(57) Abstract:
There is provided a reinforcing steel structure for use in a concrete building wall. The structure includes one or more prefabricated, welded cages having vertical reinforcing bars. A plurality of continuous ties extends around the vertical reinforcing bars and a
(57) **Abrégé(suite)/Abstract(continued):**
plurality of shear ties extends generally horizontally between the vertical reinforcing bars. Each welded cage is sized and shaped for shipping and said structure can be formed onsite from a plurality of said cages lapped together. Concrete is added to the reinforcing steel structure to form a concrete building wall. There is also provided a reinforcing steel structure for use in a concrete building transfer or raft slab. The structure includes one or more prefabricated, welded beams. The prefabricated, welded beams have a top beam layer and a bottom beam layer, each having horizontal reinforcing bars, and a plurality of continuous ties extending generally vertically around the top and bottom beam layers. Each welded beam is sized and shaped for shipping and said structure can be formed onsite from a plurality of said beams lapped together. Concrete is added to the reinforcing steel structure to form a concrete building slab.
ABSTRACT

There is provided a reinforcing steel structure for use in a concrete building wall. The structure includes one or more prefabricated, welded cages having vertical reinforcing bars. A plurality of continuous ties extends around the vertical reinforcing bars and a plurality of shear ties extends generally horizontally between the vertical reinforcing bars. Each welded cage is sized and shaped for shipping and said structure can be formed onsite from a plurality of said cages lapped together. Concrete is added to the reinforcing steel structure to form a concrete building wall.

There is also provided a reinforcing steel structure for use in a concrete building transfer or raft slab. The structure includes one or more prefabricated, welded beams. The prefabricated, welded beams have a top beam layer and a bottom beam layer, each having horizontal reinforcing bars, and a plurality of continuous ties extending generally vertically around the top and bottom beam layers. Each welded beam is sized and shaped for shipping and said structure can be formed onsite from a plurality of said beams lapped together. Concrete is added to the reinforcing steel structure to form a concrete building slab.
PREFABRICATED MODULAR REBAR MODULES AND METHODS OF USING THE SAME

FIELD OF THE INVENTION

This invention relates generally to the broad field of reinforced concrete and more particularly to the steel, or rebar used to reinforce the concrete. More particularly, this invention relates to methods and apparatus for constructing and installing rebar used in concrete construction.

BACKGROUND OF THE INVENTION

Reinforced concrete is a well known and widely used building material which is used in building, bridges, roads, tunnels and other structural construction projects. Essentially the concrete, which is strong in compression but has no strength in tension, is reinforced with steel rods which pass through the zones of tension in the structural element. Engineers design the structural components; calculate the forces which will be generated by the structure, which may be carrying dynamic or static loads or both; and then develop a rebar plan to provide enough rebar reinforcement in the regions of the concrete structure where tension forces may be created. The rebar plan often requires complex cages with rebar elements bent from, for example, a top surface to a bottom surface and then back to the top surface to accommodate the load pattern created in a beam supported by a column for example.

Conventionally, rebar rods are transported individually to a work site and then assembled on site. In some cases they may be bent on site and in other cases they may be bent at the factory and merely assembled on site. Assembly means placing the rebar rods into a form which will then hold the liquid concrete which is poured into the form around the rebar. Once the concrete cures and hardens the forms can be removed and the structural element is ready for use.

The rebar is typically provided with a textured outer surface to enable the concrete to better grip the steel bars. The assembly of the rebar into the forms is done with great care – the correct positioning of the rebar is required to ensure the structural element has the strength that it has been designed for. Each rebar element must be precisely located in the three dimensional space within the form to ensure appropriate load bearing capacity of the finished structural element. Thus the engineers provide the fabricators with exact rebar cage plans and designs and every rod is checked for correct positioning before any concrete is poured.
The fabrication of the re-bar cage according to the detailed design specifications can be slow and tedious work. The rebar components are connected on site by workers using ties with wires. The rods themselves can be long and unwieldy. The position of the components each have to carefully measured to ensure that they are properly spaced and located and that they will be located at an appropriate depth within the concrete once the concrete is poured into the form. The entire process of installing the components on site can be time consuming, which in turns increases the costs of the projects. Delays in the construction of rebar cages can cause significant delays in the entire construction project since the installation of reinforced concrete will often be one of the first steps in a major building project. For example, in a building the concrete frame of the building must be in place before the windows and interior finishing can be attempted within the frame. Since the installation of the rebar components requires rodworkers and other workers to be present on site, any staffing issues may also cause delays in the overall project. Construction of rebar structures onsite also requires each structure to be custom made.

Constructing rebar structures for raft and transfer slabs onsite is also awkward in that incomplete cage assemblies may lead to partially built cage structures that are shaky and hard to walk on, causing safety issues. Installation may also be more challenging where confined spaces exist during the construction of the slab layers. It may also be challenging to place rebar on slabs that are deeper than 1800mm or approximately 6' in depth. Slabs are typically 2' to 12' deep.

Patent applications of general interest in the field of rebar include:
U.S. Patent No. 5,392,580 patented on February 28, 1995;
U.S. Patent No. 8,381,479 patented on February 26, 2013; and

**SUMMARY OF THE INVENTION**

What is desired is a simpler and more efficient way of constructing reinforced concrete structures.

In an embodiment there is a modular reinforcing steel structure for use in a concrete building wall. The structure may comprise one or more prefabricated, welded modular cages having vertical reinforcing bars. The cages may be prefabricated in an
offsite factory where there are the space, tools and workers to quickly and easily create
the modular cages. There may be a plurality of continuous ties extending around the
vertical reinforcing bars and a plurality of shear ties extending generally horizontally
between the vertical reinforcing bars. Each prefabricated welded cage may be sized
and shaped for shipping and said structure may be quickly and easily formed onsite
from a plurality of said modular cages lapped together.

In another embodiment there is provided a method of constructing a reinforcing
steel structure for use in a concrete building wall. A plurality of prefabricated, welded
cages having vertical reinforcing bars are provided at a worksite. Each of the plurality of
prefabricated, welded cages may have a plurality of continuous ties extending around
the vertical reinforcing bars and a plurality of shear ties extending generally horizontally
between the vertical reinforcing bars. The plurality of prefabricated, welded cages may
be installed at a worksite. Reinforcing steel bars are installed between the plurality of
prefabricated, welded cages to form a continuous reinforcing steel structure. Concrete is
added to the reinforcing steel structure to form a concrete building wall.

In another embodiment there is a reinforcing steel structure for use in a concrete
building transfer or raft slab. The structure comprises one or more prefabricated, welded
beams. The prefabricated, welded beams may comprise a top beam layer having
horizontal reinforcing bars, a bottom beam layer having horizontal reinforcing bars, and
a plurality of continuous ties extending generally vertically around the top beam layer
and the bottom beam layer. Each welded beam may be sized and shaped for shipping
and said structure can be formed onsite from a plurality of said beams lapped together.

In another embodiment there is a method of constructing a reinforcing steel
structure for use in a concrete building slab. A plurality of prefabricated, welded beams
may be provided at a worksite. The welded beams may comprise a top beam layer
having horizontal reinforcing bars, a bottom beam layer having horizontal reinforcing
bars, and a plurality of continuous ties extending generally vertically around the top
beam layer and the bottom beam layer. A bottom slab layer comprising a plurality of
horizontal reinforcing bars may be installed. The plurality of prefabricated, welded
beams may be installed adjacent to one another on the bottom slab layer. A top slab
layer comprising a plurality of horizontal reinforcing bars is installed on the plurality of
welded beams to form a reinforcing steel structure. Concrete is poured around the
reinforcing steel structure and permitted to cure to form a concrete building slab.

**BRIEF DESCRIPTION OF THE DRAWINGS**

Reference will now be made by way of example only to preferred embodiments of the invention by reference to the following drawings in which:

Figure 1 is a top view of an embodiment of a prefabricated, welded cage for a heavy wall;

Figure 2 is a top view of an embodiment of a continuous tie for use in a prefabricated, welded cage;

Figure 3 is a top view of a PRIOR ART configuration of u-caps and horizontal bars for use in a concrete wall structure;

Figure 4 is a top view of an embodiment having two prefabricated, welded cages for a heavy wall;

Figure 5 is a top view showing a pair of lap bars connecting two continuous ties;

Figure 6 is a top view of a PRIOR ART configuration of u-caps and horizontal bars for use in a concrete wall structure;

Figure 7 is a top view of an embodiment of a steel structure made from a plurality of pre-fabricated, welded cages;

Figure 8 is a top view of an embodiment of a steel structure made from a plurality of pre-fabricated, welded cages for use in walls with zones;

Figure 9 is a top view of a section of an embodiment of a steel structure made from a plurality of pre-fabricated, welded cages for use in a wall with zones;

Figure 10 is a top view of an embodiment of a steel structure having a plurality of prefabricated, welded cages.

Figure 11 is a side view of an embodiment having a pair of prefabricated welded beam for use in a transfer slab or raft slab;

Figure 12 is a perspective view of an embodiment of a bottom slab layer of Figure 11 for a transfer slab or raft slab;

Figure 13 is a perspective view of an embodiment of a prefabricated, welded beam of Figure 11 for installation in a transfer slab or raft slab;

Figure 14 is a perspective view of an embodiment of Figure 11 having a pair of prefabricated, welded beams installed on a bottom slab layer;
Figure 15 is a perspective view of an embodiment of Figure 11 of a top slab layer installed on top of a pair of prefabricated, welded beams;

Figure 16 is a side view of an embodiment having a pair of prefabricated, welded beams having shear ties;

Figure 17 is a perspective view of an embodiment of a bottom slab layer of Figure 16;

Figure 18 is a perspective view of an embodiment of a prefabricated, welded beam of Figure 16 for a transfer slab or raft slab;

Figure 19 is a perspective view of an embodiment of a steel structure having a pair of prefabricated, welded beams of Figure 16 installed on a bottom slab layer; and

Figure 20 is a perspective view of an embodiment of a steel structure of Figure 16 having a top slab layer installed on a pair of prefabricated, welded beams.

**DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS**

A prefabricated welded cage 104 is shown in Fig. 1. The prefabricated welded cage 104 includes a number of vertical reinforcing bars 106. A continuous tie 108 extends around the vertical reinforcing bars 106. Although only one continuous tie is shown in Fig. 1, it will be understood that the welded cage 104 includes a plurality of continuous ties 108 which are placed at vertical intervals around the vertical reinforcing bars 106. Preferably, the plurality of continuous ties 108 are spaced at even intervals along the height of the vertical reinforcing bars 106. A plurality of shear ties 110 extend generally horizontally between the vertical reinforcing bars 106. The welded cage 104 is sized and shaped for shipping.

The structure of one of the plurality of continuous ties 108 is shown in Fig. 2. The continuous tie 108 shown in Fig. 2 is a single piece of reinforcing steel that forms a closed loop with, for example, ends that overlap.

In Fig. 3, a prior art design for rebar components in a wall structure is shown. A pair of horizontal bars 120 is connected to a pair of u-caps 118 at each end. This structure would need to be constructed using individual horizontal bars and u-caps on site and then carefully connected to each of the vertical reinforcing bars 106. Installation of this prior art system would likely be expensive and time consuming.
Fig. 4 and 5 show how two prefabricated welded cages 104B and 104C may be installed at a work site. The two cages 104B and 104C are placed side-by-side as shown in Fig. 4. As shown in Fig. 5, a pair of lap bars 116 are connected between each of the adjacent continuous ties 108B and 108C. For each of the plurality of continuous ties 108B and 108C in each of the cages 104B and 104C, pairs of lap bars 116 are connected between them. Multiple cages may be connected in this manner. The pair of welded cages 104B and 104C are placed adjacent and parallel to each other for use in a single length of a concrete building wall. The plurality of lap bars 116 extend generally horizontally between overlapping adjacent ends of the pair of welded cages.

As shown in Fig. 4, each of the plurality of shear ties 110 have a hook end 112 and a flat end 114. In the embodiment shown in Fig. 4, the plurality of shear ties 110 are arranged between the vertical reinforcing bars 106 in an alternating parallel pattern with the hook ends 112 of each adjacent shear tie facing in an opposite direction.

Fig. 6 shows a prior art method of installing a section of wall, which requires a long horizontal bar 120 and u-caps 118 connecting the horizontal bars 120 at the ends of the components. This installation method has similar drawbacks to the prior art method shown in Fig. 3.

Fig. 7 shows a reinforcing steel structure 100 including a plurality of the one or more prefabricated, welded cages 104. In this case there are shown four welded cages 104A, 104B, 104C, and 104D. The reinforcing steel structure 100 has a corner pair of welded cages 104A and 104B which are placed adjacent and perpendicular to each other for use in two adjoining walls forming a corner of a concrete building wall. A plurality of u-caps 118 extend generally horizontally around adjacent ends of the pair of welded cages. The welded cages 104A and 104B meet at a corner generally denoted by 126. Similarly, welded cages 104C and 104D are adjacent corner pieces connected by a plurality of u-caps 118. Welded cages 104B and 104C form a parallel pair of welded cages placed adjacent and parallel to each other to together form a structure for a single length of a concrete building wall. A plurality of lap bars 116 extend generally horizontally within the vertically reinforcing bars 106 and between overlapping adjacent ends of the parallel pair of welded cages 104B and 104C. As will be understood, various different combinations and configurations of welded cages 104 may be connected to form steel structures for concrete walls of various different configurations and sizes.
Fig. 8 shows an embodiment of the steel structure 100 having walls with zones having a different configuration of shear ties 110. In the embodiment shown in Fig. 8, shear ties 110 are placed with the hook ends 112 oriented in the same direction as each other and the shear bars 110 are placed at each end of the welded cages 104A to 104D. Also, although in the embodiment shown in Fig. 7, add bars 122 are used exclusively as the vertical reinforcing bars 106, in the embodiment shown in Fig. 8, add bars 122 are used only at each end of the respective welded cages 104A to 104B. The shear ties 110 are placed between the add bars 122. The darker vertical bars 122 are zone concentrated reinforcing bars and the lighter of the vertical bars 106 represent stress distributed reinforcing bars.

Fig. 9 shows an embodiment of a portion of a steel structure having welded cages 104C and 104D. Hooked horizontal bars 124 are placed at the corner 126 where welded cages 104C and 104D are adjacent. Horizontal j-bars 116 are located inside the vertical reinforcing bars 106 and match the continuous ties 108. The horizontal bars 124 are also closed ties. The j-bars 116 are embedded between the modular welded cages 104C and 104D and which may assist in preventing failure when concrete spalls under stress.

Fig. 10 shows a steel structure 400 having a plurality of prefabricated welded cages 404A to 404D. Vertical reinforcing bars 406, all in the form of add bars 422, lie between continuous ties 408 in each of the welded cages 404A to 404D. Shear ties 410 connect between the vertical reinforce bars 406 and are placed with the hooked ends 412 of adjacent shear ties 410 facing in opposite directions. Opposite the hooked ends 412 of each shear tie is a flat end 414. U-caps 418 provide a connection between corners 426 of adjacent welded cages 404A and 404B, as well as adjacent welded cages 404C and 404D. The embodiment shown in Fig. 10 is similar to the embodiment of reinforcing steel structure of Fig. 7, except with the addition of a plurality of lap bars 416 extending generally horizontally within the vertical reinforcing bars 406 and between the corner pairs of welded cages 404A and 404B as well as welded cages 404C and 404D. The addition of the plurality of lap bars 416 may be preferred in cases where a seismic resistant design is required.

The reinforcing steel structure 100 of Figs. 1, 4, and 7 to 9, may be installed for use in a concrete building wall by the following method. The method of constructing the
steel structure 400 in the embodiment shown in Fig. 10 is similar to the method of installing the steel structure 100 shown in Fig. 7. A plurality of prefabricated, welded cages 104 are provided on site at a worksite. The plurality of prefabricated, welded cages are installed at a worksite where a concrete wall is to be made. Reinforcing steel bars are installed between the plurality of prefabricated, welded cages to form a reinforcing steel structure. As shown in Figs. 1, 4 and 7 to 9, the reinforcing bars installed between the welded cages 104 may include u-bars, lap bars or other rebar structures that allow for the communication of tension stress between the cages. As a final step, concrete (not shown) is poured into the reinforcing steel structure 100 to form a concrete building wall.

Although the walls shown in Figs. 1 to 10 have certain dimensions, it will be understood that various difference dimensions of walls may be constructed, using different sizes of cages depending on the application. The size of the cages should be chosen to fall within transportation limits, which may be, for example, 12 feet by 12 feet by 60 feet. In this sense transportation limits means the size of module that can be readily accommodated within the existing size of conventional transport vehicle (truck, or train car) that may be used for shipping rebar. While at present the size as outlined above is suitable in some jurisdictions, it will be understood that the present invention comprehends adapting the size of the modular cages to meet whatever the local transportation limits might be. Further, while the above noted size limit is the maximum size, the present invention comprehends a modular approach and therefore in some cases depending upon the structural design, the equipment available on site to assemble multiple modules into compound cage assemblies the modules may be made smaller than the maximum size and yet dimensioned to be efficiently fit within the typical transportable volume.

Fig. 11 shows a side view of two prefabricated welded beams 204A and 204B. The welded beams together form a reinforcing steel structure 200 (Fig. 15) for use in a concrete building transfer or raft slab. A plurality of continuous ties 212 extend generally vertically around a top beam layer 206 having horizontal reinforcing bars and a bottom beam layer 208 having horizontal reinforcing bars. Each welded beam 204A and 204B is sized and shaped for shipping. As shown in Fig. 11, the prefabricated welded beams 204A and 204B are installed between a top slab layer 214 and a bottom slab later 218. The continuous ties 212 shown in Fig. 11 are a single piece of reinforcing steel that
forms a closed loop.

The components of the reinforcing steel structure 200 are shown in Figs. 12-15. The bottom slab layer 218 is shown in Fig. 12. A plurality of bottom horizontal reinforcing bars 220 are installed parallel to one another.

A prefabricated welded beam 204 is shown in Fig. 13. The welded beam 204 has a plurality of vertical continuous ties 212 that extend around top and bottom beam layers 206 and 208. The top beam layer 206 has a plurality of top horizontal reinforcing bars 210. The bottom beam layer 208 has a plurality of bottom horizontal reinforcing bars 211. The top and bottom horizontal reinforcing bars 210 and 211 are oriented lengthways along the welded beam 204 and are parallel with one another. Different orientations of the horizontal reinforcing bars may be used.

Fig. 14 shows one of the steps in installing the welded beams 204A and 204B in a steel structure. The welded beams are placed side-by-side on top of the bottom slab layer 218. As shown in Fig. 15, the top slab layer 214 is then installed on top of the welded beams to form the steel structure 200. As shown in Fig. 15, the top horizontal reinforcing bars 210 of the top beam layer 206 lie adjacent to and in the same plane as the top horizontal reinforcing bars 216 of the top slab layer 214, with the two layers oriented so that the plurality of horizontal reinforcing bars 216 of the top slab layer 214 are oriented generally perpendicularly to the horizontal reinforcing bars 210 of the top beam layer 206. Similarly, the bottom horizontal reinforcing bars 211 of the bottom beam layer 208 lie adjacent to and in the same plane as the top horizontal reinforcing bars 220 of the bottom slab layer 218, with the two layers oriented so that plurality of horizontal reinforcing bars 220 of the bottom slab layer 218 are oriented generally perpendicularly to the horizontal reinforcing bars 211 of the bottom beam layer 208. It will be understood that different orientations of each of the various horizontal reinforcing bars may be used.

Figs. 16 to 20 show a steel structure 300 (Fig. 20) comprising a plurality of prefabricated welded beams 304 installed side-by-side between a bottom slab layer 318 (Fig. 17) having horizontal reinforcing bars 320 and a top slab layer 314 (Fig. 20) having horizontal reinforcing bars 316. The prefabricated welded beams 304 are shown in more detail in Fig. 16 where the welded beams 304 each include a plurality of vertical continuous ties 312 which extend around a top beam layer 306 and a bottom beam
layer 308. The top beam layer 306 formed from a plurality of top horizontal reinforcing bars 310 and the bottom beam layer 308 being formed from a plurality of bottom horizontal reinforcing bars 311.

The embodiment of the steel structure 300 shown in Figs. 16 to 20 is similar to the steel structure 200 shown in Figs. 11 to 15, except that the embodiment of the steel structure 300 includes a plurality of shear ties 322 extending generally vertically between the horizontal reinforcing bars 310 of the top beam layer 306 and the horizontal reinforcing bars 311 of the bottom beam layer 308. The shear ties 322 include a hook end 324 and a flat end 326. Each of the one or more prefabricated, welded beams 304A, 304B include shear ties 322 that are oriented with the hook ends 324 connected to the horizontal reinforcing bars 310 of the top beam layer 306. As shown in Fig. 16, the plurality of shear ties 322 form two parallel rows of shear ties 322 extending along a length of the one or more prefabricated, welded beams 304A and 304B.

Figs. 12 to 15 and 17 to 20 generally set out the steps in constructing a reinforcing steel structure 200 or 300 for use in a concrete building slab. Reference will be made hereafter to the embodiment of the steel structure 200 shown in Figs. 12 to 15, but the same method installation applies to the steel structure 300 in Figs. 17 to 20. Generally, the beams are assembled as units using a combination of welds and ties at intersections. The ratio between the number of ties and welds is adjusted as required due to loading and flexibility requirements. Although the process described herein has two layers of rebar in the top and bottom formed from the top and bottom beam layers and the top and bottom slab layers, a similar procedure may be used when there are more than two layers of rebar for the top and bottom mats. All welding may be done in accordance with local welding standards. Different numbers, orientations and sizes of welded beams may be used in a steel structure depending on the application desired.

Initially, a plurality of prefabricated, welded beams 204 are provided at a worksite. The beams preferably have dimensions equal to or less than 12 feet by 12 feet by 60 feet, in order to conform with transportation limits. The size of the beams may depend on the transportation limits in different jurisdictions. The plurality of prefabricated welded beams 204 may be assembled and welded at a separate facility from the worksite. The beams 204 may be delivered on site when the concrete slab
structure is being constructed. By providing the beams 204 in a prefabricated form, the installation process on site may be simplified. The bottom slab layer 218 is installed as shown in Fig. 12 at a work site. Next, each of the prefabricated, welded beams 204 are placed adjacent to one another on the bottom slab layer 218. The bottom slab layer 218 and the beams 204 may be connected by a suitable combination of welding or wire ties. After the welded beams are installed, the top slab layer 214 is installed on the plurality of welded beams to form the reinforcing steel structure 200. The top slab layer 214 and the beams are connected using welding or wire ties. Finally, concrete (not shown) is added to the reinforcing steel structure to form a concrete building transfer or raft slab.

By installing the steel structure 200 using modular components in the form of prefabricated welded beams 204, the beams are generally sturdy for transportation and installation. The rigidity of the beams 204 may allow them to be walked on and can provide a surface to stand on during installation. By providing the beams 204 in a completed form, it may lessen the need for workers to install rebar components in confined spaces. Testing has shown that installation using modulated welded cages may reduce installation time by as much as half of the time compared to traditional methods.

The prefabrication of welded cages and beams allows each of the connections to be provided entirely by welding. Preferably, the reinforcing steel in each of the welded cages and welded beams are joined using 100% welding, which may increase the strength of the prefabricated components compared to using wire ties. Preferably, each of the one or more prefabricated, welded cages or beams have dimensions equal to or less than 12 feet by 12 feet by 60 feet or other suitable dimensions that may be required by transportation limits. Different sizes of welded beams may be constructed. The welded beams are sized and shaped to suit the profile of the transfer or raft slab. Variations of the size and shape may also be required since slabs may have steps or slopes on the top or bottom. The welded beams and welded cages are generally arranged on the transportation vehicles to fit as many as possible onto a single load. The amount loaded onto each vehicle also depends on the sequence of delivery, which should follow a logical order based on the order each component is installed. A load of welded beams or cages may also be combined with additional loads, such as loose bars to fully load a transport vehicle. The sequence of transportation may be of
heightened important since there are frequently issues with the amount of free space on site.

Welded cages generally are no wider than 12' in width to meet certain transportation requirements and the length may be dependent on the length of wall. The welded cages may be sized and shaped to fit the least number of cages as possible in each wall in order to reduce the number of laps required when installing the cages. It may be beneficial to ensure that the wall cages are each the same size and there are a number of factors which may have an effect on the size and shape of a cage, and there may be variation from cage to cage. Factors which may dictate width of a welded cage may include the thickness of the walls, any additional openings in the walls and the intersections with other walls, etc.

From a delivery point of view, in some jurisdictions, the welded cages and beams may be limited to being no more than 12' wide in one direction, since the trailers are 8' wide and the limit for the overhang is 2' on each side. Trailers also come in different sizes, and in some jurisdictions, the maximum length may be 60'. Longer or wider assemblies than the maximums in a particular jurisdiction are possible with special permits and may require heavy duty cranes for positioning and offloading. Another factor for the size of welded cages and beams is crane lifting capacity onsite, since cages cannot be designed heavier than allowed by the crane lifting capacity, which may vary from site to site.

Although the prefabricated welded cages 104 and 404, and the prefabricated welded beams 204 and 304 are shown with particular arrangements of reinforcing steel, it will be understood that various modifications may be made which allow for the construction of prefabricated welded components offsite which may be transported in a completed form. The welded cages 104 and 404 are preferably made using vertical reinforcing bars which are welded inside a plurality of parallel horizontal continuous ties. The welded beams 204 and 304 are preferably made using top and bottom beam layers which are welded inside a plurality of vertical continuous ties.

The prefabricated beams and cages described herein may be mass produced, since each component may be fabricated following a specific design.

Although the foregoing description has been made with respect to preferred embodiments of the present invention it will be understood by those skilled in the art
that many variations and alterations are possible. Some of these variations have been discussed above and others will be apparent to those skilled in the art.

In the claims, the word "comprising" is used in its inclusive sense and does not exclude the possibility of other elements being present. The indefinite article "a/an" before a claim feature does not exclude more than one of the feature being present unless it is clear from the context that only a single element is intended.
THE EMBODIMENTS OF THE INVENTION IN WHICH AN EXCLUSIVE PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:

1. A reinforcing steel structure for use in a concrete building wall, the structure comprising:
   one or more prefabricated, welded cages having vertical reinforcing bars;
   a plurality of continuous ties extending around the vertical reinforcing bars
   and a plurality of shear ties extending generally horizontally between the vertical
   reinforcing bars; and
   wherein each welded cage is sized and shaped for shipping and said
   structure can be formed onsite from a plurality of said cages lapped together.

2. The reinforcing steel structure of claim 1 wherein each of the plurality of shear ties have a hook end and a flat end, and the plurality of shear ties are arranged between
   the vertical reinforcing bars in an alternating parallel pattern with the hook ends of each
   adjacent shear tie facing in an opposite direction.

3. The reinforcing steel structure of claim 1 further comprising a plurality of the one
   or more prefabricated, welded cages and the reinforcing steel structure further
   comprising a pair of welded cages placed adjacent and parallel to each other for use in
   a single length of a concrete building wall and having a plurality of lap bars extending
   generally horizontally between overlapping adjacent ends of the pair of welded cages.

4. The reinforcing steel structure of claim 1 further comprising a plurality of the one
   or more prefabricated, welded cages and the reinforcing steel structure further
   comprising a corner pair of welded cages placed adjacent and perpendicular to each
   other for use in two adjoining walls forming a corner of a concrete building wall and
   having a plurality of u-caps extending generally horizontally around adjacent ends of the
   pair of welded cages.

5. The reinforcing steel structure of claim 4 further comprising a parallel pair of
   welded cages placed adjacent and parallel to each other for use in a single length of a
concrete building wall and having a plurality of lap bars extending generally horizontally within the vertically reinforcing bars and between overlapping adjacent ends of the parallel pair of welded cages.

6. The reinforcing steel structure of claim 5 further comprising a plurality of lap bars extending generally horizontally within the vertical reinforcing bars and between the corner pair of welded cages.

7. The reinforcing steel structure of any of claims 1 to 6, wherein each of the one or more prefabricated, welded cages have dimensions equal to or less than 12 feet by 12 feet by 60 feet.

8. A method of constructing a reinforcing steel structure for use in a concrete building wall, the method comprising:

   providing a plurality prefabricated, welded cages having vertical reinforcing bars at a worksite, each of the plurality of prefabricated, welded cages having a plurality of continuous ties extending around the vertical reinforcing bars and a plurality of shear ties extending generally horizontally between the vertical reinforcing bars; and

   installing the plurality of prefabricated, welded cages at a worksite;
   installing reinforcing steel bars between the plurality of prefabricated, welded cages to form a reinforcing steel structure; and
   adding concrete to the reinforcing steel structure to form a concrete building wall.

9. A reinforcing steel structure for use in a concrete building transfer or raft slab, the structure comprising:

   one or more prefabricated, welded beams comprising:
   a top beam layer having horizontal reinforcing bars,
   a bottom beam layer having horizontal reinforcing bars, and
   a plurality of continuous ties extending generally vertically around the top beam layer and the bottom beam layer; and
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wherein each welded beam is sized and shaped for shipping and said structure can be formed onsite from a plurality of said beams lapped together.

10. The reinforcing steel structure of claim 9, wherein the structure further comprises:

a plurality of prefabricated, welded beams lapped together;

a top slab layer comprising a plurality of horizontal reinforcing bars oriented generally perpendicularly to the horizontal reinforcing bars of the top beam layer;

a bottom slab layer comprising a plurality of horizontal reinforcing bars oriented generally perpendicularly to the horizontal reinforcing bars of the bottom beam layer;

wherein the structure can be formed onsite by installing the bottom slab layer, installing the plurality of welded beams on the bottom slab layer and installing the top slab layer on the plurality of welded beams.

11. The reinforcing steel structure of claim 9, wherein each of the one or more prefabricated, welded beams further comprises a plurality of shear ties extending generally vertically between the horizontal reinforcing bars of the top beam layer and the horizontal reinforcing bars of the bottom beam layer.

12. The reinforcing steel structure of claim 11, wherein each of the one or more prefabricated, welded beams further comprises the plurality of shear ties being oriented with the hook ends connected to the horizontal reinforcing bars of the top layer slab.

13. The reinforcing steel structure of claim 12, wherein the plurality of shear ties further comprise two or more parallel rows of shear ties extending along a length of the one or more prefabricated, welded beams.

14. The reinforcing steel structure of any of claims 9 to 13, wherein each of the one or more prefabricated, welded beams have dimensions equal to or less than 12 feet by 12 feet by 60 feet.
15. The reinforcing steel structure of any of claims 9 to 14 for use in a concrete transfer slab or a concrete raft slab.

16. A method of constructing a reinforcing steel structure for use in a concrete building slab, comprising:
   providing a plurality of prefabricated, welded beams at a worksite, the welded beams comprising:
   a top beam layer having horizontal reinforcing bars,
   a bottom beam layer having horizontal reinforcing bars, and
   a plurality of continuous ties extending generally vertically around the top beam layer and the bottom beam layer;
   installing a bottom slab layer comprising a plurality of horizontal reinforcing bars;
   installing the plurality of prefabricated, welded beams adjacent to one another on the bottom slab layer; and
   installing a top slab layer comprising a plurality of horizontal reinforcing bars on the plurality of welded beams to form a reinforcing steel structure; and
   adding concrete to the reinforcing steel structure to form a concrete building slab.
FOR LONGER WALLS REPEAT THE SAME MODULE SEVERAL TIMES
WALLS WITH ZONES SHOWN IN MODULAR SECTIONS
WALLS WITH ZONES SHOWN IN MODULAR SECTIONS

HORIZONTAL BARS ARE PROVIDED AS CLOSED TIES MAKING MODULAR SECTIONS AND WITH ENDS HOOKED 135 DEGREES ARE EMBEDDED INTO ZONE TO PREVENT FAILURE IN CASE OF SPALING OF CONCRETE.
BEAMS IN MODULAR SECTIONS

Fig. 11
Fig. 12

BOTTOM LOWER LAYER INSTALLED FIRST

RAFT AND TRANSFER SLAB WITH NO SHEAR BARS
RAFT AND TRANSFER SLAB WITH NO SHEAR BARS

MODULAR BEAMS DELIVERED & INSTALLED SECOND
RAFT AND TRANSFER SLAB WITH NO SHEAR BARS

MODULAR BEAMS INSTALLED
RAFT AND TRANSFER SLAB WITH NO SHEAR BARS
BEAMS IN MODULAR SECTIONS
RAFT AND TRANSFER SLAB WITH SHEAR BARS

Fig. 17

218

BOTTOM LAYER INSTALLED FIRST

220
RAFT AND TRANSFER SLAB WITH SHEAR BARS

Fig. 2D

TOP UPPER LAYER BARS INSTALLED
HEAVY WALLS IN MODULAR SECTIONS