Jan. 3, 1967 H. P. BAKKE ETAL 3,295,288

FRAME CONSTRUCTION METHOD

Filed July 5, 1963 3 Sheets-Sheet 1

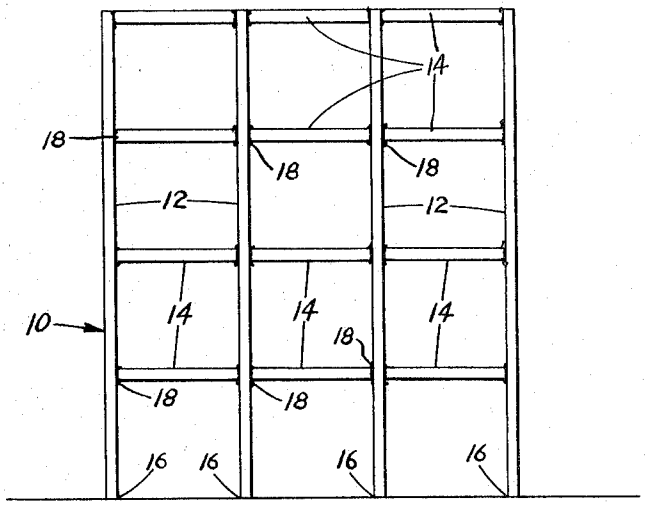


FIG. 1

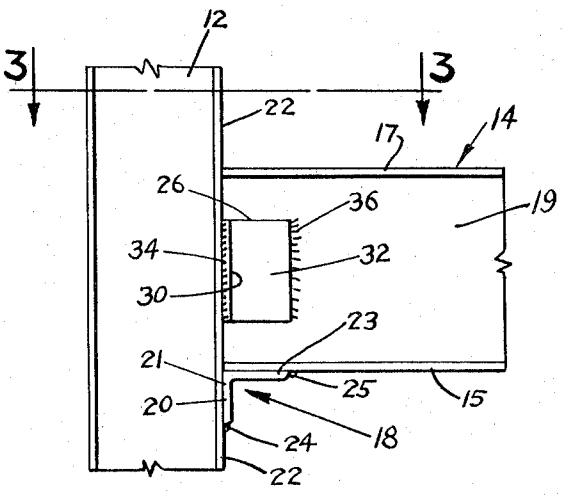


FIG. 2

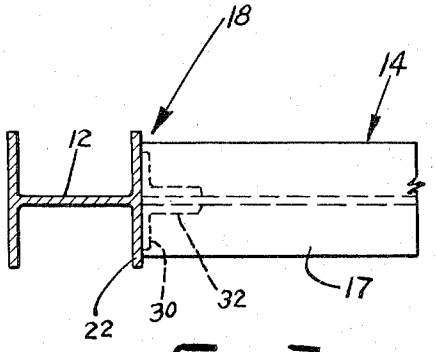


FIG. 3

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Filed July 5, 1963 3 Sheets-Sheet 2

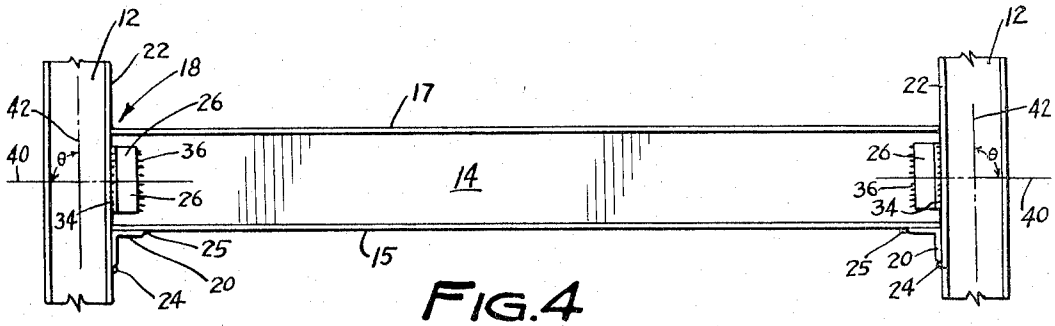


FIG. 4

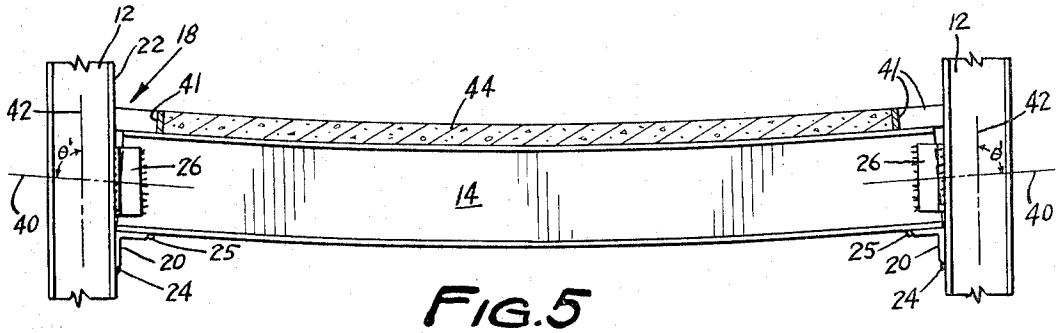


FIG. 5

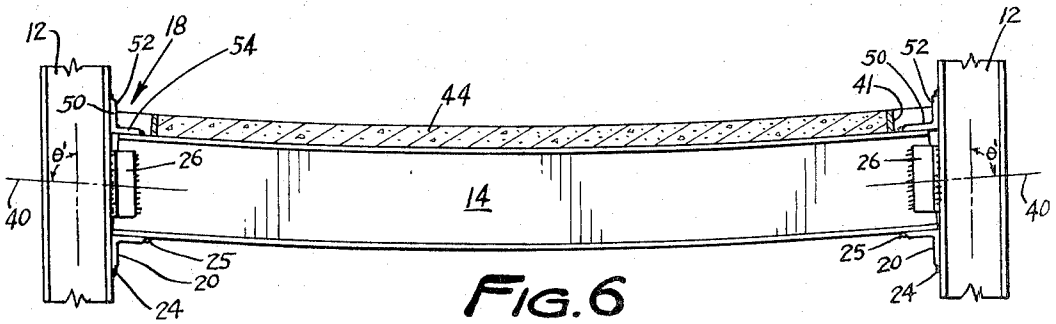


FIG. 6

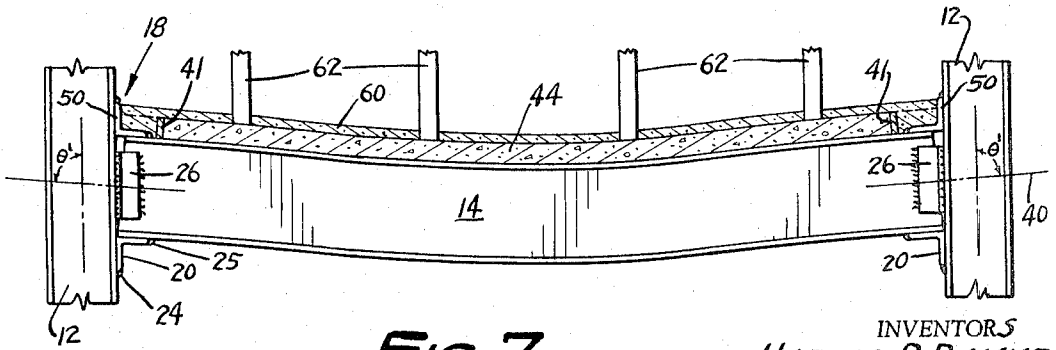


FIG. 7

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FRAME CONSTRUCTION METHOD

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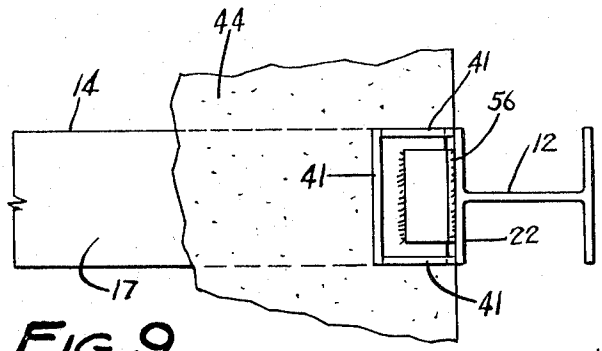


FIG. 9

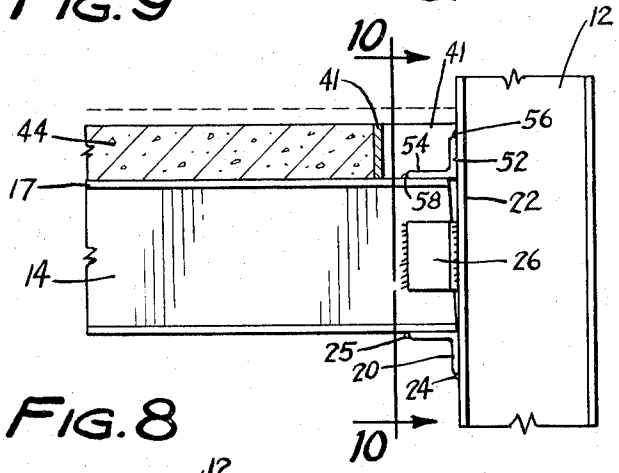


FIG. 8

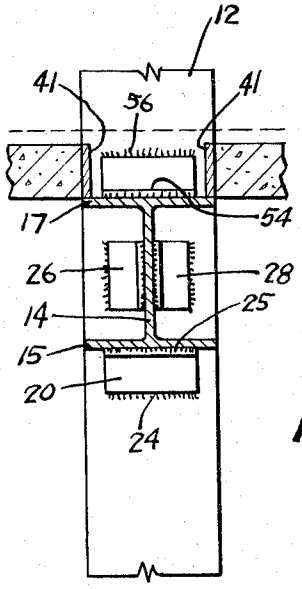


FIG. 10

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FRAME CONSTRUCTION METHOD

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7 Claims. (Cl. 52—741)

The present invention relates to the construction framing art and more particularly to a framing system especially well adapted for use in the construction of steel buildings and the like and to a method for producing the same.

A number of framework construction systems have been previously proposed. In some of these prior systems, a connecting member fastened between the beam and the column is allowed to deform beyond the yield point as the beam is deflected under load in order to reduce stresses present at the beam ends. This deformation can, of course, weaken the connection or produce an uncertain safety factor since relatively small forces will produce a substantial deformation once the yield point has been exceeded.

In other connections, the beam end is secured rigidly to the columns before a load is placed on the beam. In this type of connection, negative moments are introduced into the beam ends along with smaller positive moments being introduced at the beam mid-span. These negative moments must be transferred almost entirely to the columns thus causing the connection to be relatively expensive and large in size if it is to provide the requisite strength. In general, under the same loading conditions rigid connections will require more material for the columns and less material for the beams than in other types of construction.

In yet another type of connection a fastening member is provided which will allow rotation of the beam ends about a horizontal axis normal to the beam axis relative to the column face. As a result of this relatively free rotation, the bending moment is at a maximum at the mid-span of the beam and substantially zero at the beam ends. This distribution of moments leads to an uneconomical use of materials since most metal beams have the same cross-sectional area throughout their length.

In contrast with the prior art and in accordance with the present invention, there is provided a framework construction including vertically disposed columns and horizontally disposed cross-members or beams extending between the columns and connecting means rigidly securing the ends of the beams to the column faces with the axis of the beam at each end thereof intersecting the axis of the column adjacent thereto at an oblique angle such that the beam ends are inclined downwardly proceeding toward the center of the beam.

The framework construction of the present invention can be constructed in various ways. Thus, for example, one may suspend a large weight below the center of the beam to deflect the mid-span of the beam downwardly before the rigid connections are made between the beam ends and the column. However, according to a preferred form of practicing the present invention, a portion of the dead load which will in most instances comprise concrete flooring, roofing or the like is constructed upon the beams while the ends of each beam are hingedly secured to the columns and before the rigid connection is formed. After the beam is thus deflected, a rigid connection is formed between the ends of the beam and the column and thereafter the remaining portion of the dead load may be constructed upon the beam.

In view of these and other defects of the prior art it is a general object of the present invention to provide an improved framing system for buildings and the like which

is rugged in construction, reliable in operation and can be fabricated at a relatively low cost.

A further object of the present invention is the provision of an improved framing construction which will allow distribution of stresses in the columns and beams so as to make possible a saving of structural material without the requirement for an appreciable increase in labor cost during construction.

Another object of the present invention is the provision of an improved framework construction including a means for introducing a positive moment at the center of the beam, negative moments at each end of the beam as well as in the column adjacent to the beam ends.

Another object of the present invention is the provision of an improved framing system wherein an approximate balance can be obtained between positive and negative moments in each beam and the adjacent column segments.

Yet another object of the present invention is the provision of an improved connection between a column and a beam including a provision for allowing the fabrication of a pair of vertically spaced joints and a means permitting the fabrication of one of said joints after the construction of a floor upon said beam.

Still another object of the present invention is the provision of an improved frame construction method wherein a beam is first secured to the column such that the beam ends are allowed to rotate about horizontal axes relative to the face of the column when a load is applied to the beam, the beam then being deflected downwardly at the center and thereafter a rigid connection is formed between the ends of the beam and the column.

Other objects of the invention will become apparent as the description proceeds.

To the accomplishment of the foregoing and related ends, this invention then comprises the features hereinafter fully described and particularly pointed out in the claims, the following description setting forth in detail certain illustrative embodiments of the invention, these being indicative, however, of but a few of the various ways in which the principles of the invention may be employed.

The invention is illustrated by the accompanying drawings in which the same numerals refer to corresponding parts and in which:

FIGURE 1 is a diagrammatic side elevational view of a building embodying the present invention;

FIGURE 2 is a partial side elevational view of a connection according to a preferred form of the present invention during its first stage of construction;

FIGURE 3 is a plan view of the connection taken on line 3—3 of FIGURE 2;

FIGURE 4 is a diagrammatic side elevational view of a beam secured to columns at both ends by means in accordance with the construction framing of the present invention during its first stage of fabrication;

FIGURE 5 is a view similar to FIGURE 4 showing the construction framing during its second stage of fabrication;

FIGURE 6 is a view similar to FIGURE 5 showing the next successive stage of fabrication;

FIGURE 7 is a view similar to FIGURE 6 showing the last stage of fabrication;

FIGURE 8 is an enlarged side elevational view of one end of a beam secured to a column by means of a connection embodying the present invention;

FIGURE 9 is a partial plan view of the connection of FIGURE 8; and

FIGURE 10 is a vertical sectional view taken on line 10—10 of FIGURE 8.

Referring now specifically to the drawings there is shown in FIGURE 1 in semidiagrammatic form a building 10 embodying the present invention. The building 10 includes a plurality of vertically disposed parallel columns 12 between which are secured a plurality of beams 14 including lower and upper flanges 15 and 17 respectively and a web portion 19 at the center thereof. The lower end of each column 12 is suitably secured to the earth by well-known connections at 16 so as to be reliably retained in a vertical position. At each end of each of the beams 14 between each beam and each column 12 is provided a connection 18 acording to the present invention.

As can be best seen in FIGURES 2 and 3, fabrication of the connection 18 between beams 14 and columns 12 is begun by fastening a first pair of support members such as angle irons 20 including a vertical leg 21 and a horizontal leg 23 to the flanges 22 of a pair of adjacent columns 12. The angle irons 20 are fastened to the columns by a fillet weld 24 or, if desired, by other means such as bolts (not shown).

The beam 14 is then lowered into place conventionally with the ends of the lower flange 15 resting upon the leg 23 of the angle iron 20. As soon as the beam 14 has been put in place, the lower flange 15 is fastened to the leg 23 of each of the angle irons 20 in a suitable manner as by a fillet weld 25. In the alternative, the angle irons 20 can, if desired, be rigidly secured to the beams 14 before being secured to the columns 12.

Second and third connecting members 26 and 28 are then placed on opposite sides of the web 19 of the beam 14 and suitably secured between the beam and column. The connecting members 26 and 28 while they may have a variety of forms preferably comprise vertically disposed angle irons including a first leg 30 positioned parallel with and abutting the flange 22 of the column and a second leg 32 abutting the web 19 of the beam 14. As best shown in FIGURES 2 and 4 through 7, the connecting members 26 are secured to the column 12 and beam 14 respectively by means of fillet welds 34 and 36. It is of course understood that other types of fasteners such as bolts can be used in place of the welds 34 and 36, if desired. In some applications the support members 26 and 28 will be unnecessary and can be omitted.

Turning now particularly to FIGURES 4 through 7, it will be seen that the framework construction of the invention as has been described up to the present point is illustrated in FIGURE 4. It should be noted that the beam 14 as illustrated in FIGURE 4 is deflected only to a very small extent due to its own weight and for the purposes of this description will be considered flat along the top and bottom edges i.e., undeflected. A segment of the longitudinal axis of the beam 14 is illustrated at each end of the beam. Each of these segments is designated 40. The longitudinal axes of the columns 12 is designated 42. Since the mid-span of beam 14 of FIGURE 4 can be considered undeflected, the angle θ between the axes 40 and 42 at each end of each beam can be considered to be 90°.

Upon the upper surface of each of the upper flanges 17 of the beams 14 are placed a plurality of uprights which can be made of either metal or wood to form a dam or bulkhead 41. The dam 41 extends to the side edges of the flange 22 as clearly shown in FIGURES 8 through 10 and a predetermined distance toward the center of the beam 14. The size of the dam is not of critical importance so long as the enclosure defined by the dam is of sufficient size to accommodate an additional fastening member as will be described fully hereinbelow. It will of course be apparent that as the floor 44 is poured, the concrete will be prevented from covering the upper aspect of each end of the beam due to the presence of the dam 41 at each end. The dam may therefore be thought of as a means for maintaining the concrete out of contact with each end portion of each beam.

The next stage of construction is illustrated in FIGURE 5 wherein it will be seen that a load such as a floor 44 formed from concrete or the like is poured upon the upper surface of each beam 14 and extends laterally therefrom in all directions over the upper faces of all of the beams 14 at the same elevation in the building. The method of providing support scaffolding for the pouring of such floors is well-known and therefore will not be described in detail herein. After the floor 44 has been completed, the beam 14 will be deflected downwardly at the center with the fasteners 20, 26 and 28 functioning as hinges and allowing the upper aspect of the end of beam 14 to separate from the columns 12 as shown in FIGURE 5. As this hinging movement takes place, the web 23 of the angle iron 20 will be deflected downwardly to a slight extent. Simultaneously, the webs 30 of the fasteners 26 and 28 will be deflected outwardly a slight distance from the columns 12 but since this deflection is so small, it has not been illustrated in the figures. The separation of the upper aspects of the ends of the beam 14 and the column 12 is a significant factor and therefore has been illustrated clearly in the figures.

Thus, after the beams 14 have been placed under the load of the floor 44, there will result a positive bending movement at the mid-span of the beam but without introducing substantial moments to the beam end or columns at each end of the beam due to the fact that connecting members 20, 26 and 28 allow a relatively free hinging movement of each end of the beam. While some moments will occur in the column, those that do occur result primarily from eccentric column loading.

After the beams 14 have been thus loaded, an additional fastener member such as an angle iron 50 is mounted above the end of each beam. The angle iron 50 includes a vertical web 52 adjacent to the flange 22 and a horizontal web 54 adjacent the upper flange 17. The flanges 52 and 54 are then suitably secured to the column and beam respectively as by fillet welds 56 and 58 respectively, see FIGURES 8, 9 and 10. Again, as with the connecting members 20, 26 and 28, other fasteners such as bolts can be used in place of welding.

After the angle irons 50 have been put in place, the ends of the beams 14 may be considered rigidly connected to the columns 12 but as clearly shown in FIGURES 5 through 7, the angular relationship between the axes 42 and the segments 40 at each end of the longitudinal axis of the beam 14 will be an oblique angle designated θ' with the end portions of the beam being inclined downwardly toward the center thereof. It is important to note that the oblique angle θ' between the axes of the ends of each beam and each column has not resulted from stresses in the connecting members which either approach or exceed the yield point since the separation between the flange 17 and column 12 takes place before the placement of fasteners 50. As a result, none of the connecting members 20, 26, 28 and 50 is operating at or near the yield point and for this reason the physical condition and strength of the connection 18 can be accurately predicted and maintained within prescribed limits.

After the fastener 50 has thus been put in place, an additional portion of the dead load such as a concrete floor finish 60, partitions and walls 62 can then be constructed. A portion of the floor finish 60 can frequently be employed to fill the enclosure defined by the dam 41. As can be seen in FIGURE 7, the additional load composed of the floor finish 60 and partitions and walls 62 is applied while the ends of the beam are prevented from further rotation by means of the fasteners 50 so that additional positive moments are introduced at the beam mid-span and negative moments at the ends of the beam. The loads consequently are more evenly distributed than in prior practice and a significant saving in material can be accomplished in most instances. According to calculations carried out for a typical multiple floor steel frame building, savings of steel costs on the order of 10% can

be realized without a sacrifice in the required safety factor. The present invention moreover can be produced without substantial additional labor costs as compared with a prior art connection which does not embody the features of the present invention. A further significant advantage of the present invention is the fact that none of the connecting members are stressed to their yield point. As a result, the strength factor can be exactly predicted.

While the percentage of the loading placed upon the beams 14 before the upper connecting member 50 is installed will ordinarily vary from 25 to 75% of the total load to be placed on the beam, it need not be within these limits nor is it considered critical except, of course, that as the percentage of the initial load is decreased, the moments in the finished joints will be increased and the positive moment at the mid-span of the beam will be decreased. Moreover, while the second portion of the beam load to be put in place has been illustrated by way of example as a floor finish and walls, it may in some cases be composed entirely of live load as for example the snow and rain accumulation upon a roof.

It is apparent that many modifications and variations of this invention as hereinbefore set forth may be made without departing from the spirit and scope thereof. The specific embodiments described are given by way of example only and the invention is limited only by the terms of the appended claims.

We claim:

1. A method of constructing a supporting framework including a plurality of vertically disposed columns and a plurality of horizontally disposed beams extending therebetween, the steps of first, fastening the ends of each of the beams to each of the columns to provide a hinged connection therebetween; second, placing a load at the center of said beam to deflect the center thereof downwardly; third, rigidly connecting each end of the beam to the column to thereby prevent further pivotal movement between the beam and the column about a horizontal axis.

2. A method of constructing a supporting framework including a plurality of vertically disposed columns and a plurality of horizontally disposed beams extending therebetween, the steps of first, fastening the ends of each of the beams to each of the columns to provide a hinged construction therebetween; second, placing a load at the center of said beam to deflect the center thereof downwardly; third, rigidly connecting each end of the beam to the column at a point spaced vertically from said first point to thereby prevent further pivotal movement between the beam and the column about a horizontal axis, the end of the beam being thus rigidly connected to each column.

3. The method of constructing a supporting framework including a plurality of vertically disposed columns, a plurality of horizontally disposed beams extending therebetween, the steps of first fastening the ends of each of the beams to each of the columns at a first location to provide a hinged connection therebetween, second, placing a load at the center of said, beam to deflect the center thereof downwardly, third, connecting the ends of each beam to said columns at a second location spaced vertically from said first location to thereby prevent further pivotal movement between the beam ends and the column about a horizontal axis, said connections at said first and second locations cooperating to provide a rigid connection between the end of each beam and each column and thereafter placing an additional load upon the beam, the additional load being adapted to deflect the mid-span of the beam downwardly and said rigid connection between each end of the beam and each column preventing further pivotal movement between the columns and each beam.

4. The method of constructing a building including a plurality of vertically disposed columns and a plurality of horizontally disposed beams extending therebetween, the steps of hingedly connecting the ends of the beams between columns for movement about a horizontal axis normal to said beam axis, constructing a floor upon the beams to provide a first load adapted for deflecting the center of beams downwardly and thereby pivot each end of each beam about said hinged connection, next rigidly connecting each end of the beam to each column at a point spaced vertically with respect to said hinged connection.

5. The method of constructing a building including a plurality of vertically disposed columns and a plurality of horizontally disposed beams extending therebetween, the steps of hingedly connecting the ends of the beams between columns for movement about a horizontal axis normal to said beam axis, constructing a floor upon the beams to provide a first load adapted for deflecting the center of beams downwardly and thereby pivot each end of each beam about said hinged connection, next rigidly connecting each end of the beam to each column at a point spaced vertically with respect to said hinged connection, next constructing a second load upon said floor, said second load being adapted to deflect the center of the beam downwardly but said hinged and said rigid connection being adapted to prevent further pivotal movement between the ends of each beam and the columns.

6. The method of erecting a building including a plurality of vertically disposed columns and a plurality of horizontally disposed beams extending between said columns, fastening members for connecting the ends of the beams with the columns, a floor finish and walls, the steps of first rigidly connecting one said fastening member between the lower aspect of each end of each such beam with the side of one of said columns, second, positioning a dam about the upper aspect of each end of each beam to define an enclosure at the end of each beam, third, constructing a floor upon the beams, said floor being adapted to deflect the mid-span of the beam downwardly so that the longitudinal axis at the end of each beam intersects the longitudinal axis of each of the columns at an oblique angle with the ends of the beam being inclined downwardly toward the center thereof, next placing the other of said fastening members into each said enclosure and rigidly connecting said other fastening members between the upper aspect of said beam and the adjacent portion of said column and thereafter constructing said floor finish and said walls upon said floor.

7. The method according to claim 6 wherein said enclosure is filled immediately preceding the construction of said floor finish.

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