

Energy and Weight Efficient Building Block, Manufacturing and Application Process Thereof

The subject matter of the invention is an energy and weight efficient building block, manufacturing and application process thereof.

The solution of the invention may be preferably used in the building industry for the construction of building structures, buildings (detached houses, semi-detached houses, office buildings, educational establishments) with homogenous, solid, lightweight wall structure and good vapour diffusion, excellent fire retardant, heat and sound insulation properties in a relatively short time and in an economical way.

As it is known, several methods have been worked out for the construction of building structures as well as for the production of polystyrene foam concrete.

For example, patent description No. GB1498383 describes a mortar suitable for the construction of lightweight building structures with good heat and sound insulation properties that contains foamed polystyrene, cement and water. The mortar thus produced is suitable for the construction of building blocks either in situ or at the company manufacturing the building material.

The building structure having an inner frame and permanent formwork to support the weight as well as the moulded piece, along with the manufacturing process thereof, set forth in the patent description with registration number HU223387, are of the same technical level. This known solution does not allow the joining of a wall section higher than 3-4 rows because concrete forces apart permanent formwork elements, and it can be surrounded by wall in about 3 days only because technological drying has to be waited for with each operation. Another disadvantage of this solution is that the building structure does not breathe because polystyrene is not air permeable.

The heat-insulated soundproof concrete load-bearing shear wall with steel wire net-cages, which is characterized in that the wall comprises a polystyrene foam board, both

sides of which are respectively provided with a steel wire net-cage which forms the wall framework, set forth in patent description No. CN201137225, is of the same technical level. This known solution is deficient in that the steel loses its temper at 400-500°C and can resist fire for up to 30 minutes since the steel wire net-cage is not protected with a fire retardant material. Another deficiency of this solution is that the use of a steel wire net-cage does not allow the fastening of heavier objects into the wall.

The wall system with insulation properties, made up of building blocks (formwork elements) joined with grooves and tongues of different shape, set forth in patent description No. DE19714626, is of the same technical level. The building blocks may be combined in various ways and used in particular for making walls with concrete core after the filling in of the concrete, leaving the shuttering elements in place. This known solution does not allow the joining of a wall section higher than 3-4 rows either because concrete forces apart permanent formwork elements, furthermore, smoke generation is high according to fire protection rules, therefore it cannot be used for making community buildings (for example, office buildings, educational establishments, hotels). Besides mechanical basic wires can be fastened only to the concrete core, in consequence of which sound insulation of the buildings will not be adequate.

The invention aims at eliminating the deficiencies of known solutions and creating an energy and weight efficient building block as well as working out the manufacturing and application process thereof, which enable the construction of building structures, residential and community buildings as well as industrial buildings with homogenous, solid, lightweight wall structure, without a cold bridge and having good vapour diffusion, excellent fire retardant, heat and sound insulation properties in a environmentally friendly way, simply, quickly and economically.

The solution of the invention is based on the recognition that producing a building block made from two kinds of material, namely a lightweight, post-hardening material and a flexible static insert structure, the thermal conductivity (heat technical parameter) of which is the same, furthermore, if the static insert structure is formed in a way that it is flexible for shape changes in directions perpendicular to the loading direction and

suitable for damping mechanical vibrations, it achieves the objectives of the energy and weight efficient building block of the invention and the manufacturing process thereof and its application process pertaining to the production of building structures.

The most general embodiment of the energy and weight efficient building block of the invention shall be implemented according to claim 1. The individual embodiments may be implemented according to claims 2-10.

The most general implementation of the manufacturing process of the invention shall be carried out according to claim 11. The individual process variants are described under claims 12-14.

The most general implementation of the application process of the invention shall be carried out according to claim 15.

The solution of the invention is described in detail on the basis of drawings which are the following:

Figure 1 shows the axonometric exploded view drawing of a preferred embodiment of the building block of the invention,

Figure 2 shows the axonometric drawing of a preferred embodiment of the static insert structure of the invention,

Figure 3 shows the axonometric drawing of another preferred embodiment of the static insert structure of the invention,

Figure 4 shows the axonometric drawing of a third preferred embodiment of the static insert structure of the invention,

Figure 5 shows the axonometric exploded view drawing of a preferred embodiment of the building block of the invention, implemented with a static insert structure made of metal,

Figure 6 shows the axonometric drawing of a preferred embodiment of the base face of the form body necessary for the manufacturing of the building block of the invention,

Figure 7 shows the axonometric drawing of a preferred embodiment of the base face of the form body necessary for the manufacturing of the building block of the invention and of the static insert structure placed thereon,

Figure 8 shows the axonometric drawing of a preferred embodiment of the building block produced according to the manufacturing process of the invention,

whereas Figure 9 shows the axonometric drawing of a preferred embodiment of the building structure constructed with the use of the building block of the invention.

Figure 1 shows the axonometric exploded view drawing of a preferred embodiment of the building block of the invention. The building block is depicted as standing on its ground plane 10, and with this preferred embodiment its body is of prism shape, as it is visible in the drawing. The body of the building block is formed from a post-hardening material 1, inside which a flexible static insert structure 2 is placed, which is made of metal. With this embodiment, the static insert structure 2 is preferably assembled from several insert profiles 3 with the same structure. On the upper plane 11 of the building block, protruding from the plane thereof, at nearly the same distance from the edges, positive adapters 12 are formed, which are preferably frustums of pyramids with a square base. On one of the faces of the right rectangular prism, perpendicular to its flat front plane, grooves 14 are formed, whereas on the other face, tongues 15 are formed. In another preferred embodiment, this can be implemented the other way around, too.

Figure 2 shows the axonometric drawing of a preferred embodiment of the static insert structure 2 of the invention. In this case, the flexible static insert structure 2 is made of metal, preferably of hot-dip galvanized steel 0.25-2 mm thick. The static insert structure 2 is assembled from at least one, preferably more insert profiles 3 with the same structure. One insert profile 3 can be regarded as a basic unit, which is made from two mirror-symmetric half elements 4, a straight-line part 5 on its two edges, and an arched-line part 6 in its middle third. In case of more than one insert profiles 3, an auxiliary tensioning element 7 is connected to both sides of both edges. Between two insert profiles 3, the auxiliary tensioning element 7 is preferably made from one piece. The straight-line part 5 of the insert profile 3 and the joining auxiliary tensioning elements 7 are together shaped as a cutting edge 8. The cutting edges 8 play an important role at the

construction of the building structures, when cutting edges 8 thus formed, in case of placing the building blocks of the invention on each other, cut into the positive adapters 12 at the superposition of negative adapters 13 on positive adapters 12, and actually fasten the static insert structure 2. Thus they increase stability against horizontal pressure (in directions perpendicular to the loading direction), furthermore, they ensure the even static distribution of the cumulative load by way of the coupling of the insert profiles 3 of the static insert structure 2, placed on each other. At the same time, static insert structure 2 will be suitable for damping possible mechanical vibrations due to its flexibility, in consequence of which the possibility of occurrence of cracks in the wall structure of the building structures will be minimized. There are perforations 9 made on the surface of the half elements 4 and the auxiliary tensioning elements 7, which enable an even spread of the post-hardening material 1 in the form body 16, lighten the weight of the building block, as well as make the way of the heat longer, thus increase heat insulation.

Figure 3 shows the axonometric drawing of another preferred embodiment of the static insert structure 2 of the invention. With this preferred embodiment, the static insert structure 2 is made from cylindrical plastic tubes, which is also suitable for the even static distribution of the cumulative load due to its flexibility.

Figure 4 shows the axonometric drawing of a third preferred embodiment of the static insert structure 2 of the invention. With this solution, the static insert structure 2 is made from an organic material, preferably from latticed bamboo, which is also of a flexible material. Besides the organic matter can also be wood or cane.

The building blocks implemented with the static insert structures 2 shown either in Figure 3 or in Figure 4 should be used for the construction of buildings in case of which no outstandingly high fire prevention and/or relatively not great static stress has to be ensured, for example, for the construction of two-storey buildings at most.

Figure 5 shows the axonometric exploded view drawing of a preferred embodiment of the building block of the invention, implemented with a static insert structure 2 made of

metal, with special regard to the design of cutting edges 8. Insert profile 3 is made from two mirror-symmetric half elements 4, a straight-line part 5 on its two edges, and an arched-line part 6 in its middle third. Since the static insert structure 2 is assembled from more than one insert profiles 3, an auxiliary tensioning element 7 is connected to both sides of both edges of the insert profile 3. The straight-line part 5 and the joining auxiliary tensioning elements 7 are together shaped as a cutting edge 8, as it can be seen in the drawing. The size of the positive adapters 12 and the distance there between is determined in a way that for example in the case of a static insert structure 2 assembled from five insert profiles 3 three cutting edges 8 cut about into the middle of the positive adapter 12, preferably to a depth of 1 cm, because on the basis of practical experience, this cutting depth ensures the best result as regards stability and the even static distribution of the load. The drawing also depicts half elements 4, the perforations 9 made on the surface of the auxiliary tensioning elements 7, the grooves 14 and the tongues 15.

Figure 6 shows the axonometric drawing of a preferred embodiment of the base face of the form body 16 necessary for the manufacturing of the building block of the invention. Negative adapters 13 are formed on the ground plane of the building block 10, on the base face of the form body 16 in a way that profiles, preferably frustum of pyramids with a rectangular base, are formed on the base face, protruding from the plane thereof, in the middle of which the places necessary for the cutting edges 8 are formed, preferably by means of milling. As the drawing shows, in case of a preferred embodiment, six companion pieces necessary for the production of six negative adapters 13 are formed on the base face of form body 16.

Figure 7 shows the axonometric drawing of a preferred embodiment of the base face of the form body 16 necessary for the manufacturing of the building block of the invention and of the static insert structure 2 placed thereon. With this preferred embodiment, in comparison with the previous Figure 6, the static insert structure 2 is placed in the places milled for the cutting edges 8, which is a further step of the manufacturing process. Both the previous figure and this figure show the companion pieces necessary

for the forming of grooves 14 on one face of the form body 16, and for the forming of tongues 15 on the other, and the other way around.

Figure 8 shows the axonometric drawing of a preferred embodiment of the building block produced according to the manufacturing process of the invention, when it has already been filled with the post-hardening material 1, shown as transparent in the drawing, and is complete. In addition to the post-hardening material 1, the building block contains a static insert structure 2 assembled from flexible insert profiles 3, which has cutting edges 8. With the building block standing on its ground plane 10, positive adapters 12 are formed on the upper plane 11, while on the ground plane 10, negative adapters 13 are formed. On one of the faces of the building block, perpendicular to its flat front plane, grooves 14 designed for the lateral joining of the building blocks are formed, whereas on the other face, tongues 15 are formed, or the other way around. In case of a preferred embodiment, six positive adapters 12 are shaped on the upper plane 11, whereas on the ground plane 10, also six negative adapters 13 are shaped, for which a static insert structure 2 assembled from five insert profiles 3 was proved to be the most appropriate.

Figure 9 shows the axonometric drawing of a preferred embodiment of the building structure constructed with the use of the building block of the invention. For greater clarity, the figure shows the first two rows and the last two rows of the building structure between the lower blocking layer 17 and the upper blocking layer 18. (Intermediate rows of a similar structure are marked with a broken line.) The lower blocking layer 17 and the upper blocking layer 18 which are not the subject matter of the invention is preferably a U-channel receptor, which fastened into the concrete base, and the last row is also closed with a profile turned down, on which beams are placed at particular distances. For the sake of stable fixing, the building blocks expediently overreach the U-channel on both sides, in the direction of their width. A row can be made in a way that the neighbouring elements are fitted to each other by their sides, preferably in the longitudinal direction, in a way that the tongues 15 formed on one face of a building block is fitted into the grooves 14 formed on the other face of the other building block, or the other way around. Then the building blocks fitted to each other

are stuck together and/or pressed together, and a row is built up this way, for example, the first row of the building structure. The building blocks of the next (second) row are placed on the building blocks of the first row, displaced in the longitudinal direction (preferably, for example, by one third of the length of the building block) in a way that the negative adapters 13 formed on the ground planes 10 of the building blocks, invisible in the drawing, are fitted on the positive adapters 12 formed on the upper plane 11 of the building blocks of the first row located thereunder so that the cutting edges formed on the ground planes 10 cut into the positive adapters 12 formed on the upper plane 11 of the building blocks of the first row thereunder. These steps are continued until the planned height of the building structure is built up, then the upper blocking layer 18 is fixed to the last row. If preferably building blocks 61.5 cm long, 41 cm wide and 27 cm high are used, at the corner junction, the joint is created simply with two whole building blocks, with four pairs of adapters, with the help of the cutting edges 8, by means of joining the insert profiles 3 of the static insert structure 2, that is, one of the building blocks covers the other at any time and in any direction, and take its bearing on it on the whole surface, thus ensuring the even static distribution of the load. Consequently, at the corner junctions, the joint of the adapter pairs shall be four-four?, then two-four, two-four, and so on.

The making of the building block of the invention is carried out as follows, in consideration of the figures and the explanations thereof already set forth:

By mixing a lightening material with a density less than 500 kg/m^3 , cement and water, a post-hardening material 1 is produced. The building block is produced with the help of a form body 16 (template) in a way that a flexible static insert structure 2 preferably made of metal is placed in the form body 16, then the form body 16 is filled up with the mixed post-hardening material 1. (If the mixed post-hardening material 1 is quite thin, it is poured into the form body 16 first, then the static insert structure 2 is placed therein afterwards.)

If the static insert structure 2 has been embedded in the post-hardening material 1, the moist building block thus produced is let to dry in the form body 16 itself or after being taken out thereof until it is set. It is better to use a dense post-hardening material 1

mixed until it is earth-moist, because it can be poured into the form body 16 immediately, furthermore, setting time will be shorter.

The form body 16 is made to be preferably suitable for the production of a prismatic building block.

The lightening material with a density less than 500 kg/m^3 is preferably new, whole polystyrene foam balls with a diameter of 1-15 mm, or crushed or granulated polystyrene foam, or waste polystyrene foam, or perlite or chopped wood. In case of crushed or granulated polystyrene foam, the thermal conductivity value of post-hardening material 1 will be better. The post-hardening material 1 made from polystyrene foam, cement and water is preferably a polystyrene foam concrete, which has the good features of all building materials, namely, it is of lightweight (its mass per unit volume is 350 kg/m^3 , while that of the brick or the silicate is $800\text{-}1200 \text{ kg/m}^3$), furthermore with a thickness of 8 cm, it is fire resistant for 90 minutes.

The flexible static insert structure 2 is preferably made of metal, expediently hot-dip galvanized steel 0.25-2 mm thick, which is assembled from at least one, preferably more insert profiles 3 with the same structure. Depending on the length of the building block, the use of one, two, four or five insert profiles 3 is appropriate. With one piece, there is no need for an auxiliary tensioning element 7. The insert profiles 3 are joined with a permanent joint, such as spot welding, or with a detachable joint, such as bolts and nuts, thus they take over the static role in case of load, ensuring even load distribution.

For example, the building block produced from the post-hardening material 1 and the static insert structure 2 can be taken out of the form body 16 after being pressed together, and let it dry until set. Drying can be natural drying (28 days) or with the hot air drying it can take about 1 week. The accelerated drying of the building block can also be facilitated with the accelerator additive added to the post-hardening material 1. The following substances and approximately the following quantities thereof are necessary for the production of 1 m^3 of building block of the invention:

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|--|--------|
| - polystyrene foam | 15 kg |
| - cement (CEMI 32,5S quality) | 280 kg |
| - static insert structure made of metal | 50 kg |
| - crystal bound water (about 60 l water) | 5 kg |

The application process implemented with the building block of the invention for the production of building structures has already been described in connection with Figure 9, but it has to be emphasized that only a building block produced from the combination of two materials, namely the lightweight post-hardening material 1 and the flexible static insert structure 2, enables the construction of homogenous, solid, energy and weight efficient buildings, without a cold bridge, with high permeability and excellent fire retardant properties due to the identity of the thermal conductivity of the two materials and in consequence of the entire and even space filling of the post-hardening material 1 and the surrounding and retention of the static insert structure 2.

Buildings built up from the building block of the invention has a very good price/value rate, which is about 4,200 HUF/m², as opposed to that of buildings made of brick, which is 8,000 HUF/m², whereas that of buildings made of YTONG, it is 11,000 HUF/m², plus heat insulation.

For a 1 m² surface, 6 lightweight building blocks with dimensions of 61.5x41x27 cm, 24 kg each are required.

The building block of the invention has accomplished the aims of its manufacturing and application process and has the following advantages:

- it is energy and weight efficient (heat retaining, with a mass of 350 kg/m³,
- horizontal effect and wind uplift resistant,
- its bearing capacity is 18 t/m,
- it has excellent air and vapour permeability properties (vapour diffusion coefficient $\mu=22$),
- good thermal conductivity ($\lambda=0.065$ below passive house),

- good heat insulation properties (heat-transmission coefficient in case of a wall 41 cm thick $U=0.17 \text{ W/m}^2\text{K}$)
- there is no need for traditional plastering, its internal and external wall surface can be coloured or covered with any material following technological gypsum plastering,
- it has good sound insulation properties,
- it is fire retardant, the wall structure does not burn just glow, its smoke generation coefficient is within the limit prescribed by the standard,
- it enables environmentally friendly, waste-free building, the waste of polystyrene foam concrete is reusable,
- it allows for simple and quick building (concrete about 30-40% less is necessary for groundwork, the building blocks can be fitted to each other easily),
- pipelines and wiring can be placed in the wall by milling with millimetre precision instead of slotting,
- mechanical systems can be built in with small-sized tools,
- building and construction can be continued until the temperature reaches -10°C , thus it can practically be used independently of the weather and the season,
- it can be economically produced; its production cost is about half, third of that of the known solutions.

PATENT CLAIMS

1. Energy and weight efficient building block that has a prismatic body made from a post-hardening material (1), characterized in that a flexible static insert structure (2) is placed inside the body, positive adapters (12) are formed on an upper plane (11) of the building block and negative adapters (13) are formed on a ground plane (10) of the building block, wherein the negative adapters (13) are configured for being fitted on the positive adapters (12) of a building block located thereunder and the flexible static insert structure (2) is adapted for touching the flexible static insert structure of a building block located thereunder when the building blocks are placed on each other.
2. The building block of claim 1, characterized in that the flexible static insert structure (2) is assembled from one or more insert profiles (3) with the same structure.
3. The building block of claim 2, characterized in that the insert profile (3) is made from two mirror-symmetric half elements (4), a straight-line part (5) on its two edges, and an arched-line part (6) in its middle third; in case of more than one insert profiles (3), an auxiliary tensioning element (7) is connected to both sides of both edges, the straight-line part (5) and the joining auxiliary tensioning elements (7) together form a cutting edge (8), furthermore, there are perforations (9) made on the surface of the half elements (4) and the auxiliary tensioning elements (7).
4. The building block of claim 1, characterized in that the static insert structure (2) is made of metal.
5. The building block of claim 1, characterized in that the static insert structure (2) is made from cylindrical plastic tubes.
6. The building block of claim 1, characterized in that the static insert structure (2) is made of organic material.

7. The building block of any of the claims 1-6, characterized in that the post-hardening material (1) is polystyrene foam concrete.

8. The building block of any of the claims 1-7, characterized in that with the building block standing on its ground plane (10), the positive adapters (12) are formed on its upper plane (11), protruding from the plane thereof, at nearly the same distance from the edges, while on the ground plane (10), hollowed from the plane thereof, also at nearly the same distance from the edges, the negative adapters (13) are formed.

9. The building block of any of the claims 1-8, characterized in that the positive adapters (12) are formed as prisms or pyramids with a rectangular base or cylindrical or cone-shaped bodies.

10. The building block of any of the claims 1-9, characterized in that on one of the faces perpendicular to its flat front plane, grooves (14) and tongues (15) are formed alternately, whereas on the other face opposite thereto, tongues (15) and grooves (14) are formed alternately.

11. Manufacturing process for the production of the building block of claim 1, in the course of which a post-hardening material (1) is produced by mixing a lightening material with a density less than 500 kg/m^3 , cement and water, characterized in that the static insert structure (2) is placed into a form body (16), then the form body (16) is filled up with the stirred post-hardening material (1) or at first the stirred post-hardening material (1) is poured into the form body (16), and the static insert structure (2) is placed therein afterwards, then the building block with the static insert structure (2), embedded in the post-hardening material (1) is let to dry until set in the form body (16) itself or after being taken out thereof.

12. The process of claim 11, characterized in that new, whole polystyrene foam balls with a diameter of 1-15 mm, or crushed or granulated polystyrene foam, or waste polystyrene foam, or perlite or chopped wood is used as lightening material.

13. The process of any of the claims 11-12, characterized in that the mixing of the post-hardening material (1) is continued until it is earth-moist.

14. The process of any of the claims 11-13, characterized in that accelerated drying of the building block is carried out with an accelerator additive added to the post-hardening material (1).

15. Application process from the production of a building structure between a lower blocking layer (17) and an upper blocking layer (18) from the building block of claim 1, in the course of which the building blocks are aligned to each other on the fixed lower blocking layer (17), characterized in that two neighbouring building blocks are fitted to each other in a way that tongues (15) formed on one face of a building block are fitted into grooves (14) formed on the other face of the other building block, the building blocks fitted to each other are stuck together and/or pressed together, thus the first row of the building structure is built up this way, then the building blocks of the next row are placed on the building blocks of the first row, displaced in the longitudinal direction in a way that the negative adapters (13) formed on the ground planes (10) of the building blocks of this row are fitted on the positive adapters (12) formed on the upper plane (11) of the building blocks of the first row located thereunder and the flexible static insert structures (2) of the building blocks of this row touch the flexible static insert structures of the building blocks of the row thereunder, then the previous steps are continued until the planned height of the building structure is built up.