March 18, 1969 D. O. ERICKSON 3,432,978

CONCRETE WALL AND WALL PANEL CONSTRUCTION

Filed May 18, 1967 Sheet 1 of 3

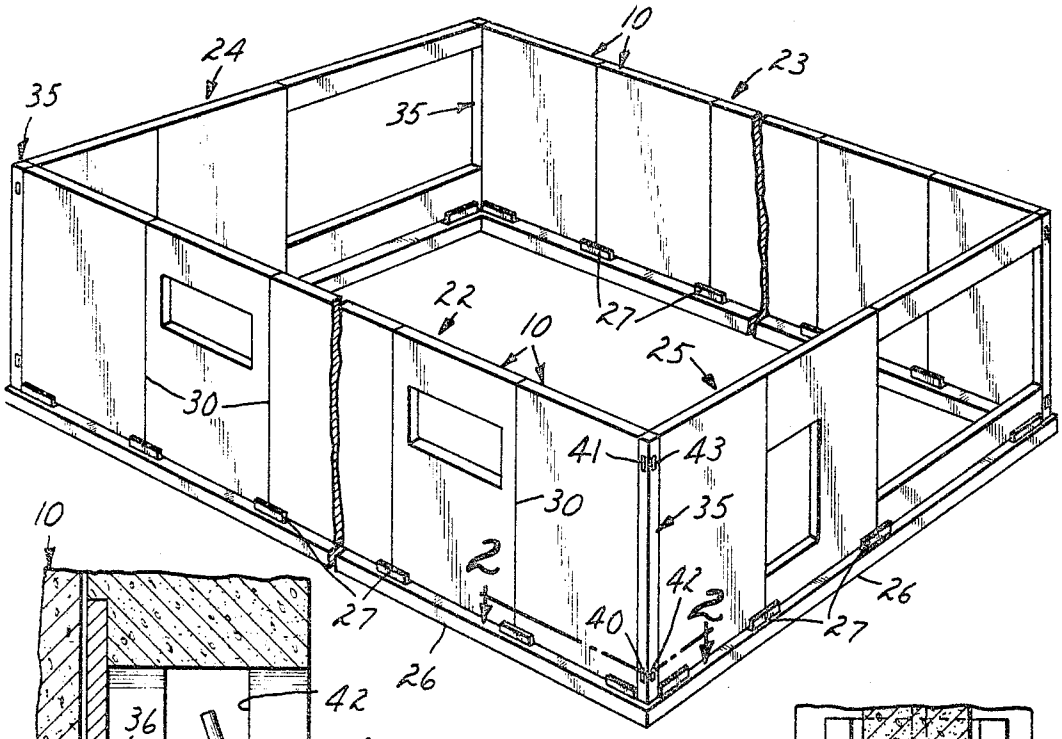


FIG. 1

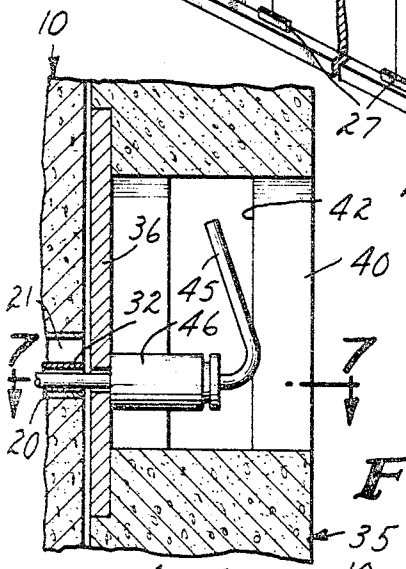


FIG. 3

FIG. 2

INVENTOR.
DONALD O. ERICKSON
BY Merchant & Gould
ATTORNEYS

March 18, 1969 D. O. ERICKSON 3,432,978

CONCRETE WALL AND WALL PANEL CONSTRUCTION

Filed May 18, 1967 Sheet 2 of 3

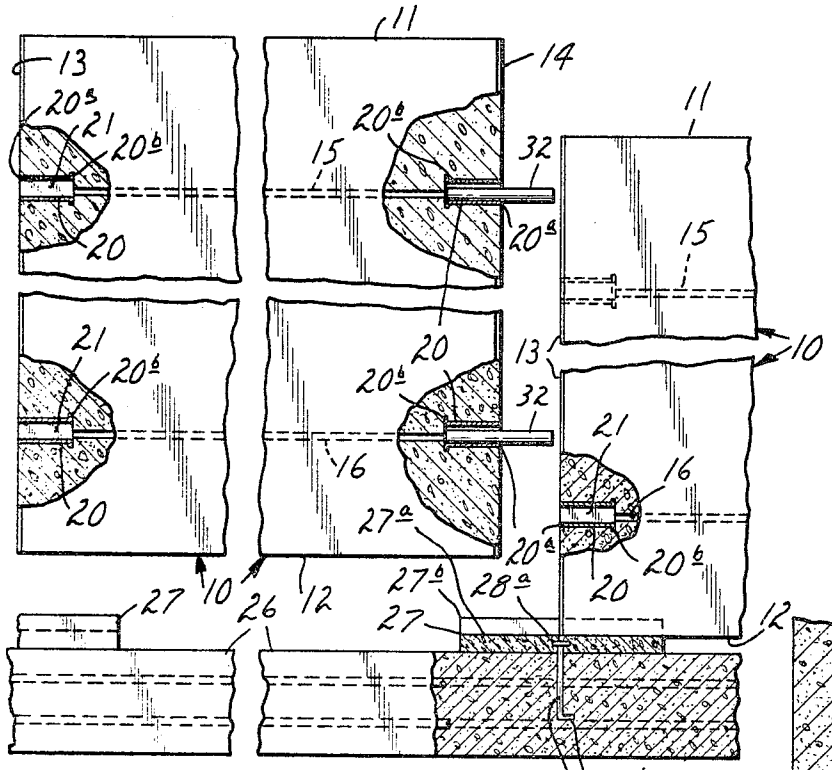


FIG. 4

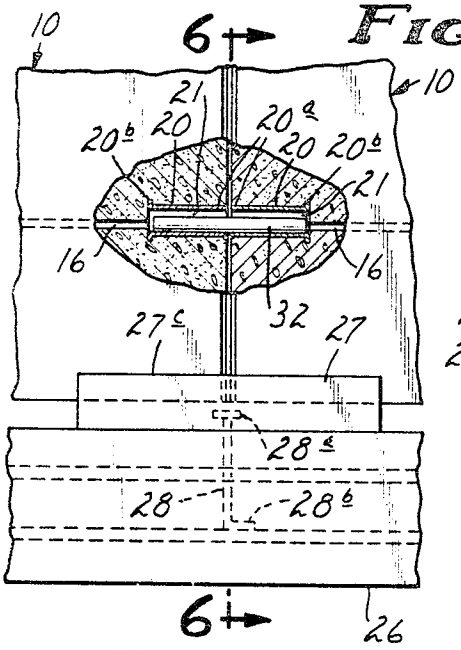


FIG. 5

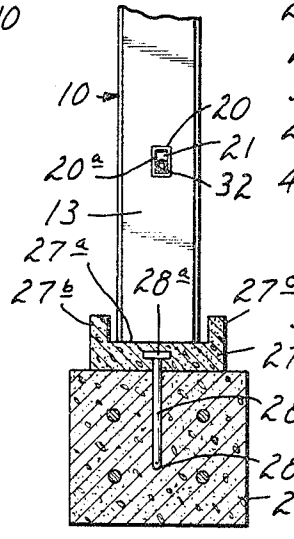


FIG. 6

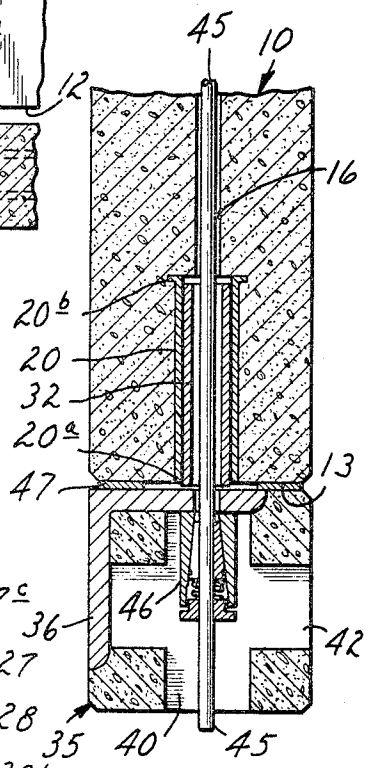


FIG. 7

INVENTOR.
DONALD O. ERICKSON
BY Merchant & Gould
ATTORNEYS

March 18, 1969 D. O. ERICKSON 3,432,978

CONCRETE WALL AND WALL PANEL CONSTRUCTION

Filed May 18, 1967 Sheet 3 of 3

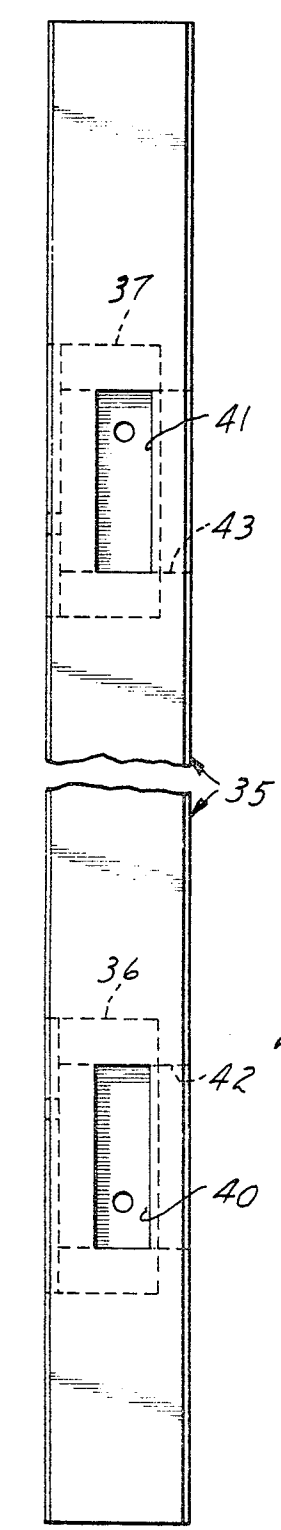


FIG. 8

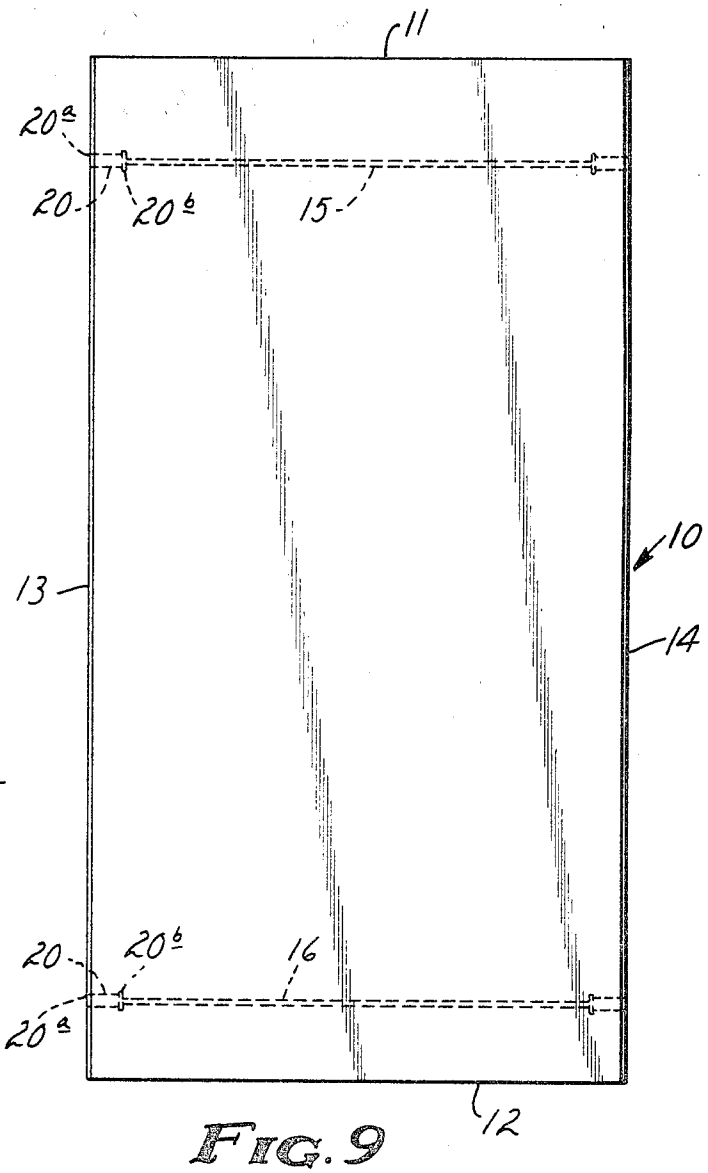


FIG. 9

INVENTOR.
DONALD O. ERICKSON
BY Merchant & Gould
ATTORNEYS

United States Patent Office 3,432,978 Patented Mar. 18, 1969

3,432,978

CONCRETE WALL AND WALL PANEL CONSTRUCTION

Donald O. Erickson, 7009 France Ave. S., Minneapolis, Minn. 55435

Filed May 18, 1967, Ser. No. 639,485
U.S. Cl. 52—227 2 Claims
Int. Cl. E04c 2/04, 2/46; E02d 27/32

ABSTRACT OF THE DISCLOSURE

A generally rectangular pre-cast concrete wall panel having upper and lower continuous openings or ducts extending between the side edges thereof. A plurality of these wall panels are mounted on a suitable foundation in an edge-to-edge relationship to form a wall, and steel strands are threaded through the upper and lower ducts. The steel strands are placed under tension by stretching and then anchoring their ends at opposite ends of the wall to apply a compressive force to the wall to generally cause the wall to act as one monolithic structure rather than as individual elements. This compressive force seals the joints thereof and prevents settlement cracking of the wall.

BACKGROUND OF THE INVENTION

Field of the invention

This invention relates generally to the "system building" of pre-engineered buildings utilizing precast structural elements, and more particularly relates to an improved precast concrete wall panel construction and to an improved wall construction wherein a plurality of the wall panels are mounted in an edge-to-edge relationship and tied together by tensioned steel strands extending through horizontal open ducts formed in the wall.

Description of the prior art

In the building industry, the terms "system building" or "industrialized building" refer to the concept of mass producing as many building elements as possible at a factory so that the amount of time and effort necessary to actually construct the building at the building site is reduced as much as possible. Many different approaches have been taken, but common to all these approaches is the standardization of various building elements. In addition to standardizing those elements that are required, the designers in this area are constantly attempting to reduce the different types of basic building elements that are required, by designing elements that will perform a variety of functions.

In constructing most buildings, a framework is first erected to which walls, floors and other structural features are attached. In concrete buildings, constructed in this manner, the walls are attached to the framework but are not themselves load bearing. Each individual precast wall slab or panel is attached to the framework by means well known in the art. An example of this type of building construction is shown in the Lasker Patent 1,957,026 that issued May 1, 1934. The wall panels in this type of construction are very often prestressed to prevent cracking due to temperature changes and settlement of the building. It is difficult to seal the joints between the wall panels in this type of building, however, because the panels do expand and contract with temperature changes. If the sealing between the joints does fail, moisture leakage into the building will occur.

In recent years, prefabricated concrete buildings have been designed that do not utilize a supporting framework. In this type of building, the panels themselves are connected so as to bear the load of the building by themselves. For example, the Midby Patent 2,883,852 that issued Apr. 28, 1959 discloses a masonry building construction employing a plurality of precast reinforced concrete wall panels. These wall panels are mounted in an edge-to-edge relationship and are fastened together by steel channel members that extend along the top and bottom edges of the wall panels. Steel rods extend vertically through the panels to hold the channel members to the top and bottom edges thereof. In this type of building construction, the wall panels must be reinforced to prevent settlement cracking or cracking due to temperature changes since the wall panels react individually to environmental changes. The problem of moisture leakage through the vertical joints between the wall panels is also present in this type of construction. Since the wall is not a rigid monolithic unit, the joints will tend to open and close when the wall panels are subjected to changes in temperature or moisture conditions.

It has been normal practice in the prior art to reinforce those concrete wall panels that are load bearing. This has been necessary in order to avoid cracking of the wall panels when stress is applied to them. Stresses of this type will occur in a load bearing wall panel if the building settles at all or if an excessive amount of expansion and contraction occurs as a result of extreme temperature changes. In any event, as far as I am aware, it has not been general practice to utilize unreinforced wall panels in those buildings where the wall panels are load bearing.

Regardless of whether the wall panels are load bearing or not, moisture leakage through the joints between the wall panels always presents a problem. When the building is constructed, a sealant of some type is normally placed between the adjoining wall panels to prevent the entrance of moisture. After the wall panels have been subjected to several cycles of contraction and expansion caused by seasonal temperature changes, however, the sealant often loses its effectiveness and moisture leakage results. Thus, it has often been necessary to recaulk or reseal the joints in this type of building construction at periodic intervals.

SUMMARY OF THE INVENTION

I have designed a concrete building construction, employing load bearing wall panels, that overcomes many of the problems inherent in the prior art. In the system described here, it is not necessary that the individual wall panels be reinforced, and the joints between the wall panels are permanently sealed so that they cannot open and close with temperature changes.

The precast, unreinforced concrete wall panels of the preferred embodiment of my invention are generally rectangular in shape and have a pair of spaced apart open ducts extending horizontally through the panel between the side edges thereof. A complete wall is constructed by placing a plurality of these wall panels in an edge-to-edge relationship on a suitable foundation. The upper and lower open ducts in each wall panel are correspondingly positioned so that the pair of ducts are aligned throughout the length of the wall.

After the wall is placed in position, a steel strand is threaded through each of the open ducts in the wall. A predetermined amount of compressive force is applied to the ends of the wall by tightly stretching the steel strand. Since the force tending to stretch the steel strands is applied to the opposite ends of the wall, the adjoining wall panels are forced tightly against each other. After the proper amount of compressive force has been applied to the wall, an anchor device is attached to each end of the steel strand. The anchor devices bear against the opposite ends of the wall to hold the steel strand in the stressed

condition to maintain the compressive force on the wall.

The constantly maintained compression force on the entire wall permanently seals the vertical joints between the wall panels. Therefore, the joints cannot open and close or otherwise move with temperature changes to permit the entrance of moisture.

Although the wall panels utilized in this building construction do not need to be pre-stressed, the stress imposed upon them by the stretched steel strand imparts to them many of the desirable qualities normally found only in a pre-stressed concrete panel. Cracking within wall elements normally caused by volume changes, due to variations of temperature and moisture, to settlement or to creeping of the concrete, are eliminated by keeping the entire wall in compression. Since all of the walls of the building are tied together by means of the steel strands and corner posts, the building has great rigidity but is still elastic enough to absorb stresses caused by settlement, or by temperature or moisture changes.

A building constructed according to my invention is a rigid monolithic structure that reacts to environmental conditions as a unit rather than as a group of individual structural elements. Despite its great rigidity, the building is sufficiently elastic to absorb stresses that would normally cause cracking or other structural problems. Also, since each wall is rigid structural unit, a beam effect is achieved in that the walls act as deep beams to prevent cracking caused by uneven settlement of the footing or base. Further, the need for intermediate lateral wall supports is greatly reduced.

The structural components described herein can be efficiently manufactured at a central plant, utilizing modern production techniques to achieve uniform high quality standards. After the components are manufactured, they can be transported to the job site where the structure can be quickly erected with a minimum expenditure for job site labor. It is therefore a primary object of the present invention to provide a system of building construction whereby the structural elements used in forming a wall are joined together by threading a strand through horizontal ducts within the elements, and tensioning the strands by stretching and anchoring their ends at opposite ends of the wall, thereby placing the structural elements under compression.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of a building constructed in accordance with my invention;

FIG. 2 is an enlarged sectional view taken along line 2—2 of FIG. 1, some parts thereof being broken away;

FIG. 3 is an enlarged sectional view taken along line 3—3 of FIG. 2;

FIG. 4 is a side elevational view of two wall panels showing one step in the assembly of the complete wall structure, some parts thereof being broken away and some parts being shown in section;

FIG. 5 is a side elevational view of a portion of the wall panel shown in FIG. 4. after the two wall panels have been assembled in an edge-to-edge relationship, some parts being broken away and some parts being shown in section;

FIG. 6 is a sectional view taken along line 6—6 of FIG. 5;

FIG. 7 is a sectional view taken along lie 7—7 of FIG. 3;

FIG. 8 is a side elevational view of a corner post, some parts thereof being broken away; and

FIG. 9 is a side elevational view of a single precast wall panel constructed in accordance with my invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings, wherein like reference numerals are used throughout the several views to identify like elements of the invention, there is disclosed in FIG. 9 a single wall panel **10** constructed in accordance with my invention. Wall panel **10** is a precast, unreinforced concrete panel having a generally rectangular configuration. Panel **10** has a top edge **11**, a bottom edge **12** and a pair of oppositely facing parallel side edges **13** and **14**. A pair of open ducts **15** and **16** are formed in wall panel **10** and extend therethrough between side edges **13** and **14**.

A relatively short, metal duct support member **20** is cast into each end of each of the open ducts **15** and **16**. A first end **20***a* of duct support member **20** terminates flush with the side edge of wall panel **10**. A second flanged end **20***b* terminates a predetermined distance within wall panel **10**. As best shown in FIG. 6, duct support members **20** have an opening **21** formed therein, at least a bottom portion of which is aligned with the open duct **15** or **16**. Open **21** of duct support member **20** has a rectangular cross section with the longer dimension extending vertically in the wall panel **10**.

As shown in FIG. 1, wall panels **10** can be cast as a single unit or can have openings cast therein for windows and doors. The building shown in FIG. 1 includes a pair of side walls **22** and **23** and a pair of end walls **24** and **25** connected thereto to form a rectangular enclosure. Each of the walls **22**, **23**, **24** and **25** includes a plurality of wall panels **10** mounted in an edge-to-edge relationship on a concrete foundation **26**. Concrete foundation **26** has a generally level top surface and has a plurality of concrete aligners **27** each securely fastened on the top surface by means of suitable connections such as a steel bolt **28**. Bolt **28** has a flat head **28***a* that is cast into aligner **27** and a curved opposite end **28***b* that extends downwardly into foundation **26**. Aligners **27** are placed on foundation **26**, and are leveled thereon prior to the hardening of the foundation. Where soil conditions and other structural considerations permit, individual spot footings can be utilized instead of a continuous foundation.

Each of the aligners has an open upwardly facing groove formed therein with a flat bottom surface **27***a* and a pair of upstanding side walls **27***b* and **27***c*. Wall panels **10** are mounted in this groove for support by flat bottom surface **27***a*. Aligners **27** are fastened to foundation **26** at positions corresponding to the joints **30** formed between adjoining wall panels **10**. Aligner side walls **27***b* and **27***c* extend upwardly a short distance along the opposing faces of the wall panels **10**. Again, all of the aligners **27** are leveled prior to the hardening of foundation **26** so that the walls **22**, **23**, **24**, and **25** are supported at the same level.

Aligner side walls **27***b* and **27***c* are preferably each spaced from the opposing faces of wall panels **10** approximately one inch as best shown in FIGURE 6. This restricts lateral movement of wall panels **10** beyond these limits, but permits the wall to be laterally shifted in either direction after it is erected, to align the wall or the entire building. A suitable tool can be inserted between wall panel **10** and aligner side walls **27***b* and **27***c* to shift the wall in the desired direction. After the wall has been properly aligned, spacers are inserted in the spaces between the aligner side walls and the wall panel to prevent further lateral movement.

Referring now to FIG. 4, the method of placing two adjoining wall panels initially in position is shown. A first wall panel **10** is placed in position on aligners **27** and a suitable sealant material is attached to side edge **13**. Before the adjoining wall panel is placed in position, a metal tube **32** is inserted in opening **21** in each of the duct support members **20**. Metal tube **32** is longer than the individual duct support member **20** so that when the two wall panels are placed in an edge-to-edge relationship, tube **32** will extend into both of the adjoining duct support members **20**. It is noted at this point that all of the upper ducts **15** and lower ducts **16** in any given wall are correspondingly positioned so that they are aligned throughout the length of the wall. The outside diameter of metal tube **32** is slightly smaller than the shorter dimension of a rectangular opening **21**. Thus, metal tube

32 can move vertically within opening 21 but cannot move laterally. As shown in FIG. 4, the second wall panel 10 is moved into position at an angle rather than being moved vertically or horizontally into position adjoining the first wall panel. Since some vertical movement of metal tubes 32 with respect to openings 21 is permitted, the second wall panel can be moved into position at an angle rather than being slid into position horizontally. When the two adjoining wall panels are placed in edge-to-edge relationship, metal tube 32 extends into both of the adjoining duct support members 20 as shown in FIG. 5. Since tube 32 cannot move laterally within openings 21, relative lateral movement between the adjoining wall panels cannot occur.

When a wall is assembled, metal tube 32 lies at the bottom of aligned openings 21 in duct support members 20. Duct support members 20 are positioned in wall panels 10 such that the axial opening in metal tube 32 is aligned with the open duct in the wall.

Metal tubes 32 together with duct support members 20 provide two important functions. First, during wall erection, the need for shoring is reduced since tubes 32 and members 20 will support, without additional shoring, two or three wall panels 10 from a single wall panel 10 that is initially shored, secondly, after the wall is erected and placed under compression, tubes 32 and members 20 prevent any relative lateral shifting of adjoining wall panels. Although metal tubes are used in the preferred embodiment and the strands are threaded through the tubes, solid dowels or pins could also be used to perform the same functions by offsetting such solid dowels or pins from the ducts.

After a complete wall has been assembled in the manner shown in FIGS. 4 and 5, a pre-cast concrete corner post 35 is mounted at each end of the wall. Corner post 35 has a generally square cross section and extends the full height of the wall. Post 35 has a pair of metal angle plates 36 and 37 cast therein at positions corresponding to the positions of the open ducts in the wall. As best shown in FIG. 2, for example, one corner post 35 is designed to bear against both wall 22 and wall 25. Angle plates 36 and 37 are angle members that extend around the faces of post 35 adjoining walls 22 and 25. Angle plates 36 and 37 thus bear directly against the side edges of the adjoining wall panels 10 in walls 22 and 25.

As shown in FIG. 2, ducts 15 and 16 are aligned within a wall but are vertically offset with respect to the aligned upper and lower ducts in the adjoining wall. Thus, the lower duct 16 in wall 25 is positioned slightly lower than the lower duct 16 in wall 22. Post 35 has a pair of openings 40 and 41 extending therethrough opposite wall 25 from plates 36 and 37. Openings 40 and 41 in post 35 have a rectangular cross section and are in line with ducts 15 and 16 in wall 25. A second pair of openings 42 and 43 extend through post 35 in line with ducts 15 and 16 in wall 22. Angle plates 36 and 37 also have openings formed therein aligned with the open ducts in each wall, as best shown in FIG. 8.

After a complete wall, such as wall 22, has been initially assembled by placing a plurality of wall panels 10 in an edge-to-edge relationship on aligners 27, a steel strand 45 is inserted or threaded through open duct 16 and a similar strand is inserted through open duct 15. Steel strand 45 extends through the opening in post 35, the opening in plate 36, and the axial opening in metal tubes 32 throughout duct 16. Strand 45 also, of course, extends through a similar corner post 35 at the opposite end of the wall. After strand 45 has been inserted, a hydraulic jack or other similar means, (not shown) is used to stretch strand 45 while applying an equal but opposite compressive force against the opposite ends of wall 22. Wall panels 10 in wall 22 are thus forced tightly together to seal joints 30 between the panels. After a predetermined amount of compressive force has been applied to wall 22, an anchor device 46, which has previously been inserted over strand 45, is tightened to hold strand 45 in the stressed condition. As shown in FIG. 3, anchor device 46 bears against the outside surface of metal angle plate 36 so that metal angle plate 36 is forced tightly against the side edge of the adjoining wall panel. A similar anchor device is attached to strand 45 at the opposite end of the wall to maintain the predetermined amount of compressive force on the wall. As best shown in FIG. 2, metal angle plates 36 and 37 act as bearing plates for anchor device 46 and also act to physicaly tie together the two adjoining walls.

After anchor device 46 has been locked on strand 45, strand 45 is cut off, and the free end thereof stored in opening 40 as shown in FIG. 3. Strand 45 is not cut off directly adjacent to anchor device 46 since this would make it virtually impossible to later disassemble the wall. If several inches of strand 45 are allowed to extend from anchor device 46, this free end of the strand can later be used to either tighten or release anchor device 46 with respect to strand 45. By removing anchor device 46 and strand 45, the entire wall can be disassembled and moved to a new site, or various wall elements can be removed or added. The length of the wall and the positioning of doors and windows can be readily changed.

The wall panels 10 that have been described herein are constructed at a factory and are then moved to a job site where the complete building can quickly be constructed. Wall panels 10 are of pre-cast concrete, but are unreinforced and are not prestressed. If desired, however, one or more layers of insulation material can be pre-cast into the panel to form a sandwich type panel. In addition, a variety of colors, textures and patterns can be used for both sides of the wall panels.

In the preferred embodiment of my invention, strand 45 is a steel strand consisting of 7 individual wires that are twisted into a single strand. Other types of strands can of course be utilized without departing from the invention. In order to absolutely prevent moisture leakage through the joints 30, I also utilize a suitable sealant 47 between adjoining wall panels. Such sealant 47 flows out to cover most of the adjoining side edges of the wall panels when they are compressed together.

The wall construction according to my invention offers many advantages over the structures known to the prior art. Since all of the walls of the building are maintained under a compressive force, the joints 30 between the wall panels are permanently sealed to prevent the entrance of moisture. Joints 30 cannot open and close with expansion and contraction of the wall panels since this type of wall movement is absorbed by the stressed steel cable. When the wall expands, the cable is placed under greater stress. When the wall contracts, the joints between the panels cannot open because the cable has sufficient elasticity to maintain the wall under the necessary compressive force.

The building concept described herein can be readily adapted to incorporate structural elements other than those specifically described herein. For example, pilasters, columns, partition walls and other elements are easily incorporated into the structure by providing suitable openings or ducts in them. In all cases, regardless of the structural elements that are used, one or more strands are inserted through ducts formed therein, tension is applied to the strands, and the tensioned strands are anchored to place the structural elements under compression.

Although I have described herein a wall construction wherein a pair of ducts and strands are used in a wall, I wish to point out that in some cases, a single duct and strand may suffice, while in other cases more than two may be required to achieve the desired strength and rigidity. Further, the individual structural element could be constructed from a material or materials other than concrete without departing from the inventive concept.

I have not described a roof structure herein since it forms no part of the present invention. However, it is

evident that a suitable roof will support the top edges of the walls to prevent any lateral movement thereof, thus further increasing the rigidity of the building.

From the foregoing description, it will be seen that a building of this type can be constructed very quickly at the job site utilizing a minimum amount of skilled labor. Although I have described my invention in considerable detail, I intend to be bound only by the spirit and scope of the invention as expressed in the appended claims.

What is claimed is:

1. A wall construction, comprising:

(a) a base;

(b) at least two concrete wall panels, each having a pair of side edges, said wall panels being mounted on said base in an edge-to-edge relationship and each having correspondingly positioned upper and lower open ducts formed therein extending between said side edges;

(c) separate tie means extending through said aligned upper ducts and through said aligned lower ducts;

(d) means including said tie means applying a predetermined amount of compressive force to said wall panels and thereafter maintaining said compressive force to provide a monolithic wall to permanently seal the joints between said wall panels;

(e) a relatively short, metal duct support member cast into each end of each of said open ducts of each panel with a first end thereof terminating flush with a side edge of said wall panel and a second end thereof terminating a predetermined distance within said wall panel, each of said duct support members having an opening therein aligned with said corresponding open duct, said opening in each of said duct support members having a rectangular cross section with the longer lateral dimension thereof extending vertically in said wall panel; and

(f) a metal tube positioned within the aligned openings in adjoining duct support members, said tube being longer than said individual duct support members to thereby extend into both of the adjoining duct support members, said tube having an outside diameter slightly smaller than the shorter dimension of said rectangular opening in said duct support members whereby relative lateral movement of said adjoining wall panels is prevented but relative vertical movement permitted, said tube having an axial opening aligned with said ducts when positioned in the lower portion of said adjoining duct support members.

2. A wall construction, comprising:

(a) a concrete wall panel having a pair of side edges, said wall panel being in a vertical-side-edge to vertical-side-edge relationship with another wall panel having the same construction;

(b) a horizontally extending support member mounted in said panel with a first end thereof terminating generally flush with a vertical side edge of said panel and a second end thereof terminating a predetermined distance within said wall panel, said support member having an opening therein, said opening having an elongated cross section with the longer lateral dimension thereof extending vertically and the shorter lateral dimension thereof extending horizontally in said wall panel; and

(c) a metal pin positioned within the aligned openings in adjoining support members of adjoining panels, said pin extending into both of the openings in the adjoining support members, said pin having an outside dimension slightly smaller than the shorter lateral dimension of said elongated opening in said support member to prevent relative lateral movement of said adjoining wall panels but permit relative vertical movement thereof.

References Cited

UNITED STATES PATENTS

1,375,043	4/1921	Finlayson	52—365
1,385,606	7/1921	Christensen	52—227
1,477,665	12/1923	Richman	52—227
1,702,340	2/1929	Gates	52—227
1,972,475	9/1934	Davison	52—583
3,173,226	3/1965	Solnick	52—228
3,292,329	12/1966	Garancsy	52—251

FOREIGN PATENTS

50,909	1/1910	Switzerland.
3,549	8/1926	Australia.

HENRY C. SUTHERLAND, *Primary Examiner.*

J. L. RIDGILL, JR., *Assistant Examiner.*

U.S. Cl. X.R.

52—274. 281. 293, 584, 585