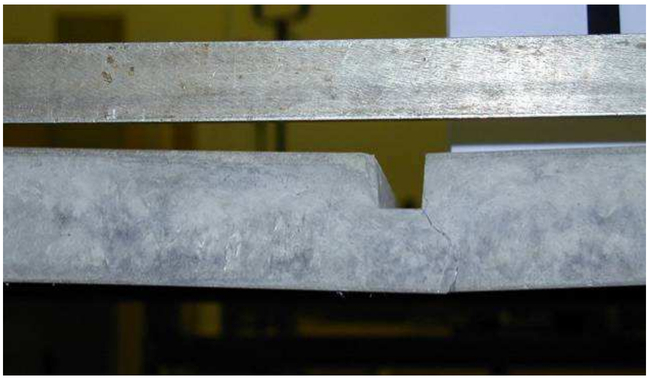
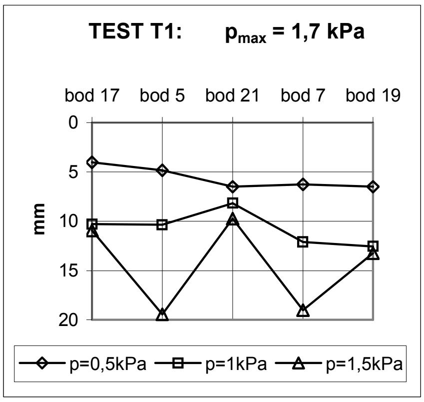
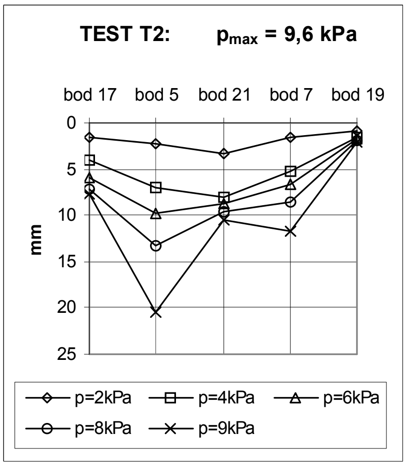


Fig. 5 Illustration of failure of edge ribs weakened by longitudinal groove

Fig. 6 Illustration of failed test specimen T3





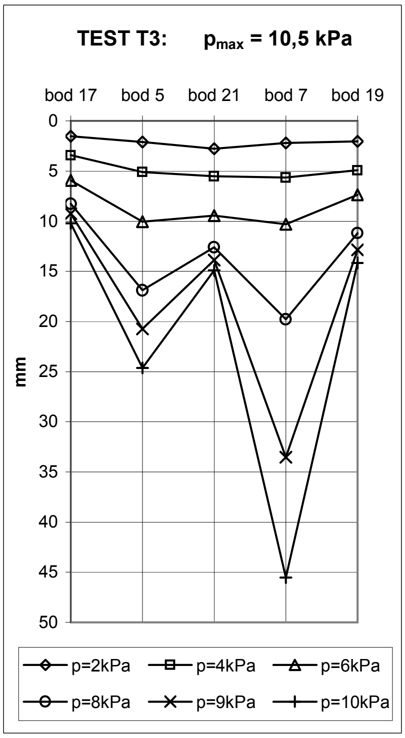


Fig. 7 Deflections in the line of the points 17-5-21-7-19

The examples of the results illustrating the deflections of GFC façade cassette in the process of increasing load are depicted in Fig. 7. The objective ultimate load-carrying capacities of the specimens subjected to wind pressure are in the top of the graphs. The illustration of the corresponding deflection of the locally supported plate cassette before collapse is seen e.g. from Fig. 2.

Conclusions

Glass-fibre-concrete is the suitable material for the building façade panels, both from the viewpoint of the architectural expression and environmental properties, and from the viewpoint of the actual static behaviour and load-carrying capacity. However, the actual behaviour of the façade panel under loading actions and load-carrying capacity can be significantly influenced by the structural detailing, as it has been shown on the particular façade component and its properties and behaviour mentioned above.

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