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amendments (Rule 48.2(h))

(54) Title: METHOD FOR REINFORCING STONE SLABS BY MEANS OF A HONEYCOMB PANEL INCLUDING THE SIMULTANEOUS CONSTRUCTION OF SAID HONEYCOMB PANEL

(57) Abstract: A method for producing a slab, in planar or non planar form, of stone material reinforced by a naked honeycomb structure without covering skins having empty cells, by at least one or two woven fabrics and by a structural resin characterized in that it comprises the following steps: - pouring said structural resin on a face of a first woven fabric until impregnation of said fabric; - placing said honeycomb structure on said structural resin impregnated face of fabric, and performing a first warm maturation of the resin; - adhering the open face of the honeycomb obtained by the first maturation, to the back of said stone slab by means of a structural resin, with or out without a second woven fabric preimpregnated by the same structural resin, and performing a second maturation of the obtained article.



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METHOD FOR REINFORCING STONE SLABS BY MEANS OF A HONEYCOMB PANEL INCLUDING THE SIMULTANEOUS CONSTRUCTION OF SAID HONEYCOMB PANEL

DESCRIPTION

The invention discloses a method for solving the problem of building stone slabs reinforced by a panel having an internal honeycomb structure, or by a polyurethane internal structure with holes and/or grooves to form small cells, wherein said reinforcing panel shows an improved adhesion to the slab and it is built starting from a naked honeycomb structure (without skins) during the production procedure, thus allowing to directly obtain said reinforced stone slabs in planar or non planar form.

TECHNICAL FIELD

The invention finds use and application in the general field of stone coverings and linings mainly in the shipbuildings, housebuildings and furniture sectors.

BACKGROUND ART

The problem of improving properties of structural strength and other favorable physical properties in planar stone slabs, to be applied as coverings or linings, is well known in the building industry, also in its naval and furniture sectors. Said problem arises from the need to better and improve the natural strength, or other physical properties, in stone materials employed for special needs; for reducing weight; for reducing to a minimum the amount of precious or rare materials to be employed in coverings and linings. Such problem did find many and proper solutions, for example by gluing or otherwise connecting to the internal face of a stone slab a panel of the material generally known as honeycomb or sandwich panel, which is formed by a honeycomb structure placed between two sheets (skins), as disclosed for example in US 3,723,233, or a panel of polyurethane foam, or a panel made by a material, to be found in nature or industrially built, endowed with the desired structural properties. Panels internally structured with central honeycomb are a choice solution whenever low weight and high specific structural strength are required; whenever thermal or acoustic insulation would be preferred, plastic foams would find better use. All these materials are industrially produced, in big quantities and following strict specific procedures, in the form of planar panels (and mass produced are also their basic

components, like the internal honeycomb structure, to be later used for producing the same panels). Therefore the said technical problem has got many and different solutions, for planar stone slabs.

For non planar stone slabs, this inventor disclosed a solution by his international patent WO 2009/060492. This application discloses a method for reinforcing curved stone slabs starting from honeycomb sandwich panels by removing the skins from the central honeycomb structure (destruction), then applying the single removed elements to the back in such a way as to accommodate each of them in the shape of the curved slab, performing then a strong connection between them by means of glue.

In the case of planar stone slabs reinforced with honeycomb panels, a critical structural point revealed itself, with time and experience, in the bond between panel and slab where, in given situations and time, the actual detachment and separation of said elements could arise. The honeycomb panel, as industrially produced and sold to the general public is lined, on both its faces (in a sandwich like fashion) by means of a fabric or sheet (skin) glued to its internal honeycomb structure. In connecting said panel to a stone slab, the honeycomb panel is glued to it by means of a special glue to produce a very strong bond between the material of said fabric or sheet and the stone itself. The critical point in connecting panel and slab is instead in the glue originally bonding the fabric or sheet to the honeycombed internal structure of the honeycomb panel since it has the aim of adhering the sheet to the honeycomb structure only: said bond, in given special situations of applied loads, will break, eventually followed by disjunction between the stone slab and the honeycomb structure, losing then the honeycomb reinforcement,

This invention proposes a solution to said problem, greatly bettering the honeycomb structural reinforcements presently applied and the adhesion thereof, in the case of planar stone slabs and also in the case of non planar stone slabs, for example curved slabs, by means of actually mending said critical point: therefore achieving the goal of increasing and improving their applicability in the building and furniture industries, especially in their most advanced and most requiring sectors as ship and yacht furniture sector.

DISCLOSURE OF INVENTION

Conceptually: given a stone slab (a face of which will be the external face of the finished product); a reinforcing material (which, could be endowed also of other favorable physical properties); and a glue to be placed between them in order to connect them in a firm way; I propose to operate in such a way as to place, between the stone slab and said reinforcement, a material able to improve their connection and as to take away, instead, every and each material able to worsen such connection; to increase, as much as possible, the surface of the stone slab and of the reinforcing material, in contact with said glue which is specific to adhere the reinforcing central honeycomb structure to the stone slab; to use a single type of glue, specific and optimal for the materials to be connected; and to let it mature, for the necessary time, in optimal temperature and pressure conditions. Such conceptual method will be better shown and understood by the following, non limiting examples.

BEST MODE FOR CARRYING OUT THE INVENTION

A sheet of nylon or of other material with no adhesive properties will be put on a table; upon said nylon sheet will be spread a first woven fabric (a fiberglass or silica fabric will be preferred, not excluding other materials useful or proper for specific ends) which is a pure and unused fabric; upon said fabric will be poured and spread a glue (a structural epoxy resin will be a preferred solution as described here below) in amounts and quantities such as for said fabric to be imbued by it and to drench, by surface adhesion, the reinforcing material, placed in contact with said fabric, and its immediate surroundings. The reinforcing material here proposed is the naked honeycomb structure without skins, which is not thus in the form of a sandwich panel. This naked structure is available, and to be acquired in the market, in its compacted form as a rod, with given height and dimensions, in aluminum or other metals. Said rod will be opened by laterally stretching it, as for an accordion, to form a sort of reticular structure, with tridimensional empty cells of height given by construction and width and length given by the lateral pulling effort, Said structure, opened in said way, will be made to rest upon the resin impregnated fabric in such a way that the resin itself will wet and adhere to, by surface adhesion in the immediate surrounding of the contact points, the sides of the walls of said opened cells. The whole will be lightly warmed up in oven for a first maturing of the resin at a preferred temperature as defined here below.

The face of the stone material to be reinforced (defined herein as the back of the slab) will have the rough surface finishing given to it by cutting, polishing or other methods of surface working processes. Upon said face will be spread a second pure woven fabric (a fiberglass or silica fabric will be preferred, not excluding other materials useful or proper for specific ends); upon said pure fabric will be poured a glue (a structural epoxy resin will be a preferred solution) in amounts and quantities such as for the fabric to be imbued and to drench, by surface adhesion, the reinforcing material to be placed in contact with said fabric and its immediate surroundings, as described above.

The used structural resin is an epoxydic bicomponent resin and has such characteristics as to allow a suitable adhesion between the stony material and the honeycomb structure with an high tight between said two elements, and to allow the impregnation of the fabric thanks to the specific parameters of viscosity, specific gravity, and structural strength at high temperature (up to 90°C) before and after maturation.

Such specific parameters are required to the supplier in order to obtain a minimal desired mechanical strength, evaluated according to ASTM D 638 (direct tensile test) and according to ASTM D 1002 (shear strength test), depending on the final use. A non limitative example is a structural bicomponent epoxydic resin having a minimum resistance of 60 MPa according to ASTM D 638 (direct tensile test) and 7,5 MPa according to ASTM D 1002 (shear strength test).

After being removed from the oven, the honeycomb structure, prepared as above, will be put in contact, with the open side (i.e. the side not covered by the first fabric) of the honeycomb cells, to the said second resin impregnated fabric which covers the back of the stone slab to be reinforced, in such a way that the resin will drench by surface adhesion, in the above described ways, the contact points of said honeycomb structure and its immediate surroundings, the wall of the cells.

The whole will be warmed, possibly in an oven, under optimal conditions of time, temperature and pressure depending on the type of stony material, for the final maturing of the resin. A non limitative example of optimal conditions can be as follows: a temperature comprised between 30°C and 70°C depending on the type of stony material, preferably about

60°C; pressure ranging from under vacuum (0 atm) to 1 atm, preferably under vacuum at 0 atm, for a time comprised between 1 and 8 hours depending on the type of stony material, preferably about 6 hours.

The product, resulting from said procedure, is new and, because of its properties of strength and durability, confronts itself very favorably to similar products actually proposed. From said procedure can result also a new, simplified product, where the fabric between the stone slab and the naked honeycomb structure is omitted (the resin being poured and spread directly upon the stone slab and the naked honeycomb structure which will be made to rest upon the slab itself).

The process of the present invention allows to build the honeycomb panel simultaneously to the process for reinforcing the respective stone slab.

The Applicant has found that the use of a pure honeycomb structure without skins, in place of a honeycomb sandwich panel, allows to obtain an improved adhesion between the reinforcing honeycomb structure and the planar stone slab since the detachment of the honeycomb reinforcing structure from the skin glued to the slab does not occur as instead in the prior art.

Beside, the use of a pure fabric which is more impregnable with the structural resin than the sheets or fabrics of the panel brings to an improved adhesion between the naked honeycomb structure and the planar stone slab.

Actually, a fabric is more impregnable by the resin, which drenches it and pass through said fabric, with respect to the sheets of a preformed panel, and allows to connect directly the objects that are on the faces of said fabric. Furthermore, the pure fabric is also more impregnable than the fabrics of the preformed honeycomb panels since a portion of said fabric surface of said panel is already occupied by the original glue of the panel, thus offering less surface to the resin for the impregnation.

The present invention is also advantageously applicable to curved slabs since, in this case as well, it is obtained an improved adhesion of the reinforcement with respect to that obtained

by following the teaching of WO 2009/060492. Indeed, also in this case, the impregnation of a pure fabric is greater than that of a delaminated fabric or sheet of a preformed honeycomb sandwich panel since said delaminated fabric or sheet normally has "dirty" zones where the original glue is already present and which cannot be impregnated by the resin, thus attaining to a minor adhesion.

Furthermore, also in this case, a pure honeycomb structure is more drenchable with respect to a detached honeycomb internal structure since the latter has cells which are dirty due to the previous gluing: thus a minor surface is available for the impregnation with the structural resin, thus resulting in a minor adhesion of said honeycomb reinforcement to the stone slab,

In the present invention, the central honeycomb structure without skins can be replaced by a foamed polyurethane central structure of a panel, generally used for insulation, in which holes and/or grooves have been formed in both surfaces in such a way as to form small cells, also passing through cells, in analogy with the cells of the honeycomb structure.

CLAIMS

1. A method for producing a slab, in planar or non planar form, of stone material which are reinforced by a naked honeycomb structure without covering skins having empty cells, by at least one woven fabric and by a structural resin characterized in that it comprises the following steps:

- pouring said structural resin on a face of a first woven fabric until impregnation of said fabric;
- making said honeycomb structure to rest on said structural resin impregnated face of fabric, and performing a first warm maturation of the resin;
- adhering the open face of the honeycomb obtained by said first maturation, to the back of said stone slab by means of the structural resin, and performing a second maturation of the obtained assembled article.

2. Method according to claim 1 wherein the open face of the honeycomb structure previously matured is adhered to a second woven fabric which is already placed on the back of the stone slab and then impregnated with the structural resin.

3. Method according to claim 1 or 2 wherein the back of said stone slab has a rough surface finishing.

4. Method according to any one of the preceding claims wherein the adhesion of said honeycomb structure to said back of stone slab is performed by exerting a pressure before performing the second maturation.

5. Method according to any one of the preceding claims characterized in that said fabric is a plain woven fiberglass fabric.

6. Method according to any one of the preceding claims characterized in that the naked honeycomb structure is in aluminum or stainless steel material.

7. Method according to any one of the preceding claims characterized in that the structural resin is of the epoxy type.

8. Method according to any one of the preceding claims characterized in that in the maturation the assembled article is warmed up, preferably in a suitable oven, for a given time, temperature and pressure, depending on the type of stone material, in order to achieve optimal results in the maturing of said resin, preferably at a temperature comprised between 30°C and 70°C and under a pressure comprised between vacuum and 1 atm.

9. Method according to any one of the preceding claims characterized in that the second fabric between the stone slab and the naked honeycomb structure is omitted.

10. Method according to any one of the preceding claims characterized in that naked honeycomb structure without covering skins having empty cells is replaced by a central structure or core of a polyurethane foamed panel (expanded polyisocyanurate), which has holes and/or grooves on both surfaces to form cells.

11. Slab, in planar or non planar form, made of stone material reinforced by a honeycomb structure obtained by the method according to any one of the preceding claims.

12. Slab, in planar or non planar form, made of stone material reinforced by the central structure or core of a polyurethane foamed panel (expanded polyisocyanurate) having holes and/or grooves on both surfaces to form cells, obtained by the method according to any one of the preceding claims 1 to 10.

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2011/06Q582

A. CLASSIFICATION OF SUBJECT MATTER
INV. B32B3/12 B32B9/00
ADD.

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)
B32B

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 practical, search terms used)

EPO-Internal , WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 3 723 233 A (BOURKE P) 27 March 1973 (1973-03-27) col umn 1, line 1 - col umn 4, line 10; cl aims 1-2; figures 1-2 -----	1-8, 11, 12
X	US 5 004 512 A (FODERA FRANK [US]) 2 April 1991 (1991-04-02) col umn 1, line 1 - col umn 4, line 4; cl aims 1-14; figures 1-2 -----	1-8, 11, 12
X	DE 41 04 556 A1 (ETERNIT WERKE HATSCHEK L [AT] ; POSCHACHER NATURSTEINWERKE AG [AT]) 12 September 1991 (1991-09-12) col umn 1, line 1 - col umn 4, line 19; cl aims 1-3; figures 1-3 ----- - / - -	1-8, 11, 12



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 document 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.
"&" document member of the same patent family

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Name and mailing address of the ISA/

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INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2011/06Q582

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	wo 2009/060492 AI (FULVI FABIANO [IT]) 14 May 2009 (2009-05-14) cited in the appl icati on page 1, line 1 - page 3, last line; claims 1-10 -----	1-8, 11, 12
X	EP 1 149 691 AI (SANYO CHEMICAL IND LTD [JP] ; ASAHI FIBREGLASS co [JP]) 31 October 2001 (2001-10-31) paragraphs [0006] - [0126] ; claims 1-11 -----	1-8, 11, 12
X	EP 0 314 625 AI (CIBA GEIGY AG [CH] ; CIBA GEIGY GMBH [DE]) 3 May 1989 (1989-05-03) col umn 1, line 1 - col umn 5, last line; claims 1-13; figure 1 -----	1-8, 11, 12
A	DE 103 00 779 AI (SCHRAPS GUENTER [DE]) 22 July 2004 (2004-07-22) paragraphs [0001] - [0017] ; claims 1-10; figures 1,2 -----	1-9, 11, 12
A	wo 2005/102696 AI (SINDAT S R O [CZ] ; FRYBERT BORIV0J [CZ] ; SLAIS ZDENEK [CZ]) 3 November 2005 (2005-11-03) page 1, line 1 - page 5, last line; claims 1-7; figure 1 -----	1-9, 11, 12

INTERNATIONAL SEARCH REPORT

International application No.
PCT/EP2011/06Q582

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☒ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

I-9(completely) ; 11, 12(partial ly)

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☒ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-9(completely) ; 11, 12(partially)

A method for producing a slab of stone material reinforced with a honeycomb structure

2. claims: 10(completely) ; 11, 12(partially)

A method for producing a slab of stone material reinforced with a central structure or core of a polyurethane foamed panel

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2011/06Q582

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 3723233	A	27-03-1973	NONE
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