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Design of a Suspended Ventilated Facade with Composite Facing

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Abstract. A suspended ventilated façade is the most efficient solution to insulate and improve aesthetics of both a refurbished and a newly built building. Today, a wide variety of rainscreen cladding systems exist, offering different bearing structures, cladding subframes and cladding materials. Composite cladding is the most widely used.

Introduction

The suspended ventilated systems are needed to meet requirements such as strength, reliability, fire safety, durability, efficient insulant ventilation, accomodation of thermal movement by bearing structure [1], higher insulation values, corrosion resistance, earthquake resistance, lower man-hours for assembly and repair, lower materials consumption and lower manufacturing cost of rainscreen subframe.

Developed system

There has been developed a suspended ventilated façade system with composite cassette cladding (aluminium composite panels). A general view of the system is shown in Fig.1.

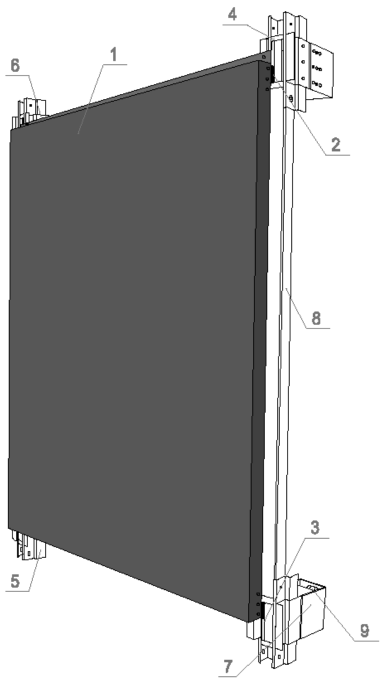

Figure 1. General view of composite cladding with nodal toothed subframe
1 – composite cassette; 2 – open-slotted clip; 3 – slide's toothed bracket ; 4 – slide; 5 – back of extension; 6 – extension; 7 – bracket; 8 – drainage profile; 9 – anchor dowel.

The bearing structure is made from AMг6 aluminium alloy. Cladding panels are fixed to the subframe at nodal points (bracket mounting locations) using open-slotted clips. Since such subframe has no vertical or horizontal rails, it consumes fewer materials and therefore offers low manufacturing cost. Carrier brackets transfer all cladding loads from nodal points to the substrate wall. The subframe allows for free thermal movement of the cladding and the system as a whole by enabling the open-slotted clip to move vertically within the body of the toothed bracket and the latter, in turn, to move horizontally within the body of the slide. The use of open-slotted clipsoffers the minimum assembly man-hours and improves the maintainability of the system as aluminium composite panels are toothed into said fixings instead of being hung on elements of the bearing structure (as is the case for existing systems), which thus reduces the number of processes. Where a defective cassette needs to be replaced, such fixings are easily dismounted by unwedging the toothed bracket of the slide. Air feed channels specially provided in the cladding panels efficiently ventilate the air gap and allow the insulant to resist moisture, thus maintaining thermal properties of the latter and enhancing the durability of the entire system.

A static analysis

A static analysis of the facade system was carried out to determine the limits of its possible use. The analysis was aided by a LIRA software system. To simulate performance of the system, the analysis built a finite-element model for 1.2 × 1.2m cassettes that are most often used in building practices, and for the maximum cladding standoff distance of 340 mm (Fig. 2).

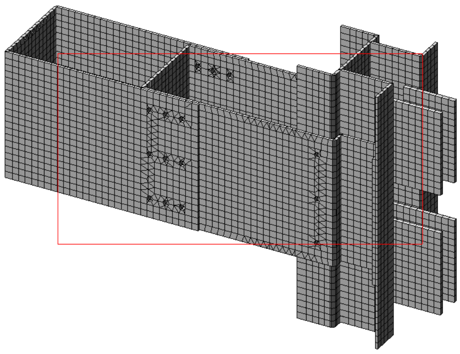

Figure 2. Finite-element model of subframe node.

The system was given a simulated test to withstand wind-suction forces and those exerted by the weight of the bearing structure and cladding. The below Figures (Figs.3 and 4) plot stresses against building height and wind region. These are the stresses induced by tension forces with bending in the most loaded brackets of the row and corner areas of the rainscreen.

The stress values are found to be much lower than the maximum allowed ones equalling 117 MPa. It is clear from the analysis of the results obtained that the system can be used in all wind regions, in buildings as high as 75 m with all standoff distances possible.

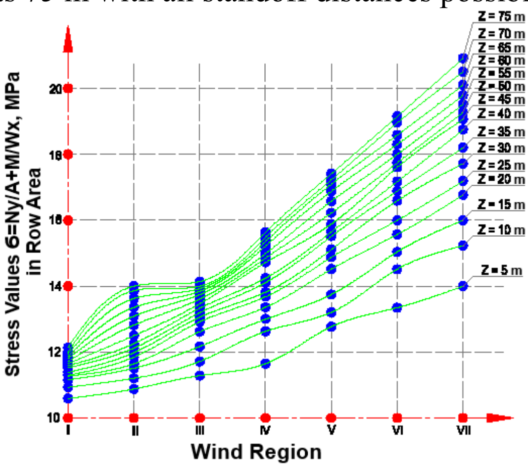

Figure 3. Maximum stress curve for row-area bracket

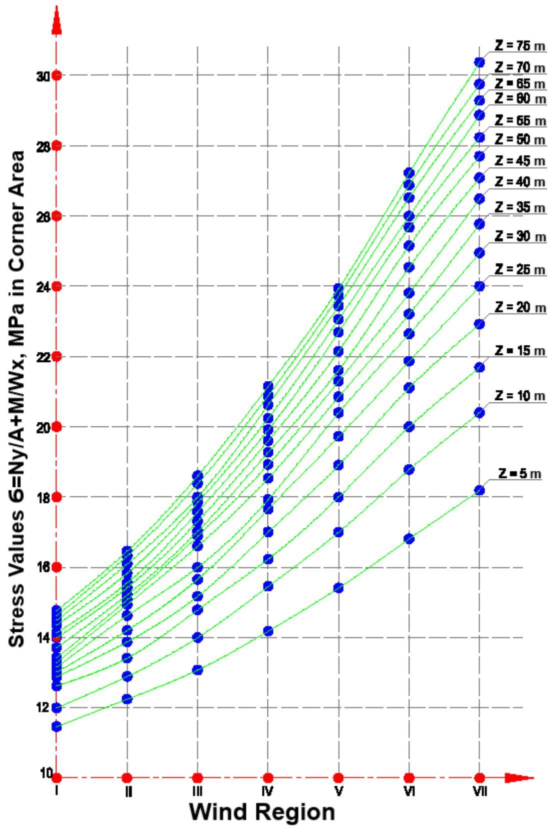

Figure 4. Maximum stress curve for corner-area bracket

There was manufactured a pilot batch of rainscreen system elements, with geometries of toothed subframe connections having been verified experimentally, to check system's strength by static and dynamic load testing [2].

An experimental study

An experimental pull test was carried out on a toothed subframe connection to determine the limits of the possible system use that is dependent on wind-suction force. To do that, an Instron 3382 tester was used (Fig. 5). Failure occurred when tabs of the toothed bracket opened. The maximum load was observed to be 2,663.8 N, which is higher than the maximum allowed load of 2,346.6 N obtained through numerical computation of the system (wind load calculation was made for 75m high buildings and wind region VII).

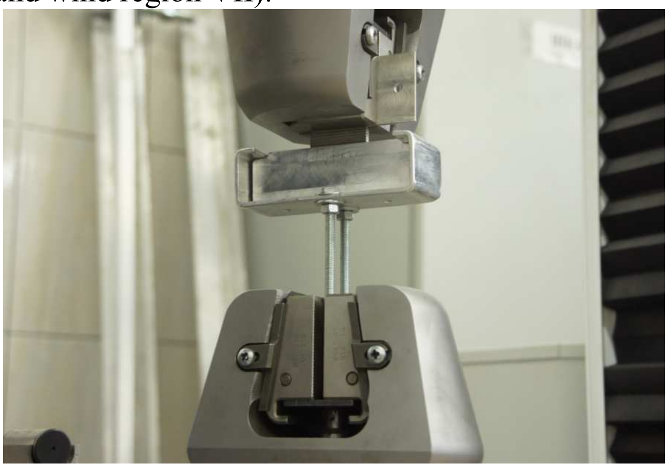

Figure 5. General view of tester with subframe specimen

To determine assembly man-hours and system maintainability, a part of the system was mounted and dismounted and thus revealed low man-hours and high maintainability. Fig.6 depicts a general view of the mounted corner cladding element.


Figure 6. General view of mounted façade cladding element (side view)

Laboratory tests were carried out to determine whether the developed rainscreen cladding system is reliable enough to be used in earthquake-prone regions rated from 7 to 9 points on MSK-64 scale [4]. These were the vibration tests (resonance method tests) allowing to measure numerical/power load that simulates seismic forces within a wide frequency range. A ВИД-12М vibration machine mounted on a special pendulum vibration rig was used to excite vibrations.

The tests showed that the facade system withstands seismic loads of 7 to 9 points.

A cost analysis

As well, system's economics and materials consumption were analysed. The cost of the system with the maximum bracket depth (with a 250 mm thick insulant) is found to be not more than 439 RUB/sq. m of blind wall, which is close to the cost of galvanised steel systems; and materials consumption is not more than 2 kg/sq m of blind wall, which is significantly lower than the consumption of most of the systems (materials consumption of existing systems averages 3.5 kg/sq m of blind wall).

An album of engineering solutions with detailed design of the main assemblies of the system and drawings of system elements was prepared.

Summary

In summary, the subframe design of the rainscreen cladding system features high strength properties, high earthquake resistance, accommodates thermal movement of the cladding material and the system as a whole, offers low assembly man-hours, high maintainability, and efficient insulant ventilation, and provides relatively low materials consumption and low manufacturing cost.

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