March 22, 1960 D. B. CHESKIN 2,929,235

REINFORCED CONCRETE FRAMING SYSTEM

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Figure 1

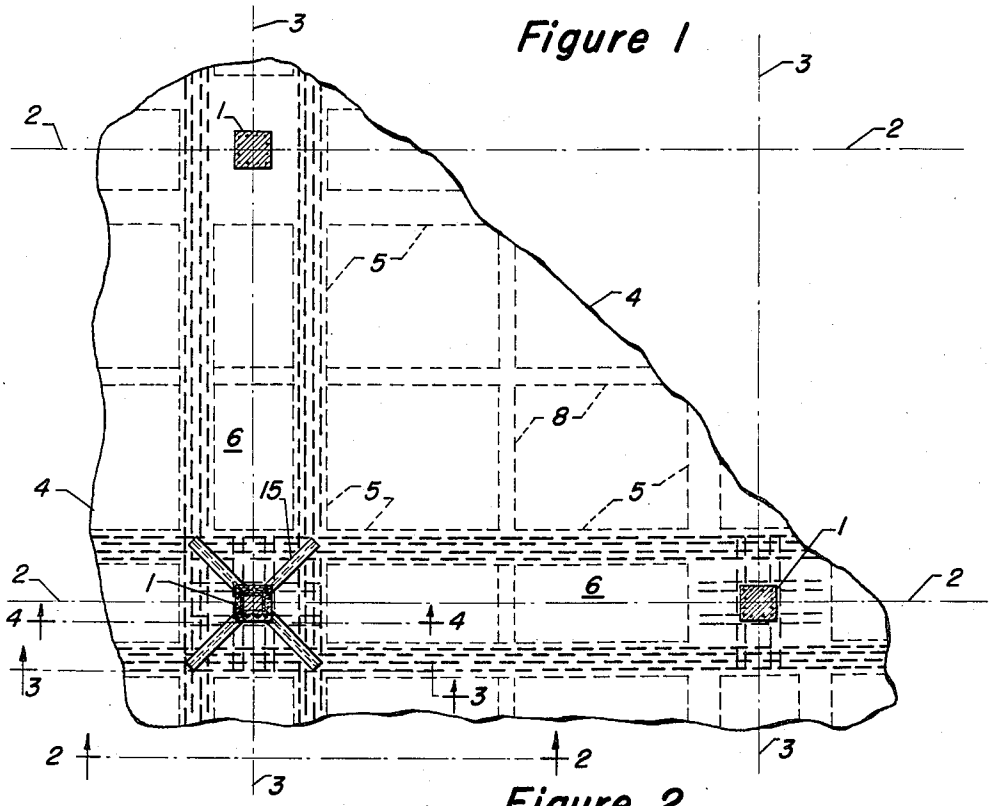


Figure 2

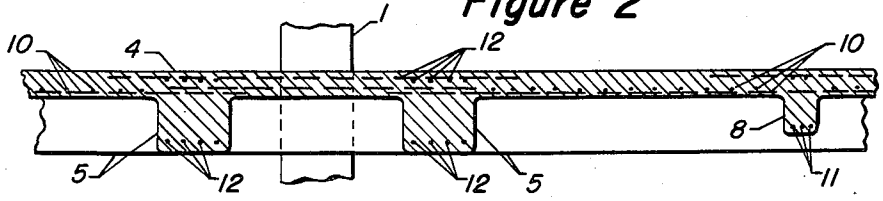


Figure 3

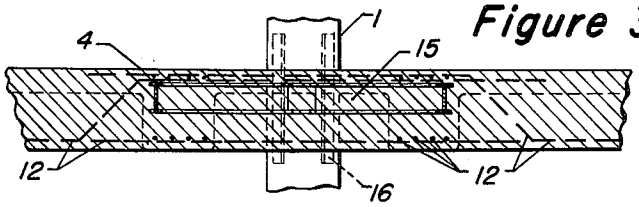
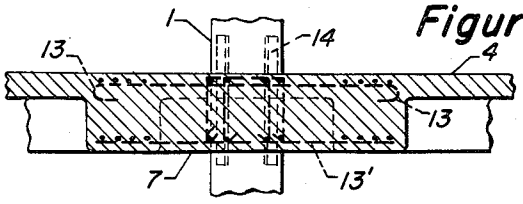


Figure 4



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REINFORCED CONCRETE FRAMING SYSTEM

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Figure 5

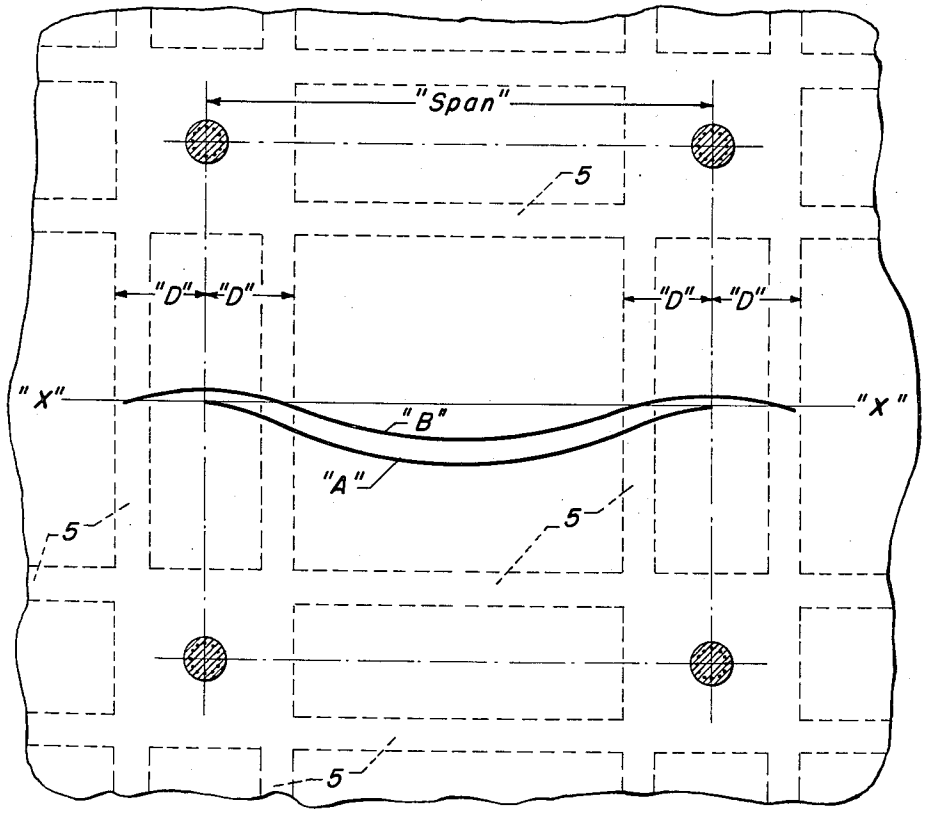
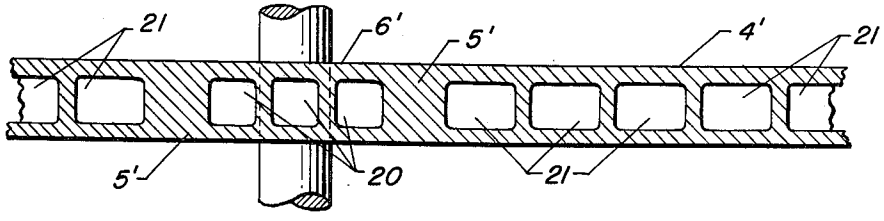


Figure 6



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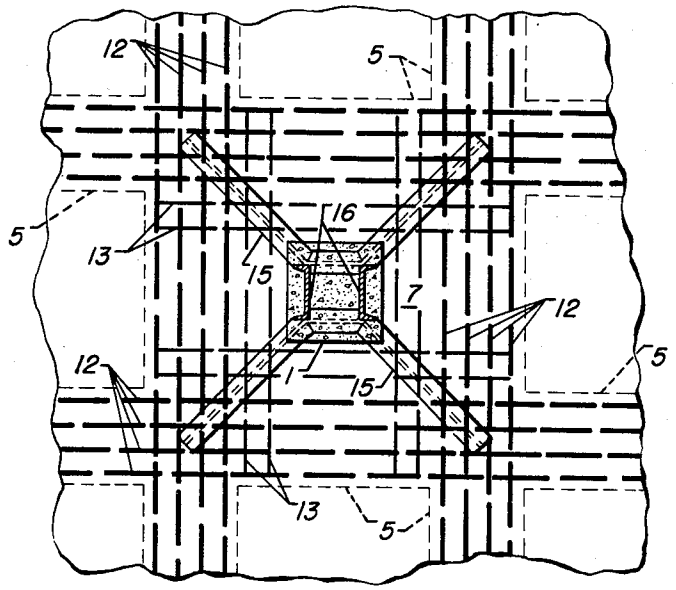


Figure 7

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REINFORCED CONCRETE FRAMING SYSTEM

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4 Claims. (Cl. 72—15)

This invention relates to a reinforced concrete framing system, and more particularly to an improved floor construction of the monolithic slab, beam end column type, having both steel reinforcing bars and structural shapes in a novel arrangement of composite construction.

A conventional type of reinforced concrete building construction utilizes a slab, joist, and girder construction, which has the load from square or rectangular slab sections carried by spaced joists or beams to girders which extend between spaced columns. The supporting columns are normally in parallel or two-directional rows, with the girders thus being on the center line of the column rows and effective to divide the building floor into a plurality of slabs positioned intermediately between the rows of columns. The spacing of columns and the length of the girder spans is largely determined by architectural considerations. One of the principal problems or difficulties in this conventional type of construction is the proper placing of reinforcing bars at the columns, where there must be heavy vertical reinforcing in the columns and heavy girder bars in both the top and bottom of the girders which intersect the columns from two directions, normally at right angles to one another. Also in the case of heavily loaded floor systems the girders or cross beams must be designed to have considerable depth, and deep girders interfere with desirable head-room between floors.

It is a principal object of the present invention to provide a reinforced concrete framing system to eliminate beams or girders on the center lines of the rows of columns and the direct intersecting of the slab supporting beams or girders with the columns, by the use of continuous beams which pass on each side of the columns in both directions and which in turn provide for smaller intermediate floor slab sections of reduced depths and quantities of reinforcing steel.

It is also an object of the invention to provide a relatively deep shear slab section at the zone of each column, between the sets of two way beams, which is reinforced by a structural steel frame adapted to carry shear and compression stresses to the column.

It is a further object of the present two-way framing system to provide an overall construction which is stiff and rigid and particularly adapted to resist torsional stresses set up in the floor because of unsymmetrical or unequal loadings on the various floor panels.

Briefly, the improved monolithic reinforced concrete framing system comprises, a plurality of vertical columns arranged in parallel rows in a two-directional manner, intermediate floor slabs or panel sections, continuous beams bounding and supporting each slab section, with these continuous supporting beams extending parallel with the rows of columns on each side thereof, small slab sections at each vertical column formed between the continuous beams which straddle each of the columns in two directions, each of the small slab sections having a structural steel frame therein which has laterally projecting members suitable to carry the beam loadings to the adjacent column.

The continuous slab supporting beams preferably pass relatively close to the plurality of columns so that the small slab sections, surrounding each column and carrying the beam loads into the column by bending and shear, need not require excessive depth or a large quantity of reinforcing. The beams themselves extend continuously each side of the columns for the entire length of the two-directional rows thereof, and reinforcing is positioned in both the upper and lower portions of each beam to provide for the positive and negative moments exerted on each beam, due respectively to the slab loadings and to the fixity and continuity developed with the beams and small supporting slabs intersected at each of the vertical columns. Since each continuous beam is cast monolithically with the columns and the floor system and intersects with the crossing continuous beams straddling each column, as well as with the small two-way load carrying slab therebetween, there is developed fixity in the zone of each column and a high degree of rigidity in the entire floor.

The floor panels may be reinforced in a two-way manner, or alternatively they may be provided with spaced reinforced joists formed by customary types of removable forms, pans, or the like. Tile fillers may also be used in the intermediate slab sections to provide spaced joists and thinner slab sections.

The construction and arrangement of the floor slab system, as well as additional advantages, will be more readily understood upon reference to the accompanying drawing and the following description thereof.

Figure 1 of the drawing is a diagrammatic plan view of a portion of the improved reinforced concrete framing system.

Figure 2 of the drawing is a sectional view through a portion of the floor slab and two of the continuous beams which straddle a supporting column, as indicated by the line 2—2 in Figure 1 of the drawing.

Figure 3 of the drawing is a sectional view through a longitudinal portion of one of the continuous beams, as indicated by the line 3—3 in Figure 1 of the drawing.

Figure 4 is a sectional view through the small two-way reinforced slab section at each column, as indicated by the line 4—4 in Figure 1 of the drawing.

Figure 5 is a diagrammatic plan view having composited therewith curves which indicate relative deflections.

Figure 6 is a sectional view which illustrates a modification in construction to provide a flush ceiling.

Figure 7 is an enlarged diagrammatic plan view at the zone of a column showing the position of a shear-compression frame.

Referring now to Figure 1 of the drawing, there is shown in the plan view a portion of one embodiment of the improved floor framing system, with a portion of the reinforcing steel which is placed therein indicated diagrammatically. The vertical supporting columns 1 are spaced as may be desired and positioned in two-directional parallel rows, as indicated by the center lines 2 and 3. The large central floor slabs or panels 4, between the rows of columns, are bounded in each case by continuous reinforced beams 5. The beams 5 are the principal slab supporting members and in accordance with the invention, the beams do not intersect the columns but straddle them, extending longitudinally parallel with each of the plurality of two-way rows of columns 2 and 3 for their entire length. The beams thus form two-way sets extending in two directions, with one pair crossing the other at right angles at each column. The beams also form and bound long narrow floor slab sections 6, which extend in both directions be-

tween the plurality of spaced columns 1 on the centerlines thereof, as well as bound and form small thick slab sections 7 at each of the columns 1. These small sections 7 are reinforced in two directions, as indicated, with reinforcing bars 13 running at right angles to each of the pairs of continuous beams 5 in order to carry at least a part of the loadings therefrom, however, in accordance with a novel feature of the present composite construction, there is utilized in addition to the bars 13, a shear-compression frame 15 having structural steel flanged members projecting to at least each of the four intersecting corners formed by the two-way sets of beams 5, as better shown in Figure 7 of the drawing. Further reference to the shear-compression frames 15 will be set forth hereinafter.

As hereinbefore noted, the larger floor slabs 4 may be designed and formed in various conventional ways. The present drawing illustrates a slab construction having two-directional joists 8 extending at right angles to one another at the center line of each slab so as to divide each larger slab section into four sections having smaller spans. The joists 8 are designed with sufficient reinforcing to carry their share of the slab loading to the supporting beams 5. The joists, being monolithic with the slab and beams are preferably reinforced to have continuity therewith across the entire floor, and therefore joists 9 extend across each of the narrow slab sections 6. However, various other slab constructions may be utilized. For example, a ribbed floor slab or a pan-joist construction may be employed, with removable pans forming a plurality of small joists and zones of thin slab therebetween. Also tile fillers may be employed in lieu of the pan construction to form joists and a lightened floor. Reference may be made to Figure 6 of the drawing showing a construction which has a flush ceiling line along the lower face of beams and slabs. Suitable tubular forms are used during the construction of the composite steel and reinforced concrete structure to provide hollow areas 20 and 21, and at the same time for straddling beams 5', narrow slab 6', and the central floor slab section 4'. Although not shown, in an alternative construction hollow precast sections can also be used in combination with poured-in-place reinforced concrete portions. Reinforcing bars are not shown in this diagrammatic Figure 6, however, bars may be placed substantially as shown in Figure 2. The openings 20 and 21 provide desirable space for conduits, heating and air-conditioning ducts and the like which are used in modern day building construction.

Reinforcing bars are not indicated in the floor slabs or the joists in the plan view of the drawing, however, as is better shown in Figure 2, reinforcing bars 10 are diagrammatically indicated in the slabs 4, as extending in a two-way manner. Also, reinforcing bars 11 are provided as necessary in the floor joists 8.

The principal supporting beams 5, which are shown in section in the Figures 2 and 3, have top and bottom reinforcing bars 12 placed in accordance with good design to provide continuous longitudinal beams. Top steel is used at the zones of fixity or negative moment. As indicated in Figure 3, a portion of the bottom bars may be bent upwardly at the points of inflection to provide top reinforcing. Stirrups are of course utilized as required in all the beams to take care of web shearing stresses, but are not indicated in this drawing, which illustrates the improved arrangement and construction and is not concerned with the design of any one particular beam. The monolithic construction and the intersection of the plurality of beams 5, at right angles to one another, at each of the columns 1, provides a tremendous amount of rigidity in the overall construction, and particularly provides resistance to torsional effects or stresses which are set up in a symmetrically designed floor system when there are unequal loadings on adjacent panels of the floor. Reference to Figure 5 of the drawings shows that the straddling beam arrangement and the resulting smaller central floor slab section 4 result in a construction also having the advantage of minimized deflections. The deflection curve "A," drawn above axis X—X, indicates graphically the nature and order of the deflection which would be obtained with a construction having girders extending along centerlines of columns in the conventional way. Also shown is a curve "B," with respect to axis X—X, which indicates graphically the lesser deflections obtained in the beams 5, straddling the columns, even though such beams 5 will have substantially lesser depths and less reinforcing for equivalent floor loadings. In the present improved construction, the double beams 5, when analyzed elastically, are of relatively shorter span, extending only between shear slabs 7 in the two-way manner. The beams 5 are of course constructed, designed, and reinforced in a continuous manner through the entire width and length of each building structure to provide fully continuous beams.

One embodiment of the shear-compression frame 15 is shown in elevation in Figure 3 and in plan view in Figure 7. Laterally extending flanged I-beam sections are bent to have a member extend out to each corner of the slab 7 and into the juncture of each of the intersecting beams 5. These flanged sections in turn radiate from and connect with vertically positioned flanged structural sections, such as channels 16, which are placed into the area of columns 1.

The present supporting frame is designed in a manner that does not interfere with the pouring of the concrete columns and in addition is fabricated of structural steel members in a manner to properly provide bond with the slab, beams and vertical columns. Such a frame is also easily set into the form work normally used for setting slab, beam and column reinforcing, whereby normal pouring of the concrete may be pursued. In other words, the reinforced concrete design for the entire building system may be as desired, and the placing of the beam and slab reinforcing steel in the design of the vertical reinforced columns is in no way limited by combining into the system the present improved types of supporting frames.

It is not intended, however, to limit the present invention to any one type of shear-compression frame or "shear-head," other than the limitation of having at least four projecting flanged sections and an open center portion. Thus, for the purposes of my improved composite construction system, such a frame may comprise, briefly, a plurality of bent structural steel flanged members having their end portions projecting outwardly from an inside bent section thereof, an upright structural steel channel-shaped member positioned with the flanges thereof extending vertically between the upwardly projecting end portions of each of said bent members and thereby spacing all next adjacent bent members, with the vertical channel-shaped members having their flanged portions attached to the bent members at a point adjacent the bent sections thereof and extending above and below the latter, and the vertical members in turn spacing adjacent bent members at the central portion thereof and effecting the attachment of frame with the supporting reinforced concrete columns.

In addition to the shear-compression frame 15, the small beam supporting slabs 7 at each of the columns are reinforced in a two-way manner, as shown in the plan view, Figure 1 and the sectional view, Figure 4. Bars 13 are shown extending in both directions in the top of the slab 7 and bars 13' in the lower portion of the slab as may be required by elastic analysis. The reinforcing bars should of course extend into each of the beams 5, which bound the slabs 7, in order to develop proper bond, fixity and load carrying capacity. Also, stirrups 14 may be used to tie top and bottom slab bars 13 and 13', however, in the present construction, it is unnecessary to have the stirrups to carry web shear in the slab section 7.

The heavy shear loads are carried by the laterally projecting structural members, with loads being picked up at the corners of the slabs. Normally the slab 7 is made equivalent to the thickness of the beams 5. It is a particular advantage of the present design and construction to obtain the necessary strength and rigity at the zone of the column without the use of haunches or increased floor slab thicknesses and without large amounts of reinforcing steel and stirrups. Thus, there is attained good uncluttered clearances between floors in a multistory construction and a construction which permits more free space to have openings for conduits, air ducts, etc., because of less reinforcing bars.

It may again be pointed out that the use of double beams straddling the columns provides more clearance between floors than does the use of a single deep girder type of construction, or any other type of two-way construction. The reduction in the size of intermediate floor slabs or panels effects a substantial reduction in thickness and reinforcing steel required for each of the slabs, which in turn comprise the principal portion of the floor area. It is not intended to limit the positioning, or spacing, of the continuous beams 5, with respect to the columns 1, to any predetermined distance, however, a preferred construction provides that each beam 5 have its outside edge spaced away from the centerline of columns a distance equivalent to 1/7 to 1/4 of the distance between rows of columns 1. For example, as shown in Figure 5 of the drawing, the distance "D" is preferably in the range of about 1/7 to 1/4 of the "span" between centerlines of columns (the distance between column centerlines being referred to in the drawing as "span"), and twice "D," or the distance from outside face to outside face of a pair of parallel beams, will vary preferably within the range of from 2/7 to 1/2 of the span. To minimize intermediate slab dimensions and to provide a desirable relationship of members resulting in economy and rigidity, it has been found that beams being spaced apart (outside face to outside face) approximately 2/5 of the span length effects a preferred design.

Further, it is not intended to limit the improved design and construction to the placing of the reinforcing bars, stirrups, etc., which have been shown in the present drawing. The bars themselves may be round or square, and plain or deformed, in accordance with the design, while structural shapes may also be incorporated to provide, at least in a part, a composite reinforced concrete construction.

I claim as my invention:

1. In a composite steel and monolithic reinforced concrete slab, beam and framing system having a plurality of columns maintained in rows in a two-directional manner and a plurality of intermediate floor slab sections with slab supporting beams, the improved framing system which comprises, continuous beams reinforced with top and bottom longitudinal bars and extending in pairs in a two-directional manner and bounding and supporting thin central slab sections, said beams straddling the plurality of columns and providing intersecting pairs of beams at each individual column and further providing in addition to large central slab sections, elongated slab sections along the rows of the columns and relatively small thick slab sections surrounding each column and contiguous therewith, each of said small slab sections having a shear-compression frame of structural steel flanged members in turn having laterally projecting means radiating from the central portion thereof to a zone between the top and bottom steel of said continuous straddling beams, whereby loadings from the latter are transferred to said columns.

2. The framing system of claim 1 further characterized in that each of said structural steel shear-compression frames have a flange member projecting laterally within said relatively small slab section at each column to a junction between the reinforcing steel bars of said sets of continuous beams straddling said column.

3. In a composite structural steel and monolithic reinforced slab, beam and column framing system having a plurality of columns aligned in rows at right angles to one another, a plurality of relatively large thin intermediate floor slab sections and slab supporting beams, the improved composite framing system which comprises, providing sets of parallel continuous longitudinal beams reinforced with top and bottom longitudinal bars and extending in a two-directional manner straddling said rows of columns and thereby forming and bounding thinner intermediate floor slab sections, relatively narrow thin floor slab sections along the rows of columns and between the latter, and a relatively small square slab section at each of said columns between said two-way rows of pairs of beams, said small slab sections being entirely monolithic with said beams and of the same depth, two-way reinforcing positioned in all of said slab sections, a structural steel shear-compression frame within said small slab section having flanged structural members projecting laterally from the zone of the column, with said frame having at least one laterally projecting flange member for each corner of said square small slab section which has a portion thereof extending laterally and being positioned in a zone between the top and bottom steel at the intersection point between intersecting pairs of the reinforced continuous beams, whereby to aid in the transfer of load from said beam to said column.

4. The framing system of claim 3 further characterized in that each of said shear-compression frames has a plurality of flanged members extending vertically from said laterally projecting flanged member at the central portion of said frame whereby to provide bond with said columns.

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