PRESTRESSED FRAMING SYSTEM

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This invention is directed to an improved prestressed framing system for building structures. More particularly, the improved design relates to a floor framing system which utilizes novel interconnected prestressed horizontal panel sections extending between spaced prestressed shearhead means and their respective connecting columns. The result is a shallow and economical lightweight construction which is easily assembled and erected.

There are various methods for effecting the prestressing of beam and girder sections in building structures; however, the tensioning or prestressing means are usually confined to individual beams and girder sections in order to reduce the size of each particular section. Also, in some cases, tensioning cables or rods are utilized with king post or vertical truss designs. Seldom are tensioning members used to traverse or extend around a substantially horizontal framing system and effect the desired simultaneous prestressing of the plurality of interconnected beam sections.

It is a principal object of this invention to provide prestressing in entire substantially horizontally positioned frame sections and in shear-head sections at spaced columns to in turn provide a shallow lightweight floor framing system.

It is also an object of the present invention to provide one or more loop-form tensioning members in each of a plurality of horizontal frame sections such that intersecting and interconnecting beam members making up such panel sections are all prestressed to permit higher allowable loadings than could normally be placed on the beam sizes involved.

In a broad aspect, the improved prestressed framing system for structures, provided by this invention, comprises in combination, spaced columns, a cantilevered shear-head section from each of the spaced columns, and intermediate rectangular frame sections connecting therebetween, with each of said shear-head sections and said intermediate frame sections having intersecting intermediate beam members therein and at least one high tensile strength tensioning member traversing the section and slidably connecting to the outer end portions of said intermediate beam members therein, whereby to provide prestressing in each of such members in the panel sections and to increase allowable loadings for predetermined sized members.

The term “shear-head” as used herein refers to a structural unit encompassing a column and is designed to join with the several surrounding panel sections and transfer the loadings therefrom directly into the column. In other words, each shear-head serves primarily to carry the “shear” or vertical forces into its accompanying column, although a shear-head may serve to also carry bending moments into a column section.

In the present improved prestressed framing system, each of the shear-heads preferably embodies at least four cantilevering beam sections extending outwardly from a collar section or central connecting means providing for direct connection to a column. Also, preferably, each beam section angles slightly upwardly from the horizontal such that a continuous tension member connecting the ends of the cantilevering beams forms a generally square or rectangular-form of loop. The loop member may be pretensioned in the shop or field as required and will serve to absorb all bending moments resulting from loadings on the adjacent connecting panel sections and all horizontal vectors or forces being passed to the sides of the shear-head.

Each intermediate section of the present system embodies at least two crossing or intersecting beam sections and encompassing beam or girder members, which members may be common to two different adjacent prestressed frames, in order to carry loadings to the columns. The encompassing beam members extend in a two-way manner, generally straddling the center lines of the columns, but parallel to the rows of the columns, in order to join the adjacent sections and to eventually carry the loadings to the ends or sides of the shear-heads and from the latter to the plurality of spaced columns. Each section utilizes one or more traversing loop-form tension members that encompass the ends of the interior intersecting beam sections to permit prestressing within the frame. In addition, a preferred construction uses diagonally positioned tensioning rods across the center section or across the panel sections which straddle the rows of columns such that prestressing can be placed in the beam or girder members encompassing such sections.

Reference to the accompanying drawings and the following description thereof will serve to better explain the present improved prestressed framing system and the advantages in connection therewith.

FIGURE 1 of the drawing is a diagrammatic plan view of one embodiment of the framing system.

FIGURE 2 of the drawing is a partial sectional elevational view indicating the design and construction of the shear-head portion of the system.

FIGURE 3 of the drawing is a partial plan view indicating an end portion of the shear-head section, as indicated by the line 3—3 in FIGURE 2.

FIGURE 4 of the drawing is a partial sectional elevational view indicating the connection of intermediate beam members and loop form tensioning members in adjacent sections as indicated by the line 4—4 in FIGURE 1.

FIGURE 5 of the drawing indicates, in an enlarged view, the connection of a diagonal prestressing tensioning member to the corner of an intermediate panel section.

Referring now particularly to FIGURE 1 of the drawing, there is shown a framing system utilizing a plurality of columns 1 in two-way rows 2 and 3, with such rows or center lines of columns being spaced in a predetermined manner to suit the particular building construction. Each column of the framing system, at each floor level, is encompassed with a connecting shear-head section indicated as A which in turn has a central collar section 4 adapted to connect to the column 1, a plurality of outwardly projecting cantilevering beam members 5 and a loop form tension member 6 with tensioning means 7.

Extending between the spaced columns 1 and shear-head sections A are intermediate prestressed frame sections B which carry loadings from their respective areas and from central frame sections C to the shear-heads A. Where desired, each of the quadrants of the central frame sections
C may in turn be provided with intersecting beam members forming internal panel sections D.

The present embodiment, as best shown in FIGURES 1 and 2, includes directly each of the intersecting beam members 5 to be diagonally positioned with respect to the center lines of the columns such that they extend the corners of the shear-head section. The collar sections 4 of the shear-head sections A are adapted to connect directly to the flanges of the columns 1. Actual connections of the collar sections 4 to the columns may be made by bolting, riveting, or welding. The outer ends of the beam members 5 are provided with end beam connecting members 7. Also, at the ends of beams 5, adjacent the beam connecting members 7, are provided curved saddle-like support members 8 for the tension member 6. Each of the curved members 8 are shown as being above the upper flanges of the beam members 5 such that the loop-form tensioning rod or cable 6 likewise traverses the shear-head section A above the top end portions thereof.

A horizontal tie plate 9 extends between the connector members 7 and the saddle member 8 at each end portion so as to preclude the displacement of tension member 6 while at the same time providing a reinforcing member between the saddle 8 and the connector member 7. Also, as best shown in FIGURE 3 of the drawing, there are end plate members 10 at the respective ends of each connector 7 such that there may be bolted, riveted or welded connections to adjacent panel sections B of the framing system.

In accordance with the present invention, each of the intermediate sections B and C utilize intersecting centrally positioned beam members which in turn have their ends connected by end connectors 7 and connecting means 25. Thus, as best shown in FIGURE 1 of the drawing, each section B is bounded by external beam members 11 and 12 and has intermediate intersecting beam members 13 and 14 which are positioned symmetrically along center line portions thereof. The elongated beam members 13 extend along the center lines of columns 2 and 3, connecting to end members 12, while the cross beam members 14 positioned at a midpoint across the elongated sections connect to the side beam members 11. A cable or other loop-form of tension member 15 couples the ends of beam members 13 and 14 such that prestressing forces may be exerted in the flanges of such beam members to counteract normal floor loadings. Suitable turnbuckle or other tensioning means 17 may be utilized to exert the desired prestressing of the loop 15 and the intersecting beam members 13 and 14 in turn provide a prestressed panel section B.

As best shown in FIGURE 4 of the drawing, there is indicated the tension member 15 being held in position and connecting with an end of each beam member 14 by a suitable saddle member 16, which in turn is welded or otherwise attached along the bottom flange of the beam member 14. A similar saddle means may be used in connection with the lower end portions of beam 13.

In a rather similar arrangement to the construction of the intermediate frame members B, there may be provided centrally positioned intersecting beam members 18 and 19 within each frame section C and a loop form tensioning member 20, having tensioning means 21. As best shown in FIGURE 4 of the drawing, there is indicated a saddle type of support member 22 connecting to the bottom of a beam member 18, and suitable for slidably holding and connecting the loop form tensioning member 20 to the bottom side of beam members forming the panel section C. The present simplified embodiment indicates a single channel as forming the side beam member 11 between frame sections B and C; however, where desired, an additional channel or other framing member may be utilized in connection with the center frame sections C to provide an encompassing structural member for each center frame section C.

Each of the center frame sections C also indicate the use of diagonal tensioning members 23 and 24 which in turn utilize connecting means 25, as best shown in FIGURE 5 of the drawing, to connect the tensioning members 23 and 24 directly each of the intersecting beam members 5 and 6 having tensioning means 21. As best shown in FIGURE 5 of the drawing, the rods 23 and 24 connect directly with the junctures of the ends of the encompassing beams 11 and at effective points below the level of their neutral axis such that beams 11 may be prestressed to overcome normal vertical loads 5 may be utilized to support the ends of the encompassing beams 11.

For wide column spacings and resulting large intermediate and center sections B and C, it may be desirable to effect the placement of intermediate intersecting beams 26 and 27 within the respective quadrants of the section C, as formed by the symmetrically intersecting beam members 18 and 19. In other words, where closely spaced intermediate floor framing members are desired in the central section C, then such intermediate beam members may be positioned in the manner of beams 26 and 27. Still further, where desired to assist in providing lightweight beam sections, there may be additional loop-form tensioning members 28 traversing the ends of the beam members 26 and 27 such that compression may also be introduced into the bottom flanges of such members to counteract the positive moment from subsequent floor loadings.

Floor loadings within each center section C which extend to the intermediate intersecting beams 18 and 19 normally provide therein simple beam types of stresses, with tension in the bottom flanges and compression in the upper flanges. However, by prestressing the members 18 and 19 with the tension member 20 there are initial countering stresses in such members, i.e., compression in the bottom flanges and tension in the upper flanges such that bending moments from floor loadings on the entire section may, if desired, be entirely counteracted by the prestressing, whereby very nominal size members may be used in the entire section. There will, of course, be resulting vertical shear or end loadings transferred by the beam members 18 and 19 to the encompassing beam members 11.

In connection with sections B, the intersecting intermediate beam members 13 and 14 may be prestressed by the encompassing loop-form tension member 15 such that there is an initial countering beam stress in the beam members 13 and 14 and tension in the upper flanges. Subsequent floor loadings which provide simple beam type of positive moments may be counteracted and resulting sections provided in nominal sizes. The vertical shear loadings, or end loads, from the beams 13 and 14, will be transferred from the latter to the encompassing beam members 11 and 12 and that from all of the plurality of intermediate sections B and center panel sections C there will be an ultimate transfer of loadings to the corner of the shear-head sections A. In each of the latter, a major portion of the vertical loading effect on the projecting beams 5 can be absorbed or eliminated therefrom by tension in the loop-form member 6. A conventional cantilevering beam member from a column, such as a beam member 5 from a column 1, will provide both shear and bending moments with respect to the column; however, in the present modified embodiment, the tension member 6, by pretensioning or post-tensioning, can eliminate the bending moments in the beam members 5 and in the columns 1 such that the only resulting loading to the columns are the vertical shear forces carried through beams 5 to the column members 4.

Thus, the latter shall necessarily be fabricated to provide sufficient bolting, riveting or welding to transfer design loadings from a floor framing system to the respective columns.

It may also be noted that a preferred embodiment of the present improved framing system incorporates the use of diagonal tensioning members 23 and 24 which extend diagonally across the central sections C between diagonally opposing corners thereof to connect to the ends of beams 11. As best shown in FIGURE 5 of the drawing, the diagonals 23 and 24 may connect into the junc-
ture of intersecting beam members II by suitable corner connection means 29 having stiffener plates 30. The pre-
tensioning of members 23 and 24, prior to making fixed connections with the corners of the shear-head sections A, will provide counteracting prestressing in each of the beam members II. An alternative construction utilizes the diagonals 23' and 24' in each section B, in lieu of the members 23 and 24 in center frame C. The tension mem-
bers 23' and 24' shown illustratively in broken lines in one of the elongated panel sections B, will also serve to
prestress the beam members 11; however, such rods or cables 23' and 24' would have to be in each panel sec-
ction B and a greater number would be required for any one system. It should be pointed out that the present improved framing system may incorporate variations in the location of intermediate intersecting beam members within each of the intermediate panel sections. However, in each in-
stance, it is necessary that there be at least one intersecting set of intermediate beam members and one loop-form traversing tension member to slidably attach to the end portions of such intersecting beam members in order that loading conditions may be counteracted. Generally, the intermediate beam members in the panel sections will run parallel to rows of columns, but it is, of course, possible to place the intersecting beam members in the panel sec-
ctions in a different manner, as, for example, on the di-
agonal with respect to encompassing beam members and with respect to rows of columns such that the beam mem-
bers do not necessarily join with the encompassing beam members at midpoints. In other words, floor loadings car-
rying to beam members can be counteracted by preten-
sioning from a loop-form tension member as long as the latter traverses the ends of the intersecting members to
effect tensioning in the top flange members and compression in the lower flange members and thereby counteract normal bending moments.

It may also be pointed out that there may be modificat-
ions in connection with the structural design and arrange-
ment within the shear-head sections A by providing more than four cantilevering beam sections to transmit shear
loadings into the columns I. It is, of course, necessary with the improved shear-head design to have the one or
two loop-form tension members traversing the shear-
head section to attach to the end extremities of the can-
tilevering beam members. The connections are also pref-
erably made along the top flange of each end portion of each cantilevering beam member such that there may be pretensioning to form compression in the top flanges and tension in the bottom flanges of the cantilevering mem-
bers whereby to in turn counteract subsequent floor load-
ings at the ends of the shear head sections which would normally cause tension in the top flanges and compres-
sion in the lower flanges.

The indicated connector means between beams and the loop-form tensioning members illustrate merely one possible embodiment, and it is not intended to limit the scope of the improved and modified prestressed framing system to the use of any one form of connector means or any one type of beam section or tension rod or cable. Still further, various types of tightening or tensioning devices may be incorporated within the loop-form tensioning members and it is not intended to limit the construction to any one form of turnbuckle or tensioning device.

Although, it has not been emphasized herebefore, it is a particular feature and advantage of the improved pre-
stressed framing system to result in a lightweight section which may be easily assembled and erected. For example, each of the shear-head sections A and the intermediate sections B and C may be shop assembled and prestressed prior to being shipped onto the job site for erection. Alter-
atively, if desired, prefabricated sections can be erected without prestressing and then subsequently pre-
strained by the tensioning members in each of the sec-
tions. It is necessary that the beam members in each of

the sections be subjected to prestressing by the various tensioning members prior to making the final fixed con-
nections with the ends of the beams 5 in the shear-head sections A. Further, the system makes it possible to actu-
ally increase load carrying capacity for any one or all of the various intermediate sections without making any es-
sential change in the beams or framing members. In other words, as long as the tensioning members in the various loop-form positions are adequate to take increased load-
ings and providing greater prestressing, it is possible to accommodate greater floor loadings and bending moments without having to change the size of intermediate beam members. In an open type of building construction, the tensioning cables or rods are any time the building has been in use for some time, be adjusted to accommodate proposed greater floor loadings.

The present system is also suitable for a single story build-
ing or a multiple story building of any height. At the
same time, the system is suitable for a small size build-
ing, utilizing but four columns per bay and a wide spread building construction utilizing a multiplicity of columns spaced along a plurality of column rows. Where the system is to be used along an outside bay, there may be slight modification in symmetry by way of the narrowing of shear head sections and Intermediate frame sections which extend along the outside rows of columns of the building.

I claim as my invention:
1. A prestressed framing system for building structures which comprises in combination, spaced columns, a cantile-
levered shear-head section from each of the spaced col-
umns, and intermediate rectangular frame sections con-
ected therewith in a two-directional manner, with each of said shear-head sections and each of said inter-
mediate frame sections having intersecting beam mem-
bers therein and at least one high tensile strength ten-
sioning member traversing each of the sections in a single plane and slidably connected to the outer end portions of said intersecting beam members whereby to pro-
vide prestressing in each of such members and increased allowable loadings for predetermined sized members.
2. The framing system of claim 1 further characterized in that said pretensioning member in each frame section is positioned and connected therein to extend as a continu-
ous loop substantially encompassing the ends of said inter-
secting beam members whereby each of the latter may be prestressed as tension is exerted in said pretensioning member.
3. A prestressed framing system for building structures having each floor level comprising in combination, two-
way rows of spaced columns, positioned and connected thereto in a shear-head section connected to and cantilevering outwardly from each of said spaced columns, elongated rect-
angular frame sections positioned between said shear-
head sections and connected thereto in a two-directional manner along the spaced two-way rows of such columns, and a central frame section having intermediate intersecting beam members, and there being at least one continuous loop-form tensioning member individually traversing each of said shear-head sections and each of said frame sections in a singleplane slidably connected with end portions of said beam members wherein whereby the latter may be prestressed by application of tension in said pretensioning member.
4. The framing system of claim 3 further characterized in that said cantilevering beams from said columns, in each of said shear-head sections, are elevated at their outer ends to provide an angular position with respect to
a horizontal plane, and connections at the ends of such beams for the loop-form tensioning member in said shearhead section are along the top end portions thereof to provide prestressing that opposes normal cantilever beam loadings.

5. The framing system of claim 3 further characterized in that said intersecting beam members in said rectangular and said central frame sections have tensioning member connecting means positioned along the lower end portions thereof to thereby provide prestressing opposing bending moments from normal vertical loadings across such frame sections.

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