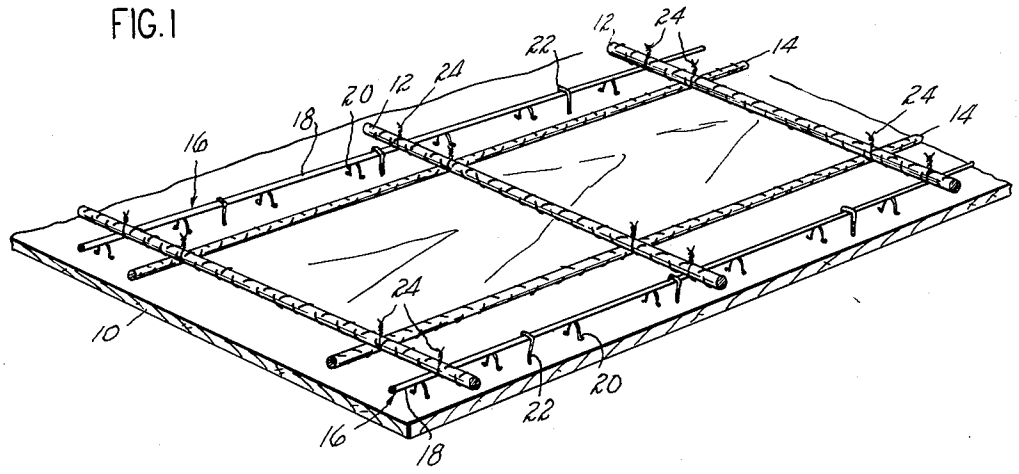
Oct. 26, 1965 A. J. MACCHI 3,213,581

CONCRETE FLOOR AND CEILING SLAB CONSTRUCTION

Filed Jan. 25, 1956 2 Sheets-Sheet 1

FIG. 1



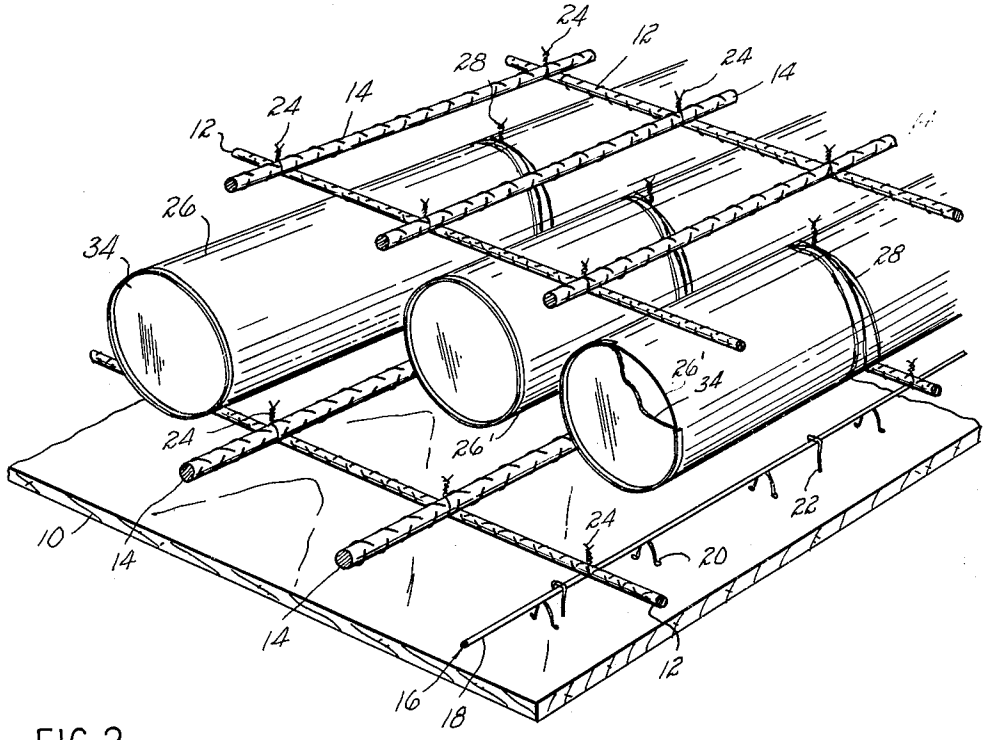


FIG. 2

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CONCRETE FLOOR AND CEILING SLAB CONSTRUCTION

Filed Jan. 25, 1956 2 Sheets-Sheet 2

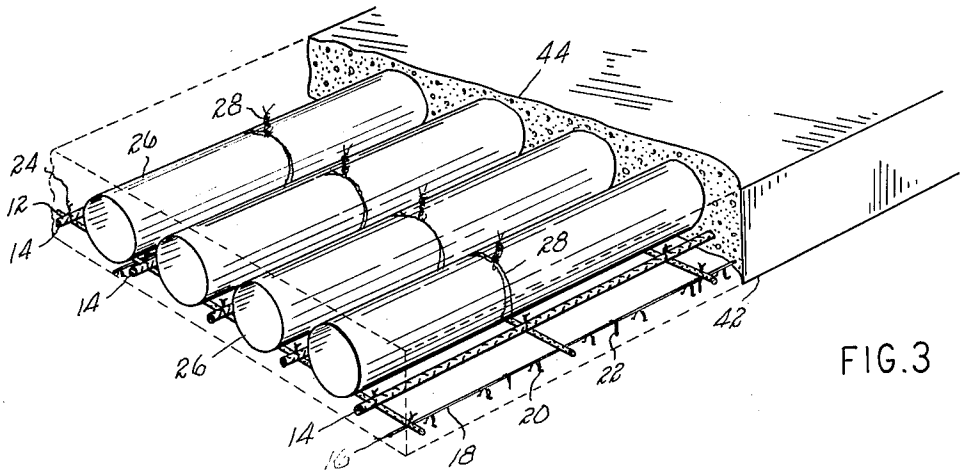


FIG.3

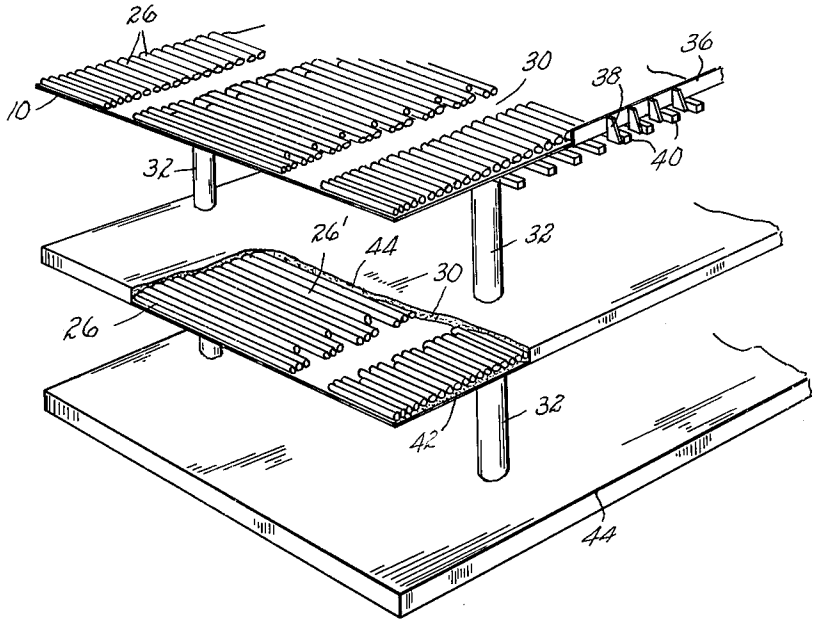


FIG.4

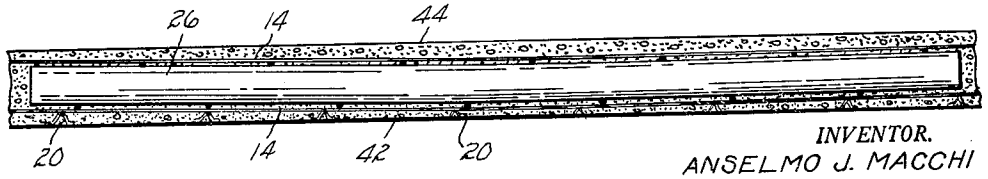


FIG.5

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3,213,581

CONCRETE FLOOR AND CEILING SLAB CONSTRUCTION

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Filed Jan. 25, 1956, Ser. No. 561,191
9 Claims. (Cl. 52—319)

The present invention relates to a reinforced concrete floor and ceiling construction affording an economy of materials and yet of calculable high strength and which is simple to construct, whereby improved concrete floors and ceilings of light weight, particularly for commercial buildings, schools and the like, may be provided at reduced cost. The present application is a continuation-in-part of my co-pending application, Serial No. 186,459 filed September 23, 1950 now abandoned.

It has been proposed heretofore to provide concrete slabs with hollow metallic reinforcing elements, which because of their shape will displace some of the concrete, but the cost of fabricating and installing such reinforcing elements far exceeds the advantages of strength or reduced weight gained, so that such expedients are of little value commercially. It also has been proposed to form voids in small structural units, such as concrete blocks, where the production of suitable moulds to form the voids is a relatively simple matter. However, prior to the present invention it has not been commercially feasible to form large slabs of concrete such as used in floor and ceiling constructions with regularly spaced voids so that unneeded concrete can be omitted and the remaining concrete is monolithic in structure and regularly spaced to provide a maximum calculable strength without external beams or similar supporting members, and wherein the calculated strength will closely approximate the actual strength.

The aim of the present invention is to provide a concrete floor and ceiling construction wherein the concrete is of monolithic form and reinforced, and wherein there is located a series of regular voids of predetermined arrangement such that the portion of the concrete structure which adds relatively little strength in comparison to its dead weight is omitted, and at the same time the remaining concrete is of uniform and regular configuration characterized by a flat floor surface, upon its upper side, a flat ceiling upon its underside, and regularly spaced joists therebetween, all in one integral structure. Included in this aim is the purpose of providing a slab of maximum strength and light weight whose strength may be calculated for design purpose with assurance that actual performance will conform to calculations. Also included in this aim is the provision of a structure which can be formed by ordinary skilled workmen with presently available equipment and wherein the cost of materials and labor costs are kept at a minimum so that the improved structure may be provided at reduced cost.

Other objects will be in part obvious, and in part pointed out more in detail hereinafter.

The invention accordingly consists in the features of construction, combination of elements and arrangement of parts which will be exemplified in the construction hereafter set forth and the scope of the application of which will be indicated in the appended claims.

In the drawings:

FIG. 1 is a fragmentary perspective view showing a temporary floor on which a network of reinforcing steel has been secured in spaced relationship;

FIG. 2 is a similar view showing a slightly different arrangement of the reinforcing steel shown in FIG. 1, and also including a series of paper tubes and an upper layet of crossed reinforcing steel;

FIG. 3 is a fragmentary perspective view of a concrete slab formed in accordance with the invention with the concrete cut away to show the internal structure;

FIG. 4 is a fragmentary perspective view, partially diagrammatic, showing a three floor construction utilizing the present invention, the first floor being complete, the second floor being partially cut away to show the tube arrangement, and the third floor being in process of formation, the structural steel being omitted for clarity of presentation; and

FIG. 5 is a cross-sectional view of a modified form of the slab construction.

Referring to the drawings, the first step in producing the novel floor and ceiling construction of the present invention is to provide a temporary floor **10** in the usual manner and then to mount on this floor in spaced relationship a network of reinforcing bars such as the tie steel rods **12** and main steel rods **14**. These rods have a serrated surface as indicated in the drawings so as to form a structural bond with the concrete poured thereon. As shown in the drawings, the reinforcing steel may be supported in spaced relationship with respect to the temporary floor by spacers or booster chairs **16** which comprise lengths of steel wire **18** having spaced supporting chairs **20**. The spacers **16** are anchored to the temporary floor in parallel spaced apart relationship, usually approximately 4' apart, by staples **22** which can be driven into the temporary floor by means of a hammer. In the arrangement shown in FIG. 1 the main steel rods **14** are placed transversely across the spacers **16** in parallel relationship and secured in place by means of tie wires **24** in the usual manner. The tie steel rods **12** are secured to the underside of the main steel rods **14** transversely thereto and in parallel relationship by similar tie wires **24**. In the arrangement shown in FIG. 2 of the drawings the steel rods are reversed, the tie steel rods **12** being secured to the spacers **16** while the main steel rods are tied to the upper side of the tie steel rods. These two figures are illustrative of typical variations in the arrangement of the network of tie steel rods and main steel rods which are utilized in accordance with the invention.

The next step in producing the concrete slab of the present invention is to place a series of hollow tubes **26** parallel to one set of steel rods and disposed therebetween so as to rest upon the transverse rods. The tubes **26** may be formed of a variety of materials depending upon the characteristics desired. In the specific embodiment shown in the drawings, the tubes **26** are formed of fibrous cardboard or paper material hereinafter referred to generically as "paper." Paper tubes of this type are available commercially in various lengths and diameters and are relatively inexpensive. Although formed of paper of relatively small thickness, the tubes **26** are sufficiently rigid so that they can withstand the pressure of a workman standing thereon or the weight of many inches of wet concrete. At the same time they are sufficiently flexible lengthwise so that they may be slightly arched, if desired,

as explained more fully hereinafter. The paper tubes **26** as such do not impart any appreciable structural strength to the final slab, but their function is to displace the concrete which normally would occupy the place of the tubes, thus greatly decreasing the weight of the concrete slab. The tubes preferably have a diameter in the range of 60 to 90% of the thickness of the slab for optimum results. The paper tubes **26**, which are supported on the transverse rods **12** or **14** as the case may be, are held in uniform spaced relationship by tie wires **28** which are looped around the transverse rods and extend over the top of the paper tubes **26** where the ends are fastened by twisting. Twine may be substituted for the wires **28**, if desired, but wires are preferred since they are easier to handle and may be secured in place by the same tools used to secure the steel rods **12**, **14** together. The tie wires **28** preferably are disposed at approximately four foot intervals. It has been found from actual experience that the anchoring of the tubes in this manner insures that the tubes will be secured in regular spaced relationship and the time and labor required is maintained at a minimum. As best illustrated in FIG. 4 of the drawings, the individual tubes **26** are of continuous length, but preferably the lengths are selected so that the ends thereof may be spaced apart to provide transversely extending zones **30** of solid concrete to form integral internal beams located as required. In FIG. 4, the zones or beams **30** are located in alignment with the columns **32**. Some of the paper tubes as indicated at **26'** may be of slightly shortened length so as to provide additional concrete at the end-portions thereof. The tubes **26** are capped in any suitable manner, such as by means of the metal discs **34**, to prevent concrete from entering therein.

In many instances, the internal portions of the slab are completed upon the installation and anchoring of the tubes **26**. However, it is an advantage of the invention, as illustrated in FIG. 2, that reinforcement may be added to the upper strata of concrete, if desired, simply by laying across the tops of the tubes **26** a second network of main steel rods **14** and tie steel rods secured together by tie wires **24** as previously described. It is not necessary that the upper network be secured or fastened in any way to the tubes **26** or the lower network of steel rods.

Turning to FIG. 4 the form is completed as, for example, by means of removable side members **36** which may be braced in a position by braces **38**, secured to the temporary joists **40** which are partly illustrated in the showing of the top floor of FIG. 4. The form containing the reinforcing steel and the tubes **26** is now ready for receiving the concrete in the usual manner. During the pouring of the concrete the workmen can walk on top of the tubes **26**, the tubes being sufficiently rigid for this purpose and being adequately secured against displacement since they are supported on the underside either by the tie steel rods **12** or the main steel rods **14** as the case may be and are tied thereto. During the pouring of the concrete, the concrete is preferably tamped and/or vibrated so that concrete will completely fill the zone beneath the paper tubes **26** and embed the steel rods **12**, **14**. When sufficient concrete has been poured to embed or embrace the tubes **26**, flotation of the tubes **26** is prevented by the tie wires **28** and the accurate spaced relationship is maintained throughout. The pouring of the concrete is continued until the tubes are completely covered and the surface is then leveled off in the usual manner. The entire slab is poured in one operation so that the concrete is of monolithic structure, forming a structural bond with the steel rods **12**, **14** and with regular voids formed by the paper tubes **26**. Thus, in one operation there is formed a lower ceiling surface **42**, an upper floor surface **44** and internal regular concrete joists **30** in the spaces between the tubes **26**, all in one integral structure of calculable high strength and light weight. After the concrete has been set and cured in the usual manner, the temporary forms may be removed and the ceiling and floor surfaces require no further treatment.

In FIG. 5 of the drawings there is illustrated a modified version of the floor and ceiling slab which takes advantage of the flexibility of the tubes **26** to form an upper floor strata which is of greater thickness at the center than at the edges and a lower ceiling strata which is of greater thickness at the edges than at the center, thus providing a beam effect with a larger proportion of concrete situated at the areas of compression, and with a reduction of the amount of concrete in the areas of tension, thus increasing the strength of the slab for a given weight. This construction is accomplished by utilizing spacers **16**, formed with chairs **20** of varying height, those at the center being of lesser height than those at the ends of the slab as illustrated in FIG. 5.

It thus will be seen that there has been provided in accordance with the invention, an improved concrete ceiling and floor slap construction of greatly reduced weight, and yet of high strength and uniform configuration so that one skilled in the art can accurately calculate the performance thereof with assurance that the calculated strength will closely approximate the actual strength. The structure can be formed by ordinary skilled workmen with readily available materials at comparatively low cost. The final structure is monolithic and reinforced as required with the concrete located in the areas required and with the elimination of concrete which otherwise would add little strength in comparison to its dead weight. The structure has been found to be particularly adaptable for use in commercial buildings, schools and their like to provide an improved floor and ceiling construction at reduced cost.

As many changes could be made in the above construction and many apparently widely different embodiments of this invention could be made without departing from the scope thereof, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

It is also to be understood that the language used in the following claims is intended to cover all of the generic and specific features of the invention herein described and all statements of the scope of the invention which, as a matter of language, might be said to fall therebetween.

I claim:

1. An assembly for use in pouring a monolithic concrete floor and ceiling slab of the conventional reinforced type wherein the reinforcing rods act as a tension member only and the concrete acts in compression with the transfer of stresses between them through bond and shear of the concrete and having low weight and calculable high strength, comprising: a planar floor; a network of reinforcing rods in a predetermined spaced relationship, said network comprising a first set of parallel regularly spaced apart longitudinally extending rods and a second set of parallel regularly spaced apart transversely extending rods; a plurality of hollow cylindrical tubes extending parallel to one set of rods and supported crosswise upon the other set of rods in parallel, predetermined spaced relationship, said tubes being buoyant in wet concrete; a multiplicity of supporting means on said floor supporting said network at a predetermined spacing upwardly therefrom, said supporting means being located at spaced points about said reinforcing network and at a plurality of spaced points along the length of said tubes to provide relatively firm support for said tubes and reinforcing network against undesired downward displacement; and a plurality of tie down means spaced along the length of each of said tubes and holding said tubes tightly against the reinforcing network in said predetermined parallel spaced relationship, said tie down means cooperating with said supporting means and reinforcing network to anchor said tubes to the floor in predetermined spaced position there-

from and to prevent flotation or displacement thereof during pouring of the concrete, the vertical spaces between said tubes being free from reinforcing rods to provide uninterrupted vertical ribs of concrete therebetween, and said planar floor being separable and removable from the assembly after setting of concrete poured thereon.

2. An assembly in accordance with claim 1 wherein a second network of reinforcing rods is disposed upon and entirely supported by said tubes.

3. An assembly in accordance with claim 1 wherein said cylindrical tubes are paper tubes and wherein said paper tubes and said rods extending parallel thereto are regularly downwardly bowed intermediate their length.

4. An assembly in accordance with claim 1 wherein the supporting means for said reinforcing network includes a plurality of booster chairs, a plurality of staples securing said booster chairs to said planar floor, and tie means securing said network to said booster chairs.

5. An assembly for use in pouring a monolithic concrete floor and ceiling slab of the conventional reinforced type wherein the reinforcing rods act as a tension member only and the concrete acts in compression with the transfer of stresses between them through bond and shear of the concrete and having low weight and calculable high strength and having internal beams of concrete, comprising: a planar floor; a network of reinforcing rods in a predetermined spaced relationship, said network comprising a first set of parallel regularly spaced apart longitudinally extending rods and a second set of parallel regularly spaced apart transversely extending rods; a plurality of sets of hollow cylindrical tubes, each set comprising a plurality of tubes in relatively spaced apart parallel relationship extending between one set of reinforcing rods and supported crosswise upon the other set of reinforcing rods, said sets of hollow cylindrical tubes being arranged with the ends of the tubes in spaced apart relationship from the ends of the tubes of an opposing set to form an open area therebetween for the formation of an internal beam, said tubes being buoyant in wet concrete; a multiplicity of supporting means on said floor supporting said network at a predetermined spacing upwardly therefrom, said supporting means being located at spaced points about said reinforcing network and at a plurality of spaced points along the length of said tubes to provide relatively firm support for said tubes and reinforcing network against undesired downward displacement; and a plurality of tie down means spaced along the length of each of said tubes and holding said tubes tightly against said reinforcing network in regularly spaced apart parallel relationship, said tie down means cooperating with said supporting means and reinforcing network to anchor said tubes to the floor in predetermined spaced position therefrom and to prevent flotation or displacement thereof during pouring of the concrete, the vertical spaces between adjacent parallel tubes being free from reinforcing rods to provide uninterrupted vertical ribs of concrete therebetween, and said planar floor being separable and removable from the assembly after setting of the concrete poured thereon.

6. A monolithic floor and ceiling slab construction of low weight and calculable high strength providing a flat floor surface upon its upper side and a continuous flat ceiling upon its under surface, said construction comprising a plurality of reinforcing rods extending longitudinally of the slab and lying in a common plane spaced upwardly from the under surface, said rods being parallel and regularly spaced apart; a plurality of transverse reinforcing rods connected to the longitudinal rods to form a reinforcing network and extending ocntinuously in parallel and regularly spaced apart relationship transversely of the slab; a plurality of parallel hollow cylindrical tubes supported directly upon and secured tightly to the tops of the transverse reinforcing rods in a fixed predetermined regularly spaced relationship; and a concrete matrix embedding and bonded to the reinforcing rods and embedding the tubes, said matrix including an upper floor portion extending continuously across the top of the tubes and reinforced ceiling portion extending continuously across the bottom of the tubes, said portions being interconnected by a series of uninterrupted monolithic vertical internal beams of predetermined configuration and spacing which are free from reinforcing rods, said reinforcing network acting as a tension member only and the concrete acting in compression with the transfer of stresses between them through bond and shear of the concrete.

7. A monolithic floor and ceiling slab construction in accordance with claim 6 wherein a second network of regularly spaced transverse and longitudinal reinforcing rods is disposed directly upon and supported by the upper surface of said tubes and embedded in and bonded to said concrete matrix.

8. A monolithic floor and ceiling slab construction of low weight and calculable high strength providing a flat floor surface upon its upper side and a continuous flat ceiling upon its under surface, said construction comprising a plurality of regularly spaced apart reinforcing rods extending longitudinally of the slab and spaced upwardly from the under surface; a plurality of transverse reinforcing rods connected to the longitudinal rods in parallel, regularly spaced apart relationship to form a reinforcing network; a plurality of parallel hollow cylindrical paper tubes disposed between the longitudinally extending rods, said tubes being flexible laterally of their longitudinal axes and being supported entirely upon and secured tightly to the tops of the transverse reinforcing rods in a fixed predetermined regularly spaced relationship, said longitudinally extending rods and tubes being downwardly bowed longitudinally thereof; and a concrete matrix embedding and bonded to the reinforcing rods and embedding the tubes, said matrix including an upper floor portion extending continuously across the top of the tubes of greater thickness at the center than at the ends of the slab, and a reinforced ceiling portion extending continuously across the bottom of the tubes of greater thickness at the ends than at the center of the slab, said portions being interconnected by a series of uninterrupted monolithic vertical internal beams of regular predetermined configuration and spacing which are free from reinforcing rods, said reinforcing network acting as a tension member only and the concrete acting in compression with the transfer of stresses between them through bond and shear of the concrete.

9. A monolithic floor and ceiling slab construction of low weight and calculable high strength having internal beams of regular predetermined configuration and spacing and providing a flat floor surface upon its upper side and a continuous flat ceiling surface upon its lower side, said construction comprising a plurality of reinforcing rods extending longitudinally of the slab and lying in a common plane parallel to but spaced upwardly from the underside, said rods being parallel and regularly spaced apart; a plurality of transverse reinforcing rods secured to the longitudinal rods to form a reinforcing network and extending continuously in parallel and regularly spaced apart relationship transversely of the slabs; a plurality of sets of parallel hollow cylindrical paper tubes supported entirely upon the transverse reinforcing rods, said tubes being disposed in a fixed predetermined regularly spaced relationship, said sets of tubes being disposed with the ends of the tubes of one set spaced from the ends of the tubes of another set to define an open area therebetween; means securing said tubes in tight contact against the transverse reinforcing rods; and a concrete matrix embedding and bonded to the reinforcing rods and embedding the paper tubes, said matrix including an upper floor portion extending continuously across the tops of the tubes and a reinforced ceiling portion extending continuously across the bottom of the tubes, said portions being interconnected by a series of uninterrupted monolithic vertical internal beams of regular predetermined configura-

tion and spacing between the tubes which are free from reinforcing rods and a transverse beam in the open area between the adjacent ends of opposed sets of tubes, said reinforcing network acting as a tension member only and the concrete acting in compression with the transfer of stresses between them through bond and shear of the concrete.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,213,581 October 26, 1965

Anselmo J. Macchi

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

In the drawings, Sheet 1, FIG. 1, the reinforcing rods bearing the numeral 14 should bear the numeral 12 and the reinforcing rods bearing the numeral 12 should bear the numeral 14.

This Certificate supersedes Certificate of Correction issued May 30, 1967.

Signed and sealed this 6th day of May 1969.

(SEAL)

Attest:

Edward M. Fletcher, Jr.

Attesting Officer

Edward J. Brenner

Commissioner of Patents