

ACCESS STRUCTURE INTEGRATION ASSEMBLY AND INTEGRATED ACCESS SYSTEMS AND METHODS OF USING THE SAME

CROSS-REFERENCE TO RELATED APPLICATION

[0001] None.

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

[0002] None.

FIELD OF THE INVENTION

[0003] The invention relates, generally, to the field of construction and temporary structures that are erected to access various parts of various structures. In one aspect, the invention relates to the integration of supported work platform systems and suspended work platform systems and a structural assembly for accomplishing the same.

BACKGROUND OF THE INVENTION

[0004] Work platforms and other access structures, including suspended work platform systems and scaffolding, allow workers to access difficult to reach worksites and can be assembled on the job site as needed. For example, when working on structures such as bridges where there is no stable or suitable bottom surface for building up standard supported work platforms, suspended work platforms allow workers to access the undersides of these structures. Suspended work platforms also eliminate the need to build standard work platforms and platform systems to significant and unwieldy heights. However, suspended work platforms are not always ideal for accessing some structures. Supported work platforms may be beneficial to provide improved access to some structures, even after suspended work platforms are in place. It may therefore be beneficial to install supported work platforms on top of suspended work platforms.

[0005] Suspended work platforms use plywood panels secured in a frame-like structure to create a platform which is suspended from an overhead structure. The legs used with traditional supported work platforms impart large concentrated loads. The plywood panels

used in suspended work platform systems are not able to withstand the pressures exerted by frame legs, and the loads must be properly distributed on structural members using dunnage and/or beams. Installing dunnage systems or beams requires significant equipment, effort and time. Further, dunnage systems only resist downward loads, and additional guy wires or bracing is necessary to resist sideways, upward or overturning forces. In other words, dunnage systems only prevent movement in a single direction, and a significant amount of extra equipment and material is needed to prevent standard work platform systems from moving or shifting when installed on a suspended work platform system. Dunnage cannot truly structurally integrate a standard supported work platform system with a suspended work platform system.

[0006] In summary, a need exists to overcome the above stated, and other, deficiencies in the art of work platform and work platform support systems. A need exists for an improved system to truly integrate suspended and supported work platforms and which properly distributes the forces exerted by supported work platform systems on structural members of suspended work platform systems.

SUMMARY OF THE INVENTION

[0007] To overcome the aforementioned, and other, deficiencies, the present invention provides a device for use with work platform system, a work platform support system, a work platform system, and a method of manufacturing and installing same.

[0008] In a first general aspect, the present invention provides an access structure integration assembly comprising at least one channeled structure, which may be a C channel, and at least one joist socket, wherein the joist socket is slidably engaged with the channeled structure. In some embodiments, the channeled structure is a C channel comprising a solid, flattened bottom portion; two flattened side wall portions extending upward from the bottom portion at approximately right angles, each side wall portion terminating in a flange extending at a right angle from the side wall portions such that the flanges extend toward each other; and a linear gap extending the length of the C channel and having a width. In further embodiments, the joist socket is slidably engaged with the channeled structure using at least one T-bolt which is slidably engaged with the linear gap of the C channel. The T-bolt comprises a head having a width greater than that of the linear gap. In further embodiments, the joist socket comprises a hollow tubular body; and a base. In one

embodiment of an integration assembly, the C channel is configured to secure to a base structure and the joist socket is configured to secure to a second structure. The base structure may be a suspended work platform system which is articulatable, and the second structure may be a supported work platform system. An access structure integration assembly according to the embodiments described herein may include a deck retainer.

[0009] According to a second general aspect, the present invention provides an access structure integration assembly comprising: at least one substantially squared channeled structure, the channeled structure comprising a solid, flattened bottom portion containing a plurality of apertures corresponding to the apertures of the deck retainer, two flattened side wall portions extending upward from the bottom portion at approximately right angles, each side wall portion terminating in a flange extending at a right angle from the side wall portions such that the flanges extend toward each other, and a linear gap extending the length of the channeled structure and having a width; at least one joist socket comprising a hollow tubular body and a base having a plurality of apertures; a plurality of T-bolts extending through the apertures of the joist socket and into the linear gap of the channeled structure and having a head portion with a width greater than that of the linear gap, wherein the T-bolts are slidingly engaged with the channeled structure and each of the T-bolts is secured with a nut; and optionally, at least one substantially linear deck retainer comprising a plurality of apertures corresponding to the apertures of the channeled structure, wherein the deck retainer is parallel to the channeled structure and secured to the channeled structure by a plurality of bolts, each bolt extending through a set of corresponding apertures of the channeled structure and deck retainer.

[0010] According to a third general aspect, the present invention provides a base structure comprising: at least one unit; at least two access structure integration assemblies secured to the at least one unit, each integration assembly comprising at least one channeled structure and at least one joist socket slidingly engaged with the channeled structure, wherein each channeled structure is secured to the unit.

[0011] In one embodiment, the channeled structure is a C channel which is a substantially squared tubular structure comprising a solid, flattened bottom portion; two flattened side wall portions extending upward from the bottom portion at approximately right angles, each side wall portion terminating in a flange extending at a right angle from the side

wall portions such that the flanges extend toward each other; and a linear gap extending the length of the C channel and having a width. The joist sockets are slidably engaged with the C channels using at least one T-bolt which is slidably engaged with the linear gap of the C channel.

[0012] In some embodiments, the base structure further comprises a deck retainer secured between the unit and a C channel such that the deck retainer is parallel with the C channel. The joist sockets in any embodiment provided are configured to secure to a second structure, which may be a supported work platform system.

[0013] In one embodiment, at least one unit of the base structure comprises four joists interconnected with four hubs. In another embodiment, the unit comprises at least two joists and each integration assembly is secured to one of the joists. The joists may contain a plurality of cage nuts and the C channels may comprise a plurality of apertures corresponding to the cage nuts so that the integration assemblies may be secured to the joists by a plurality of bolts, each bolt extending through an aperture of the C channels and engaging a corresponding cage nut.

[0014] A base structure according to the embodiments described here may include a plurality of units, each unit defined by four joists interconnected with four hubs, wherein the joists and hubs are interconnected such that the joists are coplanar with respect to one another. Each joist may comprise an upper element and a bottom element. The base structure may also include a plurality of integration assemblies, each integration assembly secured to the upper element of a joist and parallel to the joist. Each joist may further include a plurality of cage nuts, and each channeled structure a plurality of apertures corresponding to the cage nuts, such that the integration assemblies are secured to the joists using bolts extending through the apertures of the channeled structure and engaging the cage nuts.

[0015] In a further embodiment, the base structure further comprises a plurality of suspension connectors secured to the hubs.

[0016] According to a fourth general aspect, the present invention provides a suspended work platform system comprising: a plurality of joists, each having an upper element and a bottom element; and a plurality of hubs, wherein the plurality of joists comprises at least four joists and wherein the plurality of hubs comprises at least four hubs; wherein the joists and

hubs are interconnected such that the joists are coplanar with respect to each other; a plurality of access structure integration assemblies, each integration assembly comprising a substantially linear deck retainer comprising a plurality of apertures, a substantially squared channeled structure parallel with the deck retainer comprising a solid, flattened bottom portion containing a plurality of apertures corresponding to the apertures of the deck retainer, two flattened side wall portions extending upward from the bottom portion at approximately right angles, each side wall portion terminating in a flange extending at a right angle from the side wall portions such that the flanges extend toward each other, and a linear gap having extending the length of the channeled structure and having a width; a plurality of deck retainer bolts extending through the corresponding apertures of the deck retainer and channeled structure; a plurality of joist sockets comprising a hollow tubular body and a base having a plurality of apertures; and a plurality of T-bolts extending through the apertures of the joist socket and into the linear gap of the channeled structure and having a head portion with a width greater than that of the linear gap, wherein the T-bolts are slidably engaged with the channeled structure and each of the T-bolts is secured with a nut; wherein each channeled structure secures at least two joist sockets, wherein each integration assembly is secured to the upper element of one of the joists, and wherein the number of joists is greater than the number of integration assemblies.

[0017] In one embodiment of the third aspect, the joists comprise a plurality of cage nuts which engage the deck retainer bolts to secure deck retainer and channeled structure to joists.

[0018] The suspended work platform system may also include at least two suspension connectors, each secured to one of the hubs. At least one of the hubs may comprise a first surface with a set of openings; a second surface substantially parallel to the first surface, the second surface having a second set of openings; and a structural element connected between the first surface and second surface, wherein at least one of the first set and the second set of openings is co-axial with respect to one of the openings in the second set of openings.

[0019] In a further embodiment, the joist sockets of the suspended work platform system are configured to secure a second structure. The second structure may be a supported work platform system, and the suspended work platform system may be articulatable.

[0020] According to a fifth general aspect, the present invention provides an integrated system comprising a base structure; a second structure; and at least two access structure

integration assemblies, each assembly comprising a channeled structure, which may be a C channel, and at least one joist socket slidably engaged with the channeled structure; wherein the base structure is secured to the channeled structure, and wherein the second structure is secured to the joist socket. The integrated systems may also include a deck retainer. The base structure may be a work platform system, such as a suspended work platform system or an articulatable suspended work platform system. The base structure may comprise one or more units, with at least one unit comprising at least four joists, each having an upper element and a bottom element, wherein at least two of the joists include at least four cage nuts; and at least four hubs, wherein the joists and hubs are interconnected such that the joists are coplanar with respect to each other.

[0021] In one embodiment, each access structure integration assembly is secured to a joist such that the integration assembly is parallel with the joist. Each joist may further include at least two cage nuts, and each integration assembly may be secured to a joist using at least two bolts which each bolt engaging one cage nut.

[0022] In one embodiment of an integrated system, each channeled structure comprises a solid, flattened bottom portion, two flattened side wall portions extending upward from the bottom portion at approximately right angles, each side wall portion terminating in a flange extending at a right angle from the side wall portions such that the flanges extend toward each other, and a linear gap extending the length of the channeled structure and having a width. Each joist socket may therefore be slidably engaged with the channeled structure by a T-bolt slidably engaged with the linear gap of the channeled structure. In some embodiments, each joist socket comprises a hollow tubular body and a base. The integration assembly may comprise two joist sockets.

[0023] In an embodiment, the second structure is at least one unit of a work platform system, and the second structure may further be a supported work platform system or shoring. A supported work platform according to an embodiment may have at least two levels. The second structure may also include a barrier secured to it.

[0024] In a further embodiment, an integrated system further comprises a third structure, the third structure comprising at least four hubs; and at least four joists, each of the four joists configured to be interconnected with at least two of the four hubs; wherein the joists and hubs are configured to be interconnected so that (i) one of the joists – and two of the hubs –

configured to remain stationary; (ii) two of the joists are rotatable; and (iii) two of the hubs – and one of the joists – are translatable; wherein the two stationary hubs are each connected to the second structure; wherein, when interconnected, the two rotatable joists, the two translatable hubs, and the one translatable joist can articulate from an initial position to a final position with respect to the stationary joist and the stationary hubs; wherein the at least four joists are substantially coplanar with respect to each other in the initial and final positions; wherein at least one of the joists is configured to be connected with at least one of the hubs using a pin to provide free rotation of the at least one joist with respect to the at least one hub about the pin; and wherein the free rotation is restricted by at least one of (i) an additional pin that is to be located proximate a perimeter of the at least one hub; and (ii) at least a portion of a platform when the platform is positioned with respect to the hubs and joists in the final position.

[0025] According to a sixth general aspect, the invention provides an integrated work platform system for suspending from an overhead structure, the system comprising: a first structure comprising at least two suspension connectors with a first end and a second end, wherein the second end is configured to secure to an overhead structure, a plurality of joists, each having an upper element and a bottom element, and a plurality of hubs, at least two of the hubs having a first surface with an opening configured to engage the first end of the suspension connectors, wherein the plurality of joists comprises at least four joists and wherein the plurality of hubs comprises at least four hubs and wherein the joists and hubs are interconnected such that the joists are coplanar with respect to each other; a plurality of integration assemblies, each secured to a joist and each integration assembly comprising a substantially linear deck retainer comprising a plurality of apertures, a substantially squared tubular C channel parallel with the deck retainer, each C-channel comprising (a) a solid, flattened bottom portion containing a plurality of apertures corresponding to the apertures of the deck retainer, (b) two flattened side wall portions extending upward from the bottom portion at approximately right angles, each side wall portion terminating in a flange extending at a right angle from the side wall portions such that the flanges extend toward each other, and (c) a linear gap extending the length of the C channel and having a width, a plurality of deck retainer bolts extending through the corresponding apertures of the deck retainer and C channel, a plurality of joist sockets comprising a hollow tubular body and a

base having a plurality of apertures, and a plurality of T-bolts extending through the apertures of the joist socket and into the linear gap of the C channel and having a head portion with a width greater than that of the linear gap, wherein the T-bolts are slidably engaged with the C channels and each of the T-bolts is secured with a nut; wherein each C channel secures at least two joist sockets; and a second structure having framework secured to the joist sockets.

[0026] The second structure may include a plurality of coplanar platforms, at least one additional platform parallel to, but not coplanar with, the platforms, and/or at least three parallel, non-coplanar platforms.

[0027] According to a seventh aspect, the present invention provides a method of integrated a second structure with respect to a base structure, the method comprising: providing a base structure; providing a second structure; providing at least two integration assemblies, each integration assembly comprising a channeled structure and a joist socket slidably engaged with the channeled structure; securing the channeled structures of the integration assemblies to the base structure; and securing the joist sockets of the integration assemblies to the second structure.

[0028] The base structure may be a suspended work platform system or an articulatable suspended work platform system. The second structure may be a work platform system.

[0029] According to an eighth aspect, the present invention provides a method of installing a supported work platform system with respect to a suspended work platform system, the method comprising: providing a suspended work platform system that is suspended from a structure, the suspended work platform system comprising a plurality of interconnected hubs and joists such the joists are coplanar with respect to each other; aligning a plurality of deck retainers parallel to a plurality of joists such that the number of deck retainers is less than the number of joists and the deck retainers are each parallel with respect to each other; aligning a plurality of channeled structures collinear with the deck retainers, wherein the channeled structures comprise a solid, flattened bottom portion containing a plurality of apertures corresponding to the apertures of the deck retainer, two flattened side wall portions extending upward from the bottom portion at approximately right angles, each side wall portion terminating in a flange extending at a right angle from the side wall portions such that the flanges extend toward each other, and a linear gap extending the length of the

channeled structure, wherein each flange has an inner surface and an outer surface; securing the deck retainers and channeled structures to the joists using a plurality of bolts; providing a plurality of joist sockets, the joist sockets comprising a tubular body, a base with at least two apertures, one T-bolt projecting through each of the apertures such that the T-bolt is oppose that tubular body, and a nut partially engaged with each T-bolt; sliding each joist socket along the outer surface of one of the flanges such that the T-bolts pass through the linear gap; tightening the nuts so that the head of the T-bolts engage the inner surfaces of the flanges; and securing a first end of a supported work platform system frame member in each of the plurality of joist sockets.

[0030] In one embodiment, the method further comprises providing a work platform assembly on a second end of the supported work platform system frame members.

[0031] The method may also further include providing an articulatable work platform assembly comprising a plurality of hubs and a plurality of joists connected to the plurality of hubs; and articulating the articulatable work platform assembly from an initial position to a final position, the articulating including at least one of rotating and translating one or more of the plurality of joists with respect to one or more of the plurality of hubs; wherein the plurality of joists are substantially coplanar with respect to each other in the initial and final positions.

[0032] The foregoing and other features and advantages of the invention will be apparent from the following more particular description of embodiments of the invention. It is to be understood that both the foregoing general description and the following detailed description are exemplary, but are not restrictive, of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0033] The features of the present invention will best be understood from a detailed description of the invention and an embodiment thereof selected for the purposes of illustration and shown in the accompanying drawings in which:

[0034] FIG. 1 is a top perspective view of an exemplary unit for a base structure;

[0035] FIG. 2 is a top perspective view of an exemplary base structure;

[0036] FIG. 3 is an exemplary hub for use with the base structure of FIG. 2;

[0037] FIG. 4 is a side view of base structure suspended from an overhead structure;

[0038] FIG. 5 is a top perspective view of the hub of FIG. 3 connected with a joist;

[0039] FIG. 6 is a top perspective view of a base structure and a unit frame prior to articulation;

[0040] FIG. 7 is a top perspective view of the embodiment of FIG. 6 undergoing articulation;

[0041] FIG. 8 is a top perspective view of the embodiment in FIG. 7 undergoing further articulation;

[0042] FIG. 9 is a top perspective view of the embodiment of FIG. 8 undergoing further articulation;

[0043] FIG. 10 is a top perspective view of the embodiment in FIG. 6 having completed articulation;

[0044] FIG. 11 is a top perspective view of an exemplary base unit with multiple integration assemblies;

[0045] FIG. 12 is a top perspective view of a joist containing an access structure integration assembly;

[0046] FIG. 13 is a detailed view of a joist socket;

[0047] FIGS. 14a and 14b are exploded views an exemplary integration assembly;

[0048] FIG. 15 is an isometric view of a joist socket;

[0049] FIG. 16 is an end elevation view of an integration assembly;

[0050] FIG. 17 is an exploded view of FIG. 16;

[0051] FIG. 18 is an end elevation view of an integration assembly secured to a joist;

[0052] FIG. 19 is an exploded view of FIG. 18;

[0053] FIG. 20 is an exemplary base structure with an integrated second structure using a plurality of integration assemblies; and

[0054] FIGS. 21-24 illustrate exemplary integrated systems.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0055] Although certain preferred embodiments of the present invention will be shown and described in detail, it should be understood that various changes and modifications may be made without departing from the scope of the appended claims. The scope of the present invention will in no way be limited to the number of constituting components, the materials

thereof, the shapes thereof, the relative arrangement thereof, etc., and are disclosed simply as an example of an embodiment. The features and advantages of the present invention are illustrated in detail in the accompanying drawings, wherein like reference numerals refer to like elements throughout the drawings.

[0056] As a preface to the detailed description, it should be noted that, as used in this specification and the appended claims, the singular forms "a", "an" and "the" include plural referents, unless the context clearly dictates otherwise. Further, as used herein, the term "overhead structure" refers to any physical structure from which a work platform may be suspended. Similarly, the term "structure" refers to any physical structure which is accessible using a suspended work platform system, with or without an integrated supported work platform system. In some embodiments, a structure and an overhead structure may be the same. Exemplary structures and overhead structures include, but are not limited to, bridges, offshore rigs, boilers, boiler pendants, elevated and suspended structures, and ships.

[0057] Referring now to the drawings, FIG. 1 illustrates an exemplary unit **120** of a base structure **100**. In the exemplary embodiment shown, unit **120**, which is a unit of a first work platform system, includes four joists **140** joined by four hubs **150** such that joists **140** are coplanar and secured with hubs **150** at approximately right angles. Hubs **150** and joists **140**, together with optional middle support deck joist **52**, provide a framework to support a platform **170**. In the exemplary embodiment shown, platform **170** is divided into two platforms **170A** and **170B**, with middle support deck joist **52** providing structural support between platforms **170A**, **170B**. In further exemplary embodiments, a single platform **170** may be used, or platform **170** may be subdivided into two, three or more platforms.

[0058] FIG. 2 illustrates an exemplary base structure **100** comprising a plurality of units **120** joined together at hubs **150**. In the exemplary embodiment shown, base structure **100** is a work platform system comprising a plurality of work platform units. In further exemplary embodiments, base structure **100** may be a single unit **120**. In still further exemplary embodiments, base structure **100** may be any structure or system which provides a substantially planar surface having at least two coplanar joists **140** or a single joist **140** configured to have two coplanar portions, the portions not linear with respect to each other and separated by a distance.

[0059] A joist **140** is any elongate structural member adapted for bearing or supporting a load, such as a bar joist, truss, shaped-steel (i.e., I-beam, C-beam, etc.), or the like. A hub **150** is an interconnection structure, such as a node, hinge, pivot, post, column, center, shaft, spindle, or the like. One skilled in the art will therefore appreciate that size, shape and arrangement of hubs **150** and joists **140** may vary to provide a work platform unit **120** and system **100**.

[0060] For example, the length of joists **140** and positioning of joists **140** and hubs **150** can vary depending on the desired size and configuration of base structure **100**. While the exemplary embodiments shown, units **120** are rectangular, forming an overall rectangular base structure **100** with joists **140** in one direction being longer than the joists **140** extending in the opposite direction, joists **140** may be any length and joined with hubs **150** at any angle permitted by the design of hubs **150**. The size and shape of support platforms **170A**, **170B** may similarly vary depending on the configuration of joists **140** and hubs **150**.

[0061] In the exemplary embodiments shown in FIGS. 1 and 2, base structure **100** is shown as an access structure, such as a work platform system. Specifically, base structure **100** is shown as a work platform system designed to be suspended from an overhead structure (i.e., a suspended work platform system). However, the base structure **100** may be any base structure, as discussed above, including any type of access structure (i.e., suspended work platform system, supported work platform system, scaffolding, shoring). In preferred exemplary embodiments, base structure **100** is any structure having at least one unit **120** having two coplanar, parallel joists **140**. More preferably, base structure **100** is a work platform system, and even more preferably a suspended work platform system. In a most preferred embodiment, base structure **100** is an articulatable suspended work platform system as described herein.

[0062] FIG. 3 illustrates an exemplary hub **150** for use with a base structure **100**, which in the exemplary embodiment described is an articulatable suspended work platform system. In the exemplary embodiment shown, hub **150** is configured so that, when attached to a joist **140**, it allows for articulation of both the hub **150** and the joist **140**. Articulation, as used herein, is defined as the capability to swing, and/or rotate, about a pivot point or axis. Hub **150** also permits unit **120**, and subsequently a base structure **100**, to be suspended from an overhead structure. However, in further exemplary embodiments, hub **150** may provide for

articulation of only hub **150** or joist **140**, or allow no articulation. In still further exemplary embodiments, hub **150** may not permit suspension of the unit **120** or base structure **100**.

[0063] In the exemplary embodiment depicted in FIG. 3, showing a hub **150** which permits articulation of both the hub **150** and the joist **140** as well as suspension of a unit **120** and base structure **100**, the hub **150** includes a top element **11** and a bottom element **12** spaced at distal ends of a middle section **15**. The top element **11** and bottom element **12** may be substantially planar in configuration as well as being parallel to each other. The top element **11** and bottom element **12**, in the embodiment shown, are octagonal. The middle section **15** may be a cylindrical section wherein a longitudinal axis of the middle section **15** is normal to the planes of the top element **11** and bottom element **12**. In the embodiment shown, the middle section **15** is a right circular cylinder. In the exemplary embodiment shown, a lower portion of the middle section **15** is removed for clarity purposes to show that the middle section **15** is hollow.

[0064] There are a plurality of openings **13**, **14**, extending through both the top element **11** and bottom element **12**, respectively. The plurality of openings **13** (e.g., **13A**, **13B**, **13C**, **13D**, **13E**, **13F**, **13G**, **13H**) are interspersed on the top element **11** so as to offer various locations for connecting to one, or more, joists **140**. The plurality of openings **14** (e.g., **14A**, **14B**, **14C**, **14D**, **14E**, **14F**, **14G**, **14H**) are similarly spaced on the bottom element **12** so that respective openings (e.g., **13A** and **14A**) are coaxial.

[0065] At the center of the top element **11** is a center opening **16** which is configured to receive a suspension connector for securing a unit **120** and base structure **100** to an overhead structure. The center opening **16** may be generally cruciform in configuration due to its center opening area **19** with four slots **17** (e.g., **17A**, **17B**, **17C**, **17D**) extending therefrom. Transverse to each of the four slots **17A**, **17B**, **17C**, **17D**, and interconnected thereto, are a series of cross slots **18A**, **18B**, **18C**, **18D**. Slots **17**, **18** and center opening area **19** interact with and secure one end of a suspension connector **80** to hub **150**, as shown in FIG. 4. The other end of suspension connector **80** secures to an overhead structure **90** to suspend a base structure **100**. One skilled in the art will readily appreciate that slots **17**, **18** and center opening area **19** may have other configurations and designs so long as a suspension connector **80** can engage hub **150**.

[0066] For added strength a second reinforcing plate **20** may be added to the underside of the top element **11** wherein openings on the reinforcing plate **20** correspond to the center opening **16** configuration and all the ancillary openings thereto (**17, 18, 19**). A handle **22** is optionally added to the side of the middle section **15**.

[0067] FIG. 5 depicts a top perspective view of the interconnection between a single hub **150** and a single joist **140**. The exemplary joist **140** illustrated in FIG. 5 includes an upper element **32** and a bottom element **33**. Interspersed between elements **32, 33** are a plurality of diagonal support members **38**. Each element **32, 33** is made of two L-shaped pieces of angle iron **39A, 39B** called joist chords. Elements **32, 33** typically may be identical in construction, with the exception being upper element **32** includes connector holes **54A, 54B** at its midspan. The joist **140** includes a first end **31A** and a second end **31B**. At either end **31A, 31B** of both the upper element **32** and bottom element **33** extends an upper connecting flange **35** and a lower connecting flange **36**. Through both upper and lower connection flanges **35, 36** are connecting holes **37**. Thus, there are four upper connecting flanges **35A, 35B, 35C, 35D** and four lower connecting flanges **36A, 36B, 36C, 36D**. Thus, at a first end **31A**, extending from the upper element **32**, is an upper connection flange **35A** and lower connection flange **36A**, with a connecting hole **37A** therethrough. Similarly, at the second end **31B** of the upper element **32**, extends an upper connection flange **35B** and lower connection flange **36B**, with a connecting hole **37B** therethrough. Continuing, at the first end **31A** of the lower element **33** extends an upper connection flange **35D** and lower connection flange **36D**. Through these connection flanges **35D, 36D** are a connecting hole **37D**. At the second end **31B** of the joist **30** extending from the lower element **33** is an upper connection flange **35C** and lower connection flange **36C** with a connecting hole **37C** therethrough.

[0068] Interior to each of the connector holes **37A, 37B, 37C, 37D** are additional locking holes **360A, 360B, 360C, 360D** also located on the connection flanges **35A, 35B, 35C, 35D**. A pin may be placed through the connecting holes **37** and any two corresponding top and bottom openings **13, 14** of hub **150**. For example, a pin may be placed in through an upper connection flange **35A**; through an opening **13A**; through a lower connection flange **36A** (all of the first end **31A** of the upper element **32**); through an upper connection flange **35D**; through an opening **14A**; and, then through the lower connection flange **36D**. In this scenario, the pin further threads through connecting holes **37A, 37D**. The pin may include

two roll pins at its upper end, the lower of the two roll pins acting as a stop, thereby preventing the pin from slipping all the way through joist **140** and hub **150**. The upper roll pin may act as a finger hold to allow easy maneuvering of the pin.

[0069] The design of these parts is such that free rotation of both the joist **140** and hub **150** is allowed, even while joist **140** and hub **150** are connected together. Rotational arrow R_1 shows that rotation of the joist **140** while R_2 shows rotation of the hub **150**. These rotational capabilities provide, in part, the articulating capability of the joists **140** and hubs **150**.

[0070] As will be appreciated by those skilled in the art, joists **140** can be of any length and positioned at any angle which may be accommodated by hub **150**. When multiple hubs **150** and joists **140** are joined, such as in the case of a single unit **120** or a base structure **100**, joists **140** may be pivotal on hubs **150** to create any configuration of units **120** and therefore base structure **100**. Because of this articulation, the framework of units **120** may also be assembled in a collapsed form while a base structure **100** is in place and then expanded outward from the base structure **100**. Once in a desired configuration, the unit **120** is secured to prevent further articulation.

[0071] This “in-the-air” assembly of further units **120** is illustrated in FIGS. 6-10. FIG. 6 shows an exemplary framework for a unit **120A** assembled and joined to an existing base structure **100** at unit **120B**. The new unit **120A** is in its initial position, prior to articulation. As FIGS. 7-9 clearly show through the motion arrows “M,” by a combination or rotation of joists **140D**, **140E** and **140F**, and hubs **150D** and **150E**, the framework for unit **120A** is able to move and rotate into its final requisite position (FIG. 10). That is, the unit **120A** articulates into place.

[0072] Once in position, unit **120A** may be locked into its final position using locking pins as described above. In further exemplary embodiments, further articulation of unit **120A** may be prevented by securing a platform **170** (not shown) in the framework.

[0073] In alternative embodiments, joist **140** and hub **150** may be secured to each other using other structures and methods known in the art and may not allow articulation of the joist **140** and hub **150** relative to each other. For example, in some embodiments, joist **140** and hub **150** may be securely joined and locked into place such that articulation is prevented.

[0074] FIG. 11 is a top perspective view of an exemplary base structure **100** as shown in FIG. 2 with access structure integration assemblies **300** secured to some joists **140**. As discussed in more detail below, access structure integration assemblies **300** include at least one joist socket **60** and channeled structure **50**, which in the exemplary embodiment shown are secured to joists **140** running perpendicular to middle support deck joists **52**. Access structure integration assemblies **300** are used to integrate a second structure **200**, or unit **220** or framework **210** of a second structure, to a base structure **100** or unit **120** of a base structure.

[0075] In one embodiment, the second structure **200** may be any structure capable of being integrated using access structure integration assemblies **300**, such as, for example, any access structure. Access structures include, for example, suspended work platform system, supported work platform system, scaffolding, and shoring.

[0076] As illustrated, joist sockets **60** are arranged on channeled structures **50** which run parallel with and are secured to joists **140**. The size of base structure **100**, and specifically the arrangement of joists **140**, therefore necessarily limits the configuration of joist sockets **60** and, ultimately, a second structure **200** which is integrated with base structure **100**. In the exemplary embodiment shown, channeled structures **50** are secured to joists which are perpendicular to middle support deck joists **52**. However, in further exemplary embodiments, channeled structures **50** may be secured to joists parallel to middle support deck joists **52** or both.

[0077] To save materials and assembly time and cost, channeled structures **50** are typically secured to joists **140** running in a single direction, such as those running perpendicular to middle support deck joists **52** as shown in FIG. 11. The distance between two joist sockets **60** on a given linear path of joists **140** (such as joist sockets **60A**, **60C** and **60D**) is therefore variable, while the distance between joist sockets **60** on parallel joists (such as joist sockets **60A** and **60B**) remains the same. Typically, the length of joists **140** extending perpendicular to channeled structures **50** is equal to (or a factor or multiple of) the desired length of one dimension of a second structure **200**.

[0078] In some exemplary embodiments, second structure **200** is a work platform system, and the length of joists **140** extending perpendicular to channeled structures **50** is equal to (or a factor or multiple of) the bay size of the work platform system or the length of a frame

member for the work platform system. In a preferred exemplary embodiment, the second structure **200** is a supported work platform system. The bay size of most supported work platform systems, and therefore the length of most frame members for supported work platform systems, can be 3 feet, 42 inches, 4 feet, 5 feet, 7 feet, 8 feet or 10 feet. The joists **140** of a base structure **100** which will be integrated with a second structure **200** which is a supported work platform system may therefore be preferably 3 feet, 42 inches, 4 feet, 5 feet, 7 feet, 8 feet or 10 feet in length.

[0079] FIG. 12 illustrates an exemplary joist **140** with an access structure integration assembly **300** comprising a single channeled structure **50** and two joist sockets **60**. FIG. 13 shows the junction between a channeled structure **50** and joist socket **60** in more detail. As more fully described below, joist sockets **60** may be positioned and secured anywhere along channeled structures **50**.

[0080] In the exemplary embodiments shown, channeled structure **50** is a substantially squared tubular structure having a solid, flattened bottom portion **51** with solid, flattened side walls **54** extended upward from bottom portion **51** at approximately right angles. Each side wall **54** terminates in a flange **53** which is at an approximate right angle inward from side walls **54** such that the flanges **53** extend towards each other but are not in physical contact with each other to form a linear gap the length of channeled structures, thereby creating a “C” shape. The inner and outer surfaces of flanges **53** are substantially planar. In some embodiments, the channeled structure **50** is referred to as a C channel **50**.

[0081] In the exemplary embodiments shown, C channel **50** is secured to joist **140** with deck retainer **58** between the joist **140** and C channel **50**. Deck retainer **58** is a substantially linear, solid structure which transfers and distributes force from a second structure **200** integrated with the base structure **100** using integration assemblies **300** along joist **140**, and specifically to joist chords **144**. When joist socket **60** is used on an end joist, a toe board may be used instead of deck retainer **58**.

[0082] In the exemplary embodiment shown in FIG. 12, two deck retainers **58** are required to span the length of joist **140** while a single C channel **50** is used. In further embodiments, deck retainers **58** and C channels **50** may be of any length as long as the apertures of each align with the cage nuts **142** of the joists **140** so that the integration assemblies **300** may be secured to joists **140**.

[0083] Joist socket **60** includes tubular body **65** structurally integrated as a single unit with base **62** and supporting braces **67**. Tubular body **65** is configured to receive a framework **210** from a second structure **200** to integrate the second structure **200** with the base structure **100**. In the exemplary embodiments described, the framework **210** is cylindrical to correspond to tubular body **65** of joist socket **60**. However, it should be understood that the shape and size of tubular body **65** may vary to accommodate any shape of framework **210** for a second structure **200** or unit **220** of a second structure.

[0084] T-bolts **70** with nuts **78** secure joist socket **60** in C channel **50** while still permitting joist socket **60** to slidably engage C channel **50**. As used herein, slidably engaged means that two components (i.e., a joist socket and C channel) are secured to each other in a manner permitting sliding movement relative to one another. As will be shown in FIGS. 16 and 17, T-bolts **70** have a T-like shape such that the bolt head **72** is shaped to slide within C channel **50** and engage with the inner surface of flanges **53**. When joist socket **60** is at a desired location on C channel **50**, nuts **78** are tightened on T-bolts **70** to lock joist socket **60** in place. When nuts **78** are loosened, T-bolts are able to freely slide within the linear gap of C channels **50**, and joist sockets **60** are therefore slidably engaged with C channels **50**.

[0085] As will be shown, apertures **69** on joist socket **60** align with apertures in a supported work platform system component, such as a leg, to secure a supported work platform system to suspended work platform system **100**.

[0086] In the exemplary embodiment shown, joist socket base **62** has a width just greater than that of C channel **50** and a length sufficient to support a single tubular body **65**. However, it may be understood that joist socket base **62** may be of any length to include one or more tubular bodies **65**, and the diameter of tubular body **65** is dependent on the dimension of the leg or other component of a supported work platform system which will be engaging joist socket **60**. Further, the width of joist socket base **62** may permissibly vary depending on the diameter of tubular body **65** keeping in mind that T-bolt **70** must still fully engage base **62**.

[0087] As will be appreciated by one skilled in the art, when integrating a second structure **200** with base structure **100**, framework **210**, such as the legs of a second structure, will need to distributed weight to the joists **140**. The strongest portions of joists **140** are panel points **144** (shown more clearly in FIGS. 14A and 14B) where diagonal support

members **38** intersect. Traditionally, dunnage, such as I-beams or other supportive materials, is placed over joists **140** to transfer the load of a second structure to the panel points **144**. However, as discussed above, such dunnage systems prevent downward movement and provide little resistance to horizontal, vertical and rotational movement. Additional securing devices (i.e., tie-downs, bracing, guy lines, etc.) are therefore used to more securely support a second structure on a base structure.

[0088] By securing deck retainer **58** and channeled structure **50** directly on top of and parallel with joists **140**, the load of a supported work platform system is concentrated at joist sockets **60** and transferred by the channeled structures **50** to panel points **144**. Further, because joist sockets **60** completely enclose the ends of frame members for a supported work platform system, movement in all directions (including rotational movement) is prevented.

[0089] In the exemplary embodiments shown, access structure integration assembly **300** secures a second structure **200** to prevent or limit movement in more than just the downward direction. For example, in the exemplary embodiment described, joist socket **60** will prevent movement of framework **210** secured in it all directions along the *x* axis, *y* axis and *z* axis, including rotationally in each axis for a total of six potential types of movement, relative to joist **140** when joist socket **60** is secured in channeled structure **50**. However, in further exemplary embodiments, integration assembly **300** may limit or prevent movement in at least one, preferably at least two, and more preferably at least three of the above directions. In the most preferred embodiment, however, all six types of movement of a frame member **210** (and therefore second structure **200**) relative to joist **140** (and therefore base structure **100**) is limited or prevented by integration assembly **300**.

[0090] FIGS. 14A and 14B show an exploded view of the joist **140** with access structure integration assembly **300**. In the exemplary embodiment shown, integration assembly **300** comprises joint socket **60** and channeled structure **50**, which in the exemplary embodiment shown is a C channel. Although the bracket denoting integration assembly **300** as illustrated in FIGS. 14A and 14B encompass nuts **78**, T-bolts **70** and deck retainer bolts **57**, it is understood that these components do not form essential components of an integration assembly **300** as described herein. Other securing components and mechanisms may be used to secure a C channel **50** (and deck retainer **58**, when used) to a joist **140**, and joist sockets **60** may slidably engage C channels **50** using structures and components other than T-bolts **70**.

[0091] Apertures **56** (not shown) in bottom portion **51** of C channel **50** align with apertures **59** of deck retainer **58** (or toe board). Deck retainer bolts **57** secure C channel **50** to deck retainer **58** and joist **140** by engaging cage nuts **142** installed in joist **140**.

[0092] T-bolts **70** may be inserted through apertures **64** in base **62** of joist socket **60** to partially engage nuts **78**. Joist socket **60**, with T-bolts **70** loosely and slidingly engaged in apertures **64**, may be slide over the end of C channel **50** such that the head **72** of T-bolts **70** is within C channel **50**. The head **72** of the T-bolts **70** is wider than the opening in the C channel **50** so that the T-bolt head **72** engages the inner surfaces of flanges **53**. Upward movement of the joist socket **60** relative to the C channel **50** is thereby prevented. Once the joist socket **60** is in a desired position along C channel **50**, nuts **78** are tightened on T-bolts **70** to secure joist sockets **60** in place using compression force.

[0093] FIG. 15 is an isometric view of a joist socket **60** showing tubular body **65** with apertures **69** for engaging structural elements of a supported work platform system. Base **62** includes apertures **64** for receiving T-bolts **70** and supporting braces **67** for structural integrity. In some exemplary embodiments, base **62** may include additional apertures **64** for T-bolts **70**, and braces **67** may be of different sizes or configurations.

[0094] FIG. 16 is an end elevation view of an assembled integration assembly **300**. Tubular body **65** is hollow, with apertures **69** open to hollow tubular body **65**. T-bolt **70** is extended through base **62** and opening of channeled structure **50**, which in the exemplary embodiment shown is a C channel. Bolt head **72** is wider than the opening of C channel **50** and therefore engages flanges **53** when tightened in place by nut **78**. FIG. 17 is an exploded view of the integration assembly **300** of FIG. 16.

[0095] FIG. 18 is side view of an integration assembly **300** secured to a joist **140**. Deck retainer bolt **57** extends through channeled structure **50**, which in the exemplary embodiment shown is a C channel, and deck retainer **58** and into cage nut **142** in joist **140** to secure C channel **50** to joist **140**. FIG. 19 is an exploded view of the integration assembly **300** with deck retainer **58** FIG. 18. FIG. 19 illustrates aperture **59** of deck retainer **58** as having a protuberance around the underside of the aperture **59**. As shown more clearly in FIG. 18, the protuberance around aperture **59** fits between the two L-shaped pieces of angle iron **39A**, **39B** of elements **32**, **33** to provide additional stability.

[0096] FIG. 20 illustrates an exemplary second structure **200** integrated with the base structure **100** shown in FIG. 11 using access structure integration assemblies **300**. In the exemplary embodiment shown, framework **210** of second structure **200** comprises interconnected legs which are secured in joist sockets **60**. Preferably, and as illustrated in FIG. 20, second structure **200** is a work platform system, such as a supported work platform system, comprising a plurality of individual units **220**.

[0097] In the exemplary embodiment shown, base structure **100** comprises a plurality of units **120**, and the framework **210** of the second structure includes a plurality of interconnected legs and is configured to define a plurality of individual units **220**. In further exemplary embodiments, base structure **100** may be only a single unit **120** or two or more units **120**. In further exemplary embodiments, second structure **200** may be configured to be a single unit **220** or have framework **210** defining a single unit **220**. In further exemplary embodiments, framework **210** of second structure **200** may secure platforms.

[0098] With legs of framework **210** secured in joist sockets **60**, movement of the second structure **200** is prevented along the *x*, *y* and *z* axes, as well as rotationally about each axis, relative to joist sockets **60**. When joist sockets **60** secured on C channels **50** (i.e., tightened on C channels as to be immovable), movement is prevented along the *x*, *y* and *z* axes, as well as rotationally about each axis, relative to base structure **100**. Access structure integration assemblies **300** therefore effectively integrate base structure **100** and second structure **200**. The term “integrated” as used herein and in reference to a suspended work platform or platform system supporting a supported work platform or platform system means that all six forms of movement (i.e., linear movement along the *x*, *y* and *z* axes and rotational movement about the *x*, *y* and *z* axes) of the supported work platform or platform system is prevented.

[0099] However, because joist sockets **60** are movable along C channels **50** when not secured in place, second structure **200** may be built at a convenient location on base structure **100** and slid into a final position after assembly. Similarly, a second structure **200** may be built and slid into different positions on base structure **100** to access various structures at different spots along base structure **100** as needed.

[00100] Because access structure integration assemblies **300** transfer the pressures exerted by the framework **210** of second structure **200** to panel points **144**, the size of second structure **200** is limited by the amount of weight joists **140** of suspended work platform

system **100** can bear. For example, when base structure **100** is a suspended work platform system and second structure **200** is a supported work platform system, the supported work platform system may include a single level or multiple levels, provided joists **140** continue to support the weight and pressures exerted by the supported work platform system.

[00101] FIG. 21 illustrates exemplary base structures **100** which are suspended work platform systems, with integrated second structures **200** which are supported work platform systems. In the embodiment shown, base structures **100** are suspended from structure **90**, which is a diagonal beam. As illustrated, second structure **200** is integrated with base structure **100** using integration system **300** to provide access not only the undersides of structure **90**, but also the side portions of structure **90** between suspended work platforms.

[00102] FIG. 21 also shows that base structures **100** may be integrated with and depend on second structure **200**. For example, as illustrated in FIG. 21, base structure **100** may be an articulatable suspended work platform system, with suspended work platform system **100b** built off of supported work platform system **200a** and suspended work platform system **100c** is built off of supported work platform system **200b** as described in relation to FIGS. 6-10. Therefore, to continue accessing structure **90** above supported work platform **200c**, workers can assemble additional suspended work platforms, such as described in FIGS. 6-10, from supported work platform **200c** and then assemble additional supported work platform systems integrated with the newly suspended platform system as described herein.

[00103] FIG. 22 illustrates a further exemplary embodiment of a base structure **100** integrated with a second structure **200** using access structure integration assemblies **300**. In the exemplary embodiment shown, base structure **100** is a suspended work platform assembly and second structure **200** is a supported work platform assembly. Base structure **100** is suspended from an overhead structure (not shown) and used to access substructures **91**. For example,

[00104] As illustrated in FIG. 22, base structure **100** is suspended from an overhead structure with second structure **200**, which is a supported work platform system, built upward from base structure **100**. In the exemplary embodiment shown in FIG. 22, six levels of supported work platform are secured above base structure **100**. As illustrated in FIG. 22, the levels of the supported work platform system are parallel with, but not coplanar to, each other. As described above, the number of levels of second structure **200** integrated with a

base structure **100** will vary depending on the job to be done and the maximum about of weight joists **140** can support.

[00105] FIG. 23 illustrates an exemplary embodiment of a base structure **100** with access structure integration assemblies **300** integrating a second structure **200**, wherein the base structure **100** is a suspended work platform system and the second structure **200** is a supported work structure system. The supported work platform system is built upward from the suspended work platform system secured under structure **90**, which in the embodiment shown is a structure spanning two points, such as, for example, a bridge or portion of an off-shore rig. As illustrated, base structure **100** is suspended under structure **90** and also extends outside the footprint of the overhead structure **90**. Second structure **200** is built upward from the portion of base structure **100** which is not directly under structure **90** in order to access the sides of structure **90**.

[00106] In further embodiments, a second structure may be integrated with a base structure to provide support for objects, such as tarps or barriers, as shown in FIG. 24. In FIG. 24, second structure **200** is integrated with base structure **100** using integration assemblies **300**, and second structure is used to secure barrier **95** which is a tarp. When, for example, painting structure **90**, barrier **95** prevents debris (e.g., dirt, dust, water, pollen) from entering the work area and damaging or disrupting the painting or drying processes. Barrier **95** also prevents contaminants (e.g., fumes, vapor, particles) from escaping the work area and entering the environment. Second structure **200** is therefore used to create factory-like conditions in the field.

[00107] Although the figures and description provided herein illustrate a base structure **100** which is a suspended or articulated suspended work platform system integrated with a second structure which is a supported work platform system, it is understood that integration assembly **300** may be used to integrate a variety of base structures and second structures.

[00108] The foregoing description of the present invention has been presented for purposes of illustration and description. It is not intended to be exhaustive or to limit the invention to the precise form disclosed or to the materials in which the form may be embodied, and many modifications and variations are possible in light of the above teaching.

[00109] It is specifically intended that the present invention not be limited to the embodiments and illustrations contained herein, but include modified forms of those

embodiments including portions of the embodiments and combinations of elements of different embodiments as come within the scope of the following claims.

CLAIMS

1. An access structure integration assembly comprising:
 - at least one channeled structure including a linear gap, wherein the channeled structure has a bottom portion having a plurality of apertures and two flattened side walls extending from the bottom portion thereby creating the linear gap; and
 - at least one socket which comprises a hollow tubular body, a base and at least one T-bolt, wherein the base of the socket is slidably engaged with the linear gap of the channeled structure using the at least one T-bolt
2. The assembly of claim 1, wherein the bottom portion of the at least one channeled structure is configured to secure to an elongate structural member by a plurality of bolts, each of said bolts configured to engage a corresponding aperture of the plurality of apertures.
3. The assembly of claim 2, wherein the channeled structure is configured to secure to the elongate structural member of a base structure, the elongate structural member comprising a plurality of intersecting diagonal support members and joist socket is configured to secure to a second structure.
4. The assembly of claim 3, wherein the base structure is a suspended work platform system.
5. The assembly of claim 4, wherein the second structure is a supported work platform system.
6. The assembly of claim 1, further comprising a deck retainer.
7. A base structure comprising:
 - at least one unit comprising at least two elongate structural members;
 - at least two access structure integration assemblies, each assembly secured to and parallel with a respective one of the elongate structural members of the at least one unit, each integration assembly comprising
 - at least one channeled structure including a linear gap, wherein the channeled structure comprises a bottom portion having a plurality of apertures, and

at least one socket comprising a hollow tubular body, a base and at least one T-bolt, wherein the base of the socket is slidingly engaged with the linear gap of the channeled structure using the at least one T-bolt,

wherein each of the channeled structures of the integration assemblies is secured to and parallel with one of the elongate structural members.

8. The base structure of claim 7, wherein the at least two elongate structural members each comprise an upper element, a lower element, and a plurality of diagonal support members interspersed between the upper and lower elements, wherein at least two pairs of the diagonal support members intersect to form at least two panel points along the upper element.

9. The base structure of claim 8, wherein each channeled structure of the integration assemblies is secured to and parallel with one of the upper elements of one of the elongate structural members by a plurality of bolts engaging the upper element at or around the panel points

10. The base structure of any of claims 7-9, wherein the sockets are configured to secure to a supported work platform system.

11. The base structure of any of claims 7-10, comprising a plurality of units, each unit defined by four elongate structural members interconnected with four hubs, wherein the elongate structural members and hubs are interconnected such that the elongate structural members are coplanar with respect to one another.

12. The base structure of any of claims 7-11, further comprising a deck retainer.

13. An integrated system comprising:

a base structure comprising

at least two elongate structural members; and

at least two access structure integration assemblies, each assembly secured to and parallel with a respective one of the elongate structural members, each integration assembly comprising

at least one channeled structure including a linear gap, wherein the channeled structure comprises a bottom portion having a plurality of apertures, and
at least one socket comprising a hollow tubular body, a base and at least one T-bolt, wherein the base of the socket is slidingly engaged with the linear gap of the channeled structure using the at least one T-bolt,
wherein each channeled structure of the respective integration assemblies is secured to and parallel with one of the elongate structural members; and
an integrated structure comprising at least two frame members,
wherein each of the at least two frame member engages a respective socket of a respective access structure integration assembly.

14. The integrated system of claim 13, wherein each elongate structural member comprises an upper element, a lower element, and a plurality of diagonal support members interspersed between the upper and lower elements, wherein at least two pairs of the diagonal support members intersect to form at least two panel points along the upper element.

15. The integrated system of claim 14, wherein each channeled structure of the respective integration assemblies is secured to and parallel with one of the upper elements of one of the elongate structural members by a plurality of bolts engaging the upper element at or around the panel point.

16. The integrated system of any of claims 13-15, wherein the base structure is a first suspended work platform.

17. The integrated system of any of claims 13-16, wherein the integrated structure is a supported work platform.

18. The integrated system of any of claims 14-15, wherein the at least two elongate structural members each comprise the upper element, the lower element, the plurality of diagonal support members interspersed between the upper and lower elements, and a plurality of cage nuts

positioned along the upper element at or around the panel points, and each of the plurality of bolts engages one of the plurality of cage nuts.