Abstract: A modular sound absorbing structure (10) and a method for manufacturing a modular sound absorbing structure (10) are presented. The structure (10) comprises a plurality of planar rigid sound absorbing modules (M1 -M3), each one of which comprises at least one sound absorbing element (40), and support elements (21A-21D) providing a rigid frame (24) for a number of planar rigid sound absorbing modules (M1 -M3) of the plurality of planar rigid sound absorbing modules (M1 -M3), wherein each one of the number of planar rigid sound absorbing modules (M1 -M3) is arranged on a first plane, wherein the rigid frame (24) is in mechanical contact with peripheral portions of the number of planar rigid sound absorbing modules (M1 -M3), and the structure (10) comprises attaching portions (23) attaching two support elements (21A-21 D) to each other, and the planar rigid sound absorbing modules (M1 -M3) comprise first rigid sheets (41) of metal.
SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.


**Published:**

— with international search report (Art. 21(3))
MODULAR SOUND ABSORBING STRUCTURE AND A METHOD FOR MANUFACTURING A MODULAR SOUND ABSORBING STRUCTURE

TECHNICAL FIELD

The invention concerns in general the technical field of sound absorbing or acoustical structures. The invention concerns especially, however, not exclusively, sound absorbing structures used in industrial plants having machines producing high noise.

BACKGROUND

High level of noise can damage hearing and cause hearing loss. It is, therefore, of utmost importance to reduce the level of noise in spaces where people spend time, for example, when working. In such spaces, the noise may be produced by various sources, for example, by machines in industrial plants.

It is known to use noise barriers which reflect or absorb the energy of sound waves using damping structures such as sound baffles. Typically, in these structures, soundproofing material is being used. The material may be, for example, wool or foam which is attached to a wall structure.

In certain cases, however, the noise source is relatively small compared to the size of the space in which the source resides. Thus, the noise level in the whole space may increase to a high level and, thus, require personal hearing protection to be used by all persons in the space. It is known, that separate sound absorbing structures can be built to absorb some of the noise coming from the noise source. However, as the noise source can be any size or shape, the known structures are not suitable or at least not optimal to be utilized with any noise source as they may be either unnecessarily large or simply wrong shape for a particular case, and thus requires designing the structure from scratch. As the structure in total can be large, transporting the different parts to the place of installation can be expensive and difficult.

There is thus a need to develop novel sound absorbing structure and method for manufacturing thereof in order to solve at least some of the issues related to known attempts.
SUMMARY

An objective of the present invention is to provide a modular sound absorbing structure and a method for manufacturing a modular sound absorbing structure. Another objective of the present invention is that the modular sound absorbing structure and the method facilitate designing and installation of different kinds of sound absorbing structures and alleviate logistical issues related to transporting the structure to its place of installation.

The objectives of the invention are reached by a modular sound absorbing structure and a method for manufacturing a modular sound absorbing structure as defined by the respective independent claims.

According to a first aspect, a modular sound absorbing structure is provided. The structure comprises a plurality of planar rigid sound absorbing modules, each one of which comprises at least one sound absorbing element. The structure also comprises support elements providing a rigid frame for a number of planar rigid sound absorbing modules of the plurality of planar rigid sound absorbing modules. Each one of the number of planar rigid sound absorbing modules is arranged on a first plane. The rigid frame is in mechanical contact with, such as attached to or at least supported or leaning against, peripheral portions of the number of planar rigid sound absorbing modules. The structure further comprises attaching portions attaching two support elements to each other.

The number of planar rigid sound absorbing modules may at most be equal to the number of the plurality of planar rigid sound absorbing modules, however, in many cases forming a subset of the plurality of planar rigid sound absorbing modules. The subset may include any number of modules from one up to an amount equal to the number of the plurality of planar rigid sound absorbing modules.

The at least one sound absorbing element may be comprised of a single planar sound absorbing element or of several various types of sound absorbing elements.

Term "planar" is used herein to mean a three-dimensional object in which two dimensions are significantly larger relative to the third dimension. The term should not be interpreted to mean a mathematical two-dimensional plane.
Each one of the number of planar rigid sound absorbing modules may comprise a first rigid sheet, for example, comprising metal, such as steel, stainless steel or aluminium, wherein the first rigid sheets of the number of planar rigid sound absorbing modules extend over a centre area defined by the rigid frame.

Term "centre area defined by the rigid frame" refers herein to the plane-like surface residing parallel to a plane defined by the rigid frame, for example, the first plane. The centre area may essentially refer to the opening defined by the frame. The first rigid sheets of the number of planar rigid sound absorbing modules substantially cover the opening defined by the rigid frame.

Each one of the number of planar rigid sound absorbing modules may comprise a second rigid sheet, wherein the second rigid sheets of the number of planar rigid sound absorbing modules extend over a centre area defined by the rigid frame. The rigid frame may be attached to the peripheral portions of the second rigid sheets of the number of planar rigid sound absorbing modules. Furthermore, the at least one sound absorbing element may be arranged between the first and the second rigid sheets.

The at least one sound absorbing element may, preferably, be attached to the first rigid sheets, or to the second rigid sheets, or both the first and second rigid sheets.

The at least one sound absorbing element may, preferably, be a rigid sound absorbing element. The rigid sound absorbing element may, preferably, be a planar plywood element.

The plurality of planar rigid sound absorbing modules may comprise at least four planar sound absorbing wall modules and at least one planar sound absorbing roof module for forming a modular sound absorbing structure defining an inner volume when arranged on a floor surface.

It may be so that only the sound absorbing element of each one of the planar sound absorbing wall modules is a rigid sound absorbing element, such as a planar plywood element.

The rigid frame may be a metal frame, such as of steel, stainless steel or aluminium.

At least one of the first and second rigid sheets may be a metal sheet.
The at least one sound absorbing element may have a surface area of at least 80 percent of a surface area of the first rigid sheet or the second rigid sheet.

The plurality of planar rigid sound absorbing modules may comprise at least one first planar rigid sound absorbing module having a first width and at least one second planar rigid sound absorbing module having a second width.

The structure may comprise an accessory element having the first width, or the second width, or a sum of any multiple of the first width or second width, or any combination of multiples of the first and second widths such that the accessory element is suitable for fitting to the structure with respect to a spacing defined by the plurality of planar rigid sound absorbing modules. The accessory element may be, for example, one of the following: a door, a frame for feed through, an electrical power supply enclosure.

The width of the module may range from 50 to 1500 millimetres, preferably from 250 to 1250 millimetres. The width may be, for example, 250, 500, 750, or 1000 millimetres.

According to a second aspect, a method for manufacturing a modular sound absorbing structure is provided. The method comprises obtaining a plurality of planar rigid sound absorbing modules, each one of which comprises at least one sound absorbing element, and support elements for arranging a rigid frame for a number of planar rigid sound absorbing modules of the plurality of planar rigid sound absorbing modules, and attaching portions for attaching two support elements to each other. The method further comprises arranging the support elements to form the rigid frame for the number of planar rigid sound absorbing modules by attaching the support elements to each other by the attaching portions. The method also comprises arranging the number of planar rigid sound absorbing modules to be in mechanical contact with, such as attached to or at least supported or leaning against, the rigid frame at peripheral portions of the planar rigid sound absorbing modules.

Each one of the number of planar rigid sound absorbing modules may comprise a first rigid sheet and a second rigid sheet, wherein at least one of the first and the second rigid sheets may be attached to the rigid frame at the peripheral parts of the sheet and arranged to extend over a centre area defined by the rigid frame. The at least one sound absorbing element may a rigid sound absorbing
element and may be arranged between and attached to the first and the second rigid sheets.

The present invention provides a modular sound absorbing structure and a method for manufacturing a modular sound absorbing structure. The structure and method provide advantages over known solutions such that the structure can be designed by using same modules having specific dimensions to design and build different sizes and shapes of sound absorbing structures. Furthermore, the use of planar modules, the logistical issues can be alleviated due to the fact that the planar elements can efficiently be packed and transported to the place of installation. Due to the use of modules, the manufacturer of the structure may store certain number of modules, if desired, because each project doesn't require unique elements to be specifically designed for the structure to be built, thus, shortening the delivery time due to ready-made modules.

Various other advantages will become clear to a skilled person based on the following detailed description.

The expression "a number of" refers herein to any positive integer starting from one, e.g. to one, two, or three.

The expression "a plurality of" refers herein to any positive integer starting from two, e.g. to two, three, or four.

The terms "first" and "second" do not denote any order, quantity, or importance, but rather are used to distinguish one element from another.

The exemplary embodiments of the present invention presented herein are not to be interpreted to pose limitations to the applicability of the appended claims. The verb "to comprise" is used herein as an open limitation that does not exclude the existence of also un-recited features. The features recited in depending claims are mutually freely combinable unless otherwise explicitly stated.

The novel features which are considered as characteristic of the present invention are set forth in particular in the appended claims. The present invention itself, however, both as to its construction and its method of operation, together with additional objectives and advantages thereof, will be best understood from the following description of specific embodiments when read in connection with the accompanying drawings.
BRIEF DESCRIPTION OF FIGURES

The embodiments of the present invention are illustrated by way of example and not by way of limitation in the figures of the accompanying drawings.

Figure 1 illustrates schematically a modular sound absorbing structure according to an embodiment of the present invention.

Figure 2 illustrates schematically a modular sound absorbing structure according to an embodiment of the present invention.

Figure 3 illustrates schematically support elements according to an embodiment of the present invention.

Figures 4A and 4B illustrate schematically a planar rigid sound absorbing module according to an embodiment of the present invention.

Figure 5 illustrates schematically a plurality of support elements forming rigid frames according to an embodiment of the present invention.

Figures 6A-6D illustrate schematically modular sound absorbing structures according to some embodiments of the present invention.

Figures 7A-7C illustrate schematically a support element according to an embodiment of the present invention.

Figure 8 illustrates a part of a structure 10 according to an embodiment of the present invention.

Figures 9A and 9B illustrate schematically attaching portions according to an embodiment of the present invention.

Figure 10 illustrates schematically an adjustable floor support utilizable in an embodiment of the present invention.

Figures 11A and 11B illustrate schematically a support element according to an embodiment of the present invention.

Figures 12A-12C illustrate schematically a support element according to an embodiment of the present invention.
Figures 13A and 13B illustrate schematically support elements according to an embodiment of the present invention attached to each other.

Figures 14A-14C illustrate schematically an accessory element according to an embodiment of the present invention.

Figure 15 illustrates a flow diagram of a method according to an embodiment of the present invention.

DESCRIPTION OF SOME EMBODIMENTS

Figure 1 illustrates schematically a modular sound absorbing structure 10 according to an embodiment of the present invention. The structure 10 comprises a plurality of planar rigid sound absorbing modules M1-M3. There may be modules M1-M3 having different widths W1-W3. According to this particular embodiment, there are modules M1-M3, that is, first modules M1, second modules M2 and third modules M3, having three different widths W1-W3, that is, the first width W1, the second width W2 and the third width W3, respectively. There may also be more than three types of modules M1-M3.

According to an embodiment of the present invention, the width W1-W3 of a module M1-M3 may be, for example, from 50 to 1500 millimetres, preferably from 250 to 1250 millimetres. The width W1-W3 may be, for example, 250, 500, 750, or 1000 millimetres.

In Fig. 1, the sound absorbing structure 10 is essentially a cuboid, however, may also have a variety of different shapes. In addition to the planar rigid sound absorbing modules M1-M3, the structure 10 comprises accessory elements 12A-12C. The accessory element 12A-12C may be, for example, a door 12A, an electrical power supply enclosure 12B, or a frame for feed through 12C. The frame for feed through 12C may be, for example, an opening through which a belt conveyor of an industrial machine may extend. The accessory elements 12A-12C may, preferably, be dimensioned to have a width which is equal to the width W1-W3 of a planar rigid sound absorbing module M1-M3, or a sum of any two or three widths W1-W3, or any multiple of a width W1-W2, or any combination of the sums of widths W1-W3, for example, two times the first width W1 plus the second width W2. The widths W1-W3 of the modules M1-M3 essentially define the spacing of the structure 10 such that any other width other than mentioned hereinabove, for example, for a door 12A, would lead to a
situation where the door 12A wouldn't fit to the structure 10 from view of the spacing.

The spacing may depend on the used module M1-M3 having the smallest width, for example, 200 or 250 millimetres. In this case all the modules may advantageously be multiples of 200 or 250 millimetres. However, there may also be modules M1-M3 which are not multiples of the module M1-M3 having the smallest width.

According to an embodiment of the present invention, the height of the module M1-M3 may be anything above 0 to 4 metres. Preferably, the height of the module M1-M3 is from about 2 metres to about 3 metres. The height may preferably be such that sheets, if any, comprised in the module M1-M3 may be obtained from a standard size metal sheet, for example, being about 3 metres (about 10 feet). The height of the module M1-M3 may also be such that is fits indoors, that is, being less than the height of the room or space into which the structure 10 is to be assembled.

It is furthermore illustrated in Fig. 1 that the roof of the sound absorbing structure has been built by using two planar rigid sound absorbing modules M1-M3 arranged consecutively with respect to each other on a plane, that is, side by side, to form the roof. This is illustrated by the dashed line drawn across the roof perpendicularly with respect to the longitudinal direction of the modules M1-M3. It should be noted that the walls may as well be built by using more than one module M1-M3 placed side by side on a plane, thus, forming the wall. It is further shown in Fig. 1 that the rigid frames, such as metal frames, for example, of steel, stainless steel or aluminium, may have variety of heights, for example, the one above and/or below an accessory element 12A-12C.

Figure 2 illustrates schematically a modular sound absorbing structure 10 according to an embodiment of the present invention. The structure 10 is comprised of two planar rigid sound absorbing modules M1, each of which is attached to a rigid frame 24 comprised of support elements 21A-21C, such as , such as of steel, stainless steel or aluminium. An example of the rigid frame 24 has been shown in Fig. 2 wherein the rigid frame 24 comprises four support elements 21A-21C forming essentially a rectangular frame. There may be similar or different types of support elements 21A-21C utilized to form the rigid frame 24. In Fig. 2, there are shown vertical support elements 21A, top support
elements 21B and bottom support elements 21C. The bottom support elements 21C may be, for example, especially configured to be placed on a floor surface and to withstand a heavy load caused by structure 10. The top support elements 21B may, on the other hand, be lighter than the bottom support elements 21C and configured to receive roof support elements, for instance. The vertical support elements 21A may be especially configured such that the planar rigid sound absorbing modules M1-M3 may easily be attached to these support elements 21A. There may also be different kinds of vertical support portions 21A used at different parts of the structure 10, for example, at a straight part of a wall or in the corners.

Figure 3 illustrates schematically support elements 21A-21C according to an embodiment of the present invention. There are two support elements 21A, 21C shown: a vertical support element 21A and a bottom support element 21C. As can be seen, there may be holes 22 arranged via which the planar rigid sound absorbing module M1-M3 may be attached to the rigid frame 24. Furthermore, an attaching portion 23 is shown in Fig. 3 by which the support elements 21A-21C may be attached to each other. This may be implemented by a nut and bolt-type of attachment, however, there may also be special attaching portions such as flanges or separate attaching parts suitable for attaching the support elements to each other. Furthermore, Allen bolts or other known bolts may be used as well as blind rivets for the attaching. According to various advantageous embodiments, the module M1-M3 or the number of modules M1-M3 attached to one rigid frame 24 essentially extend over the centre area or opening 25 defined by the rigid frame 24. This has the advantage that the rigid module M1-M3 provides further support for the structure 10.

In Fig. 3, there is only one planar rigid sound absorbing module M1-M3 attached to each of the rigid frame 24. It should be noted, however, that there may be more than one, that is, a number of planar rigid sound absorbing module M1-M3 attached to one rigid frame 24.

Figures 4A and 4B illustrate schematically a planar rigid sound absorbing module M1 according to an embodiment of the present invention. Fig. 4A is an exploded view of an embodiment of the present invention. Fig. 4B illustrates different elements, if present, in contact with each other. The planar rigid sound absorbing module M1 comprises at least one sound absorbing element 40.

According to an embodiment of the present invention, the at least one sound
absorbing element 40 may be a rigid sound absorbing element 40 or be comprised of several rigid sound absorbing elements 40 arranged side-by-side on a plane and essentially extending over the centre area 25 or opening 25 defined by the rigid frame 24. This has the advantage that such a rigid sound absorbing element or elements provides further support for the structure 10. According to an embodiment of the present invention, the at least one rigid sound absorbing element 40 may be a rigid plywood element or elements. Plywood elements are especially advantageous due to the fact that they can be made thin, thus, making the planar rigid sound absorbing module M1-M3 thin and lightweight. This is advantageous, for example, from the logistics point of view. According to another embodiment, the at least one rigid sound absorbing element 40 may be a multilayer structure, for example, having plywood and cork layers attached to each other. Furthermore, the at least one rigid sound absorbing element 40 may be made of composite material, such as comprising plastic and wood materials. According to still another embodiment, the at least one rigid sound absorbing element 40 may comprise carbon fibres. According to another embodiment, the at least one rigid sound absorbing element 40 may comprise honeycomb structure or the like having air pockets therewithin.

According to another embodiment of the present invention such as shown in Figs. 4A and 4B, the module M1 may also comprises a rigid sheet 41, 42, for example, comprising metal, such as steel, stainless steel or aluminium, and essentially extending over the centre area 25 or opening 25 defined by the rigid frame 24, therefore, providing support for the structure 10 when attached to the rigid frame 24. According to various embodiments of the present invention utilizing one or more than one rigid sheets 41, 42, the sound absorbing element 40 or elements 40 may be non-rigid, such as wool or felt. The at least one sound absorbing element 40 may be attached to the rigid sheet 41, 42, for example, by an adhesive or by screws or by nuts and bolts or by blind rivets. Furthermore, the at least one sound absorbing element 40 do not necessarily have to extend over the centre area 25 or opening 25 defined by the rigid frame 24, because the rigid sheet or sheets 41, 42 provide support for the structure 10. According to some embodiments, the at least one sound absorbing element 40 has a surface area of at least 80 percent of a surface area of the first rigid sheet 41 or the second rigid sheet 42, thus, providing significant sound absorbing characteristics, however, not extending completely over the centre area 25 or opening 25 defined by the rigid frame 24.
According to another embodiment, the module M1 may comprise two rigid sheets: a first rigid sheet 41 and a second rigid sheet 42. The at least one sound absorbing element 40 may be arranged between the rigid sheets 41, 42. Furthermore, the at least one sound absorbing element 40 may be attached to one or both of the sheets 41, 42. According to a preferable embodiment of the present invention, the at least one sound absorbing element 40 is a rigid sound absorbing element, such as a plywood element, and is attached to both of the rigid sheet 41, 42 by, for example, an adhesive. This further enhances the rigidity of the structure 10 while at the same time providing sound absorbing characteristics.

Figure 5 illustrates schematically a plurality of support elements 21A-21C forming rigid frames 24 for a structure 10 according to an embodiment of the present invention. As can be seen, there are a plurality of support elements 21A-21C forming rigid frames 24 for a plurality of sound absorbing modules M1-M3. The rigid frames 24 are arranged have a distance from each other such that enables the modules M1-M3 having widths W1-W3 to be attached to the rigid frames 24 at the peripheral portions of the modules M1-M3. According to various embodiments, the edges of the modules M1-M3 may come into contact with one another or they may be a gap between two consecutive modules at the support portion to which the consecutive modules M1-M3 have been attached to.

Figures 6A-6D illustrate schematically modular sound absorbing structures 10 according to some embodiments of the present invention. Fig. 6A illustrates a structure 10 having four walls on which there are, for example, two openings or empty rigid frames 24 for doors 12A, four openings or empty rigid frames 24 for frames of feed throughs 12C, and one opening or empty rigid frame 24 for an electrical power supply enclosure 12B. It can be seen from Fig. 6A that the planar rigid sound absorbing modules M1-M3 have been attached to the rigid frames 24 at the peripheral portions of the modules M1-M3. Fig. 6B illustrates similar structure 10 as in Fig. 6A, however, there are roof support elements 21D arranged to extend from one wall to another, in this case, to the opposite one to provide further support. The roof support elements 21D may preferably be used to provide rigid frame 24 for a number of planar rigid sound absorbing modules M1-M3. The number of planar rigid sound absorbing modules M1-M3 used in the roof may be arranged to be in mechanical contact with the roof support elements 21D providing a rigid frame 24 for the number of planar rigid sound absorbing modules M1-M3.
Figure 6C illustrates modular sound absorbing structure 10 according to an embodiment of the present invention. The structure 10 comprises a plurality of planar rigid sound absorbing modules M1-M3 of which at least four are planar sound absorbing wall modules and at least one is a planar sound absorbing roof module for forming a modular sound absorbing structure 10 defining an inner volume when arranged on a floor surface. The structure 10 according to the embodiment of Fig. 6C or any similar embodiment has the advantage that the noise source can be enclosed in the inner volume, thus, providing sound absorbing material to all directions from the noise source. There may be, for example, a machine for sheet metal machinery arranged in to the inner volume. The structure 10 may be used also for attenuating sound coming from an external source such that the structure 10 forms a control room in which a person operates and monitors an industrial process, for instance. Fig. 6D, in which part of the structure 10 has been omitted, further illustrates the inner volume 60 defined by the structure 10.

By utilizing planar rigid sound absorbing modules M1-M3 according to various embodiments of the present invention, the modular sound absorbing structure 10 may easily be designed to cover any noise source independent of its size. This is due to the use of modules M1-M3 which may be stacked and arranged so that the dimensions of the sound absorbing structure 10 can be scaled to substantially any size as long as the support elements 21A-21C can withstand the weight of the structure 10. The dimensions may further be increased by using lighter and/or stronger materials.

Figures 7A-7C illustrate schematically a support element 21A-21C according to an embodiment of the present invention. The support element 21A-21C may be used, for example, as a vertical support element 21A as illustrated in Fig. 2. Fig. 7A illustrates the support element 21A from a perspective view. As can be seen, there are advantageously attaching holes 71 for attaching a planar rigid sound absorbing modules M1-M3 to the support element 21A, for example, by a screw. Fig. 7B illustrates the support element 21A from a side view. From this angle, it is clear that there may be attaching holes 71 for attaching two modules at their peripheral portions to the support element 21A. Fig. 7C further illustrates a cross sectional view of the support portion 21A when looking along the longitudinal direction of the support portion 21A, that is, of section A-A. The support portion 21A has a U-shape, to the outer side of the bottom of which the module M1-M3 can be attached to. The flanges may be adapted to receive further layers or
sheets, for example, if used to build a control room, there may be a further material layer, such as a decorative layer, attached to the flanges of the support element 21A. According to one embodiment, the volume between the planar rigid sound absorbing module M1-M3 and the further material layer may be filled with further sound absorbing and, optionally, thermally insulating, material.

Figure 8 illustrates a part of a structure 10 according to an embodiment of the present invention. There are two support elements, namely, a vertical support element 21A and a bottom support element 21C which are attached to each other by an attaching portion 23 on the lower portion of the flange of the vertical support element 21A. The module M1 has been attached at least to the vertical support portion 21A of the structure 10. There is in Fig. 8 a sealing element 81 attached to the bottom support element 21B. The sealing element 81 is preferably of flexible material and configured to cover the gap which can exist when the structure 10 is, for example, adjusted to horizontally by floor supports (shown in Fig. 10).

Figures 9A and 9B illustrate schematically attaching portions 23 according to an embodiment of the present invention. Fig. 9A illustrates two support portions 21A-21C, namely bottom support portions 21C, attached to each other by attaching portions 23, in this case, separate attaching portions, such as utilizing Allen bolts. Fig. 9B illustrates a vertical support portion 21A arranged to a corner of the structure 10. There may be a corner vertical support portion 21A or a corner bottom support portion 21C on which the vertical support portion 21A have been arranged on. The bottom support portions 21C have been attached to each other by separate attaching portions 23.

Figure 10 illustrates schematically an adjustable floor support 101 utilizable in an embodiment of the present invention. The adjustable floor support 101 may be arranged such that the distance of the support portion 21A-21C and, thus, also the structure 10, from the floor surface, for instance, can be adjusted, preferably, continuously. This may be implemented, for example, by using a screw threaded shaft in the adjustable floor support 101. In Fig. 10, the adjustable floor support has been attached under a bottom support element 21C.

Figures 11A and 11B illustrate schematically a support element 21B according to an embodiment of the present invention. Fig. 11A illustrates a top support
element 21B from a side view. Fig. 11B illustrates a cross-sectional side view of the top support element 21B when looking along the longitudinal direction of the top support element 21B, that is, perpendicular with respect to section B-B. The bottom surface 111 of the top support element 21B may be arranged in contact with a vertical support element 21A. The top surface 112 of the top support element 21B may be arranged in contact with a roof support element 21D.

Figures 12A-12C illustrate schematically a support element, particularly a roof support element 21D, according to an embodiment of the present invention. Fig. 12A illustrates the roof support element 21D from a side view. Fig. 12B illustrates the roof support element 21D from another side view. Fig. 12C illustrates a cross-sectional side view of the roof support element 21D when looking along the longitudinal direction of the roof support element 21D, that is, perpendicular with respect to section C-C. The top surface 121 of the roof support 21D may be arranged to receive a planar rigid sound absorbing module M1-M3 to be in mechanical contact with the top surface at the peripheral portion of the module M1-M3. The module M1-M3 may be attached to the roof support 21D at the peripheral portion of the module M1-M3 or may merely lean against the top surface 121 without further attaching the module M1-M3 to the rigid frame 24.

Figures 13A and 13B illustrate schematically support elements 21A-21D according to an embodiment of the present invention attached to each other. Fig. 13A illustrate three support elements 21A-21D attached to each other. There is a horizontal roof support element 21D, vertical support element 21A and a top support element 21B extending towards and away from the observer that is, perpendicular to the cross-sectional plane. As can be seen, the top surface of the vertical support element 21A is in contact with the bottom surface 111 of the top support element 21B. The roof support element 21D is in contact with the top surface 112 of the top support element 21B at an end portion of the element 21B. Preferably, the support elements 21A-21D are being attached to each other by attaching portions, for example, by utilizing Allen bolts, in order to obtain rigid frames 24 and rigid overall structure 10. Fig. 13B illustrates the same elements 21A-21D as in Fig. 13A essentially from above, however, the vertical support element 21A is not visible due to being arranged below the top support element 21B.

Figures 14A-14C illustrate schematically an accessory element 12A-12C according to an embodiment of the present invention. The accessory element
12A-12C illustrated is a door 12A. Fig. 14A illustrates the door 12A from one side of the door 12A and Fig. 14B from the opposite side. As can be seen, the door 12A comprises a frame 1401, a panel 1402, hinges and locking mechanism, if any. The frame 1401 preferably has a width which fits to the spacing of the structure 10 defined essentially by the widths W1-W3 of the planar rigid sound absorbing modules M1-M3 utilized in the structure 10. Fig. 14C illustrate a panel 1402 according to a preferably embodiment of the present invention. The panel 1402 may comprise two rigid sheets and a sound absorbing element therebetween similarly to the structure of a planar rigid sound absorbing modules M1-M3 as described hereinearlier. However, it should be noted that the door 12A may be different than the module M1-M3 and may, for example, comprise better or worse sound absorbing characteristics relative to said characteristics of the module M1-M3.

Figure 15 illustrates a flow diagram of a method according to an embodiment of the present invention. Step 1500 represent a start-up phase. The start-up phase may comprise designing the structure 10 to be built, for example, which kind of accessory elements 12A-12C will, if any, be used in the structure 10. Furthermore, the start-up phase may comprise determining the desired amount of sound absorbing or attenuating property from the structure 10.

At 1501, obtaining a plurality of planar rigid sound absorbing modules may be performed. Each one of the modules M1-M3, preferably, comprises at least one sound absorbing element. The step 1501 may further comprise obtaining support elements for arranging a rigid frame for a number of planar rigid sound absorbing modules of the plurality of planar rigid sound absorbing modules. The number of modules M1-M3 may be one or more than one. The step 1501 may still further comprise obtaining attaching portions for attaching two support elements to each other.

The obtaining may entail manufacturing the modules M1-M3, support elements 21A-21D, and attaching portions 23 by oneself or obtaining them from another company/person/entity to the desired location which may or may not be the place in which the sound absorbing structure 10 is to reside once built. Furthermore, the modules M1-M3, support elements 21A-21D, and attaching portions 23 may be manufactured in different locations and at different times, for instance. According to various embodiments, the attaching portions 23 may be
comprised in the support elements 21A-21 D, that is, being integrated part or parts of the support element 21A-21 D, or may be a separate part 23 or parts 23.

At 1502, arranging the support elements 21A-21 D to form the rigid frame 24 for the number of planar rigid sound absorbing modules M1-M3 by attaching the support elements 21A-21 D to each other by the attaching portions 23 may be performed. This may entail arranging the support elements one by one to obtain a frame structure of the sound absorbing structure 10. The support elements 21A-21 D may preferably be attached to each other so that the obtained frame structure becomes rigid and configured to receive the planar rigid sound absorbing modules M1-M3.

At 1503, arranging the number or the plurality of planar rigid sound absorbing modules M1-M3 to be in mechanical contact with the rigid frame 24 or frames 24 at peripheral portions of the planar rigid sound absorbing modules M1-M3 may be performed. The arranging of the plurality of planar rigid sound absorbing modules M1-M3 may entail attaching the modules M1-M3 to the rigid frames 24 or merely placing them in mechanical contact or to lean against the rigid frame, preferably, at the peripheral portions of the modules M1-M3.

According to a preferably embodiment, the number of planar rigid sound absorbing modules M1-M3 comprise a first rigid sheet and a second rigid sheet, wherein at least one of the first and the second rigid sheets is attached to the rigid frame at the peripheral parts of the sheet and arranged to extend over a centre area defined by the rigid frame. The at least one sound absorbing element is a rigid sound absorbing element, such as a planar plywood element, and is arranged between and attached to the first and the second rigid sheets. By utilizing modules M1-M3 such as these, the sound absorbing structure 10 as a whole becomes highly rigid and stable.

According to various embodiments, the accessory elements 12A-12C and/or other elements may be arranged to the structure 10.

The method is being ended at 1599. The sound absorbing structure 10 is ready and, preferably, at its place of use or ready to be moved to its place of use.

The specific examples provided in the description given above should not be construed as limiting the applicability and/or the interpretation of the appended
claims. Lists and groups of examples provided in the description given above are not exhaustive unless otherwise explicitly stated.
CLAIMS

1. A modular sound absorbing structure (10) characterised in that, the structure (10) comprises a plurality of planar rigid sound absorbing modules (M1-M3), each one of which comprises at least one sound absorbing element (40), and support elements (21A-21D) providing a rigid frame (24) for a number of planar rigid sound absorbing modules (M1-M3) of the plurality of planar rigid sound absorbing modules (M1-M3), wherein each one of the number of planar rigid sound absorbing modules (M1-M3) is arranged on a first plane, wherein the rigid frame (24) is in mechanical contact with peripheral portions of the number of planar rigid sound absorbing modules (M1-M3), and the structure (10) comprises attaching portions (23) attaching two support elements (21A-21D) to each other, and wherein each one of the number of planar rigid sound absorbing modules (M1-M3) comprises a first rigid sheet (41), wherein the first rigid sheets (41) of the number of planar rigid sound absorbing modules (M1-M3) extend over a centre area (25) defined by the rigid frame (24), wherein the rigid frame (24) is a metal frame and the first (41) rigid sheet is a metal sheet.

2. The modular sound absorbing structure (10) according to claim 1, wherein each one of the number of planar rigid sound absorbing modules (M1-M3) comprises a second rigid sheet (42), wherein the second rigid sheets (42) of the number of planar rigid sound absorbing modules (M1-M3) extend over a centre area (25) defined by the rigid frame (24), wherein the rigid frame (24) is attached to the peripheral portions of the second rigid sheets (42) of the number of planar rigid sound absorbing modules (M1-M3), and wherein the at least one sound absorbing element (40) is arranged between the first (41) and the second (42) rigid sheets.

3. The modular sound absorbing structure (10) according to claim 1 or 2, wherein the at least one sound absorbing element (40) is attached to the first rigid sheets (41), or to the second rigid sheets (42), or both the first (41) and second (42) rigid sheets.

4. The modular sound absorbing structure (10) according to any one of the preceding claims, wherein the at least one sound absorbing element (40) is a rigid sound absorbing element.

5. The modular sound absorbing structure (10) according to claim 4, wherein the rigid sound absorbing element is a planar plywood element.
6. The modular sound absorbing structure (10) according to any one of the preceding claims, wherein the plurality of planar rigid sound absorbing modules (M1-M3) comprises at least four planar sound absorbing wall modules (M1-M3) and at least one planar sound absorbing roof module (M1-M3) for forming a modular sound absorbing structure (10) defining an inner volume (60) when arranged on a floor surface.

7. The modular sound absorbing structure (10) according to claim 6, wherein only the sound absorbing element (40) of each one of the planar sound absorbing wall modules (M1-M3) is a rigid sound absorbing element, such as a planar plywood element.

8. The modular sound absorbing structure (10) according to any one of claims 2-7, wherein the rigid frame (24) is a metal frame and at least one of the first (41) and second (42) rigid sheets is a metal sheet.

9. The modular sound absorbing structure (10) according to any one of claims 2-8, wherein the at least one sound absorbing element (40) has a surface area of at least 80 percent of a surface area of the first rigid sheet (41) or the second rigid sheet (42).

10. The modular sound absorbing structure (10) according to any one of the preceding claims, wherein the plurality of planar rigid sound absorbing modules (M1-M3) comprise at least one first planar rigid sound absorbing module (M1) having a first width (W1) and at least one second planar rigid sound absorbing module (M2) having a second width (W2).

11. The modular sound absorbing structure (10) according to claim 10, comprising an accessory element (12A-1 2C) having the first width (W1), or the second width (W2), or a sum of any multiple of the first width (W1) or second width (W2), or any combination of multiples of the first and second widths (W1, W2) such that the accessory element (12A-1 2C) is suitable for fitting to the structure (10) with respect to a spacing defined by the plurality of planar rigid sound absorbing modules (M1-M3).

12. The modular sound absorbing structure (10) according to claim 11, wherein the accessory element (12A-1 2C) is one of the following: a door (12A), an electrical power supply enclosure (12B), a frame for feed through (12C).
13. A method for manufacturing a modular sound absorbing structure (10), the method comprising

- obtaining (1501) a plurality of planar rigid sound absorbing modules (M1-M3), each one of which comprises at least one sound absorbing element (40), and support elements (21A-21D) for arranging a rigid frame (24) for a number of planar rigid sound absorbing modules (M1-M3) of the plurality of planar rigid sound absorbing modules (M1-M3), and attaching portions (23) for attaching two support elements (21A-21D) to each other, and each of the planar rigid sound absorbing modules (M1-M3) comprises a first rigid sheet (41), wherein the first rigid sheets (41) of the planar rigid sound absorbing modules (M1-M3) extend over a centre area (25) defined by the rigid frame (24), wherein the rigid frame (24) is a metal frame and the first (41) rigid sheet is a metal sheet,

- arranging (1502) the support elements (21A-21D) to form the rigid frame (24) for the number of planar rigid sound absorbing modules (M1-M3) by attaching the support elements (21A-21D) to each other by the attaching portions (23), and

- arranging (1503) the number of planar rigid sound absorbing modules (M1-M3) to be in mechanical contact with the rigid frame (24) at peripheral portions of the planar rigid sound absorbing modules (M1-M3).

14. The method according to claim 13, wherein each one of the number of planar rigid sound absorbing modules (M1-M3) comprises a first rigid sheet (41) and a second rigid sheet (42), wherein at least one of the first (41) and the second (42) rigid sheets is attached to the rigid frame (24) at the peripheral parts of the sheet (41, 42) and arranged to extend over a centre area (25) defined by the rigid frame (24), and wherein the at least one sound absorbing element (40) is a rigid sound absorbing element and is arranged between and attached to the first (41) and the second (42) rigid sheets.
1500
START

1501
OBTAIN PLANAR RIGID SOUND ABSORBING MODULES, SUPPORT ELEMENTS AND ATTACHING PORTIONS

1502
ARRANGE SAID SUPPORT ELEMENTS TO FORM RIGID FRAME FOR A NUMBER OF MODULES BY ATTACHING THE ELEMENTS TO EACH OTHER

1503
ARRANGING THE NUMBER OF MODULES TO BE IN MECHANICAL CONTACT WITH THE RIGID FRAME AT PERIPHERAL PORTIONS OF THE MODULES

1599
STOP

FIG. 15
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER
INV. E04C2/292 E04B2/74 E04B1/82

According to International Patent Classification (IPC) or to both national classification and IPC.

B. FIELDS SEARCHED
Minimum documentation searched (classification system followed by classification symbols)
E04B E04C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched.

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>US 3 343 314 A (SMITH CLOYD D) 26 September 1967 (1967-09-26) column 2, line 12 - column 4, line 12; figures 1-4</td>
<td>1-14</td>
</tr>
<tr>
<td>X</td>
<td>DE 79 24 725 U1 (ERNST BOHLE GMBH [DE]) 26 February 1981 (1981-02-26) page 11, line 7 - page 13, line 21; figures 1-5</td>
<td>1-14</td>
</tr>
<tr>
<td>X</td>
<td>DE 93 18 348 U1 (SCHNEEBERG GERHARD [DE]) 17 March 1994 (1994-03-17) page 7, line 5 - page 15, line 3; figures 1-18</td>
<td>1-14</td>
</tr>
</tbody>
</table>

Further documents are listed in the continuation of Box C. See patent family annex.

* Special categories of cited documents:
A document defining the general state of the art which is not considered to be of particular relevance
E earlier application or patent but published on or after the international filing date
L document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
O document referring to an oral disclosure, use, exhibition or other means
P document published prior to the international filing date but later than the priority date claimed
T later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
X document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
Y document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
A* document member of the same patent family

Date of the actual completion of the international search: 20 November 2018

Date of mailing of the international search report: 28/11/2018

Name and mailing address of the ISA:
European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040,
Fax: (+31-70) 340-3016

Authorized officer: Couprie, Bri ce

Form PCT/ISA/210 (second sheet) (April 2005)
<table>
<thead>
<tr>
<th>Patent document cited in search report</th>
<th>Publication date</th>
<th>Patent family member(s)</th>
<th>Publication date</th>
</tr>
</thead>
<tbody>
<tr>
<td>US 3343314</td>
<td>26-09-1967</td>
<td>NONE</td>
<td></td>
</tr>
<tr>
<td>DE 7924725</td>
<td>26-02-1981</td>
<td>NONE</td>
<td></td>
</tr>
<tr>
<td>DE 9318348</td>
<td>17-03-1994</td>
<td>NONE</td>
<td></td>
</tr>
</tbody>
</table>