April 6, 1943. J. M. CROM 2,315,894

CONCRETE CONSTRUCTION

Filed Oct. 16, 1940 2 Sheets-Sheet 1

Fig. 1.

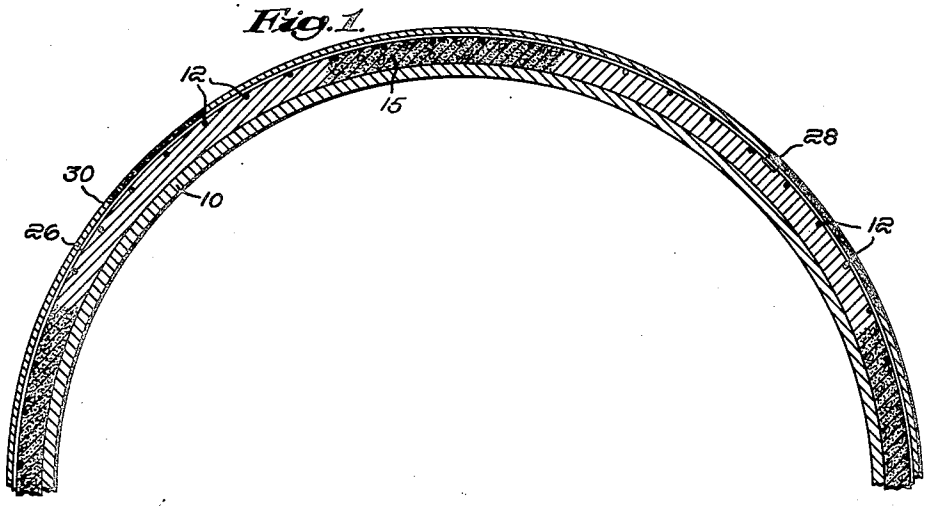


Fig. 2.

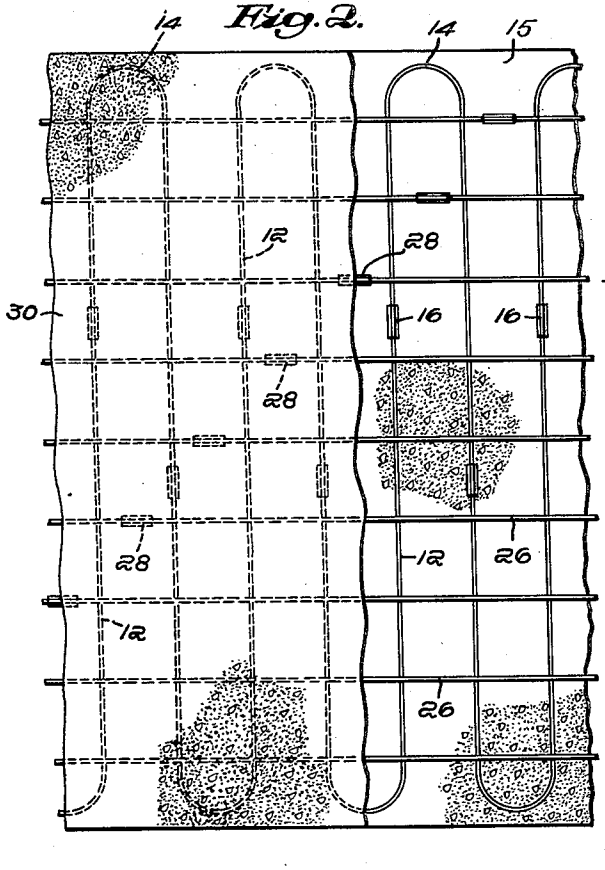


Fig. 3.

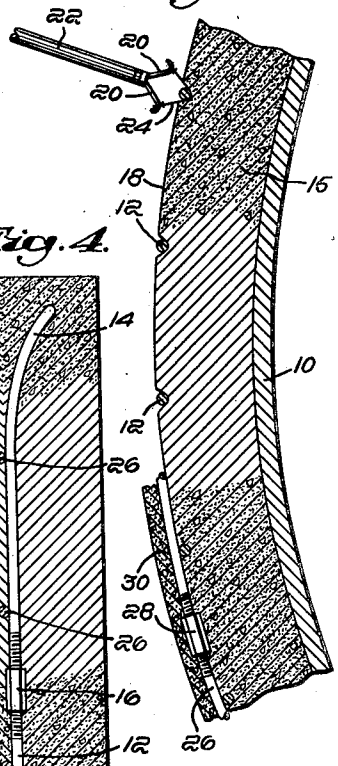


Fig. 4.

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Filed Oct. 16, 1940 2 Sheets-Sheet 2

Fig. 5.

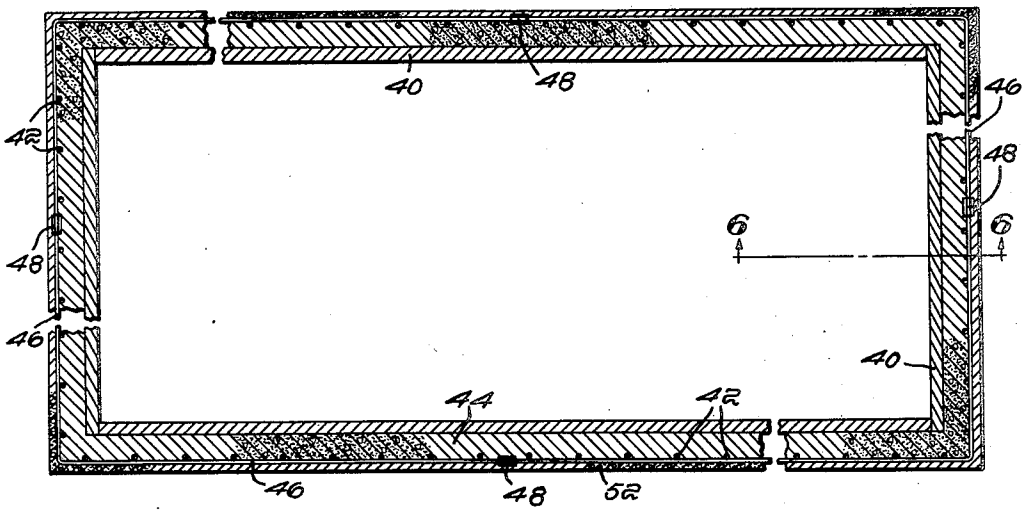


Fig. 6.

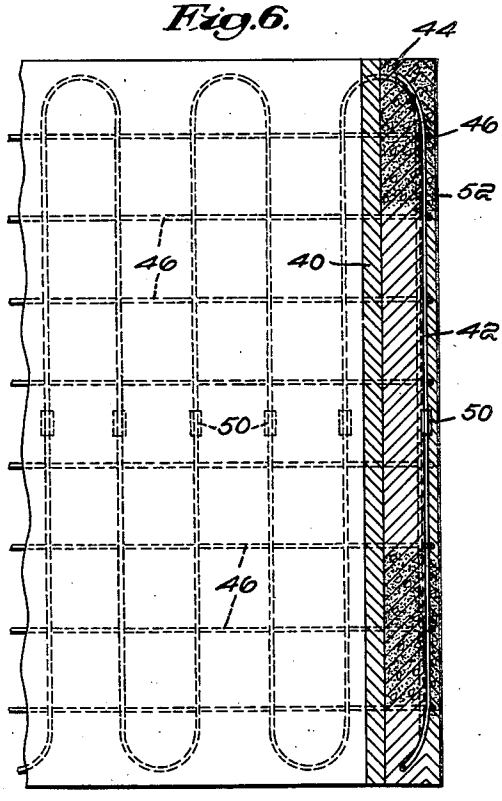
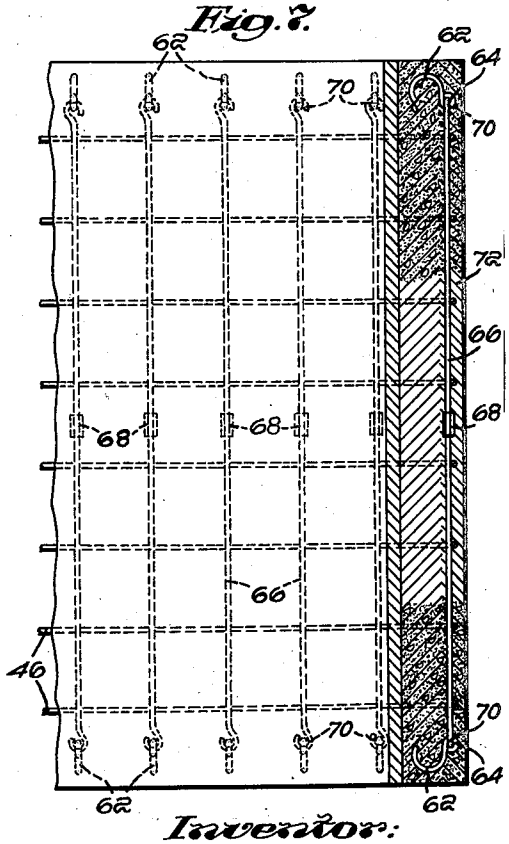


Fig. 7.



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UNITED STATES PATENT OFFICE

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CONCRETE CONSTRUCTION

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Application October 16, 1940, Serial No. 361,404

19 Claims. (Cl. 72—13)

This invention relates to concrete construction and more particularly to such construction held under a predetermined compression by steel reinforcement therein serving to hold the concrete from expanding to the point where tension occurs, since concrete will crack when under tension unless the tension is extremely small while it will not crack when kept in compression unless the compression is extremely large. Concrete is capable of withstanding without cracking relatively large compression stresses but it will crack under relatively small tensile stresses. Steel will withstand relatively large tensile stresses. In this invention steel reinforcement has been combined with concrete to keep the steel always in tension and to keep the concrete always in compression, in accordance with a "preloading" system whereby the steel has been stressed or tightened after setting and shrinking of the concrete. Sufficient tensile stress is applied to the steel so that the concrete remains in compression even after the concrete has entirely shrunk from setting and after the full working load has been applied to the structure. The primary object of my invention resides in certain improvements in concrete construction of this nature.

Concrete construction, such as tanks, flumes, pipes, conduits, etc., is largely used for storing and transferring liquids and one object of the above described construction has been to limit or prevent any cracking in the concrete so as to avoid leakage. My invention accomplishes this in a novel manner by keeping the concrete at all times in compression and the steel at all times in tension by "preloading" the steel during construction both horizontally and vertically thus eliminating cracking in either direction.

My invention is applicable to the formation of plane or curved structures and one feature thereof relates to such placing of the reinforcing rods relative to the form that the intermediate portions of the rods serve as screeding guides. The end portions thereof are arranged to bond into the concrete adjacent to opposite edges of the structure while, in accordance with my invention, the intermediate portions are not permitted thus to bond and, when the concrete has set, the rods are stressed at their exposed intermediate portions thereby placing the concrete under compression. These portions are then covered with cementitious material bonded thereto and to the first placed concrete. The production of this novel construction wherein the concrete is placed in compression in the direction of the rods and the rods under stress are bonded directly to the formed structure, all as hereinafter more fully described, comprises another object of the invention.

While some constructions require a compression of the concrete in one direction only, others require such compression in relatively transverse directions, and a further feature of my invention relates to the compressing of concrete in both directions transversely to each other. The invention furthermore includes a novel method of preventing or breaking the bonding of the original concrete to the rods before the rods have been stressed, and other features hereinafter more specifically described.

These and other features of the invention will be best understood and appreciated from the following description of preferred embodiments thereof selected for purposes of illustration and shown in the accompanying drawings in which,

Fig. 1 is a fragmentary horizontal sectional view through a cylindrical tank constructed in accordance with my invention,

Fig. 2 is a fragmentary side elevation thereof with an outer portion broken away,

Fig. 3 is an enlarged fragmentary plan section showing the construction of the tank,

Fig. 4 is a fragmentary vertical sectional view through the tank,

Fig. 5 is a horizontal sectional view through a rectangular tank constructed in accordance with my invention,

Fig. 6 is a view taken on line 6—6 of Fig. 5, and

Fig. 7 is a like view of a modified construction.

In Figs. 1–4 of the drawings I have illustrated the construction of a cylindrical tank held under compression by reinforcement within the concrete comprising the tank wall. In constructing the tank, a cylindrical form 10 of wood or steel of the desired dimensions is first erected and steel reinforcement 12 is then set up at a fixed spacing from the outer face of the form. This reinforcement comprises relatively spaced and vertical rods and may be formed by looping rod stock into substantially parallel and vertical reaches, the loops 14 being located adjacent to the top and bottom of the form and being bent inwardly toward the form as illustrated in Fig. 4. Each reach is also provided with a turnbuckle 16 or its equivalent threaded to adjacent ends of the rod.

When the form 10 and rods 12 are placed, compressed air applied concrete, commonly known as gunite, is shot onto the form to a depth substantially flush with the rods, the loops 14 being substantially buried within the concrete. This con-

crete 15 is then screeded to the uniform surface level illustrated at 18 in Fig. 3 by using the rods as a guide. Bonding of the concrete to the intermediate portions of the rods between the loops 14 can be prevented in various ways, as by breaking the initial bond before the concrete has fully set. This can be done by jarring the rods with a hammer after the initial set but I prefer to employ the tool illustrated in Fig. 3. This tool comprises bifurcations 20 carried by a handle 22 and adapted to support a loop 24 of fine wire. The loop is passed around the rod and is then moved along the rod in a manner cutting away any initial bonding of the concrete therewith.

After the bond has been broken from the rods 12, relatively spaced reinforcing rods 26 are placed circumferentially about the construction over the rods 12, each rod 26 being provided with one or more turnbuckles 28. When the concrete has fully set, all turnbuckles 16 and 26 are tightened to place the concrete 15 under compression vertically and horizontally. A substantial layer 30 of concrete is then applied to the outer face of the set and compressed concrete and to the rods in a manner and to a depth completely covering the same and bonding all into a unit, the concrete 30 being non-compressed. While this step as well as the application of the concrete to the form 10 is most conveniently and preferably performed by the shooting of gunite onto the structure, it will be understood that the broad aspects of the invention are by no means limited thereto.

It will be apparent that the completed tank as thus constructed is under compression both vertically and horizontally or radially. When the tank is filled with water or other liquid the outward pressure thereof will be taken by the reinforcement, all of which is under tension holding the tank in compression. In other words, the tank is preloaded with a compression sufficient to prevent tension coming into the concrete even with the full liquid load in the tank. Under normal conditions and as long as the rods remain sufficiently tensioned, the concrete wall cannot expand into a condition of tension or crack under load. Concrete is substantially inelastic and it is well known that when expansion takes place the break comes at the weakest point or points. Thus, under concrete construction heretofore known where there is no bond between rods and concrete, the concrete is free to slide along the rods, with the result that substantial expansion will cause one or more relatively large cracks to develop and permit substantial leakage. However, this cannot occur in my improved construction since the rods are bonded directly to the concrete or gunite which has been placed over them after they have been stressed or tightened, and thus the bonded-in rods prevent the concrete any sliding freedom along the rods which might cause large concentrated cracks, instead, any otherwise large cracks which might develop become evenly distributed along the rods as numerous minute cracks too small to permit leakage. My invention, therefore, eliminates this serious defect and its practical value in tanks and other concrete construction will be readily apparent.

In Figs. 5 and 6, I have illustrated the application of my invention to a rectangular tank. In this case a form 40 of the desired rectangular size is first constructed and vertical reinforcement 42 like the reinforcement 12 is set up in spaced relation to the outer face of the form. The concrete 44 is then applied preferably by guniting. The concrete is thereafter screeded on the rods 42 and the bond is broken from the rods, all as heretofore described in reference to Figs. 1–4.

Reinforcement 46 is then applied to and about the tank over and in contact with the rods 42. This reinforcement as illustrated comprises angular reinforcing rods embracing the corners of the structure, extending along the adjacent sides and connected together at their ends by turnbuckles 48. The rods are thereafter stressed by rotating the turnbuckles 48 and 50 whereby placing the tank under compression vertically and horizontally, care being exercised as to rotate the several turnbuckles 48 as to keep the angular rods 46 properly located at the corners, or the rods can be rounded at the corners to maintain uniform stress therealong or they can be bonded into the concrete at the corners if desired. The outer layer 52 of concrete is then applied to cover and bond to the reinforcement and the set concrete, all as above described. The resulting tank and its advantages are substantially the same as has been described in reference to Figs. 1–4.

I desire it to be understood that I have herein specifically described and illustrated the application of my invention to the construction of tanks and the use of gunite as by way of example only, the invention being likewise applicable to concrete pipes of cylindrical or like construction, plane concrete structures, the pouring of concrete, application of mortar by hand, etc. It will also be apparent that such terms as "vertical" and "horizontal" as are applied to the tank construction illustrated is thus applied for purposes of description and not for purposes of limitation. The invention is furthermore adapted to various other modifications both functionally and structurally, and in Fig. 7 I have illustrated one such modification. This construction is the same as illustrated in Figs. 5 and 6 except that the vertical reinforcement comprises independent rod structures.

In Fig. 7, the form 60 is constructed and relatively spaced portions of reinforcement, in the form of pairs of hooks 62 each having an eye 64, are mounted in relatively spaced relation along the top and bottom of the form. Gunite is then shot onto the form to a depth enveloping the hooks but leaving the eyes 64 projecting outwardly therefrom. After the concrete has set, each pair of eyes 64 is connected by reinforcement rod sections 66 each embodying a turnbuckle 68 and having hooks 70 at its ends for engaging the eyes 64. The outer reinforcement 46 is then applied, all turnbuckles are tightened, and the covering and bonding layer 72 of concrete is shot into place. The construction and resulting advantages are broadly the same as has already been described.

Having thus described my invention what I claim as new and desire to secure by Letters Patent of the United States is:

1. A method of constructing reinforced concrete under compression which consists in forming a body of concrete in enveloping and bonding engagement with relatively spaced portions of reinforcement, placing the concrete under compression between said spaced portions by tensioning said portions toward each other after the concrete has set, and while the reinforcement between said portions is free of bonding engagement with the concrete and thereafter covering the exposed reinforcement between and connecting said spaced portions with concrete in bonding engagement therewith and with the first-named concrete.

2. A method of reinforcing concrete under compression which consists in providing relatively spaced reinforcing rods anchored in and to the concrete at their ends but free from bonding engagement with the concrete intermediately of such ends, tensioning the rods intermediately of said ends while thus free from bonding engagement whereby placing the concrete under compression, and covering the tensioned rods with concrete in bonding engagement with the rods and the first-named concrete.

3. A method of reinforcing concrete under compression in two directions which consists in providing relatively spaced reinforcing rods anchored in and to the concrete at their ends but free from bonding engagement with the concrete intermediately of such ends, providing other reinforcing rods over and extending transversely of the first-named rods and free from bonding engagement with the concrete, tensioning the rods while thus free from bonding engagement whereby placing the concrete under compression, and covering the tensioned rods with concrete in bonding engagement with the tensioned rods and the first-named concrete.

4. A method of reinforcing concrete under compression in two directions which consists in providing two sets of relatively spaced reinforcing rods extending across the concrete adjacent to one face and free from bonding engagement with the concrete along substantial portions of their lengths, the rods of one set extending transversely of the rods of the other set, tensioning said free portions of the rods while thus free from bonding engagement whereby placing the concrete under compression in two directions, and covering the tensioned rods with concrete in bonding engagement with the rods and the first-named concrete.

5. A method of constructing reinforced concrete under compression which consists in forming a body of concrete in conjunction with rod reinforcement, breaking the bond between the concrete and a portion of the reinforcement before the concrete has fully set while leaving other portions of the reinforcement in bonding engagement with the concrete, tensioning the reinforcement at the non-bonded portion thereof after the concrete has set, and covering the non-bonded and tensioned portion of the reinforcement with concrete in bonding engagement therewith and with the first-named concrete.

6. A method of reinforcing concrete under compression which consists in providing relatively spaced reinforcing rods, forming concrete construction adjacent to and embracing the rods, breaking the bond between the concrete and intermediate portions of the rods before the concrete has fully set by advancing along each of the rods a fine strand looped around the rod, tensioning said portions of the rods, after the concrete has set and covering the tensioned rods with concrete in bonding engagement with said portions and the first-named concrete.

7. A method of making reinforced concrete structures which consists in providing a form and a plurality of relatively spaced reinforcing rods adjacent to but spaced from one face of the form, placing concrete against the form and in bonding engagement with the end portions of the rods, preventing permanent bonding of the concrete to the intermediate portions of the rods, tensioning the intermediate portions of the rods after the concrete has set whereby placing the concrete under compression, and placing additional concrete over and bonded to the first-named concrete and the intermediate portions of the rods.

8. A method of making reinforced concrete structures which consists in providing a form and a plurality of relatively spaced reinforcing rods adjacent to but spaced from one face of the form, placing concrete against the form to a depth wherein its outer face is substantially flush with the rods, screeding the concrete by using the rods as a guide, breaking the bond between the concrete and the intermediate portions of the rods before the concrete has fully set, tensioning the rods at their intermediate portions, after the concrete has set and covering the tensioned rods with concrete in bonding engagement with the rods and the first-named concrete.

9. A method of constructing reinforced concrete structures which consists in providing a form, looping rod stock in substantially parallel reaches across and adjacent to one face of the form, adjacent reaches of the stock being connected together at their ends adjacent to opposite edges of the form, placing concrete against the form and in bonding engagement with the connecting end portions of the reaches, preventing permanent bonding of the concrete to the reaches intermediately of said ends, tensioning the reaches after the concrete has set whereby placing the concrete under compression, and placing additional concrete over and bonded to the first-named concrete and the tensioned reaches.

10. A method of making reinforced concrete structures which consists in providing a form and relatively spaced reinforcements adjacent to one face of the form, placing concrete against the form and in bonding engagement with the reinforcements, providing reinforcement connecting the relatively spaced reinforcements but not bonded to the concrete, tensioning the connecting reinforcement after the concrete has set whereby placing the concrete under compression, and placing additional concrete over and bonded to the first-named concrete and the connecting and tensioned reinforcement.

11. A method of reinforcing concrete tanks and the like under compression vertically and horizontally which consists in providing a plurality of reinforcing rods extending vertically of the tank and anchored thereto at their ends adjacent to the top and bottom of the tank but having the intermediate portions thereof free from bonding engagement with the concrete, providing a plurality of reinforcing rods extending about the tank and superposed over the first named rods, tensioning the rods after the concrete has set to place the concrete in compression vertically and horizontally, and covering the tensioned rods with concrete in bonding engagement with the rods and the first-named concrete.

12. A method of making reinforced concrete tanks and the like which consists in providing a horizontally endless form and relatively spaced reinforcing rods adjacent to but spaced from the outer face of the form and extending vertically thereof, placing concrete against the form and in bonding engagement with the end portions of the rods, preventing permanent bonding of the concrete to the intermediate portions of the rods, tensioning the rods at their intermediate portions after the concrete has set whereby placing the concrete under compression vertically, and placing additional concrete over and bonded

to the first-named concrete and the intermediate portions of the rods.

13. A method of making reinforced concrete tanks and the like which consists in providing a horizontally endless form and relatively spaced reinforcing rods adjacent to but spaced from the outer face of the form and extending vertically thereof, placing concrete against the form and in bonding engagement with the end portions of the rods, preventing permanent bonding of the concrete to the intermediate portions of the rods, placing a plurality of reinforcing rods around and superposed over the first-named rods, tensioning the rods to place the concrete in compression vertically and horizontally after the concrete has set, and placing additional concrete over and bonded to the first-named concrete and the exposed portions of the rods.

14. Concrete construction comprising a monolithic slab of concrete having reinforcing rods anchored therein and thereto at relatively spaced portions therealong and having the intermediate portions thereof tensioned in a manner holding the intermediate concrete under compression, and other non-compressed concrete covering and bonded to the tensioned rods and to the adjacent compressed concrete.

15. Concrete construction comprising a monolithic slab of concrete having reinforcing rods bonded therein and thereto at their ends, the intermediate portions of the rods being located adjacent to one face of the slab and being tensioned in a manner holding the intermediate concrete under compression, and a layer of non-compressed cementitious material covering the intermediate portions of the rods and bonded thereto and to the slab.

16. Concrete construction comprising a concrete structure having reinforcing rods anchored therein and thereto at their ends, and other reinforcing rods adjacent to and extending transversely of the first named rods, the rods being tensioned in a manner holding the concrete under compression in two directions, and other non-compressed concrete covering and bonded to the tensioned rods and to the adjacent compressed concrete.

17. Concrete construction comprising a polygonal body of concrete, angular reinforcing rods embracing the corners thereof and extending along the adjacent sides, and turnbuckles at the sides connecting the adjacent ends of the rods extending from the two adjacent corners, the turnbuckles and rods being in tension holding in compression the concrete body embraced thereby, and other non-compressed concrete covering and bonded to the tensioned rods and turnbuckles and to the adjacent compressed concrete.

18. Concrete construction comprising a cylindrical body of concrete, reinforcing rods extending longitudinally of the cylindrical body and anchored therein and thereto at relatively spaced portions therealong, other reinforcing rods adjacent to the first-named rods and extending around the body, the first and second-named rods being tensioned in a manner holding the body under compression longitudinally and transversely, and other non-compressed concrete covering and bonded to the tensioned rods and to the adjacent compressed concrete.

19. A method of making reinforced concrete structures under compression which consists in providing a form and relatively spaced reinforcing rods adjacent to but spaced from one face of the form, placing concrete against the form to a depth wherein its outer face is substantially flush with the rods, screeding the concrete by using the rods as a guide, preventing the permanent bonding of the concrete to relatively long portions of the rods, placing relatively spaced reinforcing rods over and transversely of the first-named rods, tensioning the rods to place the concrete in compression in two relatively transverse directions, and placing additional concrete over and bonded to the first-named concrete and the exposed portions of the rods.

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