Two innovative solutions based on fibre concrete blocks designed for building substructure

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Abstract. Using of fibers in a high-strength concrete allows reduction of the dimensions of small precast concrete elements, which opens up new ways of solution for traditional construction details in buildings. The paper presents two innovative technical solutions for building substructure: The special shaped plinth block from fibre concrete and the fibre concrete elements for new technical solution of ventilated floor. The main advantages of plinth block from fibre concrete blocks (compared with standard plinth solutions) is: easier and faster assembly, higher durability and thanks to the air cavity between the vertical part of the block, the building substructure reduced moisture level of structures under the waterproofing layer and a comprehensive solution to the final surface of building plinth as well as the surface of adjacent terrain. The ventilated floor based on fibre concrete precast blocks is an attractive structural alternative for tackling the problem of increased moisture in masonry in older buildings, lacking a functional waterproof layer in the substructure.

1. Introduction

Today, thanks to the development of fiber and high-strength concrete, it is possible to start thinking about the new applications of these materials in building construction. Using of fibers in high-strength concrete allows reduction of dimensions of small precast concrete elements. This opens up new ways of solution for traditional construction details in buildings. The following text presents two new technical solutions for building substructure.

2. Special shaped plinth block from fibre concrete

2.1. The building plinth – short state of the art

The “plinth area” of buildings consists of two parts: the vertical part (surface of the peripheral wall of the building) and the horizontal part (adjacent terrain surface). The contemporary building plinth (vertical part) is solved by several ways: plaster (mostly as a surface layer of ETICS), ceramic or stone facing or grid+plates system (with many types of surface). The disadvantages of these traditional solutions of the building plinth (vertical part) consist mainly in: low durability (plasters), low vapor permeability (ceramic or stone facing), low resistance to mechanical damage (plasters, grid+boards systems), high laboriousness (ceramic or stone facing, grid+boards systems) or wet process (plasters). In addition to the plinth surface, the adjacent terrain must be adjusted as well (usually concrete pavers or stone aggregate).
2.2. Special shaped plinth block from fibre concrete

The aforementioned disadvantages of existing solutions in the plinth area of buildings are significantly corrected with plinth based on precast blocks designed from high-strength concrete reinforced by fiber. This technical solution was registered by authors as a patent no. CZ305253(B6) [1]. The proposed plinth consists of a set of special shaped blocks form fibre concrete which solves the final surface of building plinth (vertical part) as well as the surface of adjacent terrain (horizontal part). The blocks have a rectangular shape, where one of the vertical “walls” is exceeded over the other thus forming a plinth surface on the peripheral wall of the building. The block comprises an internal space (open at the top) which serves to store stone aggregate which creates a surface of adjacent terrain. The side “walls” of the block (perpendicular to the wall surface of the building) are in their upper part designed in the shape of a reverse trapezoid. The reason is that they to be invisible after the deposit of stone aggregate thus ensuring the “continuous look” of surface treatment of an adjacent terrain.

The bottom of the inner space of the block (where the stone aggregate is placed) is designed in the slope, so that leaking rainwater drained towards the outer edge of the block where the drain openings are located. The purpose of the stone aggregate inside the block is: stabilization of precast block in the place, prevent splashing of falling rainwater, making nice appearance of terrain and prevent the growth of higher plants.

![Figure 1. Special shaped plinth block from fibre concrete - description: 1 - plinth block from fibre concrete, 13 -vertical part which created a surface of building plinth, 14 - internal space (open at the top) which serves to store stone aggregate, 15 - the side “walls” in the shape of a reverse trapezoid, 16 - the bottom in the slope, 17 – the drain openings, 18 - the spacer strips to create a ventilated cavity between the block and the wall of the building](image)

The rigidity of the thick “walls” of the block is ensured by the use of fibres in concrete in combination with high-strength concrete. There is placed no other reinforcement in the block. The high-strength concrete ensures the block durability in the moist environment as well because it has a closed structure that does not allow the seepage of water in the liquid phase. A significant advantage of the use of high-strength concrete in combination with fibres is a subtlety of block elements. This allows the manual handling of the block without the use of the lifting devices. The dimensions of precast element were considered as follows (can be adapted to each particular building): wall thickness: 30mm, height of the plinth part: 330 mm, width: 400mm, length: 500 mm. The weight of the block with these dimensions is only 44kg.
The proposed technical solution also reflects the problems of moisture accumulation under the waterproof layer in substructure (applies to buildings without basement). A banked vertical wall of the block (adjacent to the peripheral wall of the building) is equipped at its ends with vertical spacer strips. This adjustment creates an air cavity between the block and the wall of the building. This cavity serves for an intensification of diffusion of water vapor from the building substructure. To increase water vapor diffusion efficiency, it is possible to complement the solution by profiled foil (installed at the foundation structure and connected to cavity). For proper function of the cavity created by the block, it is necessary to realize the gap (20-30 mm) between the top of the block and the adjacent ETICS (the gap must be fitted with insect screen) - Figure 2.

2.3. Discussion

The main advantage of the above presented technical solution is that it solves the final surface of building plinth as well as the surface of adjacent terrain. Compared with standard plinth solutions, there are the following advantages: easier and faster assembly, higher durability and thanks to the air cavity between the vertical part of the block and the building substructure reduced moisture level of structures under the waterproofing layer. Special shaped plinth block can be used for refurbishment of older buildings as well as for new buildings. The disadvantage of technical solution is only a higher price of block, given by the use of high-strength concrete.

3. Ventilated floor consisting of blocks from fibre concrete

3.1. The ventilated floors – short state of the art

Ventilated floors (as a remediation measure) are currently implemented as either as the “zero” ceiling structure or in the form of plastic shaped blocks with a concrete load-bearing layer, or based on a system of ventilated piping installed below ground level [2]. The aim of these remediation measures is
to reduce the amount of rising water which increases moisture level in building walls (in case of malfunctioning or missing waterproofing layer) [3,4,5]. Today, the most often used type is the ventilated floor based on plastic shaped blocks covered with a layer of concrete. This is a system of plastic blocks (shaped like dome vault), placed side by side on the site of the future floor. Once the shaped blocks are placed, they have to be covered with a layer of concrete with a reinforcement mesh installed. This helps reinforce the gaps between the “legs” of the blocks with concrete, and they then serve as supports for the whole floor. The disadvantages of this systems is: adding a monolithic concrete slab to the floor structure (wet process), a certain risk of damage to the plastic blocks during installation, part of the concrete mixture can leaks between the shaped blocks (while the concrete slab is made).

3.2. Ventilated floor consisting of blocks from fibre concrete

The aforementioned disadvantages of floor from plastic shaped blocks with a concrete load-bearing layer are significantly corrected by a precast “fibre concrete floor” registered by the author as utility model no. CZ27462(U1) [6]. The essence of the precast fibre concrete floor is that it consists of a system of special shaped blocks made from high-strength concrete reinforced by fibers. The blocks are laid out so that they form a continuous ventilated air cavity underneath the floor surface. The system consists of two types of fibre concrete blocks: “cubes” and “slabs” (Figure 3).

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**Figure 3.** The ventilated floor from fibre concrete blocks: Basic elements „cube“ and „slab“ (left) and its arrangement in the floor (right) - description: 1-element „cube“, 2-element „slab“, 3-cavity in the „cube“, 4-air flow, 5-ventilated cavity, 6-terrain, 7- the recess for mounted of element „slab“.
The “cubes” are cuboid-shaped elements lightened at the center by an extensive air duct. They have a raised part at the top, forming a recess along the edges for mounting the “slab” element. The “cube” has a square footprint. “Slabs” are mounted on the recess in the “cube” on all four sides; their footprint is an octagon. This shape of the “slab” makes it possible to space the “cubes” at a certain distance so as not to break the continuous air duct that the floor shapes in both directions. In one direction, the air flow through the cavity formed by the double floor is additionally facilitated by the cavity contained in the “cube” elements. Therefore, it is advisable to orient the “cube” blocks in the floor so that the cavity aligns with the direction of the expected dominant air flow.

Both the “cube” and “slab” elements are made of high-strength concrete, reinforced with non-metallic fibres (fibre-reinforced concrete). The use of this material permits delicate dimensions of the elements (40 mm thick), reducing the weight of both the “cube” and the “slab” to a level that permits manual handling of the precast elements without having the use lifting devices. Another advantage, particularly compared with plastic shaped blocks with a cover of concrete, is the low thickness of the horizontal load-bearing structure separating the ventilated cavity from the floor structure. The horizontal structure consists only of a delicate slab (40 mm), the supporting “cube” elements are located inside the duct and thus do not increase the height of the load-bearing structure. Moreover, thanks to its enclosed porous texture, the high-strength concrete gives the elements excellent properties in terms of durability in long-term contact with water and moisture.

Figure 4. Example of “fibre concrete ventilated floor” installation in the building - description: 1 - element „cube”, 2 - element „slab”, 4 - air flow, 5 - ventilated cavity, 6 - terrain, 8 - gravel bedding, 9 - horizontal vent hole, 10 - foundation, 11 - vertical vent hole, 12 - masonry, 13 - cover grid, 14 - thermal insulation in the floor, 15 - separating layer, 16 - load distribution layer (e.g. concrete screed or drywall etc.), 17 - the top floor (ceramic floor tiles).

Remediation of an existing diffusion-resistant floor by replacing it with the aforesaid technical solution can be made as follows: First the existing unsatisfactory floor is demolished (down to the ground). Then, the ground is deepened to the required level (depending on the height difference between the original and new floor). A layer of fine stone aggregate is applied on the ground,
thoroughly compacted in low layers. The floor system “cubes” are installed on this layer, 600 mm apart (both ways). Then, the octagonal “slabs” are mounted on the “cubes”. Afterwards, the slabs are covered with a layer of thermal insulation (extruded polystyrene is recommended due to installation in a humid environment) of the desired thickness (in CZ depending on requirements of ČSN 730540-2 [7]). The thermal insulation layer is covered with a separating plastic sheet, on which a load-distributing layer is applied (either concrete screed with a mesh reinforcement, or a system of drywall boards laid in a criss-cross pattern, etc.). The walking floor layer is then rendered on the top of the load-distributing layer.

In protected heritage buildings, where intake holes cannot be made in the facade (negative effect on building appearance), the presented technical solution can be combined with a prefabricated ventilated tunnel as described in [8] or another type of ventilated tunnel. However, the efficiency of the whole system will then depend on the air flow speed in the tunnel duct (forced ventilation is recommended).

3.3. Discussion
A ventilated floor based on fibre concrete precast blocks is an attractive structural alternative for tackling the problem of increased moisture in masonry in older buildings, lacking a functional waterproof layer in the substructure. The chief advantage of this technical solution compared to existing double floors based on plastic shaped blocks with a concrete layer is the absence of a monolithic reinforced concrete slab in the load-bearing structure of the floor (shorter construction time, less demanding process). Another advantage is the very low thickness of the horizontal load-bearing structure (positive effect on structural floor height, less earth moving).

4. Conclusion
The special shaped plinth block from fibre concrete and the fibre concrete elements for new technical solution of ventilated floor demonstrated that using of fibers in high-strength concrete precast elements opens up new ways of solution for traditional construction details in buildings. In the future, a further specialized precast systems based on fibre concrete elements which will replace some traditional structures in buildings can be expected. The advantages of this approach are evident: easier and faster assembly, higher durability and new additional functions.

Currently, preparation for the production of the first prototype of the fibre concrete plinth block is performed. The abovementioned patent CZ305253(B6) and utility model CZ27462(U1) which contain the technical solutions presented in the paper, are valid only for Czech Republic, in other countries are free to use.

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