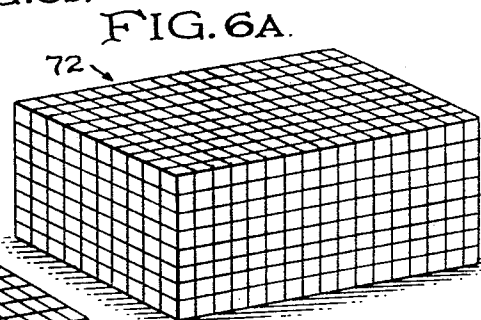
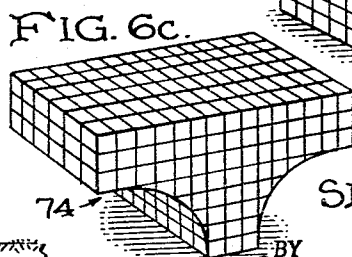
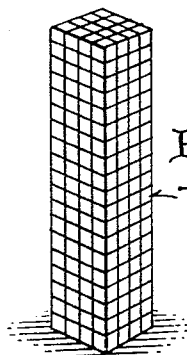
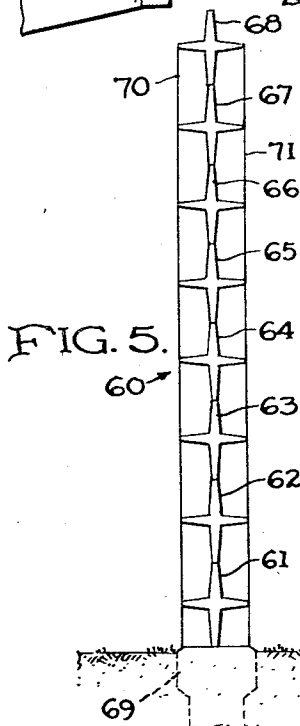
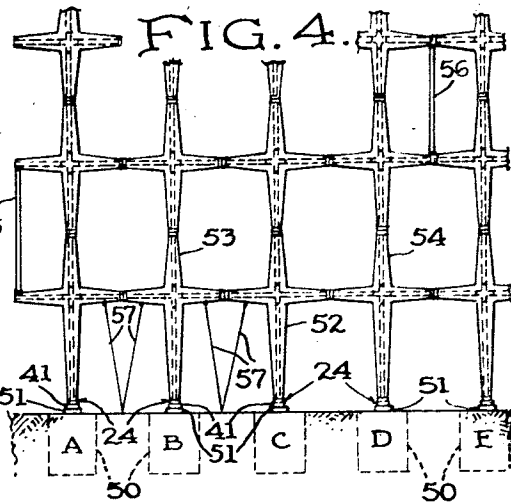
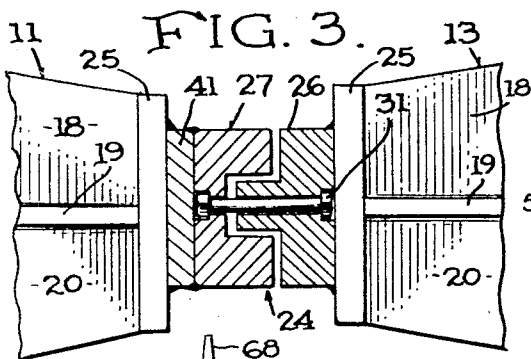
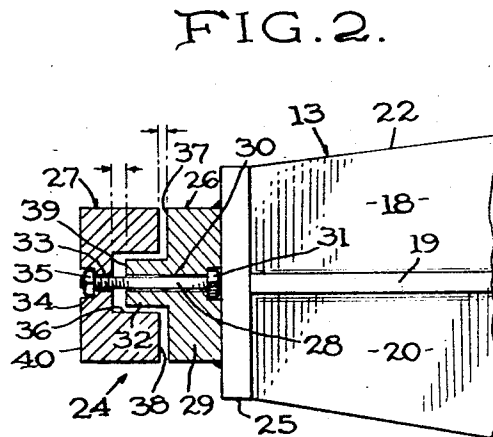
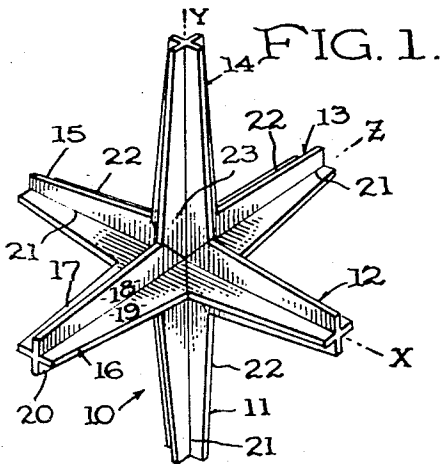


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S. DOWLING

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SPACE FORM SKELETON STRUCTURES MADE OF PREFABRICATED
TRI-AXIAL INTERLOCKING BUILDING ELEMENTS HAVING
NON-RIGID FORCE DISTRIBUTING CONNECTORS
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INVENTOR

SEAMUS DOWLING

BY
Cameron, Kerkam & Sutton
ATTORNEYS

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SPACE FORM SKELETON STRUCTURES MADE OF PREFABRICATED TRI-AXIAL INTERLOCKING BUILDING ELEMENTS HAVING NON-RIGID FORCE DISTRIBUTING CONNECTORS

Seamus Dowling, 2151 California St. NW., Apt. 504,

Washington, D.C. 20008

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8 Claims

ABSTRACT OF THE DISCLOSURE

Prefabricated tri-axial building elements are stacked to form a plurality of horizontally spaced columns which are interlocked to provide a space form skeleton for a multi-layer structure which may be a building, a bridge, a tower, or the like. Each prefabricated building element has a plurality of mutually perpendicular arms, and selected arms have provided at their ends a non-rigid force distributing connector.

BACKGROUND OF THE INVENTION

The use of prefabricated building elements for forming structures is known; however, presently used methods of construction and design of prefabricated building elements depend to a great extent on the application of conventional principles of force transmission and a rigid interconnection of all units.

Briefly, the requisite strength of elements required to transmit forces to footings which support a structure are determined by the post and lintel method, the arch method or the rigid frame method. In the post and lintel method, the horizontal member or lintel is designed to absorb the energy of load deflection and rest the load, together with its own weight on a vertical column at each end. The vertical column or post maintains the lintel in position by thrusting upward and is itself strong enough to deliver its weight and the accumulated load to the footings.

The arch method is used for designing curves or arches. A plurality of individual elements are built-up and locked together geometrically in a flat arch which acts as a lintel or a high arch which acts in combination as a lintel and a column. The rigid frame method introduces a continuity of bending by employing a horizontal member which acts as a lintel and, which upon being bent in a vertical direction, acts as a column.

In applying these principles, it has generally been assumed that a rigid interconnection of elements is necessary for proper distribution of load forces and stability of the erected structure. Where prefabricated building elements are utilized, resort is often made to prestressing or post tensioning of the elements.

SUMMARY OF THE INVENTION

In accordance with the present invention, I have found that structures such as buildings, towers, dams, bridges, scaffolding and the like can be erected from preformed or prefabricated tri-axial building elements having non-rigid force distributing connectors. The individual prefabricated elements are interlocked by field assembly of a matrix of prefabricated elements arranged in a desired space form skeleton. By space form skeleton, it is meant the frame structure of the erected unit which is adapted to support the floor panels, wall panels and other finishing materials necessary to complete the structure.

In many applications, where individual building elements are used to erect a building, the elements are cast on site. Particularly in the case of precast concrete structures, heavy precast elements create a considerable

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amount of difficulty when erecting buildings of any substantial height. The use of prefabricated tri-axial building elements and non-rigid connections in accordance with the present invention has the advantage that the individual elements can be economically manufactured on a mass production basis at a remote location. Further, the building elements can be designed to be of comparatively small size and weight and can be constructed of a variety of materials so that handling and shipping problems and problems of on site erection are minimized. Tapered construction of members forming the building elements reduces the amount of material used to reduce dead load and facilitates gradation of forms for esthetic effects.

A primary object of the present invention is to provide prefabricated building elements adapted for assembly into a space form skeleton structure.

Another object of the present invention is to provide a space form skeleton structure comprising a matrix of interlocked prefabricated building elements.

Yet another object of the present invention is to provide a non-rigid connector for interlocking prefabricated building elements.

Still another object of the present invention is to provide a non-rigid force distributing connection for prefabricated building elements adapted to be interlocked to form a rigid skeleton frame structure.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings, wherein like characters represent like parts throughout the several views:

FIG. 1 is a perspective view of a prefabricated building element, without connectors;

FIG. 2 is a fragmentary, elevational view, partly in cross-section, of a prefabricated building element and connector;

FIG. 3 is a fragmentary, elevational view, partly in cross-section, of a connection between adjacent arms of adjacently mounted prefabricated elements;

FIG. 4 is a fragmentary, elevational view, of a space form skeleton comprising columns of stacked prefabricated building elements constructed in accordance with the present invention;

FIG. 5 is an elevational view of a single column forming a tower embodying the principles of the present invention; and

FIGS. 6A-6C are schematic views of typical structures which may be formed in accordance with the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the drawings, and in particular to FIG. 1, reference character 10 designates generally a prefabricated tri-axial building element which may be used to form the skeleton support of a structure. Element 10 includes a plurality of mutually perpendicular arms 11-16, each of which is advantageously constructed from four planar members 17-20 joined to each other along one edge 21. The other edge 22 of each member 17-20 may be tapered to reduce dead load of the structure.

A portion of each member is cut or tapered at one end 23 and the member is disposed so that the end abuts the cut-away portion of the end of an adjacent planar member of an adjacent arm. The ends 23 of each of the four planar members 17-20 of each arm terminate at a point which forms the center of the building element and a central reference or point of origin for the axes x, y and z of the arms.

As illustrated in FIG. 1, the building element is symmetrical about the point of origin and, therefore, each arm is symmetrical about its axis. Such a structure not

only facilitates fabrication, but provides a unit which is readily adapted for computer computation of stresses and sizes and adaptation of computer programming to the building process. It is not necessary, however, that exact symmetry about the point of origin be maintained. In some instances, it is preferable that the lengths of the individual arms of an element be different. The lengths are chosen in accordance with design requirements of the structure in which the elements are used, but in all cases, each arm is constructed symmetrical about its axis. The elements may be fabricated from steel, aluminum, reinforced concrete, wood, plastic, or any other suitable building material.

In order to stack building elements in the form of a column and to interlock elements in adjacent columns, selected arms of each element have secured at their ends, as more clearly shown in FIG. 2, a mounting plate 25 which is attached to a non-rigid force distributing connector 24 fabricated of metal. Connector 24 is designed to withstand static and dynamic loads of the completed structure and includes bearing plate 26, mounting block 27, and inter-connecting link 28. Mounting plate 25 is preferably a disc shaped member joined to the end of an arm in any suitable manner so as to provide a flat surface to which the bearing plate 26 is welded.

Bearing plate 26 includes a main body portion 29 having a central bore 30 which receives the link 28. Bore 30 is countersunk at the face of the main body portion adjacent plate 25 to provide an enlarged bore opening that receives the head 31 of the link. The unconnected side of bearing plate 26 includes an integral cylindrical projection 32 through which the central bore 30 extends.

Mounting block 27 includes a central bore 33 which extends therethrough and adapted to receive the end of link 28 which is of a length sufficient to extend into the countersunk bore 34. Enlarged bore 34 receives a link fastening head 35 which when mounted prevents plate 26 and block 27 from separating. In the face of mounting block 27, adjacent bearing plate 26, there is provided an enlarged bore 36 which is freely received over projection 32. The depth of bore 36 is slightly greater than the length of projection 32 so that the column bearing forces are applied to mating surfaces 37, 38 of the bearing plate and mounting block and not between surface 39 of the projection and the adjacent flat surface of bore 36. The outer curved surface of projection 32 and the internal curved surface of bore 36 are dimensioned and cooperate to withstand maximum shear forces.

As hereinbefore mentioned, outer mounting block 27 is freely received over projection 32 and loosely mounted thereto by interconnecting link 28. A threaded bolt and nut may advantageously be used to mount the bearing plate and mounting block together whence none of the shear or column forces of the structure are taken up by the link. The connection should be such that the mounting block in its assembled position can be freely turned by hand. This permits a slight rotation of coupled building elements and insures that the bending moment at the point of connection will be zero, while the shear forces will be maximum. Forces are transmitted from one building element to the other through the arms which resist flexure until absorbed by structure footings or other stabilizing members. Due to the fact that the horizontal arms extend perpendicular to each other and are perpendicular to the columnar, vertically disposed arms, the completed structure is capable of taking up wind forces from all directions.

It should be readily apparent that there has thus far been described a building element which may be preassembled at a remote location as a single unit having one or more connectors mounted in place and which may be conveniently shipped to the construction site where the elements are joined to erect the structure. FIG. 3 shows the manner in which a connector on one arm of a building element is joined to an adjacent arm of an adjacent

building element. To this end, adjacent building elements are positioned in place and the elements aligned and leveled. At this point, a spacing exists between mounting plate 25 and the back, substantially flat face 40 of mounting plate 27. The spacing is measured and an appropriate shim plate 41 is welded to the surface 40 and to the adjacent mounting plate 25.

It should be apparent that, at this point, there has been described a connection which is non-rigid and completely free. That is, if one element is held firm, the other building element is free to rotate about the axis of the connector. This connection is the same whether made between two horizontal arms or two vertical arms of the building elements. When made between horizontally disposed arms, the adjacent curved surfaces of the mating male and female connecting members take the shear forces. For vertically disposed arms, the mating surfaces 37 and 38 transmit the columnar forces.

Referring to FIG. 4, there is illustrated one row of a plurality of columns A-E of a structure formed in accordance with the principles of the present invention. Each column A-E is supported on a separate footing 50 which serves to absorb the static and dynamic loads on the structure and to stabilize the structure at the base. However, stabilization can be effective through the use of tension or compression members interconnected between the extremities of selected arms of the outermost building elements. In the embodiment where the ground structure is utilized to stabilize the structure, footings 50 need not be applied beneath each column A-E, and it is only necessary that there be at least two adjacent footings to absorb all forces transmitted through the arms of the building elements.

In the process of erection, the footings 50 are first poured and a mounting plate 51 is set level on each footing. Preferably, the center column C of the structure is set first, and building element 52 is carried and set in position by a crane. The workmen set element 52 for proper height and level by the addition of shims which are welded to the mounting plate and to the mounting block of a connector on the arm of the building element in the manner hereinbefore described. Next, adjacent building elements 53 and 54 are swung into place and leveled. The process is repeated until all building elements in the first layer are positioned in place. Temporary guy wires 57 may be utilized to stay the elements in position. After the first layer is positioned, the fractional clearance between each adjoining element is measured and shim plates of accommodating thickness are welded in position. The first layer is now interlocked and the guy wires 57 may be removed. A transit is set up at the next higher level and the second layer of building elements are set in position atop the lower level, and the process repeated until roof level is reached.

Where foundation stabilization is insufficient, the outermost extremities of the building elements may be interconnected with compression bars 55, 56, either at the uppermost level or at side elevations or through any intermediate level. Lastly, the floor panels and walls and interior elements are added in any conventional manner, and are supported to the flat planar members which make up the arms of each building element.

FIG. 5 shows an elevational view of a single column 60 comprising eight stacked elements 61-68 supported on a narrow flat concrete foundation 69. Cables 70 and 71 connect the horizontal arms of each element to the base. As the column 60 is erected, the cables connecting building element 61 to the foundation are maintained taut. As the second element 62 is placed in position, the cable connection is extended and the connection again made taut, the process being repeated until the final element 68 is raised in position. The uppermost elements 67 and 68 are adapted to support a carillon system in a conventional manner. It should be apparent, that in addition to the functional tower structure, the erected tower has considerable esthetic value.

Other forms of possible structures are illustrated diagrammatically in FIGS. 6A, 6B and 6C. FIG. 6A shows a low type, seven-layer structure 72, while FIG. 6B shows a tall, multilevel, skyscraper type building 73. It should be apparent from the simplified diagrammatic views that the process of erection, particularly from the design standpoint, is considerably simplified. At each juncture of a horizontal and vertical line in the diagrammatic views, there is positioned a building element. The dimensions of the building element are automatically determined by the spacing between the juncture points, each arm being equal to one-half the distance between the juncture points. FIG. 6C illustrates a bridge structure 74 wherein the forces from the outermost building elements are transmitted to the lowermost elements in the center supporting columns. Obviously structures of various shapes and sizes can be erected in accordance with the inventive concept of the present invention, and various modifications will suggest themselves to those skilled in the art without departing from the inventive concept. It is therefore intended by the appended claims to cover all such modifications which fall within the true scope and spirit of the invention.

I claim:

1. A skeleton space form for a multi-level structure comprising a plurality of horizontally spaced vertical columns, each column including a plurality of stacked prefabricated tri-axial building elements, each element comprising a plurality of mutually perpendicular arms extending outwardly in horizontal and vertical directions from a central point and being symmetrical about said point, means for vertically supporting the corresponding arm of the building elements in each vertical column and means for non-rigidly connecting selected ends of the other arms of the building elements in each vertical column to adjacent ends of adjacent arms of the building elements in adjacent vertical columns such that there is formed a stable frame structure having interdependent building elements forming a plurality of levels, each level comprising a matrix of said tri-axial building elements.

2. A skeleton space form as set forth in claim 1 wherein said means for non-rigidly connecting selected ends of the other arms of the building elements in each vertical column to adjacent ends of arms of the building elements in adjacent vertical columns includes a bearing plate secured to each selected end and a bearing block loosely secured to each bearing plate and adapted to be rigidly connected to the corresponding adjacent ends.

3. A non-rigid force distributing connection joining arms of adjacent prefabricated building elements, each building element comprising a plurality of mutually perpendicular arms extending outwardly in horizontal and vertical directions from a central point and being symmetrical about said point, said elements adapted to be interlocked to form a rigid skeleton frame structure comprising a bearing plate having a main body portion and a projection extending therefrom, a mating block having a cylindrical bore adapted to receive said projection, the depth of said bore being greater than the length of said projection and the diameter of said bore relative to the diameter of said projection being such that a snug fit is provided between the projection and the bore, means for mounting said bearing plate to one end of the arm of one of the prefabricated building elements and means for mounting said mating block to the adjacent end of the arm of the adjacent prefabricated building element such that said projection is received within said bore.

4. A non-rigid force distributing connection as set forth in claim 3 wherein said bearing plate and said mating block are mounted to provide a beam connection with the axes parallel to ground level such that the outer surface of said projection and the adjacent surface of the

bore provide a shear bearing surface for transmission of load forces through said beam connection between adjacent prefabricated elements.

5. A non-rigid force distributing connection as set forth in claim 3 wherein said bearing plate and mating block are mounted to provide a column connection with their axes vertical such that the flat surface of the bearing plate adjacent and surrounding the projection and the flat surface of the mating plate adjacent and surrounding the bore provide a column bearing for transmission of load forces through said connection between adjacent prefabricated elements.

6. A force distributing connector interlocking prefabricated building elements, each building element comprising a plurality of mutually perpendicular arm extending outwardly in horizontal and vertical directions from a central point and being symmetrical about said point, said building elements being arranged in a rigid frame structure comprising a bearing plate having a main body portion and a cylindrical projection extending from one face thereof, the other face of said body portion being secured to one arm of a prefabricated building element, a mating block having a first bore extending partially therethrough and a second bore extending through said block, said bearing plate having a bore extending therethrough and axially aligned with said second bore and means extending through said axially aligned bores for loosely mounting said mating block to said bearing plate with said projection being received within said first bore and means secured to said mating block and adapted to be secured to an adjacent prefabricated element for effecting a non-rigid connection between adjacent prefabricated building elements.

7. A force distributing connector as set forth in claim 6 wherein the depth of said first bore is greater than the length of said projection and the diameter of said first bore is slightly greater than the diameter of said projection.

8. A skeleton space form for a multilevel structure comprising a plurality of prefabricated triaxial building elements, each element having a plurality of mutually perpendicular arms, base means for supporting the space form, first connecting means for vertically supporting one arm of one of said building elements to the base means, second connecting means for vertically supporting the other of said building elements in stacked relationship to form a vertical column, said first connecting means comprising a non-rigid connection between said one arm and said base means, said second connecting means comprising a non-rigid connection between adjacent ends of adjacent vertical arms of the stacked building elements and tension means connected between each building element and said base means for stabilizing said column and thereby form a stable column structure having a plurality of levels.

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JOHN E. MURTAGH, Primary Examiner

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