

Hybrid lightweight ventilated facade**Field of the invention**

- 5 The present invention lies in the field of lightweight ventilated facades.

Prior art

- 10 Outside the field of single-family dwellings, most buildings are erected as a concrete or steel skeleton structure, in which columns and beams support the floor plates and fulfil the structural function of the building. With such a skeleton structure, the facade can be implemented, at least for the blind non-transparent zones, in various ways, such as a masonry structure with cavity, a facade with prefabricated concrete panels, etc., but also as a ventilated facade, the exterior of which is provided with lightweight facade cladding.

- 15 Such a facade usually consists of:
- 1) a wall of the building shell, made of concrete, masonry, aerated concrete, etc.;
 - 2) thermal insulation;
 - 3) a rainscreen (optional);
 - 4) the lightweight facade cladding, fitted against a suspension structure or directly with brackets against the
- 20 wall of the building shell.

There is a ventilated cavity between the rainscreen and the facade cladding.

- In the case of such a "conventional" construction of a ventilated facade – independently of all other considerations (see further below) – there is a twofold conflict, specifically:
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- 1) the facade cladding itself is lightweight, but is fitted against a "heavy" wall of the building shell;
 - 2) the wall of the building shell is usually implemented from inside the building; however, the fitting of the cladding can be effected only along the outer side and thus working from a scaffold or similar platform.

- Together with the fact that the entire arrangement forms a heavyweight construction rather than a lightweight one,
- 30 the two mentioned observations lead to a long series of disadvantages.

The following disadvantages are related to the technical implementation.

- 1) The alignment of the architectural cladding requires specialized craftsmanship and is, by definition, not easy to perform from a scaffold or other vertical work platform.
- 35 2) The fastening anchors and/or suspension structure give rise to thermal bridges and perforation of the sealing screen.

- 3) Considerable fitting tolerances occur due to (1) the working from a scaffold and (2) the inherent tolerances when fitting the fastening anchors and/or suspension structure.
- 4) The implementation of such a facade requires a long building time.
- 5) The implementation of a wall of the building shell in concrete, or masonry or the like has three specific disadvantages, specifically:
- 5 a) a high weight at the edge of the floor plate, necessitating a heavier floor plate and additional reinforcements;
- b) a relatively long implementation time;
- c) a "wet" construction which requires several weeks for further finishing.
- 10 6) The fitting of the facade cladding from outside has a twofold consequence, specifically:
- a) a relatively low productivity of the fitters; and
- b) the weather-dependent nature of the works. In the event of bad weather, the work activities have to be interrupted, which entails incalculable costs.
- 7) The liability for implementation of the ventilated facade is split; this is because the lightweight facade cladding is fitted by a specialized facade builder, but the inner wall is implemented by the contractor building shell.
- 15 8) Loss of net floor area; the package of the insulation (usually about 20 cm thick) is placed against the wall (also usually 20 cm thick), which produces a total wall thickness of 40 cm. Each cm loss along the perimeter of the building results in a reduction of the net floor area, which also has financial consequences for the investor.
- 20 The conventional facade cladding has the following disadvantages in terms of quality and sustainability.
- 1) The social sustainability is low; the fitting of the lightweight architectural cladding requires specialized fitters with a very high level of craftsmanship, who are not only very difficult to find but also very expensive.
- 2) Working on a scaffold is less safe for the workers. Accidents occur more often and the consequences of the accidents are more severe.
- 25 3) Work activities which are effected at the exterior of a building and at height imply more difficult quality control.

30 Lastly, there are also significant budgetary disadvantages. All the above-mentioned disadvantages have de facto a cost, which may or may not be significant, with final budgetary consequences.

There is thus a need for an alternative and improved facade construction.

Summary

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The object of the present invention is to offer a solution to the mentioned disadvantages and other disadvantages.

The present invention relates to lightweight ventilated facades having both a lightweight facade cladding and a lightweight wall against which the facade cladding is fitted. The facade cladding, which is an architectural cladding, may consist of many types of materials, such as aluminium, copper, steel sheet panelling, natural stone, wood, plastic, etc. The complete implementation or fitting of all components of the ventilated facade, i.e. inner wall, insulation, rainscreen, and lightweight facade cladding, may be effected from within the building without using a scaffold or similar vertical work platform or mast climber at the exterior of the building.

In this regard, the invention offers an adequate response to all the above-mentioned disadvantages of a "conventional" ventilated facade.

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According to a first aspect of the invention, a lightweight ventilated facade is disclosed, comprising one or more anchor plates, one or more mullion profiles, one or more cladding panels and one or more insulation panels, wherein the fastening anchors are fastened along a perimeter of a floor plate of a building, wherein each of the mullion profiles is vertically fastened to an anchor plate on the outer side of the floor plate, wherein each of the cladding panels is fastened to two mullion profiles on the outer side of these mullion profiles, wherein each of the insulation panels is fastened between two mullion profiles, wherein there is a ventilated cavity between the insulation panels and the cladding panels.

Throughout this text, the terms "inner side" and "outer side" are used. The inner side of a building refers to the volume within the envelope of the building, and the outer side of a building refers to the volume outside the protective envelope of the building and is thus exposed to the climatic conditions.

However, when the text refers to the "inner side" of a component of the ventilated facade, this then means the side of the component which – under normal conditions – is oriented towards the inner side of the building, even if this "inner side" of the component is not located on the inner side of the building. The opposite interpretation applies to the "outer side" of a component. The inner side and outer side of a component of the ventilated facade thus refer to a relative orientation with respect to the building to which the facade is fastened.

It is an advantage of the facade according to the present invention that it has a lower weight than the customary systems. This is because the solid building shell wall is replaced by mullion profiles. The padding between the mullion profiles is effected using insulating panels which have a very low weight. As a result of this weight saving, the supporting structure of the building can be of lighter embodiment.

It is an additional advantage of the facade according to the present invention that the total package, measured from the outer surface of the architectural cladding to the inner surface of the inner wall, is much thinner than in the conventional systems. In the conventional systems, the insulation is placed against a solid wall. By contrast, in the facade according to the present invention the insulation is placed between the supporting structure. This

ensures that the use of the facade according to the present invention results in a greater usable floor area with the same external dimension of the building or in a smaller external dimension of the building with the same floor area.

5 It is an additional advantage of the facade according to the present invention that said facade can be completely installed from inside the building, without using a scaffold. This results in a construction process which runs in a safer, more rapid and less expensive manner and which is far less dependent on the climatic conditions.

10 It is an additional advantage of the facade according to the present invention that said facade, due to its inventive concept, can make use of a very wide range of architectural cladding and also of a wide range of insulation panels as inner wall.

15 In some embodiments of the lightweight ventilated facade, one or more of the mullion profiles consist of a single monolithic metal profile (for example aluminium, cold-rolled steel, etc.). In facade construction, such a profile is considered as being non-thermally insulating.

20 In some embodiments of the lightweight ventilated facade, one or more of the mullion profiles consist of a thermally insulating profile. Such a thermally insulating profile may for example be manufactured by means of pultrusion, and may fully or partially consist of internally steel-reinforced PVC or ASA, carbon fibre, or any other thermally insulating material with adequate structural stiffness and bending modulus.

25 In some embodiments of the lightweight ventilated facade, one or more of the mullion profiles consist of two or more subprofiles, wherein the subprofiles of a mullion profile are mechanically connected to one another, wherein at least one of the subprofiles of a mullion profile is predominantly manufactured from metal and wherein at least one other of the subprofiles of a mullion profile is predominantly manufactured from a plastic, in order to perform a thermally insulating function.

It is an advantage of these embodiments that a continuous thermal break or thermal protection of the facade is realized while the mullion profiles retain the favourable mechanical properties of metal profiles.

30 Possible materials for these plastics subprofiles are: PVC, polyamide, ASA, pultrusion, glass-fibre-reinforced polyamide, carbon fibre, or other insulating materials.

35 In some embodiments of the lightweight ventilated facade, the predominantly metal subprofile is located on the inner side of the mullion profile and the predominantly plastics subprofile is located on the outer side of the mullion profile.

In some embodiments of the lightweight ventilated facade, it is possible to opt for an inverted configuration for the two subprofiles of the mullion profile, that is to say:

- a non-thermally insulating outer shell (materials such as steel, aluminium or similar);
- a thermally insulating inner shell (materials such as solid wood, laminated wood, steel-reinforced PVC or ASA, carbon fibre, pultrusion, etc.).

In some embodiments of the lightweight ventilated facade, a cladding panel is suspended from two adjacent mullion profiles by means of four or more suspension points. These suspension points are distributed in two or more rows over the mullion profiles to which the cladding panel is fastened. In this case, the following three criteria are satisfied:

- 1) Only a single suspension point is a fixed point.
- 2) The suspension points on the same level, or horizontal line, as the above-mentioned fixed suspension point permit a lateral movement of the cladding panel.
- 3) All the other suspension points permit both a lateral and vertical movement of the cladding panel.

It is an advantage of these embodiments that a cladding panel can never come to be under mechanical stress as a result of thermal expansion or differential settlements of the building.

In some embodiments of the lightweight ventilated facade, lower mullion profiles, which are fastened to the anchor plates of a lower floor plate, are vertically connected to the corresponding upper mullion profiles, which are fastened to the anchor plates of an upper floor plate, by means of a coupling piece.

It is an advantage of these embodiments that these make the installation and alignment of the mullion profiles easier and also ensure a wind-tight and water-tight connection between mullion profiles standing one above the other.

Preferably, the coupling piece which connects lower mullion profiles to upper mullion profiles is an expanding coupling piece, such that the lower and upper mullion profiles can move in translation with respect to one another in a vertical direction. By virtue of the coupling piece, the wind-tightness and water-tightness of the facade is ensured during such a translational movement.

It is an additional advantage of these embodiments that these ensure that the mullion profiles can move with respect to one another in order to compensate for thermal expansion, deformation by wind load or differential settlement of the building.

In some embodiments of the ventilated facade, the insulation panels are supported by support brackets, wherein the support brackets are fastened to the mullion profiles.

In some embodiments, the ventilated facade comprises one or more finishing profiles, wherein the finishing profiles are fastened to the inner side of the mullion profiles.

- 5 It is an advantage of these embodiments that these finishing profiles hold the insulation panels in place.

In some embodiments of the ventilated facade, one or more vertical seals are fastened between the mullion profiles and the insulation panels.

- 10 It is an advantage of these embodiments that these ensure the air-tightness and water-tightness of the facade.

It is an additional advantage of these embodiments that the compressibility of the seals makes it possible to compensate for deformation by thermal expansion, by wind load or differential settlement of the building.

- 15 In some embodiments of the ventilated facade, one or more vertical seals are fastened between the finishing profiles and the insulation panels.

It is an advantage of these embodiments that these ensure the air-tightness and water-tightness of the facade.

- 20 It is an additional advantage of these embodiments that the compressibility of the seals makes it possible to compensate for deformation by thermal expansion, by wind load or differential settlement of the building.

In some embodiments of the ventilated facade, one or more horizontal seals are fastened between a lower insulation panel and an upper insulation panel.

- 25 It is an advantage of these embodiments that these ensure the air-tightness and water-tightness of the facade.

It is an additional advantage of these embodiments that the compressibility of the seals makes it possible to compensate for deformation by thermal expansion, by wind load or differential settlement of the building.

- 30 According to a second aspect of the invention, a method for constructing a ventilated facade according to the first aspect of the invention is disclosed, wherein the method comprises the following steps:

- fastening the anchor plates to the floor plate;
- fastening mullion profiles to the anchor plates, wherein the mullion profiles are fastened to the outer side of the building from inside the building;
- 35 - fastening the cladding panels to the mullion profiles, wherein the cladding panels are fastened to the outer side of the mullion profiles from inside the building;

- fastening the insulation panels between the mullion profiles, wherein the insulation panels are fastened between the mullion profiles from inside the building;
- fastening the finishing profiles to the inner side of the mullion profiles.

5 It is an advantage of this method that the facade can be completely installed from inside the building, without using a scaffold. This results in a construction process which runs in a safer, more rapid and less expensive manner and which is far less dependent on the climatic conditions than traditional construction methods.

10 It is an additional advantage of the method that it is not necessary for any anchors to be placed one by one for the fastening of the cladding panels. This results in a more rapid, less expensive and more accurate construction.

It is an additional advantage of the method that use can be made of all existing types of cladding panels and insulation panels, such as are already known in facade construction.

15 In some embodiments of the method, the lightweight ventilated facade is built chronologically as follows.

Step 1

Fitting the anchor plates to the edge of the floor plate. Using a surveying device, the position of the anchor plates is aligned in the x dimension, that is to say the theoretical plane of the facade. To this end, the anchor plates are provided with slotted holes. Preferably, this alignment is effected to within an accuracy of one millimetre. Once the anchor plates have been aligned, they are locked on the floor plate by means of provided locking holes so that they are no longer able to slide.

Step 2

25 Once the anchor plates have been placed and aligned – preferably to within an accuracy of one millimetre – in the facade plane, the vertical mullion profiles, which are provided with an anchor rail having a “duckbill” hook, are hung over the vertical upright of the anchor plates.

The mullion profiles are then aligned in two successive steps, namely:

- in a Y direction, that is to say the direction parallel to the facade plane, and in such a way that the axis of the mullions stands precisely in the theoretical axis lines of the facade of the building. This alignment is effected by sliding the “duckbill” horizontally over the vertical upright of the anchor plate.
- in a Z direction, that is to say in the vertical direction, wherein the mullions are aligned at the correct level. This is effected by means of an adjustment bolt which sits in the duckbill and which, in the case of a weight anchor – an anchor plate in which vertical loads, that is to say the dead weight of the ventilated facade, are also transmitted to the floor plate –, rests on the upper edge of the vertical upright of the anchor plate. In the case of a “wind anchor”, that is to say a fastening in which only horizontal wind loads

are accommodated, there is no adjustment bolt, but the duckbill is able to move freely back and forth in the vertical direction, and only in this vertical direction, in order to thus be able to accommodate differential settlements and thermal expansions.

Preferably, the alignment is effected to within an accuracy of one millimetre in both planes.

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Step 3

In this step, the lightweight cladding panels are fitted against the mullion profiles, with the fitters standing in the building.

- 10 The cladding panels are provided with a suspension profile, which are in turn provided with milled-out or punched bayonet openings, also called bayonet closures. Preferably, the suspension profiles are L-shaped profiles or similar profiles and these are glued or mechanically fastened against the cladding panels. Preferably, the suspension profiles are fitted to the cladding plates in the factory under controlled conditions. The milled-out or punched bayonet openings in the suspension profiles are usually created with a computer-controlled CNC machine and, in
- 15 this way, with deviations of less than 0.3 mm. The position of the milled-out or punched bayonet openings in the suspension profiles can thus correspond, to within the mm accuracy, to the position of the suspension points – where the suspension profiles should be hooked – which are preferably provided and fitted in the mullion profiles in the factory.
- 20 The cladding panels are suspended from four or more suspension points by means of the suspension profiles, that is to say two suspension points in the left-hand mullion profile and two suspension points in the right-hand mullion profile. Depending on the acting loadings of wind, dead weight and others, the number of suspension points can be adapted.
- 25 The position of the milled-out portions in the suspension profiles corresponds - preferably to within an accuracy of one mm – to the position of the suspension points (where the suspension profiles are hooked), which are provided and fitted on the mullion profiles in the factory.

- The foregoing implies that the cladding panels only have to be hung over the suspension points in the mullion profiles, whereby these cladding panels are automatically aligned. This is because the alignment is already effected during the placement of, on the one hand, the anchor plates (x direction) and, on the other hand, the mullion profiles (y and z direction). The fitting of these panels is thus reduced to simple "hanging work".
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There are three types of suspension points on the mullion profiles, namely

- 35 1) a fixed suspension point, which may for example be realized by means of a diabolo attachment, over which the L-shaped suspension profile of the cladding panel hooks so that it sits in a laterally locked manner.

2) The suspension points on the same level, or horizontal line, as the above-mentioned fixed suspension point permit a lateral movement of the cladding panel.

3) All the other suspension points permit both a lateral and vertical movement of the cladding panel.

In this way, thermal expansion and/or differential movements of the building shell can be accommodated and the width of the open joint can vary only on one side (since all the diabolos points of cladding panels which lie one above the other are situated on the same side), as a result of which the edges of the joint always remain the same over the entire height of the cladding.

A person skilled in the art knows that an inverted solution is also possible, wherein the L-shaped profiles of the cladding panels are provided with fixed and movable fastening points and wherein the mullion profiles are provided, on the exterior, with the necessary openings.

Step 4

This step includes the fitting of the insulation panels between the mullion profiles, wherein the insulation panels are fastened between the mullion profiles from inside the building. The necessary seals are provided beforehand. These seals may be of various nature, such as EPDM profiles, self-swelling sealing tapes with closed or open cells, seals which may or may not be impregnated, etc.

The insulation panels are placed onto brackets which are fitted against the mullion profiles and which are usually of L-shaped design. The panels are also stacked one above the other in the vertical direction by means of a telescopic coupling in order to thus produce a continuous wall which forms a perfectly wind-tight and water-tight screen. This telescopic coupling may be realized in several ways, but always such that it can move freely in the vertical direction and can simultaneously produce a wind-tight and water-tight coupling.

The thickness and the type of the insulating sandwich panels are determined by the specific requirements of the building.

On the outer side of the insulation panels, that is to say the side of the air cavity, the insulation panels are preferably provided with a rainscreen.

On the inner side of the insulation panels, various finishing options are possible, such as:

- option 1: the insulation panels are provided with a definitive finishing layer, possibly made of various materials (such as enamelled aluminium, coated steel, etc.)
- option 2: the insulation panels are subsequently also additionally clad with a finishing panel on the inner side.

This may be effected in various materials and even in wood, natural stone, etc.

Step 5

The mechanical fastening of the finishing profiles against the mullions in order to hold and press the insulation panels in the correct position. These finishing profiles are clamping and are mechanically fastened against the rear wall of the mullion profiles. The clamping provides the sealing tapes with the necessary pressure and tension in accordance with the provisions of the supplier or manufacturer.

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With this construction of a hybrid lightweight ventilated facade, all the aforementioned disadvantages of a conventional construction are remedied, but there is also a huge gain in useful floor area.

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This is because in contrast to a traditional facade in which the insulation is placed against the wall, in the hybrid solution the package of the required insulation is located in the build depth of the mullion profiles, as a result of which usually 20 cm in depth is gained. This is equivalent to a gain of 0.2 m² of useful floor area per running perimeter and per floor plate.

Here, too, there are two options, namely:

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- 1) option 1: maintain dimension of the building, as a result of which the net surface area becomes greater, and thus also the related revenues from rental or sale increase.
- 2) option 2: maintain useful surface area, as a result of which the dimension can be reduced accordingly, and thus also the related building costs decrease.

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The above-mentioned technical details and implementation steps will be illustrated in more detail on the basis of specific embodiments described in the figures and the detailed description of the invention.

Brief description of the figures

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Figures 1a and 1b show a schematic depiction of one embodiment of a facade according to the prior art.

Figure 2 shows a schematic depiction of one embodiment of the hybrid lightweight ventilated facade.

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Figure 3 shows a horizontal cross section along line A-A from Figure 2.

Figure 4 shows a vertical cross section along line B-B from Figure 2.

Figure 5a shows a horizontal cross section of the hybrid lightweight ventilated facade at the location of an anchor plate.

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Figure 5b shows a vertical cross section along line C-C from Figure 2.

Figure 6a shows a vertical cross section of detail D from Figure 2.

Figure 6b shows a horizontal cross section of detail D from Figure 2.

5 Figure 6c shows a perspective view of detail D from Figure 2.

Figure 7a shows a horizontal cross section at the location of the coupling between two plastics subprofiles placed one above the other.

10 Figure 7b shows a vertical cross section of the coupling between two plastics subprofiles placed one above the other.

Figure 7c shows a perspective view of the coupling between two plastics subprofiles placed one above the other.

15 Figure 8a shows a schematic depiction of the fitting of a "conventional" ventilated facade according to the prior art.

Figures 8b and 8c show a schematic depiction of the fitting of one embodiment of the hybrid lightweight ventilated facade according to the invention, wherein the gain in useful floor area in comparison with a conventional ventilated facade is illustrated.

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Figures 9a, 9b, 9c and 9d show a schematic vertical cross section of the possible telescopic couplings between two insulation panels placed one above the other.

Figure 10 shows an alternative embodiment of the horizontal cross section along line A-A from Figure 2.

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Figures 11a, 11b, 11c and 11d show a horizontal cross section of various embodiments of the mullion profiles.

Detailed description

30 The present invention will be described on the basis of specific embodiments, which are illustrative for the explanation but should not be regarded as limiting. A person skilled in the art will appreciate that the invention is not limited by the embodiments shown and/or described and that alternatives or modified embodiments may be developed in accordance with the general concept of this explanation. The figures shown are only schematic and not limiting.

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References throughout this explanation to "one embodiment" imply that one or more determined features, properties or structures which are described in connection with this embodiment may be incorporated in one or

more embodiments of the present explanation. The use of phrases such as "in one embodiment" or "in some embodiments" throughout this text does not necessarily make reference, but rather possibly makes reference, to the same embodiment. In addition, the features, properties or structures which are described on the basis of a determined embodiment may be combined in any suitable manner in one or more embodiments.

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Specific features, properties or structures are indicated in the figures by means of reference numbers. In order to not overload the figures, each feature is not indicated in each figure. Conversely, in order to not overload the text, each feature which is indicated in a figure is not also discussed in the context of this specific figure.

10 Lastly, the use of ordinal numbers such as "first", "second" and the like throughout this explanation in no way whatsoever implies a hierarchical relationship – neither in terms of importance, position or time – between the features for which these are used, unless explicitly specified to the contrary. These ordinal numbers serve merely to differentiate between different but similar features, properties or structures.

15 Figures 1a and 1b show a schematic depiction of one embodiment of a ventilated facade according to the prior art. This conventional ventilated facade is constructed as follows:

- on the inner side 2 of the building, a wall of the building shall 80 is erected at the edge of the floor plate. This wall may be implemented in concrete, masonry, aerated concrete, etc.
- the thermal insulation 82 is attached along the outer side of this wall 80.
- 20 - a rainscreen 86 is (optionally) attached along the outer side of the thermal insulation 82.
- the lightweight facade cladding 83 is fitted against a suspension structure 81 or directly with brackets against the wall 80 of the building shell, along the outer side 1 of the building, in such a way that an air cavity 85 is produced between the thermal insulation 82 and the facade cladding 83.

25 The many disadvantages which this construction process of a conventional ventilated facade entails have already been discussed extensively above. Embodiments of the facade according to the present invention provide a solution to these disadvantages.

Figure 2 shows a schematic depiction of one embodiment of the lightweight ventilated facade 10 according to the invention. The mullion profiles 30 are fastened along the outer periphery of the floor plates 3 of a building by means of anchor plates (not shown in Figure 2). The cladding panels 40 are in turn fastened to the mullion profiles 30. The ventilated facade 10 forms the protective shell of the building and protects the inner side 2 of the building against the climatic conditions – such as precipitation, wind and temperature fluctuations – to which the outer side 1 is exposed.

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Figure 3 shows a horizontal cross section of the lightweight ventilated facade along line A-A from Figure 2. In the embodiment according to Figure 3, the mullion profiles 30 are constructed from two subprofiles: a metal subprofile 32 and a plastics subprofile 34.

5 The metal subprofile 32 is located on the inner side of the mullion profile; it ensures the strength and stiffness of the facade and has the purpose of transmitting the weight and the wind load on the facade via the anchor plates to the floor plates and the supporting structure of the building. The metal subprofile 32 is preferably a hollow rectangular tube-like profile. Such profiles are easy to fabricate and have a greater area moment of inertia than profiles with a solid cross section for the same material use. The metal subprofile 32 is preferably predominantly
10 manufactured from (galvanized) steel or aluminium. In comparison with aluminium, steel has the advantage of a lower weight, and the elasticity modulus of steel is three times higher and therefore the mullion profiles made of steel can be of slimmer design than mullion profiles made of aluminium. By contrast, aluminium has a much greater corrosion resistance than steel and steel has to be subjected to an anti-corrosion treatment (for example galvanization).

15 The plastics subprofile 34 is located on the outer side of the mullion profile; it has the purpose of providing a thermal break, or thermal protection, of the mullion profile so that no thermal bridges are produced between the outer side 1 and the inner side 2. The plastics subprofile 34 is preferably constructed from ASA, PVC or fibre-reinforced resin, or similar. The advantage of profiles composed of fibre-reinforced resin is that these have a higher elasticity
20 modulus and fire resistance than other plastics. Profiles composed of fibre-reinforced resin may for example be manufactured by means of pultrusion.

The metal subprofile 32 and the plastics subprofile 34 are mechanically fastened to one another. Preferably, this fastening has already been realized in the workshop and not on the construction site. The connection is usually
25 effected mechanically, by means of bolts, screws or similar fastening means.

The lightweight cladding panels 40 are located on the outer side 1 of the ventilated facade. They form the outer barrier of the building against wind and precipitation and provide the architectural appearance of the facade. Preferably, each of the cladding panels 40 is fastened to two adjacent mullion profiles 30. Preferably, the cladding
30 panels 40 are lightweight architectural panels. The cladding panels 40 may for example be manufactured from aluminium, rustproof steel, corten steel, plastic or wood. The cladding panels 40 may also be manufactured from veneer wood or stone strips or a suitable carrier.

The cladding panels 40 are provided, on their inner side, with one or more L-shaped profiles 41. Preferably, each
35 cladding panel 40 comprises two L-shaped profiles 41, wherein these profiles run over the entire height of the panel and are fitted at the edge of the panel.

Preferably, the L-shaped profiles 41 are predominantly manufactured from aluminium or stainless steel from an anti-corrosion viewpoint. The L-shaped profiles 41 have already been fastened to the cladding panels 40 in the factory. Each of the L-shaped profiles 41 is provided with a plurality of fastening lugs for fastening to the plastics subprofile 34. To this end, bayonet openings, also called bayonet connections, are milled in the plastics subprofile 34 at precise intervals.

Located on a cladding panel 40 is one non-movable fastening point 42. Non-movable in this context means that the cladding panel 40 is no longer able to move in translation – in any direction – with respect to the mullion profile 30 once the fastening point 42 has been fastened. Such a non-movable fastening point 42 may for example be realized by click-fitting the threaded sleeve in diabolo form, which is fastened to the L-shaped profile, by means of the mentioned bayonet opening provided in the plastics subprofile 34.

As a result of the diabolo, the panel is no longer able to move while a threaded sleeve is provided on the other opposite side, said threaded sleeve also being hung in the bayonet opening, but thus being able to freely expand. The cladding panels are thus hooked in the plastics panels by means of a single movement and also no further intervention is required. The dead weight of the panel prevents it from lifting out of the bayonet opening. If the dead weight of the cladding panel were to be insufficient, then a simple screw fastening at the location of the fixed point of the diabolo can remedy this issue.

On the opposite side of the panel, there are only movable fastening points 43, which permit a translational movement of the cladding panel 40 with respect to the mullion profile 30, parallel to the plane of the facade. This translational movement can be effected in two directions, specifically

- 1) suspension points on the same level, or horizontal line, as the fixed suspension point, that is to say the diabolo, permit a lateral movement;
- 2) all the other suspension points permit both a lateral and vertical movement.

The fastening of the cladding panels 40 by means of one non-movable fastening point 42 on one side and only movable fastening points 43 along the other side results in an ease of fitting which has never been seen before, which is reduced to a single hanging movement whereby the panel is precisely in the correct position to within an accuracy of one millimetre.

A person skilled in the art knows that an inverted solution is also possible, wherein the mullion profiles are provided with fixed and movable fastening points and wherein the L-shaped profiles of the cladding panels are provided with the necessary openings.

The insulation panels 50 are fastened between two adjacent mullion profiles 30. Preferably, the insulation panels 50 are hard dimensionally stable insulation panels, such as panels manufactured from PIR, PUR or XPS. The

insulation panels 50 rest on the support brackets 52 (depicted in dotted lines in Figure 3). The support brackets 52 may for example consist of L-shaped profiles which are screwed against the sides of the mullion profiles 30. In the other directions, the insulation panels 50 are held in place by the plastics subprofiles 34, the sides of the mullion profiles 30 and the finishing profiles 60. An air cavity 11 is thus produced between the outer side of the insulation panels 50 and the inner side of the cladding panels 40. This cavity 11 is ventilated by the open joints 44 between the adjoining cladding panels 40. A person skilled in the art knows that a cavity contributes to the insulation value of the wall. A person skilled in the art also knows that a ventilated cavity ensures that any precipitation which has infiltrated into the cavity is discharged and that the insulation panels 50 are provided, on the outer side, with a rainscreen (for example metal plate or another non-water-permeable material), as a result of which the insulation cannot be wetted so that it will not lose its thermally insulating capability.

A first vertical seal 70 is placed between the outer side of the insulation panels 50 and the plastic subprofile 34. A second vertical seal 72 is placed between the sides of the insulation panels 50 and the sides of the mullion profile 30. A third vertical seal 71 is placed between the inner side of the insulation panels 50 and the finishing profile 60. The first, second and third vertical seal 70, 72 and 71 form, respectively, a first, second and third barrier in order to ensure the wind-tightness and water-tightness of the ventilated facade along the interface between mullion profiles 30 and insulation panels 50. While the cladding panels 40 mostly dissipate the kinetic energy of precipitation and wind, the first, second and third vertical seal 70, 72 and 71 prevent air and water from displacing through the facade due to a pressure difference between the outer side 1 and the inner side 2 of the building. In addition, due to their compressibility, the seals 70, 71 and 72 are also suitable for compensating for any deformations of the facade so that the insulation panels are not damaged or so that no cracks are produced between the insulation panels and the mullion profiles.

A person skilled in the art is aware of suitable materials for implementing the seals such as butyl, TPE, silicone or foam tape. A person skilled in the art also knows that a great number of standard seals from the building sector, which are widely available and are offered by several manufacturers, can be used for producing the seals. Preferably, one or more of the seals have already been attached to the mullion profiles 30, the insulation panels 50 or the finishing panels 60 prior to their arrival on the construction site. Preferably, the second vertical seal 72 is part of a seal which runs uninterrupted around the periphery of the insulation panel 50.

A vertical finishing profile 60 is fastened to the inner side of the metal subprofile 32. This finishing and clamping profile 60 holds the insulation panels 50 in place. Preferably, the finishing profile 60 is manufactured from aluminium and mechanically fastened to the metal subprofile 32, for example by means of screws. Other materials and other manners of fastening are, however, also possible.

Figure 4 shows a vertical cross section of the lightweight ventilated facade along line B-B from Figure 2. In the embodiment according to Figure 4, the connection between an upper insulation panel 50' and a lower insulation

panel 50'' is visible. Both insulation panels 50' and 50'' are clad along their inner, outer, top and bottom sides with a finishing layer 53. This finishing layer 53 may for example consist of a film/foil or a thin metal cladding. This finishing layer 53 may have multiple purposes. This finishing layer serves as rainscreen, in order to prevent moisture from penetrating into the panels and coming into contact with the insulation material, to increase the vapour-tightness and wind-tightness of the panels and to reinforce the panels. The finishing layer 53 is folded over on the top and bottom side of the insulation panels 50' and 50'' so as to form a projecting tongue 54 which fits into a corresponding groove of the upper or lower insulation panel. In Figure 4, the thickness of the tongue 54 is not necessarily shown to scale. The combination of the tongues and corresponding cutouts in the two panels creates a telescopic connection, which is able to accommodate limited movement and simultaneously still ensure a perfectly wind-tight and water-tight connection. A person skilled in the art understands that a projecting tongue has to have a certain stiffness and that – depending on the properties of the finishing layer 53 – the tongue 54 has to be of greater dimensions in order to achieve the required stiffness. A person skilled in the art also understands that the insulation panels 50' and 50'' as described here correspond to a standard product from the building sector which is widely available and is offered by several manufacturers.

A plurality of horizontal seals 73, 74, 75, 76 are attached between the upper and lower insulation panels 50' and 50''. Preferably, the second and third seals 74 and 75 are part of a seal which runs uninterrupted around the periphery of the insulation panels 50' and 50'' and of which the second vertical seal 72 from Figure 3 also forms part. The second horizontal seal 74, which sits more to the outer side of the facade, may for example form part of a seal which runs around the upper panel 50', and the third horizontal seal 75, which sits more to the inner side of the facade, may form part of a seal which runs around the lower panel 50'', or vice versa.

Horizontal seals 73 and 76 are attached between the tongues 54 and the corresponding grooves. The horizontal seals 73, 74, 75 and 76 form four successive barriers in order to ensure the wind-tightness and water-tightness of the ventilated facade along the interface between an upper and a lower insulation panel 50' and 50''. In addition, due to their compressibility, the seals 73, 74, 75 and 76 are also suitable for compensating for any deformations of the facade so that the insulation panels are not damaged. As is the case for the vertical seals 70, 71 and 72, a person skilled in the art is aware of suitable materials and a person skilled in the art knows that standard products from the building sector may be used. As is the case for the vertical seals 70, 71 and 72, the horizontal seals 73, 74, 75 and 76 are preferably installed prior to the fitting of the facade and more preferably even prior to the arrival of the components on the construction site. As already mentioned, the second and third horizontal seal 74 and 75 preferably form, together with a vertical seal 72, an uninterrupted seal around an insulation panel 50.

Figure 5a shows a horizontal cross section of one embodiment of the lightweight ventilated facade at the location of an anchor plate 20. Figure 5b shows a vertical cross section of the same detail along line C-C from Figure 2. The anchor plate 20 fastens the mullion profile 30 to the floor plate 3 of the building. The anchor plate 20 is thus also responsible for the transmission of the total dead weight of the lightweight ventilated facade and the wind load

on the ventilated facade to the floor plate 3. Preferably, the anchor plate 20 is implemented in galvanized steel or aluminium. The anchor plate 20 comprises an upright edge 22. The anchor plate 20 is preferably provided with both slotted holes and locking holes. The slotted holes allow the anchor plate to be aligned in the plane of the facade; the locking holes allow the anchor plate to be locked, after alignment, so that it is no longer able to slide.

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The mullion profile 30 is provided with a shoe which comprises a duckbill hook 23. Preferably, this shoe with duckbill hook 23 has already been fastened to the mullion profile in the factory.

Once the anchor plates 20 have been placed and have been accurately aligned in the facade plane, said alignment preferably being effected to within an accuracy of one millimetre, the vertical mullion profiles 30, which are provided with a "duckbill" hook 23, are hung over the vertical upright 22 of the anchor plates 20.

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The mullion profiles 30 are then aligned in two successive steps, namely:

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- in a Y direction, that is to say the direction parallel to the facade plane, and in such a way that the axis of the mullions stands precisely in the theoretical axis lines of the facade of the building. This alignment is effected by sliding the "duckbill" 23 horizontally over the vertical upright 22 of the anchor plate 20.
- in a Z direction, that is to say in the vertical direction, wherein the mullions 30 are aligned at the correct level. This is effected by means of an adjustment bolt which sits in the duckbill 23 and which, in the case of a weight anchor – an anchor plate in which vertical loads, that is to say the dead weight of the ventilated facade, are also transmitted to the floor plate –, rests on the upper edge of the vertical upright 22 of the anchor plate. In the case of a "wind anchor", that is to say a fastening in which only horizontal wind loads are accommodated, there is no adjustment bolt, but the duckbill 23 is able to move freely back and forth in the vertical direction, and only in this vertical direction, in order to thus be able to accommodate differential settlements and thermal expansions.

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25 Preferably, the alignment is effected to within an accuracy of one millimetre in both planes.

Figure 6a shows a vertical cross section of the coupling between two metal subprofiles of a mullion profile which lie one above the other and is an enlargement of detail D from Figure 2. Figure 6b and Figure 6c respectively show a horizontal cross section and a perspective view of the same detail. The upper subprofile 32' of an upper mullion profile and the lower subprofile 32'' of a lower mullion profile are connected by means of the internal coupling piece 33. This coupling piece 33 partially sits in the hollow rectangular tube of both profiles. The coupling piece may for example be manufactured from galvanized steel. The coupling piece 33 is fastened to one of the two profiles 32' or 32'', for example by means of a screw connection. This ensures that the profiles 32' and 32'', and thus the upper and lower mullion profiles, cannot move with respect to one another, other than a translational movement in the vertical direction.

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Allowing such a translational movement in the vertical direction is a technical necessity. Firstly, it is necessary for the installation and the vertical alignment of the mullion profiles of the facade. The upper subprofile 32' is part of the upper mullion profile 30' which is secured to a higher floor plate than the lower subprofile 32'' which is part of the lower mullion profile 30''. In order to be able to correctly align the upper and the lower mullion profiles in the vertical direction, it is necessary for them both to be able to perform a translational movement in the vertical direction with respect to one another. Preferably, there is a free space of 20 to 30 millimetres between the upper profile 32' and the lower profile 32'' after installation. The second necessity is that the profiles 32' and 32'' are able to move with respect to one another in the vertical plane in order to compensate for thermal expansion, deformation by wind load or differential settlement of the building without introducing mechanical stresses into the facade. A person skilled in the art will note that an analogous mechanism is accomplished in the horizontal plane by the movable fastening means 43 of the cladding panels 40.

Figure 7a shows a horizontal cross section of the coupling between two plastics subprofiles of a mullion profile which lie one above the other and is an enlargement of detail D from Figure 2. Figure 7b and Figure 7c respectively show a vertical cross section and a perspective view of the same detail. Figures 7a, 7b and 7c thus concern the same detail as Figures 6a, 6b and 6c, but for the plastics subprofile instead of for the metal subprofile.

The upper subprofile 34' of an upper mullion profile and the lower subprofile 34'' of a lower mullion profile are connected by means of the coupling piece 35. This coupling piece is partially pushed over both profiles. The coupling piece 35 may for example be manufactured from plastic. The coupling piece 35 is fastened to one of the two profiles 34' or 34'', for example by means of a glued connection. This ensures that the profiles 34' and 34'', and thus the upper and lower mullion profiles, cannot move with respect to one another, other than a translational movement in the vertical direction.

The upper metal subprofile 32' and the upper plastics subprofile 34' together form the upper mullion profile 30'. In the same way, the lower metal subprofile 32'' and the upper plastics subprofile 34'' together form the lower mullion profile 30''. The advantages of the use of a coupling piece which permits a translational movement between the profiles which lie one above the other have already been explained in the context of Figures 6a, 6b and 6c. These advantages likewise apply to the plastics subprofiles. Since the plastics subprofile and the metal subprofile of a mullion profile are fixedly connected to one another, these advantages also apply to the mullion profiles in their entirety.

Figure 8a shows a schematic depiction of the fitting of a conventional ventilated facade according to the prior art, while Figures 8b and 8c show a schematic depiction of the fitting of one embodiment of the lightweight ventilated facade according to the invention.

In the prior art, as illustrated in Figure 8a, a wall 80, usually made of concrete, masonry, aerated blocks or similar, is first placed at the edge of the floor plate. Then, first the anchors 81 and subsequently the insulation 82 are fastened against this wall 80 along the exterior. Finally, the cladding panels 83 are fastened at the free ends of the anchors 81.

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Figures 8b and 8c clearly illustrate the difference in method for the installation of a lightweight ventilated facade 10 according to the present invention. The mullion profiles (not shown in Figures 8b and 8c) are suspended at the edge of the floor plate 3 from inside the building. Subsequently, the cladding panels 40 are suspended from the mullion profiles, again from inside the building. Then, the insulation panels 50 are placed between the mullion

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profiles, once again from inside the building. The installation of the ventilated facade 10 according to the present invention can thus be effected completely from the inside and does not require a scaffold, which is safer, more rapid, less expensive and less dependent on the weather conditions than the installation of a comparable facade according to the prior art.

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In addition, the alignment of the lightweight ventilated facade 10 is effected by adjusting the anchor plates and the mullion profiles (neither of which are shown in Figures 8b and 8c). By contrast, according to the prior art, the alignment of the facade is effected by correctly placing the anchors 81. The installation and alignment of the ventilated facade 10 according to the present invention can thus be effected much more accurately – but also more easily and thus much more rapidly – than the installation of a comparable facade according to the prior art. This entails advantages on an aesthetic level; when using highly reflective facade panels, it is always very clear when the panels do not lie completely in the same plane or are deformed under the influence of residual stresses. An accurate installation also has a favourable effect on the air-tightness and water-tightness of the facade.

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Lastly, Figures 8a, 8b and 8c also very clearly illustrate the difference in the use of space of the different facade systems. The buildings of Figures 8a and 8b have the same external dimension. However, for the same insulation thickness and cavity thickness, the building of Figure 8b has a considerably greater usable floor area. Conversely, the buildings of Figures 8a and 8c have the same usable floor area, but for the same insulation thickness and cavity thickness, the building of Figure 8c has a considerably smaller external dimension. This space saving is produced due to the fact that the ventilated facade 10 according to the present invention replaces the concrete

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Figures 9a, 9b, 9c and 9d show a schematic vertical cross section of the connection or coupling between two insulation panels 50' and 50'' which are placed one above the other.

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In this case, there are four possible configurations for this coupling.

- 1) Configuration 1, depicted in Figure 9a: A double Z connection of cold-rolled tongues forming part of the panels.

- 2) Configuration 2, depicted in Figure 9b: A telescopic male/female connection.
- 3) Configuration 3, depicted in Figure 9c: A separate H-shaped coupling profile is fitted between the two panels.
- 4) Configuration 4, depicted in Figure 9d: A separate coupling profile having a double U shape is fitted between the two sandwich panels.

In each of these configurations, a telescopic coupling is thus realized, which makes it possible to accommodate deformations and to simultaneously ensure the wind-tightness and water-tightness of the coupling.

- 10 In the embodiments of Figures 9a and 9b, the upper insulation panel 50' and the lower insulation panel 50'' engage with one another by means of the tongues 54 of one panel which engage with a corresponding groove of the other panel. Such a connection is therefore always embodied as a telescopic coupling and has already been discussed in the context of Figure 4. In the embodiments of Figures 9c and 9d, a coupling piece 51 is placed between the upper insulation panel 50' and the lower insulation panel 50''. Preferably, the coupling piece is thermally broken or
- 15 made from a plastic. The coupling piece 51 may for example be used when the desired insulation panels are not available in a version with tongue and groove, or when greater movements between the panels lying one above the other are expected.

- Figure 10 shows a horizontal cross section of the lightweight ventilated facade along line A-A from Figure 2, but in another embodiment than the one depicted in Figure 3. In the embodiment of Figure 10, the mullion profile 30 is not constructed from subprofiles, but is embodied as a profile in one piece. The mullion profile 30 may be manufactured both from metal and from plastic (having sufficient structural stiffness). A mullion profile 30 which is manufactured completely from metal will only be able to be used if a thermal bridge between the inner side and outer side of the facade does not pose a problem.

- 25 Figures 11a, 11b, 11c and 11d show a horizontal cross section of various embodiments of the mullion profiles 30. The mullion profiles of Figures 11b and 11d are constructed from a metal subprofile 32 and a plastics subprofile 34. In the embodiment of Figure 11b, the metal subprofile sits on the inner side; in the embodiment of Figure 11d, the metal subprofile sits on the outer side. The mullion profile of Figure 11a is predominantly manufactured from metal, while the mullion profile of Figure 11c is manufactured predominantly from plastic.
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A person skilled in the art knows the conditions in which it is justified to manufacture the mullion profiles from a single material and the cases in which a composite profile is desirable. The specifications of the specific project will explain what is required. A person skilled in the art also knows which material can be used in which conditions.

Reference numbers

1	outer side of the building
2	inner side of the building
3	floor plate
10	ventilated facade
11	ventilated cavity
20	anchor plate
22	raised edge of the anchor plate
23	duckbill hook
30	mullion profile
30'	upper mullion profile
30''	lower mullion profile
31	coupling piece of mullion profiles
32	metal subprofile
32'	upper metal subprofile
32''	lower metal subprofile
33	coupling piece of metal subprofiles
34	plastics subprofile
34'	upper plastics subprofile
34''	lower plastics subprofile
35	coupling piece of plastics subprofile
40	cladding panel
41	L-shaped profile
42	fixed fastening point
43	expanding fastening point
44	open joint between cladding panels
50	insulation panel
50'	upper insulation panel
50''	lower insulation panel
51	telescopic coupling piece at the location of two insulation panels lying one above the other
52	support bracket
53	sealing layer of insulation panel
54	tongue of insulation panel
60	finishing profile

70	first vertical seal
71	second vertical seal
72	third vertical seal
73	first horizontal seal
74	second horizontal seal
75	third horizontal seal
76	fourth horizontal seal
80	load-bearing inner wall made from concrete, masonry or similar
81	anchor for fastening the cladding panel against the load-bearing inner wall
82	cavity insulation
83	cladding panel
84	supporting structure
85	air cavity
86	rainscreen

Claims

1. Lightweight ventilated facade (10) which comprises one or more anchor plates (20), one or more mullion profiles (30), one or more cladding panels (40) and one or more insulation panels (50), wherein the anchor plates (20) are fastened along a perimeter of a floor plate (3) of a building, wherein each of the mullion profiles (30) is vertically fastened to an anchor plate (20) on the outer side of the floor plate (3), wherein each of the cladding panels (40) is fastened to two mullion profiles (30) on the outer side of these mullion profiles (30), wherein each of the insulation panels (50) is fastened between two mullion profiles (30), wherein there is a ventilated cavity (11) between the insulation panels (50) and the cladding panels (40), wherein the cladding panels (40) can be fastened to the mullion profiles (30) from inside the building.
2. Lightweight ventilated facade (10) according to Claim 1, wherein one or more of the mullion profiles (30) consist of a single monolithic metal profile.
3. Lightweight ventilated facade (10) according to Claim 1, wherein one or more of the mullion profiles (30) consist of a thermally insulating profile.
4. Lightweight ventilated facade (10) according to Claim 1, wherein one or more of the mullion profiles (30) consist of two or more subprofiles, wherein the subprofiles of a mullion profile (30) are mechanically connected to one another, wherein at least one of the subprofiles of a mullion profile (30) is predominantly manufactured from metal and wherein at least one other of the subprofiles of a mullion profile (30) is predominantly manufactured from a plastic.
5. Lightweight ventilated facade (10) according to Claim 4, wherein the predominantly metal subprofile (32) is located on the inner side of the mullion profile (30) and wherein the predominantly plastics subprofile (34) is located on the outer side of the mullion profile (30).
6. Lightweight ventilated facade according to Claim 4, wherein the predominantly plastics subprofile (34) is located on the inner side of the mullion profile (30) and wherein the predominantly metal subprofile (32) is located on the outer side of the mullion profile (30).
7. Lightweight ventilated facade (10) according to one of the preceding claims, wherein a cladding panel (40) is suspended from two adjacent mullion profiles (30) by means of four or more suspension points, wherein the suspension points are distributed in two or more rows over the mullion profiles (30) to which the cladding panel (40) is fastened, wherein only a single suspension point is a fixed suspension point (42); wherein the suspension points (43) on the same level, or horizontal line, as the above-mentioned

fixed suspension point (42) permit a lateral movement of the cladding panel (40); wherein all the other suspension points (43) permit both a lateral and vertical movement of the cladding panel (40).

- 5 8. Lightweight ventilated facade (10) according to one of the preceding claims, wherein the lower mullion profiles (30''), which are fastened to the anchor plates (20) of a lower floor plate (3), are vertically connected to the corresponding upper mullion profiles (30'), which are fastened to the anchor plates (20) of an upper floor plate (3), by means of a coupling piece (31).
- 10 9. Lightweight ventilated facade (10) according to Claim 8, wherein the lower mullion profiles (30'') and the corresponding upper mullion profiles (30') can move in translation with respect to one another in a vertical direction, wherein the wind-tightness and water-tightness of the facade is maintained.
- 15 10. Lightweight ventilated facade (10) according to one of the preceding claims, wherein the insulation panels (50) are supported by support brackets (52), wherein the support brackets (52) are fastened to the mullion profiles (30).
- 20 11. Lightweight ventilated facade (10) according to one of the preceding claims, which further comprises one or more finishing profiles (60), wherein the finishing profiles (60) are fastened to the inner side of the mullion profiles (30).
- 25 12. Lightweight ventilated facade (10) according to one of the preceding claims, wherein one or more vertical seals (70, 72) are fastened between the mullion profiles (30) and the insulation panels (50).
- 30 13. Lightweight ventilated facade (10) according to Claim 11, wherein one or more vertical seals (71) are fastened between the finishing profiles (60) and the insulation panels (50).
- 35 14. Lightweight ventilated facade (10) according to one of the preceding claims, wherein one or more horizontal seals (73, 74, 75, 76) are fastened between a lower insulation panel (50'') and an upper insulation panel (50').
15. Method for constructing a lightweight ventilated facade (10) according to Claim 1, wherein the method comprises the following steps:
- fastening and aligning the anchor plates (20) on the floor plate (3);
 - fastening mullion profiles (30) to the anchor plates (20), wherein the mullion profiles (30) are fastened to the outer side of the building from inside the building;
 - fastening the cladding panels (40) to the mullion profiles (30), wherein the cladding panels (40) are fastened to the outer side of the mullion profiles (30) from inside the building;

- fastening the insulation panels (50) between the mullion profiles (30), wherein the insulation panels (50) are fastened between the mullion profiles (30) from inside the building;
- fastening the finishing profiles (60) to the inner side of the mullion profiles (30).