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(54) FORMWORK ELEMENT, FORMWORK ASSEMBLY PROVIDED THEREWITH, METHOD FOR MANUFACTURE THEREOF AND METHOD FOR USE THEREOF

(57) The present invention relates to a formwork element, comprising:
- a foam material;
- a smoothing covering layer arranged on one or more surfaces of the foam material; and
- wherein the foam material has a density ≥ 35 kg/m^3, wherein the formwork element, compared to a formwork element with the same compressive strength and manufactured from foam material with a density < 35 kg/m^3, has smaller dimensions and a lower resulting overall weight of the formwork element and the covering layer.

The invention further relates to a formwork assembly comprising such a formwork element, to a method for manufacturing such a formwork element and to a method for using such a formwork element.

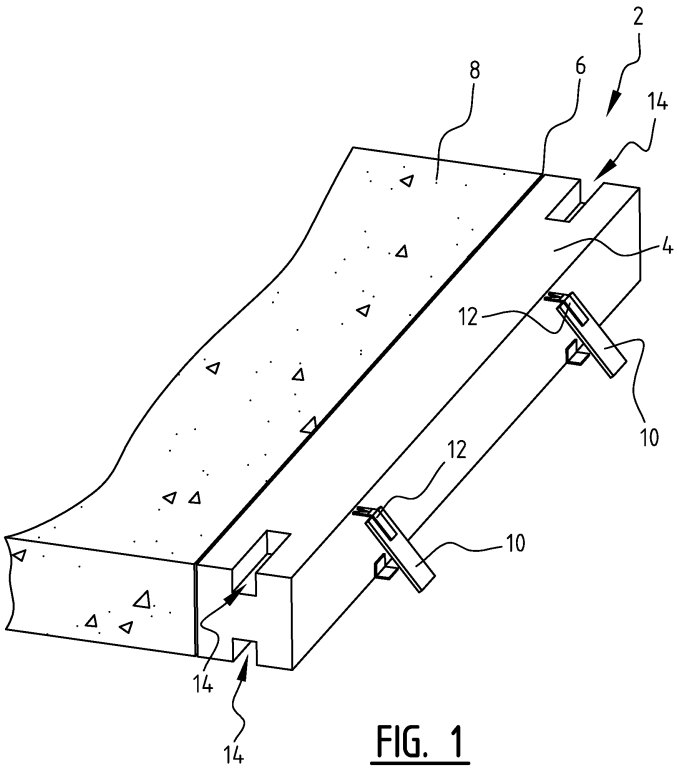

FIG. 1

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Description

[0001] The invention relates to a lightweight formwork element and to a formwork assembly comprising such a formwork element. The invention further relates to a method for manufacturing such a formwork element and to a method for using such a formwork element.

[0002] When a concrete construction is arranged a formwork is usually made from a combination of beam side formworks and floor edge formworks. Once concrete has cured sufficiently, these formworks are then removed. Conventional formworks are usually manufactured from wood and divided into a plurality of smaller segments which are still heavy physical loads for one or more workers doing the lifting.

[0003] There is a need for a lightweight formwork. Not only is the physical load for workers reduced, safety is also increased. A lightweight formwork element is safer during formwork removal and moreover enables a quicker processing.

[0004] Earlier attempts at providing a lightweight formwork comprising a foam material, such as known from US-A1-2005/0066602, have not been applied successfully in practice since expensive resins and hard coating were applied for the required strength of the construction element. Just as the present invention, US-A1-2005/0066602 makes use of EPS as preferred foam material. In order to prevent adhesion of the concrete to the formwork at least the sides coming into contact with the concrete are provided with this hard coating. Applied in US-A1-2005/0066602 as heaviest type of EPS is an EPS with a nominal density of 32 kg/m^3.

[0005] EPS is an abbreviation of the term 'Expanded Polystyrene'. EPS is also referred to more colloquially as polystyrene foam, styrofoam or PS hard foam. EPS is a thermoplastic material and the properties stated in this application are - unless stated otherwise - defined at a temperature of 20°C.

[0006] The compressive strength is one of the most important properties of expanded polystyrene. This property depends substantially on the density. Less important parameters are the cell structure, the temperature and the age of the material. The bead size or type of raw material has little influence on the compressive strength.

[0007] In accordance with the Dutch Standard NEN-EN 13163, EPS is currently based on the compressive strength at 10% deformation expressed in kPa. The compression test is performed in accordance with the European Standard EN 826 with test sample dimensions of 50 mm x 50 mm x 50 mm, a preload of 150 ± 10Pa, and a loading speed of [d(mm)/10] per minute, i.e. at a thickness of 50 mm a loading speed of 5 mm/min. It is noted that reference is made at all times in this application to a European EPS type. The table below shows an overview of EPS types for the European Standard.

European EPS-TYPE	Density [kg/m^3]	90/90 lower limit of the compressive strength at 10% deformation [kPa]
EPS-30		30
EPS-50		50
EPS-60	15	60
EPS-70		70
EPS-80		80
EPS-90		90
EPS-100	20	100
EPS-120		120
EPS-150	25	150
EPS-200	30	200
EPS-250	35	250
EPS-300	40	300
EPS-400	50	400
EPS-500	60	500

[0008] The third column of the above table states the lower limit of 90/90. This is the safe calculation value used for a short-term load with a deformation of 10%.

[0009] The above table shows that the heaviest type of EPS with a nominal density of 32 kg/m^3 applied in US-A1-2005/0066602 corresponds to a density lower than European EPS-250.

[0010] There is a need for a lightweight and preferably reusable formwork element which can be applied in practical manner.

[0011] The invention now has for its object to provide a formwork element of the above described type wherein said drawbacks do not occur, or at least do so to lesser extent.

[0012] Said object is achieved according to the invention with a formwork element comprising:

- a foam material; and
- a smoothing covering layer arranged on one or more surfaces of the foam material; and
- wherein the foam material has a density ≥ 35 kg/m^3, wherein the formwork element, compared to a formwork element with the same compressive strength and manufactured from foam material with a density < 35 kg/m^3, has smaller dimensions and a lower resulting overall weight of the formwork element and the covering layer.

[0013] It will be apparent from the table on page 2 how the compressive strength is correlated to the density of the foam material. The foam material applied according to the invention with a density > 35 kg/m^3, for instance EPS-250, has a higher compressive strength than for instance EPS-200 with a density of 30 kg/m^3.

[0014] Because in the case of foam material with a density ≥ 35 kg/m^3 extra compressive strength is obtained from the foam material, the desired compressive strength of the formwork element can be achieved with less foam material and optionally with a less thick covering layer. A formwork element with the same mechanical properties, such as compressive strength, can hereby be provided which has smaller dimensions and a lower overall weight of the formwork element.

[0015] In contrast to earlier attempts at providing a lightweight formwork element, the present invention is based on a different - opposite - concept. It would be obvious to follow the line of thought of the prior art and select the lightest core material which can withstand the required compressive load and to then strengthen it with a coating. Some form of coating is in any case desirable in order to prevent adhesion of concrete to the formwork element. Strength can moreover be derived from this coating by applying it in multiple layers over a considerable thickness Applicant has however realised that it is precisely this coating which results in a product which is so costly in respect of material and manufacture that it stands in the way of practical application. In contrast to the prior art, Applicant has opted on the contrary to apply a relatively heavy foam material for the manufacture of a lightweight formwork element, i.e. a foam material which is overdimensioned and has an unnecessarily high density for the required compressive load. The advantageous consequence is however that such a heavy foam material in itself already has more strength, whereby it is possible to suffice with a thinner layer of coating. A formwork element is hereby obtained which is on the one hand lighter than conventional (wooden) formwork elements with a typical density of about 460 kg/m^3 for beam timber, but which on the other hand meets all requirements in respect of compressive load and strength. An alternative formwork material is plywood which has a density of about 700 kg/m^3.

[0016] In addition to conventional (wooden) formwork elements, the formwork element according to the invention provides the further advantage that the strength thereof can be calculated, whereby it becomes possible to base safety regulations thereon. In the present situation shores for supporting the formwork are placed purely on the basis of personal experience by the workers on a building site. It is found in practice that for time-saving reasons too limited a number of shores are sometimes placed, which results in failure of the formwork construction during casting of the concrete. In addition to the time and cost impact of repair operations, failure of the formwork construction can also result in dangerous situations.

[0017] The invention provides a number of preferred embodiments which show an increasing weight of the foam material and which thus move away from the obvious choice of a light foam material for a lightweight formwork element. The heavier core material, in particular EPS-400 and higher, is so strong that a frequently reusable formwork unit results. Tests have shown that, in the case of for instance EPS-250, during removal of the formwork elements a part can tear away at the position of the attachment to supporting shores. This is particularly the case for formwork elements utilized as beam formwork because this beam formwork has to be pulled away after use. A beam formwork manufactured from EPS-250 is only suitable for once-only use, whereby it cannot compete with the much heavier, but reusable, conventional wooden beam formworks.

[0018] The formwork element preferably comprises a foam material with a density ≥ 40 kg/m^3, more preferably a foam material with a density > 50 kg/m^3, and still more preferably a foam material with a density ≥ 60 kg/m^3.

[0019] According to a further preferred embodiment, the foam material is EPS. Advantageous properties of EPS can be subdivided into general properties (very light and moisture-insensitive), the simple application (highly form-retaining and compression-resistant, and safe and easy in processing and use) and environmental aspects (fully recyclable, sustainable and environmentally-friendly).

[0020] According to a further preferred embodiment, the foam material is EPS of at least EPS-250. EPS-250 has a density of about 35 kg/m^3 which is more than a factor of 13 lighter than a traditional beam timber formwork element with a typical density of 460 kg/m^3. Such a light EPS allows the possibility of formwork elements being given a relatively long

form, while they are sufficiently light to be handled by workers. A longer formwork element results in quicker processing times and can moreover result in an end product with fewer joins. A formwork element manufactured from EPS-250 is particularly suitable for applications where a light and strong formwork is desired.

[0021] According to a further preferred embodiment, the foam material is EPS of at least EPS-300. EPS-300 has a density of about 40 kg/m^3 which is a factor of 11.5 lighter than a traditional beam timber formwork element with a typical density of 460 kg/m^3. A formwork element manufactured from EPS-300 is particularly suitable for applications where a light and strong formwork is desired, but where reuse is a less important requirement.

[0022] According to a further preferred embodiment, the foam material is EPS of at least EPS-400. EPS-400 has a density of about 50 kg/m^3 which is a factor of 9 lighter than a traditional beam timber formwork element with a typical density of 460 kg/m^3. EPS-400 is overdimensioned to some extent in respect of allowable compressive load, whereby the mass also increases. This is counterintuitive, although it is hereby possible to suffice with a simpler coating, whereby the final formwork element remains suitable for practical application.

[0023] According to a further preferred embodiment, the foam material is EPS of at least EPS-500. EPS-500 has a density of about 60 kg/m^3 which is still more than a factor of 7.5 lighter than a traditional beam timber formwork element with a typical density of 460 kg/m^3. EPS-500 is greatly overdimensioned in respect of allowable compressive load, whereby the mass increases still further. EPS-500 is at the moment the heaviest commercially available EPS variant. The choice of precisely this relatively heavy EPS-500 for a lightweight formwork element is counterintuitive, but results from the insight of Applicant that there is a great need to be able to apply less and simpler coating.

[0024] According to yet another preferred embodiment, the foam material of the formwork element is compressed during manufacture of the formwork element before it is provided with a smoothing covering layer. This compression on the one hand increases the compressive resistance and strength still further, and on the other has a smoothing effect on the surface of the foam material. It is precisely in the case of EPS foam material with higher values, such as EPS-400 and EPS-500, that the surface is relatively coarse. When this surface is compressed to some extent it becomes smoother, whereby less material will suffice for the covering layer. Less coating need therefore be applied.

[0025] According to yet another preferred embodiment, the formwork element is beam-like and provided on the end surfaces with one or more slot recesses. The slot recesses are preferably arranged on both the underside and the upper side of the formwork element. Contiguously placed formwork elements thus form a continuous slot recess in which a locking element (for instance a dowel) can be arranged. These locking elements ensure that adjacent formwork elements are aligned relative to each other at the outer ends and form an additional resistance to bending at the outer ends of the formwork elements. Because the locking elements can be arranged separately in the slot recesses, an assembly of formwork elements is easy to place and dismantle. The invention applies a foam material with a density > 35 kg/m^3, whereby such slot recesses display sufficient stiffness and do not fail by tearing away, for instance under pressure of poured concrete.

[0026] The invention further relates to a formwork assembly, comprising:

- a formwork element according to the invention;
- at least one support member configured to support the formwork element; and
- at least one fixing member configured to connect the support member to the formwork element.

[0027] Because according to the invention a foam material is applied with a density ≥ 35 kg/m^3, the foam material is sufficiently strong for such a fixing member to be arranged in proper manner. The higher the density, the longer the lifespan will of course be in the case of frequent use. At a lower density of the foam material the formwork element would be vulnerable such that such a fixing member could easily break away from the foam.

[0028] According to a preferred embodiment, the fixing member is provided with an engaging surface insertable into the foam material of the formwork element, this enabling simple assembling of a formwork assembly.

[0029] When the engaging surface of the fixing member insertable into the foam material of the formwork element is provided according to a preferred embodiment with a substantially V-shaped recess, an engaging surface results which combines good insertability with a relatively large contact area. Because of the V-shaped recess the engaging surface as it were acquires two teeth with which it can be inserted into the foam material.

[0030] The invention further relates to a method for manufacturing a formwork element, comprising the steps of:

- smoothing a foam material with a density ≥ 35 kg/m^3; and
- arranging a smoothing covering layer on one or more of the surfaces of the smoothed foam material.

[0031] Due to the step of smoothing a foam material it is possible to suffice with less covering material for the covering layer, this being particularly advantageous when a costly coating is applied.

[0032] When according to a preferred embodiment the step of smoothing the foam material comprises of compressing the foam material, an increase in the strength and the allowable compressive load is also obtained in addition to the

smoothing.

[0033] According to a further preferred embodiment, the method comprises the step of applying a formwork element with a foam material as described in the foregoing.

[0034] The invention further relates to a method for using a formwork element according to the invention in a formwork assembly according to the invention.

[0035] Preferred embodiments of the present invention are further elucidated in the following description with reference to the drawing, in which:

Figure 1 shows a perspective view of a formwork assembly according to the invention;
Figure 2 shows a cross-sectional view of a configuration for manufacturing a single wall;
and
Figure 3 shows a cross-sectional view of a configuration for manufacturing a cavity wall.

[0036] The formwork assembly shown in figure 1 comprises a formwork element 2 comprising a foam material 4 and a smoothing covering layer 6 arranged on a surface thereof. The foam material is preferably EPS-400 or higher so that a limited covering layer 6 will suffice to obtain the desired smoothness and strength. Covering layer 6 is arranged at least on the side against which the concrete 8 is arranged and prevents adhesion of concrete 8 to formwork element 2. Formwork element 2 is supported in figure 1 by two support members 10 in the form of shores. These support members 10 are attached to formwork element 2 with a fixing member 12.

[0037] The beam-like formwork element 2 is provided on both end surfaces with two slot recesses 14. In the shown embodiment slot recesses 14 are arranged on both the underside and upper side of formwork element 2. Contiguously placed formwork elements 2 thus form a continuous slot recess in which a locking element (not shown) can be arranged. At a typical width of 7 cm for the foam material a slot recess 14 can for instance be provided of 10 cm in length and 3 cm in depth. A continuous slot recess of two contiguously placed formwork elements 2 then has a length of 20 cm. A 19 cm long and 3 cm high beam member, manufactured for instance from plywood, can then for instance be provided as locking element.

[0038] Two formwork elements 2 can be utilized as edge/beam formwork for the purpose of erecting a concrete wall or beam (figure 2). Both formwork elements 2 are provided on their side facing toward the concrete 8 with a smoothing covering layer 6 which prevents adhesion of concrete 8 to formwork element 2. Formwork elements 2 are supported in figure 2 by support members 10 in the form of shores. These support members 10 are fixed to formwork element 2 with a fixing member 12. Formwork elements 2 are further provided on their end surfaces with slot recesses 14.

[0039] Formwork element 2 can likewise be employed to build a cavity wall as shown in figure 3. Applied in this configuration are three formwork elements 2 which are each provided on the side facing toward the concrete 8 with a smoothing covering layer 6. The central formwork element thus comprises a covering layer 6 on two opposite sides thereof. The at least two outer formwork elements 2 are removed following manufacture. The central formwork element 2 can likewise be removed and reused, but can also remain behind as insulation in the cavity wall. EPS also has very good thermally insulating and sound insulating properties.

Example I: traditional prior art beam formwork

[0040] For a beam formwork with dimensions 2.5 m long and 0.3 m high a total of 1.4 m^2 plywood is applied, distributed over a plywood top side (0.08 m x 2.5 m = 0.2 m^2), a plywood front side (0.3 m x 2.5 m = 0.75 m^2) and a plywood underside (0.18 m x 2.5 m = 0.45 m^2).

[0041] The plywood slabs have a thickness of 18 mm, whereby the total volume of plywood amounts to 1.4 m^2 x 0.018 m = 0.0252 m^3. With a density of about 700 kg/m^3 of plywood this results in a weight of plywood of 0.0252 m^3 x 700 kg/m^3 = 17.64 kg.

[0042] Eight concrete beams of for instance C12 beam timber are additionally applied with a beam size of 156 mm thickness x 56 mm width and a density of about 460 kg/m^3. Eight concrete beams together have a length of 8 x 264 mm = 2.112 m. Multiplied by the beam thickness and beam width this comes to a volume of 2.112 m x 0.156 m (thickness) x 0.056 m (width) = 0.01845 m^3 of C12 beam timber. The overall weight of beam timber comes from multiplying this volume by the density of C12 beam timber: 0.01845 m^3 x 460 kg/m^3 = 8.49 kg.

[0043] Added together this comes to an overall weight of 17.64 + 8.49 = 26.13 kg per traditional beam formwork of a length of 2.5 m, or 10.45 kg/m (excluding fixing material).

Example II: formwork element according to the invention manufactured from EPS-500

[0044] An EPS formwork with dimensions of 4 m long, 0.3 m high and 0.07 m thick has a volume of 0.3 (high) x 4.0 (long) x 0.07 (thick) = 0.084 m^3. Multiplied by the density of EPS-500 of 60 kg/m^3 this results in a weight of 5.04 kg for

the EPS.

[0045] A coating of typically 800 g/m^2 is applied over a surface of 4.0 m (length) x 0.3 m (height), this resulting in a weight of the coating of 0.96 kg.

[0046] In addition, a total of five steel angles and screws, x 0.05 kg = 0.25 kg, will be applied.

[0047] The formwork element of EPS-500 results in an overall weight of 5.04 + 0.96 + 0.25 = 6.25 kg per formwork of 4.0 m length, or 1.56 kg/m (including fixing material).

[0048] Although it shows a preferred embodiment of the invention, the above described embodiment is intended only to illustrate the present invention and not in any way to limit the specification of the invention. When measures in the claims are followed by reference numerals, such reference numerals serve only to contribute toward understanding of the claims, but are in no way limitative of the scope of protection. The rights described are defined by the following claims, within the scope of which many modifications can be envisaged.

Claims

1. Formwork element, comprising:

- a foam material; and
- a smoothing covering layer arranged on one or more surfaces of the foam material; **characterized in that** the foam material has a density ≥ 35 kg/m^3, wherein the formwork element, compared to a formwork element with the same compressive strength and manufactured from foam material with a density < 35 kg/m^3, has smaller dimensions and a lower resulting overall weight of the formwork element and the covering layer.

2. Formwork element as claimed in claim 1, comprising a foam material with a density > 40 kg/m^3.

3. Formwork element as claimed in claim 1 or 2, comprising a foam material with a density > 50 kg/m^3.

4. Formwork element as claimed in any of the claims 1-3, comprising a foam material with a density ≥ 60 kg/m^3.

5. Formwork element as claimed in any of the foregoing claims, wherein the foam material is EPS.

6. Formwork element as claimed in any of the foregoing claims, wherein the foam material is EPS of at least EPS-250.

7. Formwork element as claimed in any of the foregoing claims, wherein the foam material is EPS of at least EPS-300.

8. Formwork element as claimed in any of the foregoing claims, wherein the foam material is EPS of at least EPS-400.

9. Formwork element as claimed in any of the foregoing claims, wherein the foam material is EPS of at least EPS-500.

10. Formwork element as claimed in any of the foregoing claims, wherein the foam material of the formwork element is compressed during manufacture of the formwork element before it is provided with a smoothing covering layer.

11. Formwork element as claimed in any of the foregoing claims, wherein the formwork element is beam-like and provided on the end surfaces with one or more slot recesses.

12. Formwork assembly, comprising:

- a formwork element as claimed in any of the claims 1-11;
- at least one support member configured to support the formwork element; and
- at least one fixing member configured to connect the support member to the formwork element.

13. Formwork assembly as claimed in claim 12, wherein the fixing member is provided with an engaging surface insertable into the foam material of the formwork element.

14. Formwork assembly as claimed in claim 13, wherein the engaging surface of the fixing member insertable into the foam material of the formwork element is provided with a substantially V-shaped recess.

15. Method for manufacturing a formwork element, comprising the steps of:

- smoothing a foam material with a density ≥ 35 kg/m^3; and
- arranging a smoothing covering layer on one or more of the surfaces of the smoothed foam material.

16. Method as claimed in claim 15, wherein the step of smoothing the foam material comprises of compressing the foam material.

17. Method as claimed in claim 15 or 16, comprising the step of applying a formwork element with a foam material according to any of the claims 1-10.

18. Method for using a formwork element as claimed in any of the claims 1-11 in a formwork assembly according to any of the claims 12-14.

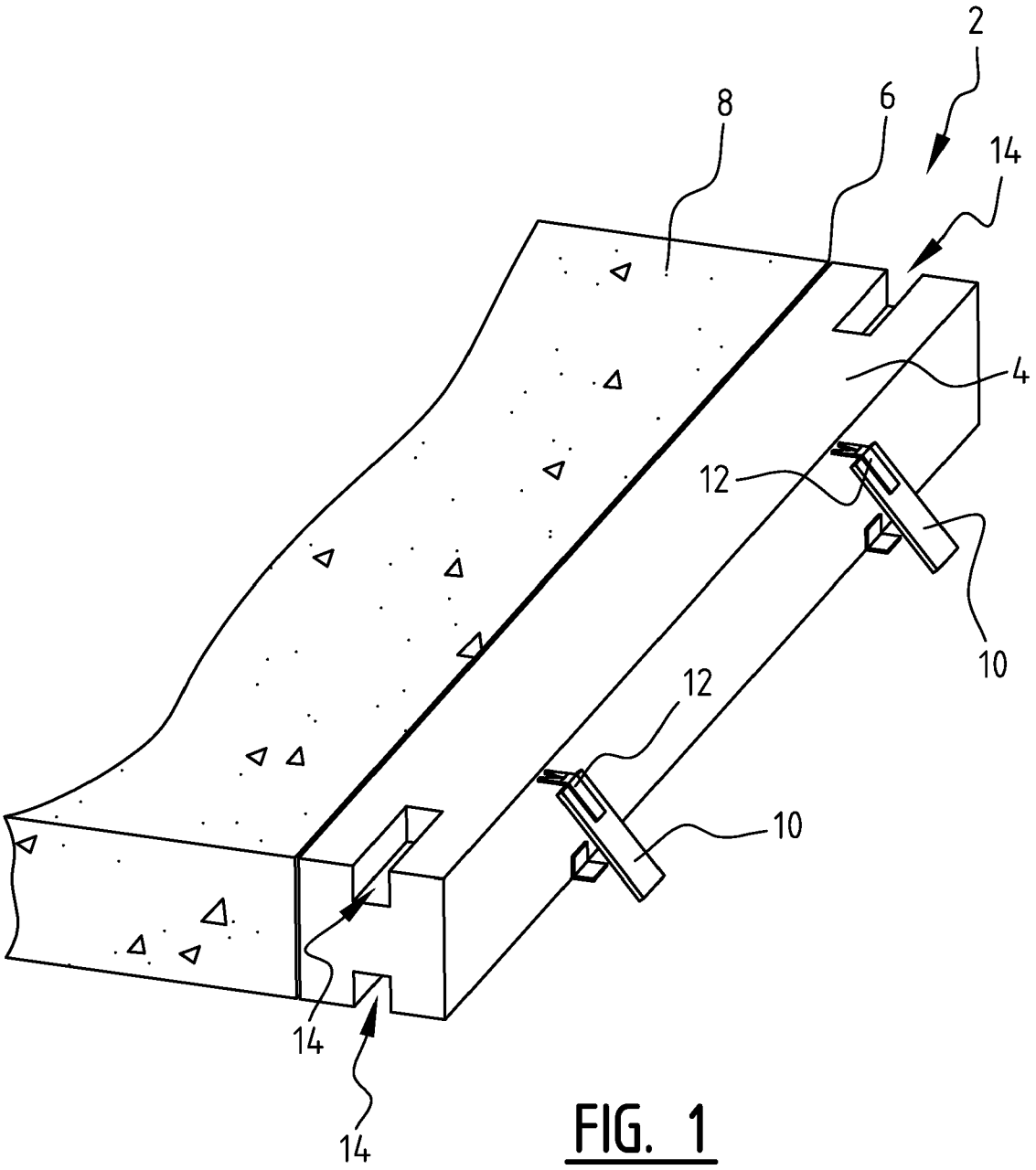

FIG. 1

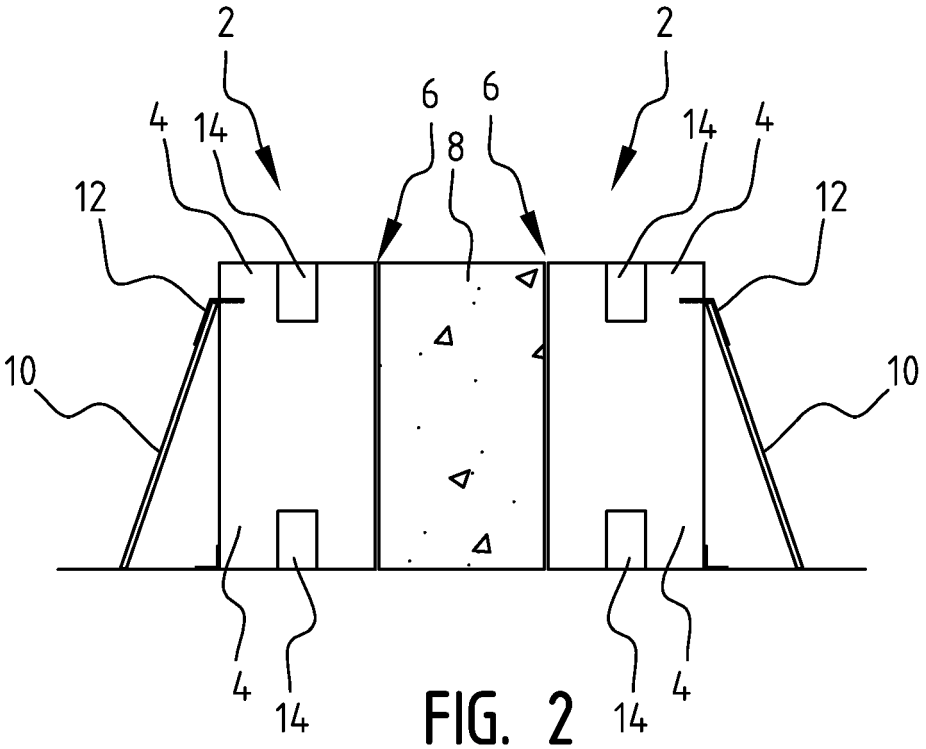
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FIG. 2

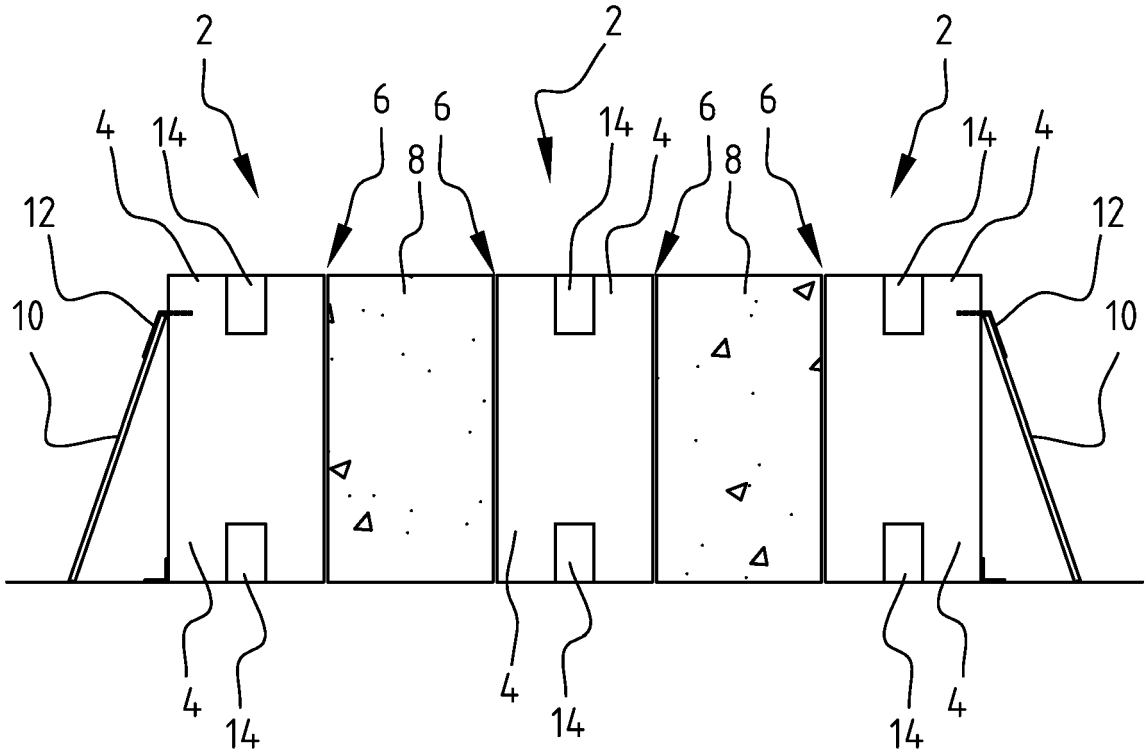
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FIG. 3

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EUROPEAN SEARCH REPORT

Application Number
EP 16 18 1030

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X,D	US 2005/066602 A1 (FULBRIGHT JOE RICHARD [US]) 31 March 2005 (2005-03-31) * figure 1 * -----	1-18	INV. E04G9/05 B28B7/00

TECHNICAL FIELDS SEARCHED (IPC)

E04G
B28B
E04B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	17 January 2017	Baumgärtel, Tim

CATEGORY OF CITED DOCUMENTS

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17-01-2017

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2005066602 A1	31-03-2005	NONE	

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

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Patent documents cited in the description

- US 20050066602 A1 **[0004] [0009]**