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April 6, 1943. O. G. PATCH 2,315,732

POROUS CONCRETE CONSTRUCTION AND METHOD OF MAKING THE SAME

Filed July 31, 1940

Fig. 1.

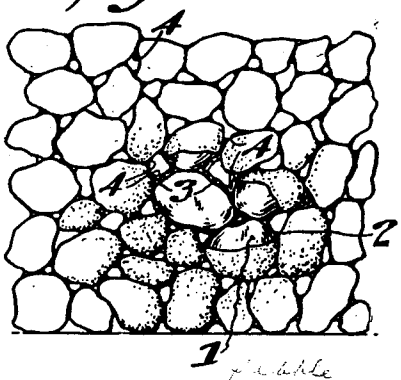


Fig. 2.

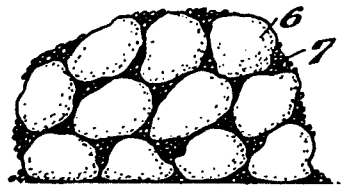


Fig. 4.

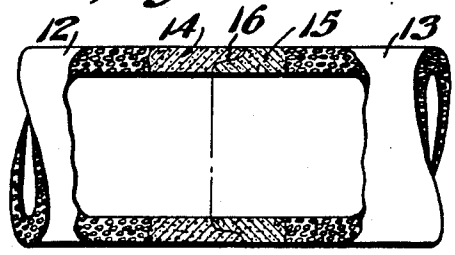


Fig. 3.

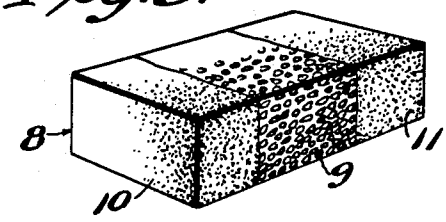


Fig. 5.

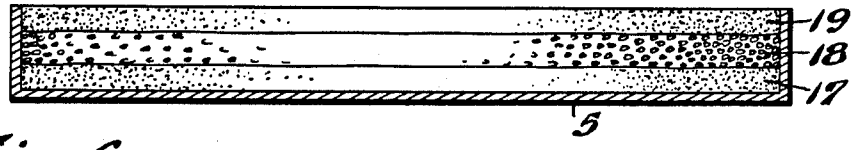


Fig. 6.

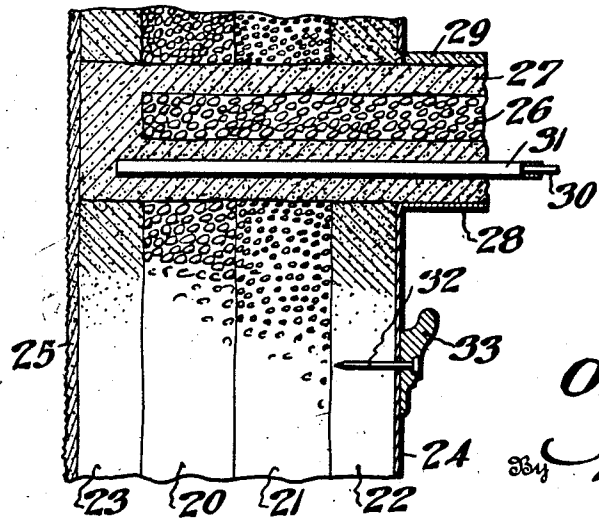
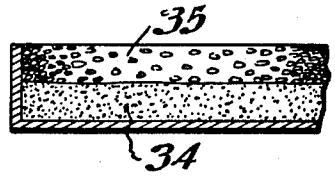


Fig. 7.



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TRUCTURES,

5 Patented Apr. 6, 1943 2,315,732

UNITED STATES PATENT OFFICE

2,315,732

POROUS CONCRETE CONSTRUCTION AND METHOD OF MAKING THE SAME

Orin G. Patch, Coulee Dam, Wash.

Application July 31, 1940, Serial No. 348,767

11 Claims. (Cl. 72—0.5)

My invention relates to improvements in porous concrete construction and the method of making the same, and particularly to construction and a method employing substantially non-compressible structural or aggregate units arranged in juxtaposition and united at their contiguous areas by an initially fluid hydraulic bonding material which subsequently chemically hardens thus binding the particles together and leaving spaces or voids between the units unoccupied and open.

The primary purpose of my invention is to provide a concrete construction and method of making the same particularly well adapted for use in concrete structures such as walls, floors, or the like, and with which the weight of the structure is reduced, chemical action in setting or curing of a monolithic structure is expedited, cooling and maintenance of the structure in condition for most advantageous curing or setting are facilitated, and shrinkage of the material during the curing period is reduced or practically eliminated.

Concrete structures as now ordinarily made up are composed of a mass of units of different sizes, including relatively large pieces of stone or other aggregates, smaller particles, and sand in one or more degrees of fineness, mixed with an hydraulic cement such as Portland cement and allowed to chemically set so as to form a solid or as nearly as possible solid mass, the present purpose seemingly being to provide a continuous material without spaces or pores between the individual particles or units. Such conventional concrete structures are necessarily heavy for the bulk occupied, being substantially solid are ready conductors of heat and sound, and are expensive both in material and work.

Another purpose of my invention is to make use of the structural advantages of concrete while providing a new construction and method which has striking and hitherto unknown functions and advantages, among which are reduction of weight to unit of volume, enhanced heat insulating qualities, improved sound insulation, water drainage capacity, a better surface for attaching wall coating or covering thereto, and, a texture and body which permits driving nails or other fastenings for ready attachment of wood or metal work or other parts, a consistency or body sufficiently stiff and self-sustaining to nearly stand alone thus requiring only light and rough forms as the unset material will not leak out and will not shift as will ordinary concrete, and at the same time a concrete almost entirely free from shrinkage and with relatively high elasticity thus eliminating much of the crack formation caused by shrinkage in ordinary concrete; and, a porous concrete construction and method of making the same which present a marked saving in the cost of materials and in the placement and use.

With the above and other objects and advantages, some of which will be apparent to those skilled in the art and others of which are inherent in the material and in the method of making and using the same, my invention includes certain novel features of construction and combinations and arrangements of parts and ingredients which will be hereinafter set forth in connection with the drawing and then pointed out in the claims.

In the drawing:

Figure 1 is a fragmentary view in elevation, and with parts in section, showing concrete construction and the method of making the same in accordance with my invention.

Fig. 2 is a similar view showing a modified adaptation of the invention.

Fig. 3 is a building block or brick or construction unit in accordance with my invention.

Fig. 4 is a fragmentary view partly in elevation and partly in section illustrating a hollow drainage pipe embodying my construction and method.

Fig. 5 is a vertical sectional view of a filled mold disclosing another modified embodiment.

Fig. 6 shows a fragmentary vertical section of one form of wall and ceiling and floor structure according to my invention.

Fig. 7 is a fragmentary sectional view somewhat similar to Fig. 5 illustrating another modified embodiment.

The carrying out of my invention broadly contemplates employment of aggregates of substantially a graded or screened size and sufficiently large that voids will exist between the aggregate particles when placed in position, coating the particles of aggregate with a thin covering of hydraulic cementing liquid such as a mixture of Portland cement, and then placing the particles in desired form while the cementing material is still liquid whereby the cementing material is displaced between abutting contacting portions of adjacent particles and accumulates as a meniscus around said contacting and abutting portions with the voids unfilled.

In carrying out my invention, it is possible to employ aggregate particles of various materials, such as stones, sand or gravel particles, pebbles, granular pumice, slag or cinder particles, and in

fact aggregate particles of any particular and suitable material and nature, whether natural or artificial.

In the adaptation shown in Figure 1, the aggregate particles 1 are shown as gravel or pebble or stone particles of substantially uniform size within commercial screening or grading limits, and such particles can be of any desired or suitable material and can be obtained in sufficiently uniform size in any desired manner, as by screening or other selective process.

In preparing the material a sufficient quantity of the aggregate particles or units 1 are coated with a film 2 of chemically hardenable cementing material such as a Portland or silicious cement grout, which grout has been advantageously prepared of cement and water with little or no sand filler or body material. This coating is desirably relatively thin, and the cementing material is advantageously not so wet as to flow by gravity from the aggregate particles. The measured aggregate material should be well mixed with a measured amount of the cementing material, and mixing should be continued until the cementing material is uniformly distributed and the aggregate particles are well coated with the semi-fluid cementing material. The quantity and consistency of this cementing medium or material, as indicated in section at 3, must be so controlled that when the coated aggregates are formed or applied in the desired construction the liquid cementing material will be substantially displaced from between adjacent particles and the juxtaposed portions of said particles will substantially bear one against the other, with the cementing material collecting around the abutting portions of adjacent particles and accumulating after the manner of a meniscus around said portions with the voids left unfilled and consequently open. The desired coating and consistency of the aggregate particles as a material for construction can be attained by mixing the aggregate particles with a quantity of cementing material or grout sufficient to coat upon the surface of the individual aggregate particles by natural adhesion thereto, and care must be taken to have the cementing material sufficiently flowable to be displaced between abutting portions of the aggregate particles and to flow into the meniscus-like accumulation around the abutting portions, as indicated at 4 in Fig. 1. At the same time, the proportion or quantity of cementing material must be held at such limits that the voids between the aggregate particles will not be filled or obstructed.

The desired coating of the aggregate particles with the cementing material can be accomplished in other ways such as by spraying or by immersion in the cementing material and then draining away or shaking off the excess cementing material upon removal from the immersion, before placing in molds or forms. The application of the cementing material should leave the particles coated but without an excess, and the coated aggregate particles are then placed in the usual forms or in any other desired position or formation for use, while the cementing material is still fluid enough to accumulate, after the manner of a meniscus, and unite around the contact points with an area somewhat larger than the actual juxtaposition contacting portions of the aggregate particles.

The thus coated and prepared aggregate particles can be deposited in the desired place for use, such as for instance the mold 5 as shown in Fig. 5, by pouring or in any other desired or approved manner, and through the inherent weight of the thus coated particles, or through light tamping, or vibrating, the coating of cementing material is displaced between adjacent portions of contiguous aggregate particles so that the juxtaposed portions of the particles substantially contact, with the cementing material displaced from between the contacting portions flowing out and accumulating substantially after the manner of a meniscus and yet not settling or flowing to fill the voids in any part of the structure where voids are desired. Thus, a porous or cellular structure is produced upon hardening of the cementing material and the aggregate units are firmly bound together and adherent upon their contiguous areas, thus producing a rigid but cellular structure of the desired form and for the desired purpose, as for instance a wall, floor column, block, pipe, or other member or building element as may be desired.

In the disclosure in Fig. 1 the cementing material at 3, between the aggregate particles 1, has been perhaps somewhat exaggerated in order to show how the aggregate particles touch each other upon adjacent portions, and how the cementing material accumulates or collects around such contacting portions, after the manner of a meniscus. Further, it will be appreciated that the showing is somewhat schematic in that when the invention is put into actual practice a great quantity of aggregate particles will be coated with cementing material and will then be poured or otherwise placed in substantially random arrangement within a mold or form or within a trench, or at such other location or in such other place as material is to be used or formed.

It has been found that such a cellular structure has remarkable compressive or crushing or load bearing strength, in many instances comparable to conventional concrete, since the aggregate particles are in actual contact in their contiguous portions and are securely and immovably held together and against shifting, by the chemically hardened cementing material and the accumulation of such material in meniscus-like form around the contacting portions. At the same time my improved porous concrete construction has many advantages not possessed by conventional or solid concrete.

In the modified embodiment shown in Fig. 2, the aggregate particles 6 are of such size that the voids or spaces therebetween will be relatively large, and relatively smaller aggregate particles 7 are incorporated in the structural material as mixed or prepared, so that these relatively smaller aggregate particles 7 will accumulate between or within the large voids between the large aggregate particles 6. In such construction, the smaller particles 7 will be surface coated in substantially the same manner as the larger particles 6, and when the material is in position for setting or hardening the particles 6 and 7 will have air spaces or voids therebetween, with the cementing material accumulating in meniscus-like manner around the contacting portions of both large and small aggregate particles and with voids or air or cellular spaces substantially throughout the mass between the particles.

In each of the adaptations, the important result is that while the aggregate particles or units contact each other in relatively contiguous areas, they do actually direct the contact and the sur-

face tension of the semi-fluid cementing material or coating forms and enlarged or meniscus-like point of bonding which provides a sufficient area of contact to effect a relatively high compressive strength and with the particles held against shifting, and yet with structural bearing directly from the body or unity of each aggregate particle to adjacent or juxtaposed aggregate particles, thus largely eliminating shrinkage and attaining and maintaining the full compressive or crushing strength of the aggregate particles. It has been hitherto unappreciated that such relatively high compressive strength could be attained without the use of graded aggregate materials of particles of varying sizes, and without the use of sand and cementing material in quantities considerably greater than the amount which adheres naturally to the surface of the units after being passed through or coated with the fluid grout, or otherwise mixed or coated as hereinabove described.

Since the material when placed is considerably drier and firmer and has relatively less liquid or flowing properties than concrete mixtures as now ordinarily employed, it is possible to accomplish economies in the building or placement or employment of this improved structural material, aside from actual economies through production in the required quantities of aggregate and cementing materials, due to the fact that a lighter weight wall or floor or other structural part is formed, thus requiring lighter foundations or understructures and less reinforcement. Further, the dry consistency and the particle to particle bearing of aggregate particles lessens greatly the tendency to flow and greatly increase the self-supporting or shape-sustaining properties of the material, thus requiring less rigid forms and less bracing or tying of such forms. Since voids will occur between the aggregate particles at the outer surface of the structure as well as within the body of the material, rough lumber or other economical material can be employed in making up the forms and any irregularities from the forms will not be readily visually perceptible. Also, as the pores or voids provide an ideal surface or key for stucco and plaster, or other surface coatings, no lathing or other surface preparation is required either inside or outside of a structural member made up after the manner of my invention. Since the resultant surface is porous with the aggregate particles and the voids in irregular arrangement, an unplastered wall or surface in accordance with my invention is possessed of excellent acoustical properties, and the wall or structural portion with the voids therein will also serve as excellent insulation against heat exchange transmission. With the porous nature of the structure, correction of structural features and repair can be readily accomplished, since the aggregate particles can be readily chipped or cut or broken out of a floor or wall or other structure, and when repair material according to the present invention, or of any other desired material, is placed within the opening the inherent porosity makes for an effective and lasting bond.

Bricks or blocks, as shown in Fig. 3, may be formed in any desired shape and size, and with any suitable apparatus. In the present instance I have shown the brick or block or building unit **8** as having a center portion **9** formed of one size of aggregate particles, while the end portions **10** and **11** are formed of a relatively different size of aggregate particles. Obviously, bricks or blocks or other building units can be made up in this material to be hollow or solid, and with the different sizes of aggregate particles employed in any desired disposition of placement within the unit.

A structure in accordance with my invention also provides an excellent drain pipe, such as for example a molded or tubular form of drain pipe or tile adapted to permit seepage of water or liquid therethrough. In Fig. 4 I have shown one adaptation of this embodiment, where the two pieces of drain tile **12** and **13** are formed of my improved porous concrete construction and in accordance with my method, to be of hollow cylindrical or other tubular form. The ends **14** and **15** of these members **12** and **13** are adapted to be pointed or fitted together, and are accordingly provided with mating or interfitting portions adapted to be brought together along the line at **16** where the two parts **12** and **13** will be held in substantially continuous extension. As shown, the end portions **14** and **16** can be of a different mixture of material and are preferably adherently and unitarily constructed or embodied with the members **12** and **13**.

As illustrated in Fig. 5, any desired form **5** can be employed to receive and to hold the porous concrete construction while setting or chemically hardening is taking place; and as further illustrated, the material can be placed in forms or in any other position or location for use, in layers or strata, as indicated at **17** and **18** and **19**, the various strata being of relatively different sizes or characters or types of aggregate particles and being placed or applied in any desired manner. With this construction it is possible to place each successive stratum successively, while the adjacent stratum is still wet, or after such stratum has hardened or cured, and the peculiar composition and nature of the material will accomplish a complete and substantially perfect bond between adjacent strata.

When formed into a wall or floor or a building structure, the sound and heat insulating properties of the improved structure will be readily apparent, as it will be appreciated that the air spaces or voids between the units and the irregular or tortuous nature of these voids will dampen or cut down or stop transmission of heat and sound waves.

A combined wall and floor and ceiling structure embodying my invention is illustrated in Fig. 6, wherein the stratum **20** of the wall is of relatively the coarsest aggregate particle material, with the stratum **21** adjoining and adhering to the stratum **20** toward the inner side of the wall of a relatively smaller or finer aggregate particle material, and the innermost stratum **22** of relatively finest material adjoining and adhering to the stratum **21** on its inner face but still enjoying the properties of the present invention by reason of being formed of relatively uniform though fine particles with spaces or air voids therebetween. If desired, an outermost stratum **23**, or aggregate particles intermediate the particles in the strata **21** and **22**, or of other desirable and suitable size can be employed on the outer face of the stratum **20**. Since the innermost surface of the stratum **22** presents relatively small aggregate particles, this surface affords a somewhat smooth face suited to receive a paint coat **24**, or other coating material, while the somewhat less smooth outer face of the outermost stratum **23** affords a rougher but sufficiently close knit surface suitable for a coating or covering of stucco or concrete plaster, as at

25, for the outside of a building. The floor may be formed of a center core 26 of relatively coarse aggregate particles of material enveloped in upper and lower covering material 27 of somewhat finer material which may be painted or coated as at 28 for the ceiling of one room and covered or coated as at 29 for the floor of the room next above. Obviously, a single grading or character of material can be employed throughout the entire floor or wall or any sequence of coarse or fine grading can be built in in any number of layers or strata. Where reinforcing is desired, the reinforcing rod 30, or other reinforcing element, is desirably first covered with a coating 31 of cement grout or the like, which coating will serve substantially after the manner of the cementing coating on the individual aggregate particles, and the thus coated reinforcing member is then embedded in one of the concrete strata. In construction, the surface stratum, as at 22, is advantageously of such aggregate material that nails or other fastenings 32 can be driven or otherwise penetrated thereinto as for holding a molding 33 or trim or any other desired part.

In the embodiment illustrated in Fig. 7, the stratum 34 can be made up of ordinary concrete material, and can have a contiguous and substantially co-extensive stratum 35 of porous concrete construction formed upon or associated therewith.

As stated, the aggregate particles can be of any desired and suitable material and I have found that some granular materials, as for example pumic, heretofore little used for building purposes can be employed in carrying out my invention since the granular pumice or like aggregate particles are light in weight and possess excellent heat and sound insulation properties. While granular pumice and the softer aggregate particles will not bear so great crushing load as gravel or stone aggregate particles, their strength is ordinarily sufficient for residence and other building construction of the porous type, and it will be appreciated that the softer aggregates will lend to more ready penetration of the porous wall by nails or other fastenings.

In actual practice, it has been found that a reduction and saving in the direct cost of materials can be accomplished up to as high as twenty-five to fifty per cent as compared with the cost of conventional concrete construction, and it has been found that aggregate materials ordinarily available to construction jobs can be employed. In this connection, it is feasible to use a wide range of sizes of gravel and sand in building construction, by screening or grading the material from the gravel pit or run of the pit, into different sizes. The medium coarse sand or aggregate particles will perhaps be used where nailing concrete is desired and the coarser gravel or particles where only higher strengths are important, but usually the large mass of any structure is adaptable to any size which may be in excess in a given supply of material, and even the finer sands can be used for finishing plaster or stucco or surface coating or treatment.

This construction and method are particularly well suited for dams for water control, for flood control work, for soil erosion treatment, and for other purposes, since the porous material can be built up or erected in the desired form and can then be made substantially impervious by surface coating or by filling the voids in part or in whole. Thus, a dam or other water control structure can be conveniently and economically erected due to the economy of material which allows large and broad foundation or footing or supporting base structures with excellent drainage for any percolating water and then the structure can be rendered water-tight by coating the water contact face with material such as cement plaster, thus preventing passage of water and at the same time guarding against internal pressures or uplift pressures within the completed structure or in the footings or foundations therefor.

In large concrete structures the chemical heat usually causes differential expansion of the mass which develops cracking as the outside cools more rapidly than the interior, probably due to more ready dissipation of the heat at the surface. By building first a porous skeleton structure with the voids therethrough, water or air or other cooling liquid or fluid can be flowed through the structure and through the cellular pores or voids, whereby the structure is cooled uniformly and rapidly, thus avoiding the danger of uneven shrinkage or contraction with resultant cracks. After cooling and hardening and proper setting, the pores or voids or interstices may be filled with cement grout or other cementing or filling material which is readily applied upon the surface or is penetrated into the spaces or voids, and the coolness of the original porous or skeleton structure and the resulting strength of the hardened skeleton together with the smaller volume of fresh cement to generate heat due to chemical action will prevent in large part, if not completely, the usual cracking of monolithic concrete structures of considerable volume and size.

Obviously, any structure made up in accordance with my invention can be treated or altered by having any suitable cementing or filling material applied upon the surface or to the interior structure to close and fill the voids in any part or in the entire structure.

In the construction of cesspools this porous concrete material is ideal, as it provides a cheap material and a large area of water dissipation, together with ample strength for withstanding soil pressure of the surrounding earth. It has been found that as much as a barrel of water per minute will flow through a square foot of one and one-half inch wall constructed according to my invention, and obviously the material thus adapts itself well for seepage of water or liquid.

Another advantage inherent in this porous concrete and structures made therefrom is that such construction is well adapted for cushion concrete as in the roofs of power houses or other buildings where there is danger of falling rock masses or other material from adjacent canyon walls or from blasting in quarries, or material from other sources. Here the yielding strength of the porous concrete will absorb and gradually bring the crushing momentum of the falling body to rest without the high concentration of impact that would shock and rupture rigid and unyielding types of construction. The required strength can be provided by proper proportioning of the cementing material and the aggregate.

While I have herein shown and described only certain specific embodiments of my invention and have suggested only certain possible modifications in materials and the manner of carrying out the construction and the method, it will be appreciated that many changes and variations can be made from the present specific disclosures, to suit different and various conditions encoun-

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tered in use, without departing from the spirit and scope of my invention.

I claim:

1. The method of producing porous concrete structures comprising first coating a plurality of aggregate particles individually with a film of chemically hardenable cementing material, placing the coated aggregates in a desired form, manipulating the material to bring adjacent portions of juxtapositioned particles into direct bearing contact by displacing the coating from between said contacting portions to accumulate around the contacting portions without appreciably filling the voids between the aggregate particles, and permitting the cementing material to harden by chemical action and unite the coated aggregate particles into a rigid porous structure.

2. The method of producing porous concrete structures comprising coating aggregate particles by agitation with a thin flowable surface covering of chemically hardenable cementing material, placing and manipulating said coated particles from a desired form with sufficient pressure to flow the coating material in between adjacent portions of juxtapositioned aggregate particles whereby the adjacent portions are in substantially direct bearing contact and the displaced cementing material is accumulated around the contacting bearing portions without appreciably filling voids between the coated particles, and permitting the cementing material to chemically harden.

3. The method of producing cellular rigid structural material which comprises the steps of coating a plurality of substantially non-compressible structural units of irregular shape individually with a flowable film of chemically hardenable bonding material, and placing the units in a desired form with sufficient pressure to flow the bonding material from between adjacent portions of juxtapositioned units whereby the units have substantially contacting areas surrounded by the bonding material but still leaving voids between the units.

4. A porous concrete construction comprising a plurality of individual substantially non-compressible units of somewhat irregular shape in juxtaposition, and a chemically hardened bonding material coating the units and expressed from between immediately adjacent portions of the units leaving the units in direct bearing contact and uniting said units by accumulation of the bonding material around contiguous areas of the units substantially after the manner of a meniscus and leaving spaces between the units unfilled.

5. In building construction the use of aggregate particles joined together by chemically hardened hydrated cement mortar with contiguous faces of the particles contacting and the mortar material accumulated around the contacting portions so as to leave air spaces between adjacent particles.

6. A porous concrete construction comprising a plurality of aggregate particles placed with adjacent portions in intimate and substantially direct bearing contact and cemented together by a film of silicious cementitious hydrate material accumulated around the contacting portions substantially after the manner of a meniscus and leaving open spaces between the individual particles thus forming a porous mass which is comparatively free from shrinkage and volume changes due to curing and changes in moisture content.

7. The method of producing cellular rigid structural material which comprises coating aggregate particles of substantially non-compressible material with a flowable film of chemically hydrating cementing medium, placing the units in desired form and exerting pressure to bring adjacent surfaces of juxtapositioned aggregate particles into direct bearing contact thus squeezing out the bonding material into an enlarged joint of contact around the contacting portions of the aggregate particles, and allowing the cementing medium to chemically harden in such position.

8. A porous concrete structure comprising a plurality of aggregate particles of substantially noncompressible material and of somewhat irregular shape in juxtaposition and a chemically hardened cementing medium coating said particles except between actual contacting bearing portions thereof and consequently squeezed out into an enlarged joint of contact around such contacting bearing portions of the aggregate particles.

9. The method of building construction comprising coating a plurality of aggregate particles with a flowable chemically hardenable cementing medium, placing said coated particles in desired form and manipulating the same to bring adjacent portions of juxtapositioned particles into direct bearing contact one with the other and thus squeezing out the cementing medium into an enlarged joint around said portions of direct bearing contact, allowing the cementing material to harden thus leaving cellular pores through the hardened mass, and filling the pores in desired areas of the hardened cellular mass with a hardenable filling material.

10. A porous concrete construction comprising a plurality of substantially non-compressible aggregate particles of somewhat irregular shape in juxtaposition, and a Portland cement bonding material coating the particles and expressed from between immediately adjacent particles in direct bearing contact and uniting said particles by accumulation of the Portland cement around contiguous areas of the particles and leaving spaces between the particles unfilled.

11. The method of producing cellular rigid concrete material which comprises the steps of coating a plurality of substantially non-compressible aggregate particles individually with a flowable coating of Portland cement, assembling the coated aggregate particles in a desired shape with sufficient pressure to flow the coating of Portland cement from between adjacent particles of juxtapositioned aggregate particles whereby the particles have contacting areas with adjacent particles and with the Portland cement coating displaced from between the contacting areas accumulated around such areas and still leaving voids between the particles, and allowing the Portland cement binding material to chemically harden and bind the particles rigidly in position.

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