Nov. 22, 1966 W. E. RADFORD 3,286,418

PRESTRESSED COMPOSITE LOAD-BEARING SLAB

Filed Aug. 14, 1962

FIG. 1.

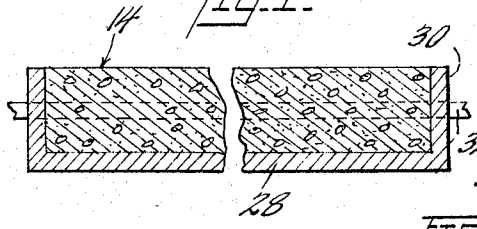


FIG. 2.

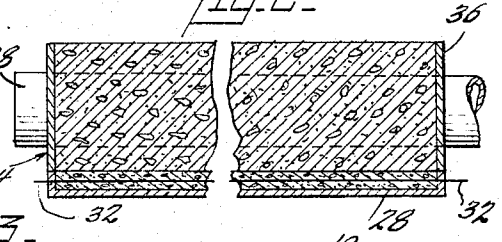


FIG. 3.

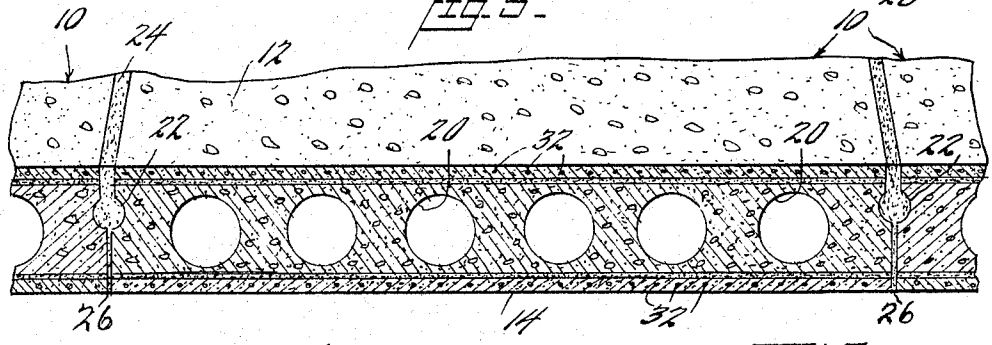


FIG. 4.

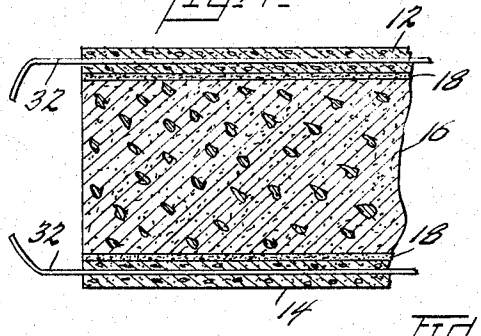


FIG. 5.

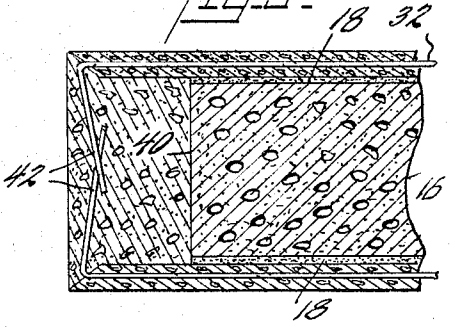
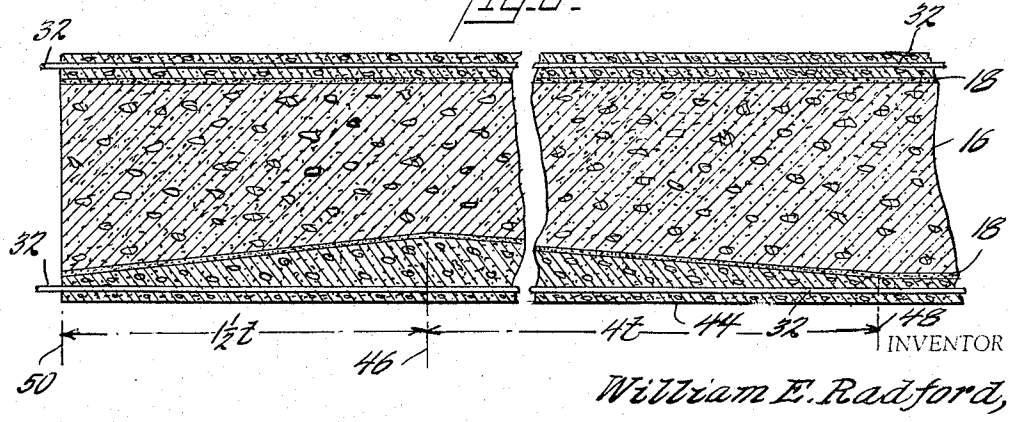


FIG. 6.



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PRESTRESSED COMPOSITE LOAD-BEARING SLAB

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3 Claims. (Cl. 52—223)

This invention relates to a composite load-bearing slab constructed essentially of reinforced concrete. It is suitable for manufacture in standard sizes for use in residential construction as well as commercial-type construction, which latter has heretofore been the only type justifying the use of building components of this general character.

Heretofore, it has been proposed to reduce the weight of concrete slabs cast of ordinary, dense concrete by creating longitudinal voids extending along the neutral axis of the slab. These voids were formed in the slabs by placing in the casting forms, inflated tubes which, after the concrete has set, could be deflated and thereby removed.

Attempts have been made to use slabs of light weight concrete with metallic reinforcement, sometimes of complex and extensive nature but it has been observed that these have not been found to be practical, save over short spans and limited loads or alternatively, their thickness has materially exceeded slabs cast of conventional, dense concrete, suitable under the same conditions.

It has also been proposed to employ a slab formed of two outer faces of dense concrete and a central core of light weight concrete, the successive layers being poured wet, one upon the other, whereby the interfaces between the layers are destroyed or substantially blurred. Such material may be longitudinally cored and provided with metallic reinforcement.

It is the purpose of this invention to provide composite concrete slabs capable of being made in such small dimensions as to find extensive use in non-commercial construction at competitive prices. Such slabs are intended to weigh substantially less than half the weight of conventional, dense concrete of comparable dimensions while demonstrating higher strength and greater rigidity than the heretofore known slabs of comparable weight and dimensions.

These objectives are attained by the formation of a composite, layered construction including a pair of face members and a light weight, thick core. The face members are relatively thin and provided with pre-stressed reinforcing members. By firmly bonding the face members to the core over substantially the entire area of contact, it is possible to cause the face members to assume substantially all of the flexural stresses provided that the mechanical properties of the face and core materials are in satisfactory relationship. I have found that this relationship is especially satisfactory when face members are made from dense, high strength concrete and the core is made from light weight concrete. The prestressed face members will successfully sustain tensile stresses equal to the capacity to sustain compressive stresses, whereas in a face member made from ordinary dense concrete, the tensile capacity is of the order of one-tenth the compressive capacity.

For a clearer understanding of the invention, reference is made to the accompanying drawings wherein:

FIGURE 1 shows a step in the formation of a part of the invention, in vertical section and to an enlarged scale.

FIGURE 2 shows a succeeding step, also in vertical section but to a much reduced scale;

FIGURE 3 shows a preferred modification of the invention in completed form, partly in perspective but primarily in vertical section; and

FIGURES 4, 5 and 6 are partial vertical sections of modifications of the invention.

The section in FIGURE 3 is taken at right angles to the sections taken in each of the other figures.

Referring now generally to the drawing, each slab **10** is made up of a top face member **12**, a bottom face member **14** and a central core **16**. The face elements **12** and **14** are united to the core by a thin, substantially continuous cement mortar bond **18**.

As viewed in FIGURE 3, where the cross section cuts at right angles to the long dimension of the slab, a number of tubular, weight-saving voids **20**, extend the length of the core of the slab. These voids may constitute as much as 40% of the total volume of the slab without substantially diminishing the flexural utility of the slab. It is also obvious that such voids are useful for housing pipe and wire for supplying essential services to the building. In a preferred embodiment, the slabs may be from seven to ten feet long, just under two feet wide and 3¾ inches thick. The external faces will be ⅜ inch thick leaving three inches for the core and adhesive layer.

Normally, the top face **12** is formed ¼ to ½ inch less wide than the lower face **14** and a semi-circular channel **22** is formed in the core **16**. In the recommended usage, the ends are set on a bed of cement mortar when the supports are of a masonry material. Each end should have support equal to at least one-half of the slab thickness. It is preferred to cement the adjoining slabs at **26** with a thin layer of organic cement, such as that sold under the name "Threadline Mortar". The resulting channel in the upper joints at **24** may be filled with a nailable concrete made of one part cement and four parts expanded perlite. If the slabs are to be exposed to the weather, the filling **24** should be recessed to allow at least 1/16 inch of caulking to be applied flush with the face **12**.

The preferred method of constructing a slab will now be set out. A shallow mold **28** is provided, two feet wide, ten feet long and ⅜ inch deep. Through the end walls **30**, wires **32** are stretched, centered as to depth. For the bottom slab face element **14**, twenty-four wires, 16 gauge, may be employed spaced on one inch centers, with the outermost wires ½ inch from the edges. By means not shown in FIGURE 1 a tension of about 330 pounds is applied to each wire.

Into the mold is cast a concrete mixture prepared from 100 pounds clean sharp sand, 42 pounds type III–A Portland cement, 35 pounds hard silica gravel and 19 pounds of water. The particle size of the gravel was such that all would pass through a ¼ inch mesh screen. A vibrating screen was used to compact the concrete and to strike it off level with the top surface of the form. The exposed face of the concrete was slightly roughened by brushing lightly with a stiff brush. The resultant cast concrete was allowed to acquire an initial set by standing for about two hours at an ambient temperature of 80° F. The purpose of this is to prevent any mixing of light weight concrete with the dense concrete of the facing, since this would materially reduce the strength of the facing.

Referring now to FIGURE 2, which is on a smaller scale than FIGURE 1, a core mold **34** is placed upon the face mold **28**. The walls of the core mold coincide substantially with the walls of the face mold and may be three inches high in the preferred embodiment. Through the ends **36** of the core mold, the pipe cores **38** project. These pipes **38** form the void spaces **20** in the finished product. In the embodiment shown they are 2¼ inches in diameter, a total of six pipes being used for a 24 inch slab. In order to permit their withdrawal from the cast body, the pipes must be checked for straightness and have smoothly polished surfaces.

Just before the core form **34** is properly positioned,

the layer **14** is coated with adhesive mortar, shown in FIGURES 3 to 6 as reference numeral **18**. Due to the reduced scale of FIGURE 2, this is not shown as such in this figure. The mortar may be made by mixing equal parts by volume of Portland cement and sharp sand and adding water until the mortar has the consistency of thick cream. This mortar is spread to the thickness of approximately ⅛ inch, uniformally over the entire exposed, roughened face of the face element **14**. Next, light weight concrete is poured into the core form. Preferably, it is poured in about three batches, each portion being compacted in place before addition of the next batch. After the final batch, the body is leveled off flush with the upper margin of the core form.

The light weight concrete employed for this embodiment of the invention is made with an aggregate of expanded perlite such as that sold under the trade name "Permalite." The material used weighs approximately 6½ pounds per cubic foot and has a particle size distribution such that 99% will pass a #4 screen and 20% will pass a #8 screen. The concrete was made by mixing the following named ingredients in the proportions of perlite aggregate, 6½ pounds; III–A Portland cement 14 pounds and water 10½ pounds. Cured test specimens weighed 27 pounds per cubic foot and possessed a compressive strength of 130 pounds per square inch.

Meanwhile, there had been prepared a top face element **12**, in the same manner as the lower face element **14** but only twelve reinforcing wires were used. It had been cured for twenty-four hours in a moist environment; whereupon the reinforcing wires were cut with about two inches protruding from the ends of the cast facing. The facing was kept in moist condition until used. After the striking off of the light weight core, it was brushed lightly with adhesive cement mortar in the same manner as the bottom facing **14** and another coating about ⅛ inch thick was applied to the roughened surface of the moist top facing **12**. Thereupon, the adhesive coated face of facing **12** was placed upon the top face of the core **16** in such manner as to insure complete, even contact. Then weights were disposed over the exposed surface of facing **12** to insure such contact during curing.

After about three hours, sufficient to permit initial setting, the pipe cores **38** were withdrawn. The completed slab was allowed to remain at normal temperature in the mold for twenty-four hours. Then the ends of the reinforcing wires **32** in the facing **14** were cut to length, the forms removed and the slab transferred to a steam room to complete its cure. Live steam at about 160° F. was used for about eighteen hours.

Slabs made in accordance with the foregoing procedure weigh about 18 pounds per square foot. A slab ten feet long supported uniformly on masonry for a distance of 2½ inches at each end supported a uniformly distributed load of 1,600 pounds with a maximum deflection of 0.17 inch. When the load was reduced to 1,000 pounds; equivalent to 50 pounds per square foot, the deflection was 0.10 inch. This latter load was permitted to remain in place for an extended period of time, without the slab acquiring a permanent set. Other slabs seven feet long and constructed in the manner shown in FIGURE 5 have demonstrated an ability to carry uniformly distributed loads of up to 250 pounds per square foot.

As shown in FIGURE 4, the ends of the reinforcing wires **32** may be cut off several inches beyond the end of the slab **10**, leaving a sufficient portion to be secured to some portion of the building structure into which the slab is to be incorporated. If then, concrete or mortar is cast around such secured ends, the slabs will become an integral part of the building structure.

As shown in FIGURE 5, the end **40** of core **16** may be terminated at a distance about half to two-thirds of the thickness of the slab short of the end of the slab by the insertion of appropriate stop members in the mold. After initial curing of the slab, the ends **42** of the wire **32** are bent back into the open space at the end of the slab and the space is then filled with dense concrete of the same general type as used for the facings. If desired, the faces of the openings may be coated with cement mortar to insure complete bonding.

As indicated by the hatching of the core **16**, in place of the light weight aggregate used in the preferred example, porous concrete may be used. In the making of porous concrete, a stabilizing agent, such as that sold under the trade name "Elastizell" is used to produce a foam for admixture with concrete to produce a foamed concrete that maintains its stability until the concrete has set. Such foamed concretes may be produced to have densities and mechanical properties comparable to those obtained by the use of perlite or vermiculite aggregates.

For slabs heavily loaded as beams over short spans, resulting in high shear stresses near the supports, the construction of FIGURE 6 may be advantageous. In the previously described construction, each facing element has a thickness of about 1/10 the total slab thickness and, for convenience, is of uniform thickness throughout the width and length of the slab. In FIGURE 6, the bottom face **44** varies in thickness from about 1/10 the thickness of the slab at the end **50** to about ¼ the thickness of the slab at a point **46** spaced about 1½ times the thickness of the slab away from the end **50**. From the point **46**, the thickness diminishes back to about 1/10 the thickness of the slab at point **48** located about 5½ times the thickness, away from the end of the slab. The opposite end of the slab has the same general configuration. The position of the reinforcing wire is uniformly fixed with respect to the lower face of the element **44**.

Heretofore, unsatisfactory results have been reported in the use of galvanized wire for pre-stressing purposes. Apparently the stress carried by the wire has exerted sufficient force to break the bond between the concrete and the wire surface. I have found that finer gauge wires from size #14 have a large enough surface to cross-sectional area ratio to make the use of galvanized wire practical. Similarly, I have also found that copper plated steel wires of comparable gauge sizes are also suitable for pre-stressing; however, such wires are presently more costly than galvanized wires which offer equal protection against corrosion. I believe that some protective measure against corrosion is desirable since only a comparatively thin layer of concrete surrounds the reinforcing wires.

It is apparent that substantial variation in the size and proportions indicated as preferred may be made where conditions of usage are not identical with those indicated. These have been given solely for guidance in the understanding of the invention.

I claim:

1. A composite, load-bearing slab made up of a pair of strong, dense face elements and a core of low-density:
   each face element comprising a relatively thin, precast sheet of Portland cement concrete of load bearing quality, reinforced with prestressed wires extending between the areas of support of the slab; and
   a low-density core clearly differentiated from said faces, of sufficient thickness to space the face elements at optimal distance from the neutral axis of the slab;
   each of the faces of the core having adhesively cemented thereto one of the face elements, the line of adhesion being sharp and well-defined and of load-transferring quality, the areas of contact between the core and the face elements being substantially continuous over the entire portion in contact;
   wherein the thickness of the lower face element increases from a thickness of 1/10 the slab thickness, at the end, to about ¼ the slab thickness at a distance of 1½ times slab thickness from the end and then decreases to 1/10 the slab thickness at a distance of 5½ times slab thickness from the end.

2. A composite, load-bearing slab made up of a pair of strong, dense face elements and a core of low-density:

each face element comprising a relatively thin, precast sheet of Portland cement concrete of load bearing quality, reinforced with prestressed wires extending between the areas of support of the slab; and

a low-density core clearly differentiated from said faces, of sufficient thickness to space the face elements at optimal distance from the neutral axis of the slab;

each of the faces of the core having adhesively cemented thereto one of the face elements, the line of adhesion being sharp and well-defined and of load-transferring quality, the areas of contact between the core and the face elements being substantially continuous over the entire portion in contact;

wherein the ends of the slab to be supported are reinforced by substituting dense concrete for low-density concrete in the core inwardly of the ends a distance equal to about ½ the thickness of the slab.

3. A slab according to claim 2 wherein the ends of the prestressed wires are bent back at the ends thereof and embedded in the dense reinforcement.

References Cited by the Examiner

UNITED STATES PATENTS

2,299,070	10/1942	Rogers et al.	52—223
2,315,732	4/1943	Patch	52—612 X
2,522,116	9/1950	Hayes	52—612 X
2,611,945	9/1952	Simonsson et al.	52—727 X
2,850,890	9/1958	Rubenstein	52—612 X
2,908,157	10/1959	Bliss et al.	52—612 X
2,920,475	1/1960	Graham	52—432
2,992,131	7/1961	Bricknell et al.	52—727 X

FOREIGN PATENTS

121,386	5/1946	Australia.
498,386	1/1939	Great Britain.

OTHER REFERENCES

"Architectural Forum" of August 1953, pages 142 and 143.

"Journal of the American Concrete Institute" of April 1949, pages 582–586.

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