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(54) Apparatus and method for producing cellular mortar and concrete

(57) The invention relates to the construction sector, to apparatus for preparation of cellular concrete, and introduces a separation between the production stages, which are performed by two distinct but complementary apparatus: one for production of the water/cement mixture, the other for foam production, foam mixing with the grout and laying. The division of the production procedures by separating the apparatus enables work to be done in a continuous mode, guaranteeing rapidity and quality. By positioning the station for foam production and pumping at the laying level, structural shrinkage caused by collapsing of air cells after pumping, typical in the prior art, is prevented. The invention remotely pumps only the grout, whereas the product integrated with the foam is produced and laid by the mobile second apparatus, which is transported by the operatives as they move up through the building's floors, meaning that the operatives can work in high buildings or in positions that are remote from the *locus* of production of the grout, without there being any need for further intermediate pumping stations.

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Description

[0001] Cellular concrete is a cement-based construction material lightened with foam which combines characteristics of good mechanical resistance with a low heat conductivity, ease of production and use, and having contained costs with respect to the conglomerates which use light aggregates such as perlite, foam polystyrene balls, or light secondary inert materials in general. Cellular concrete is constituted by a mixture of water and cement (hereinafter called grout) to which an appropriately-batched foam is added which, distributed homogeneously in the paste, gives the characteristic micro-cellular conformation thanks to the millions of air bubbles developed. The batching of the foam added to the grout gives the specific weight, density and volume of the cellular concrete. If the quantity of foam included is greater, the volume of the final mixture produced will also be greater, with a consequent reduction in the specific weight. The possibility of easily varying the density of the product, apart from making the cellular concrete versatile and usable for many building purposes, enables the fluidity of the material to be regulated according to the needs of the construction design, even during the preparation stage thereof.

[0002] The regulation of the specific weight and the volume are functional to the management of the material to be laid but can have negative effects on the qualitative constancy of the prepared product if the tools used do not have adequate production process control systems.

[0003] Among other things, the invention has the task of obviating this limitation in the known apparatus, by using two distinct volumetric control systems which guarantee constant quality and repetitivity of the characteristics of the mixture produced in a continuous cycle.

[0004] The first volumetric control is performed using a batching system located on the screw of the M300 MTEC which verifies conformity of the grout in relation to the batching of the water and cement being mixed; the second volumetric control is performed by a sensor positioned on the U-mixer of the foam generator from which the finished cellular concrete exits.

[0005] The production of foam-lightened concrete falls within the field of common production techniques for light non-structural masses destined for floors that do not make the structure heavy, which have good thermal properties and which reduce production costs as they replace the more expensive light aggregates - which are also disadvantageous for the practical management of the work-site. Differently to other secondary aggregates, foam is not transported pre-formed, but is produced *in loco,* with use of a specific additive, and therefore presents no supply, stocking and management problematics.

[0006] In order to prepare a good cellular concrete, it is of fundamental importance that the grout used should be balanced, i.e. the cement must be suitably watered with a quantity of water necessary to prevent shrinkage in the hardened mass (water/cement ration not less than 0.7).

[0007] Shrinkage happens when insufficiently-hydrated cement leaches water which together with the foaming agent constitutes the foam, causing a collapse of the air cells which release water to the grout and disappear, leading to a loss of volume in the constructed material.

[0008] A further fundamental factor is the stability of the foam, which can depend on the quality of the foaming agent and the reliability of the foamer in calibrating air/water/additive flow and the efficiency of the foaming process, in the case of the present invention performed by a special riveted lance.

[0009] Taking as given the prerequisites relating to the efficiency of the water/cement ratio and the quality of the foam produced, in order to avoid impoverishing the foam a further consideration is the quality of the mixing process of the cellular concrete, which considerably affects the qualitative and performance factors together with the stage of pumping. The known apparatus in the art commonly use a horizontal mixer that "beats" the grout in a discontinuous cycle and integrates the foam into the mixture with the aid of a double-flow screw. As the foam is a tendentially unstable product, subject to shrinkage by the intrinsic nature of its components, an aggressive mixing system, typical of a beating-type mixing, can become an aggravating factor in the impoverishment process, especially if the mixing action is protracted over time. The invention uses a helical mixer having a 90mm section which blends the foam during the transit time of the grout into the mixer, without beating actions and with no waiting time.

[0010] Another drawback typical of known apparatus, which the invention aims to obviate, is the limited hourly productivity thereof, determined by the discontinuous production cycle. In the known apparatus, normally the mixer performs three distinct and non-simultaneous tasks: 1), it mixes water and cement to prepare the grout, 2) it contains and mixes the foam produced by the generator following the preparation of the grout, and 3) it functions as a supply tank for the pump delivering the cellular concrete. Consequently the known apparatus, differently to the invention, do not normally produce in a continuous system because the three functions of the mixer imply sequential production of the grout, the foam and the pumping stage.

[0011] Having already mentioned the need to water the grout before mixing it with the foam, it is obvious that the limitation in performance of the known apparatus, which are programmed to produce the group in short times such as to increase hourly production, risks leading to use of an insufficiently hydrated grout, and thus increases the probability of a collapse of the cellular concrete, also as mentioned herein above.

[0012] A still more problematic passage in the process is the pumping of the material to the floor of a building where it is required. Owing to the conformation of the known apparatus, the grout production station, and the coinciding foam production station, is normally on the ground floor.

[0013] When the foam has been blended with the mixture, special pipes are used to pump the material to the correct floor.

[0014] This stage is very delicate as the pressure mechanically exerted by the material delivery pump tends to crush the foam during its journey through the pipes, which leads to a shrinkage that increases as the following increase: the pressure applied, the distance and/or the height of the pumping, the bends and crushing applied on the delivery pipe.

[0015] The invention has the task of resolving the problems of the known apparatus by improving the quality of the cellular concrete produced, making the production more effective in terms of continuous working, keeping the water/cement mixing and the grout/foaming stations separate, with the advantage of facilitating laying *in situ* both from the operative point of view thanks to the possibility of positioning the foamer directly on the relevant floor, and in terms of performance of the laid material, avoiding transporting the product through long delivery pipes, as the foamer is positioned in the immediate vicinity of the laying site.

[0016] The invention is designed to be used as an auxiliary with known apparatus for mortar and cement mixture production of the M300 M-TEC type.

[0017] These known apparatus have the function of producing grout (water/cement mixture) and making it available for the addition of foam.

[0018] The M300 M-TEC apparatus is located on the ground floor where water and cement are available for the production of the grout, which will be used for continuously supplying the invention via a delivery pipe, the invention being positioned close to the laying point (which can either be higher up or longitudinally distant).

[0019] This distance, differently to the prior art, does not have a negative impact on the cellular concrete produced since only the grout (water/cement mixture) flows in the pipes, and the grout is not susceptible to shrinkage due to the pumping pressure, as is foam.

[0020] In the known apparatus, the material pumped remotely has already been mixed downstream with the foam, as the foam generator is normally integrated with the apparatus which produces the grout and therefore positioned at distance from the laying point, such that the foam is inevitably subjected to negative pumping pressure.

[0021] The apparatus is made up of two machines: a known M300 M-TEC machine, appropriately interfaced with a new concept, the mobile foam generator with integrated variable-flow mixing system for production directly at the work site and pumping of variable-density cellular concrete.

[0022] The M300 M-TEC and the foam generator are interfaced with one another via a specially-designed control panel.

[0023] The invention is constituted by the following elements:

1. The known M300 M-TEC machine is a mixing machine for cement conglomerates, provided with a volumetric control system of the grout produced.
The production of the grout is done continuously with a flow rate of 53 litres per minute, and enables variations in the specific weight according to the batching of the cement. Verification of the conformity of the mixture provided is done with a volume sensor positioned on the screw. The grout prepared is pumped through the delivery pipes to supply the mobile foam generator integrated with the variable-flow static mixing system which finalises the mixture by enveloping the foam and lays it directly in the laying site.

2. A foam generator which prepares a mixture of water and foam additive, correctly batched, and transforms them into foam. The liquid components are managed by an impeller pump working at 10 litres per minute for the production of the mixture. The pump is provided with two flow-meters: the first for regulating the water flow; the second for regulating the additive flow.
A proportional venturi tube batches the quantities of the water/additive mixture and two solenoids enable a simultaneous passage of the water/additive mixture stowed in two tanks, while the other solenoid opens and closes the flow of air coming from the 300-litre-per-minute compressor with a pressure regulator, towards the foam lance. The components, thus-batched, are channelled into the foam-generating riveted lance where the mixture, in combination with air and the volumising action of the rivets, produces the foam.

3. A U-shaped helical static mixer constituted by two 90mm-diameter straight tracts, respectively 40cm long, and a 180° curved tract with a 90mm diameter. The screw of the mixture is made of polyurethane.
The mixing is not for actually producing the mixture. The foam generator positioned on the laying floor only produces the foam and the grout mixture, which is pumped to the foam generator by the M300 M-TEC apparatus positioned downstream; the apparatus supplies the generator at pressure via a delivery pipe, the generator being equipped with a mixer located on the floor constituting the laying site. The mixing of the foam with the grout takes only a few seconds, by being passed through by the screw, avoiding beating and long mixing times, both of which would compromise the quality of the foam.
The flow of the mixer is 13,000 litres per hour and enables continuous mixing with no production cycle interruptions, thanks to the constant availability of the grout supplied by the M300 M-TEC and the foam produced in a continuous flow by the foam generator.
The foam generator enables continuous production of 10-13 cubic metres per hour and the control of the

pumped material is measured with an electronic litre-counter positioned at the output of the static mixer described herein above.

The cellular concrete thus produced is laid using a pipe connectable to the outlet of the mixer.

The pumping through the tube is done at very low pressures, exploiting the inertia generated by the air pressure applied for the generation of the foam, and preserving the cellular concrete from volumetric shrinkage normally caused by the pumping pressure applied by the known apparatus.

The foam generator, provided with the mixer, can be demounted into three pieces to facilitate its transport to the floor where the work is to be carried out.

4. A 380 volt specially-designed control panel functions as an interface between the M300 M-TEC apparatus and the foam generator provided with the mixer of the invention.

[0024] The apparatus is electrically powered and uses a 380 volt on-site source. Three-phase electric motors are used. The air compressor has a 1500 watt motor.

[0025] The liquid pump motor absorbs 330 watt.

[0026] In other words, the apparatus is made up of two machines: a known machine, M300 M-TEC, for production of mortar and concrete, interfaced by a 380-volt control panel with a new-concept machine, i.e. mobile foam generator with integrated variable-flow static mixing system for production for producing, directly at the work-site, and for the pumping of variable-density cellular concrete.

[0027] Thus there is a separation of the production stages, with the use of two distinct but complementary apparatus: one for the production of grout (water/cement mixture) and the other for the production/mixing of the foam with the subsequent pumping of the finished mixture which enable optimisation of continuous production and guarantee speed and quality. The grout is produced by the M300 M-TEC at ground level, where water and cement are available, continuously and at a flow rate of 53 litres per minute, with the possibility of varying the specific weight according to the cement batches used. The grout prepared by the M300 M-TEC is pumped through the delivery pipes to supply the mobile foam generator integrated with the variable-flow static mixing system, which finishes the mixture by injecting the necessary foam and lays it directly on-site (at either a vertical or a longitudinal distance) with no interruptions to work, and at a rate of 10-13 cubic metres per hour.

[0028] By keeping the point of production of the grout (downstream) separate from the point of integration of the foam with the grout (immediately by the laying point), the operativity of the worksite is improved but more important still the quality of the cellular concrete is conserved, as, differently from the known art, it does not have to be pumped to a remote point after having acquired the foam; i.e. the more unstable element subjected to the crushing caused by the pressure applied during the pumping, the distance and/or the height of the pumping, the bends or crushing applied on the delivery pipe, is preserved. With the invention, the only product remotely pumped into the delivery pipes is the grout, which is not subject to the shrinkage inherent to the nature of the foam.

[0029] A further quality control of the conformity of the material produced is made by means of two volumetric sensors located respectively on the screw of the M300 M-TEC and the mixer integrated with the foam generator.

[0030] The foam generator prepares a water and foam additive mixture, appropriately batched, and transforms them into foam. The liquid components are managed by an 10 litre-per-minute impeller pump for the production of the mixture. The pump is provided with two flow-meters: the first for regulating the water flow; the second for regulating the flow rate of the additive.

[0031] A proportional venturi tube batches the quantity of the water/additive mixture and there are also two solenoids, one of which governs simultaneous passage of the water/additive mixture into two special tanks, while the other opens and closes the air flow coming from the 300 litre-per-minute compressor with pressure regulator, towards the foam lance. The thus-batched components are channelled into the foam-generating riveted lance, where the mixture in combination with the air and the volumising action of the rivets produces the foam.

[0032] The possibility of varying the flow of the pump and the air compressor allow modification of the specific weight of the foam to requirements, and consequently the volume and density of the cellular concrete produced.

[0033] The invention is integrated with a helical static U-mixer constituted by two straight lines having a 90 mm diameter and 40 cm length, and a 180° curved tract having a 90mm diameter. The mixer screw is made of polyurethane.

[0034] The foam-grout mixing takes only a few seconds by passage through the screw, preventing beating and long mixture time which would compromise the quality of the foam and thus overcoming one of the constructional limitations typical of the known apparatus which normally uses "beating" type mixers, which contribute to worsening the process of foam damaging. The mixer has a flow rate of 13,000 litres per hour, and enables non-interrupted continuous mixing of the production cycle thanks to the constant availability of the grout provided by the M300 M-TEC and the continuous-flow foam produced by the foam generator.

[0035] The cellular concrete is laid using a delivery pipe to be connected to the mixer outlet.

[0036] The pumping through the pipe occurs at very low working pressures, exploiting the inertia generated by the air pressure, applied during the stage of foam generation such as to conserve the cellular concrete from the volumetric shrinkage normally caused by the considerable pumping pressures normally applied by the known apparatus.

[0037] The invention requires no high working pressure for pumping because the distance from the laying point is very small and there are no height distances for the mixture to climb requiring applied powder; this is because the integrated foam generator is easily displaced from one floor of a building to another thanks to the fact that it can be separated into three sections.

[0038] The invention involves remote pumping of only the grout, while the integrated product with the foam is produced and laid by the second mobile apparatus which follows the layers in displacements to the various floors, enabling work to be carried out in sites involving height differences or laying locations considerably removed from the point of grout production, without using intermediate pumping stations.

Claims

1. An apparatus for production of cellular mortar or concrete, **characterised in that** it comprises a mixing machine for production of mortar or concrete or grout and a foam generator, the mixing machine being predisposed to supply the foam generator which is separate from the mixing machine and is locatable directly at a laying site.

2. The apparatus of claim 1, **characterised in that** the foam generator is mobile.

3. The apparatus of claim 1 or 2, wherein the mixing machine and the foam generator are interfaced via a control panel.

4. The apparatus of one of the preceding claims, wherein the foam generator is integrated with a variable-flow static mixing system for production directly at the laying site and for regulatable-density pumping of the cellular concrete.

5. The apparatus of claim 4, and further comprising two volumetric sensors located respectively on a screw of the mixing machine and on the mixing system integrated with the foam generator.

6. The apparatus of one of the preceding claims, wherein the foam generator, destined to prepare a mixture of water and foam additive, comprises:

an impeller pump for managing the water and foam additive;
two flow meters for respectively regulating the flow of water and of the foam additive;
a proportional venturi tube for batching quantities of the water/additive mixture;
a first solenoid for enabling simultaneous passage of water and additive stowed in two tanks;
a second solenoid for opening and closing flow of air coming from a compressor having a pressure regulator and flowing towards a foam lance.

7. The apparatus of one of the preceding claims, wherein the foam generator is integrated with a U-mixer comprising two straight tracts and a curved tract, the mixer comprising a screw made preferably of polyurethane in order to enable continuous mixing.

8. A method for producing cellular mortar and concrete, **characterised in that** it comprises stages of:

producing mortar and concrete or grout in a mixing machine;
supplying the mortar or concrete or grout to a foam generator which is separate from the mixing machine and which is located directly at a laying site thereof;
mixing the grout with the foam to obtain a finished mixture.

9. The method of claim 8, wherein the method is performed continuously.

10. The method of claim 8 or 9, and further comprising a stage of continuously pumping the mixture when finished to the laying site.

11. The method of one of claims from 8 to 10, wherein the stage of producing mortar and concrete or grout is done continuously at a ground floor level, where water and cement are available, the grout then being pumped by delivery pipes to supply the mobile foam generator, which mobile foam generator finalises the mixture by injecting the foam and laying the finished mixture directly and continuously in the laying site.

12. The method of one of claims from 8 to 11, wherein the cellular mortar or concrete is laid at the laying site via a delivery pipe in which the cellular mortar or concrete is pumped at low working pressures by exploiting inertia generated by air pressure applied during the foam generating stage, such as to protect the cellular mortar or concrete from volumetric shrinkage.

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EUROPEAN SEARCH REPORT

Application Number
EP 09 17 2141

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	AT 357 459 B (MAYREDER KRAUS & CO ING [AT]) 10 July 1980 (1980-07-10) * page 3, line 36 - page 4, line 2 * * page 4, lines 19-22; figure 1 *	1-12	INV. B28C5/38
X	US 5 419 632 A (STEPHENS PATRICK J [US]) 30 May 1995 (1995-05-30) * column 5, line 50 - column 6, line 19; figure 1 * * column 6, lines 53-68 * * column 8, line 37 - column 9, line 6 *	1,8	
X	DE 196 32 666 C1 (INGENIEURKONTOR FUER MASCHINEN [DE]; TESOMA TEXTIL UND SONDERMASCHI [D) 23 April 1998 (1998-04-23) * column 7, line 30 - column 8, line 9; figure 1 *	1	
A	FR 2 246 169 A5 (LEANDRI LUIGI [IT]) 25 April 1975 (1975-04-25) * page 3, line 27 - page 4, line 20 *	1,8	TECHNICAL FIELDS SEARCHED (IPC)
A	WO 99/10296 A2 (FRIATEC AG [DE]; MELCHER GERHARD [AT]) 4 March 1999 (1999-03-04) * page 5; figure 1 *	1,8	B28C

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	10 February 2010	Saretta, Guido

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 09 17 2141

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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