

## **COLLAPSIBLE CAGE**

### **FIELD OF THE INVENTION**

The present invention relates to the construction products. In particular,  
5 the present invention relates to the fabrication of metal cages used as reinforcement for concrete structures in the construction industry.

### **BACKGROUND OF THE INVENTION**

In the construction industry, steel reinforcements are required for concrete structures. For structures such as columns, beams and pile  
10 caps, steel cages made from bars, wires or meshes are used as the steel reinforcement. The steel bars are bent to required shapes and then assembled into cage on the construction site. Alternatively, cages are prefabricated in the shop and sent to site for installation. All these cages are typically fabricated as longitudinally aligned main bars with links  
15 aligned perpendicularly relative to main bars. If the cage is assembled on the construction site, the links are usually tied to the main bars with wires. If the cage is prefabricated in the shop, the links are usually welded on or wire tied to the main bar to form the cage. It is also usual to have cages partially assembled in the shop followed by full assembly  
20 only at the installation site.

Figures 7A and 7B show an example of a prior art cage assembled by a partial cage method. In this prior art method, the cage comprises a plurality of main bars **101**, partial cage **106**, and capping piece **108**. Partial cage **106** is prefabricated in the shop and transported to the

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construction site. It contains the carrier wires 104 welded to links 102 at weld joints 110. Carrier wires 104 keep the links 102 at a distance apart to maintain the cage shape. At the construction site, the partial cage 106 is lowered into the formwork, and the main bars 101 are then put  
5 through the cage opening and tied to the links with wires. After all the main bars are in place, the capping piece 108 is placed on and tied to the link or main bar 101 with wires to cover up the open side of the partial cage.

The on-site method is time consuming and labour intensive, since each  
10 cage has to be assembled by laborious wire tying. The prefabrication method improves productivity and reduces labour requirement on site, but has the drawback of transfer difficulties. Fully assembled prefabricated cages occupy large volumes and hence the number of cages each truck can take is severely limited. The additional  
15 transportation cost incurred offset the benefit gained from the improved productivity and manpower savings compared to the on-site method. Due to this shortcoming, fully assembled prefabricated cages are not widely employed in the construction industry. Furthermore, prefabricated cages are generally heavier than steel bars, and therefore some cages  
20 can be difficult to be carried by workers in the way that steel bars can be carried. Due to the difficult work site conditions in a typical construction site, there are no existing means for lifting and transporting cages that are too heavy for workers to carry. This is another limitation that prevents fully assembled prefabricated cages from being employed in the  
25 construction industry. Partially assembled prefabricated cages are quite

commonly employed in the construction industry, especially for cages that are small enough for workers to carry around. Partially assembled prefabricated cages partly reduce the amount of on-site tying efforts, and partly reduce the transfer difficulty encountered by the fully assembled prefabricated cages.

It is therefore an object of the present invention to provide a solution to the above-stated limitations.

#### **BRIEF DESCRIPTION OF THE DRAWINGS**

Figures 1A-D are schematic diagrams to show various embodiments of prefabricated cages according to the present invention.

Figures 2A and 2B are schematic diagrams to show how one precage according to the present invention may be folded sideways (Fig. 2A) or downwards (Fig. 2B) into the collapsed form.

Figures 3A and B are perspective drawings to show a steel wire as the connecting means according to the present invention in the untied (Fig.3A) and tied (Fig.3B) positions.

Figure 3C is a perspective drawing to show a spring wire as the connecting means according to the present invention.

Figure 4A and B are perspective views of a second embodiment of the connecting means before (Fig.4A) and after (Fig. 4B) fastening onto the cage.

Fig. 5A and B are perspective views of a third embodiment of the connecting means before (Fig.5A) and after (Fig. 5B) fastening onto the cage.

Fig. 6A and 6B are perspective views of a fourth and fifth embodiments  
5 respectively of the connecting means according to the present invention.

Fig. 7B is a formed cage according to the prior art. Fig.7A is the exploded view of the cage in Fig. 7B showing the open cage the main bars and the capping piece.

Fig. 8 is a flow chart to show a method of using a collapsible cage  
10 according to the present invention.

Fig. 9A and 9B show the side and front views of a hoisting jig according to one embodiment of the present invention.

Fig. 10A and 10B show the side and front views of a hoisting jig according to another embodiment of the present invention.

15 Figure 11A and 11B are precages according to the present invention showing the bracing wires and supporting bar respectively.

## **SUMMARY OF THE INVENTION**

Accordingly, the present invention provides, in one aspect, a plurality of  
20 metal main bars rotatably connected to a plurality of links to form a collapsible cage. In another aspect, connecting means are provided for the rotatable connection between the main bars and the links. In a further aspect, a method is provided for producing a cage for use as concrete

reinforcement. The method comprises assembling the collapsing cage by rotatably connecting the main bars to the links, collapsing the cage for ease of transport, transporting one or more cages to a construction site, expanding the cage to the required shape, and installing the cage. In yet  
5 another aspect, a hoisting jig is provided for the installation of cages that are too heavy to be manually carried. In a related aspect, another method is provided for the application of the collapsible cage for use as concrete reinforcement. The method comprises assembling the precage by rotatably connecting the main bars to the links, collapsing the cage for  
10 ease of transport, transporting one or more cages to a construction site, expanding the cage to the prescribed shape using a hoisting jig, and installing the cage at the prescribed site using the hoisting jig.

In one specific embodiment, the connecting means comprising metal plates and/or wires that join the links and the main bars sufficiently  
15 tightly to restrict lateral movement but sufficiently loosely to allow rotation movement of the links. In another specific embodiment, the main bars are substantially longitudinally aligned relative to each other, and the links are perpendicularly aligned relative to the main bars.

## 20 **DESCRIPTION OF THE INVENTION**

The following detailed description describes the preferred embodiment for implementing the underlying principles of the present invention. One skilled in the art should understand, however, that the following description is meant to be illustrative of the present invention, and should

not be construed as limiting the principles discussed herein. In addition, certain terms are used throughout the following description and claims to refer to particular components. As one skilled in the art will appreciate, companies may refer to a component by different names. This document  
5 does not intend to distinguish between components that differ in name but not in function. In the following discussion, and in the claims the terms "including", "having" and "comprising" are used in an open-ended fashion, and thus should be interpreted to mean "including but not limited to .....". Also, the term "couple" or "couples" is intended to mean either an  
10 indirect or direct mechanical connection. Thus if a first device "couples" to a second devices, that connection may be a direct mechanical connection or through an indirect connection via other mechanical devices or connections.

Referring now to Fig. 1A-D, four rectangular-shaped prefabricated  
15 collapsible cages (hereinafter referred to as precages) are used as examples for the types of precages provides according to the present invention. In Fig. 1A, the example is a precage containing 3 main bars **21a** aligned in parallel and equally spaced along one side of the precage. Four additional main bars **23a** arranged in two layers are  
20 found on opposite side of main bars **21a**. Main bars **21a** & **23a** are interconnected by a series of rectangular shape closed links **22a** via connecting means in the locations as indicated by the open circles **24a**.

Fig. 1B shows a precage with two main bars **21b** for supporting two corners of the rectangular cage. Six other main bars **23b** are provided  
25 on the opposite side (i.e. bottom side). As in the previous example,

closed quadrilateral links **22b** are connected perpendicularly to the main bars to form a rectangular shape. Connecting means, in the positions indicated by the open circles **24b**, are provided to connect the links at predetermined positions to the appropriate main bars.

5        Fig. 1C shows another example of a precage with main bars **21c** on the top side, main bars **23c** on the bottom side, links **22c** and connecting means (depicted only as open circles, details not shown) at locations **24c**.

10        Figure 1D shows another example of a partially assembled cage according to the present invention. The precage contains main bars **21d** and **23d**, open links **22d** and connection means (indicated only as open circles) at located **24d**.

15        Figures 1A-1D show the use of connecting means at every main bar/link junction (i.e. **24a –24d** of Fig.1A –1D respectively). However, in practising the invention, it is possible to leave out the connecting means at some of the junctions, as long as the rigidity and collapsibility of the cage is not impaired. The number and location of the junctions requiring connections may be determined by one skilled in the art without undue experimentation based on the teachings disclosed herein.

20        There are different ways in which the precages are collapsible after forming. One way to fold a precage is to rotate the links using one side of the links as the axis of rotation. Referring first to Fig. 2A as an example, link **50** has sides **50a**, **50b**, **50c** and **50d**. To fold this precage, link **50** is rotated around side **50a** as the axis of rotation as indicated by the

thick arrows. The connecting means, at positions indicated by circles 54, allow each link to be rotatable relative to main bars 52a-d. In this way, the entire precage is folded onto the side between main bars 52a and 52c when all the links are rotated in the same direction as shown by the dotted lines.

Referring to Fig. 2B, the same precage may be folded using side 50d of link 50 as the axis of rotation as shown by the thick arrows. All the links are rotated in the same way for the precage to be folded into the collapsed state as represented by the dotted lines. For some cages, such as those with main bars having bent ends as in Figures 1B and 1C, some of the bends may interfere with other structures when the cage is collapsed. The joints in such cases should therefore allow for minor traverse adjustments of the main bars along the link or rotational movement of the main bar to avoid interference. However, where traverse adjustment is not necessary, for example in the case of Figure 1A, the spacer bars 25a may be secured onto the main bar by welding, wire tying or clipping to prevent any traverse movement of the main bars along the links.

There are numerous embodiments of the connecting means for connecting the links rotatably to the main bars. In all embodiments, the connecting means provide rigidity to the cage in all directions other than the collapsing directions. Collapsible cage after expanding, are preferably held in the expanded state and prevented from re-collapsing by some supporting means. These supporting means can be of the form of two bracing wires or spacer bars as shown in Figures 11A and 11B

respectively. In Figure 11A, the bracing wires **30a** are secured to the main bars **34a** or links **36a** to prevent the expanded cage from re-collapsing. In Figure 11B, two supporting bars **30b** are tied or welded to the main bars **34b** at points **32b** after the cage has been expanded.

5 These connecting means and supporting means work collectively such that the cage can withstand all necessary handling in the collapsed and expanded state without damage, and can maintain the shape in the expanded position even after multiple collapsing and opening operations. The supporting bars or wires are fixed onto the precage after  
10 expansion. They may be loosely tied to the collapsed cage for convenience, or introduced separately after expansion. Referring first to Figures 3A and B, the link **60** may be simply tied to the main bar **62** using wires **64**, such as steel wires. Figure 3C shows a variation in which a spring wire **64c** is used to wrap around the main bar **62c** and  
15 link **60c**.

Referring now to Figures 4A and 4B, another embodiment provides an H-shaped metal plate **66** having two fastening ends **66a** connected by a middle portion **66b**. The fastening ends **66a** are folded or crimped tightly around main bar **68** with link **70** sandwiched between main bar  
20 **68** and middle portion **66b**. Fastening ends **66a** should be tightened sufficiently and in the appropriate position to keep the middle portion **66b** pressing onto link **70**. The tightening force should create sufficient frictional force between fastening end **66a** and main bar **68** so that there is relatively little or no movement therebetween. The spacing between  
25 the various links **70** are maintained by restricting the lateral movement of

the links **70** to within the space provided between the two fastening ends **66a**. The plate may be a steel plate or other metal plate.

Referring now to Fig. 5A and 5B, another embodiment is provided in which a plate **70** is provided with two main bar fastening ends **70a** and  
5 a link-fastening end **70b**. The main bar fastening ends **70a** are folded or crimped tightly around main bar **72** such that there is little or no relative movement between the fastening ends **70a** and the main bar **72**. Link  
fastening end **70b** is folded or crimped sufficiently tightly around link **74**  
such that it restricts lateral movement but allow for rotational movement  
10 of link **74** relative to link fastening end **70b**. For cages in which the main bars are ribbed, there should be sufficient frictional and resistant forces to restrict lateral movement due to the rib protrusion.

Referring to Fig. 6A, a further embodiment of the connecting means is a T-shaped metal plate **80** with a link fastening end **80a** and a wire  
15 fastening end **80b**. Link fastening end **80a** is folded or crimped around link **82** while wire fastening end **80b** is rolled around the middle section of wire **86**. Wire **86** is then wrapped or tied around main bar **84** to complete the connection. The link-fastening end **80a** serves the same function as the link-fastening end **70b**. Wire **86** may be a mild steel wire  
20 or a spring steel wire.

Referring to Fig.6B, a further embodiment of the connecting means is in the form of a straight metal strip **90**. The two ends **90a** of the metal strip are welded on the main bar **92** with link **94** sandwiched between main bar **92** and centre portion **90b** of the metal strip. The spacing between  
25 the various link **94** are maintained by restricting the lateral movement of

the links 94 to within the space provided between the two welded ends 90a.

Figure 8 shows a method for the use of the aforementioned collapsible cage as concrete reinforcement. The method described in this embodiment includes assembling the collapsible cage off-site by  
5 rotatably connecting the main bars to the links, collapsing the cage for ease of transport, transporting one or more cages to a construction site, and, at the installation site, expanding the cage to the required shape and installing the cage.

10 In another embodiment of the present method, the links and main bars are cut and bent to the required shape and dimension. A cage assembly system is used to assemble the links and main bars to form the collapsible cages. These collapsible cages are then collapsed and packed in an order to facilitate site installation. The collapsed cages are  
15 then transported to the construction site and hoisted up to the installation level, for example, on top of the building under construction. A hoisting jig is used to lift and expand the cage, and transport the expanded cage to the installation location and lower the cage into the formwork. The jig according to the present invention can travel on surfaces that are rough,  
20 with irregularities such as bent wires protruding from the concrete slab. The surface may also contain other vertical obstructions such as vertical columns starter bars protruding more than one meter above the surface. To install the cage, the jig must be able to manoeuvre easily to the installation location and be able to cross trench-like features such as  
25 framework recesses, and to go over surface irregularities. It must also

have a small turning radius or preferably turn on the spot to avoid the cage hitting the vertical obstacle.

Figure 9 shows one hoisting jig according to the present invention for hoisting, transporting and installing steel cages into the required location. Jig 120 may be used, for example, in construction sites having formwork trenches. In this embodiment, the jig is manually operated, with multiple wheels 122 or track. The wheels 122 are preferably narrow enough to allow them to cross the trenches but large enough in wheel diameter to go over surface irregularities. In general, the size and number of wheels provided on the jig should be large enough to allow the jig to be conveniently manoeuvred on the uneven construction site surface. The wheels are of the swivel type, and hence the jig can be turned on the spot. The jig 120 is also made of a material light enough to be pushed around by a single operator, while stable enough to maintain balance during the cage-hoisting step. In this embodiment, four swivel wheels 122 are aligned in a first linear row along the long side of base 126. Another four additional swivel wheels are aligned in a second linear row parallel to the first row. Frame 128 extends upwards from base 126. A chain hoist 129 hangs slidably from frame 128 and is coupled to lifting hook 130. Counter weight 131, coupled to the bottom of base 126 is provided to give stability to the jig and to prevent toppling when the jig is loaded. Locking device 133 is also provided to lock the hoisting jig in place during hoisting and lowering of the cage. During operation, expanded cage 124 is first hoisted up by lifting hook 130, for example with the longitudinal side of the cage parallel to one of the short

side of the jig. The cage is then rotated 90 degrees such that the cage is parallel to the long side of the jig. Chain hoist **129** is then slidably shifted towards the centre of the jig for transfer to the prescribed formwork. The jig is manually pushed towards the prescribed location in a stable manner since cage **124** is positioned at the centre of the jig **120**. To lower cage **124** onto rectangular formwork recess **132**, the jig is preferably positioned such that one short side of the jig is parallel to a long side of the recess. Chain hoist **129** is shifted to the short side of the jig adjacent recess **132**. Cage **124** is then rotated 90 degrees again and lowered into recess **132**.

Figure 10 shows another embodiment of a jig according to the present invention. In this embodiment, jig **140** is powered with engine **142**. Engine **142** may be battery or line power operated. Two rows of longitudinally aligned wheels are attached to base **146**. In this embodiment, the first three pairs of wheels **144a** are of the swivel type, while the last pair of wheels **144b** are the non-swivel type. Engine **142** is coupled to wheels **144b**. Wheels **144b** can be further lifted up using wheel-lifting lever **148** such that they have no contact with surface **150**. During transportation, wheels **144b** are lowered to the surface level for driving of the jig by engine **142**, but may be raised to facilitate turning. Frame **152** extends upwards from base **146**. A spreader bar **154**, with lifting hooks **156**, hang slidably from lifting frame **160**. In this example, cage **158** is hooked onto lifting hooks **156** and lifted by raising the lifting frame **160**. The operation of the jig for hoisting is similar to that described for the previous embodiment.

While the present invention has been described particularly with references to the aforementioned figures with emphasis on a cage with main bars and links, it should be understood that the figures are for illustration only and should not be taken as limitation on the invention.

5 For example, the main bars and links can be any long product and can be made of any material. Preferred long products are ribbed bars and round bars. Other usable long products may have cross sections of oval, hexagonal or octagonal shapes, among others. The main bar and links can be of any diameter (or equivalent diameter in the case of non-round  
10 shape), and various main bars within the same cage do not necessarily have the same diameter, shape, length or cross section, nor necessarily have the same material. Furthermore, the main bars do not necessarily span the whole length of the cage, and can be joined up along the length of the cage. It is possible to have cages with multiple layer of main bars.  
15 However, in this case, only the layer closest to the link is tied to the link, whereas the rest of the layers are tied to this layer.

The links are cross bars that are joined up with the main bars to allow a cage to be formed. The links may be formed by bending a long product of a variety of shapes or formed by other means such as stamping, forging  
20 and casting, among others. Suitable types of links may be round, ribbed, or have oval hexagonal or octagonal cross-sections. They may be of any diameter and any material. The distances between adjacent links do not necessarily have to be the same within the same cage.

Various types of connecting means may be used to allow for collapsing and subsequent re-expanding of the cage. Connecting means within the same cage are not necessarily of the same type.

5 Various types of jigs may be used to facilitate the transfer of the formed cages at the work site. The frame of the jig may be extendible and of various shapes and height. Different types of rolling devices may be used for horizontal transfer of the jigs, and different types of hoisting devices may be used for the horizontal and vertical transfer of the cage hoisted by the jig. The hoisting jig may be manually or electrically  
10 operated.

In addition it is clear that the method and apparatus of the present invention has utility in many applications where steel cage reinforcement is required. It is contemplated that many changes and modifications may be made by one of ordinary skill in the art without departing from the  
15 spirit and the scope of the invention described.

**CLAIMS**

- 1 1. A collapsible metal cage comprising  
2 a plurality of connecting means;  
3 a plurality of main bars; and  
4 a plurality of links rotatably connecting to said main bars via said  
5 connecting means at predetermined connection points such that said  
6 links are aligned in prescribed positions relative to said main bars,  
7 said connecting means making said connection sufficiently tight to  
8 restrict lateral movement of said links relative to said main bars.
- 1 2. A cage according to claim 1 wherein said main bars are substantially  
2 longitudinally aligned; and said links are aligned substantially  
3 perpendicularly to said main bars.
- 1 3. A cage according to claim 1 or 2 wherein said links are closed links or  
2 open links.
- 1 4. A cage according to claim 1 or 2 wherein each of said connecting  
2 means comprises a metal plate, said plate comprising a middle portion  
3 connecting two fastening ends, said fastening ends fasten to said main  
4 bar on opposing sides of said link, and said middle portion rotatably  
5 coupling said link to said main bar.
- 1 5. A cage according to claim 1 or 2 wherein each of said connecting  
2 means comprises a metal plate, said metal plate comprising a middle  
3 portion connecting two welding ends, said welding ends welded to



4 said main bar on opposing sides of said link such that said middle  
5 portion is rotatably coupled to said link.

1 6. A cage according to claim 1 or 2 wherein each of said connecting  
2 means comprises a metal plate, said plate comprising a middle portion  
3 connecting two fastening ends, said fastening ends fastening to said  
4 main bar on opposing sides of said link, and said middle portion  
5 fastening to said link.

1 7. A cage according to claim 1 or 2 wherein each of said connecting  
2 means comprises a metal plate and a metal wire, said metal plate  
3 having at least one main bar fastening end and at least one wire  
4 fastening end, said main bar fastening end fastening to said main bar  
5 juxtapose said link, said wire fastening end fastening said wire, the  
6 two ends of said metal wire fastening said link.

1 8. A cage according to claim 7 wherein said wire is a spring wire.

1 9. A cage according to claim 1 or 2 wherein each of said connecting  
2 means comprises a metal plate and a metal wire, said metal plate  
3 having at least one link fastening end and at least one wire fastening  
4 end, said link fastening end fastens to said link juxtapose said main  
5 bar, said wire fastening end fastening said wire, and the two ends of  
6 said metal wire fastening said main bar.

1 10. A cage according to claim 9 wherein said wire is a spring wire.

1 11. A cage according to claim 1 or 2 wherein each of said connecting  
2 means comprises a metal wire, said metal wire tying said link to said  
3 main bar.



- 1 12. A cage according to claim 11 wherein said wire is a spring wire.
- 1 13. A cage according to any one of the above claims wherein supporting  
2 means is secured onto said main bars to prevent said cage from  
3 collapsing after said cage is expanded.
- 1 14. A method for producing a metal cage from bars for structural  
2 reinforcement comprising :  
3 assembling said cage by rotatably connecting a plurality of main bars  
4 and links;  
5 collapsing said cage;  
6 transporting said cage to a desired site;  
7 expanding said cage to the required shaped; and  
8 installing said cage at the required structure.
- 1 15. A method according to claim 14 further comprising the step of hoisting  
2 said expanded cage from the ground onto the installation level before  
3 the installing step.
- 1 16. A method according to claim 14 or 15 wherein a step of :  
2 securing supporting structures onto said cage to prevent collapse  
3 is provided after said expanding step.
- 1 17. A method according to claim 14 wherein said expanding and installing  
2 step is performed by a hoisting jig.
- 1 18. A coupling device for connecting a first bar transversely to a second bar  
2 comprising:



3 a substantially H-shaped metal plate having two fastening ends  
4 connected by a middle section, said fastening ends fastening securely  
5 around said first bar adjacent said second bar, said middle section  
6 pressing said second bar against said first bar with sufficient force  
7 such that frictional force between said first bar and second bar  
8 prevents lateral movement but allows rotational movement  
9 therebetween.

1 19. An apparatus for transferring objects in a construction site comprising :  
2 a base;  
3 a frame attached above said base;  
4 means for movement, rotatably attached to the base, for moving said  
5 apparatus laterally over a surface;  
6 means for lifting; slidably attached to said frame, for lifting said object,  
7 said means for lifting further adapted for substantially horizontal sliding  
8 movement relative to said frame such that said object may be moved  
9 from one end of said apparatus to the opposite end.

1 20. An apparatus according to claim 19 wherein said means for lifting  
2 further allows rotational movement of said object along an axis  
3 substantially normal to said surface.

1 21. An apparatus according to claim 19 wherein said means for movement  
2 is a plurality of wheels.

1 22. An apparatus according to claim 19 wherein said means for movement  
2 is driven by an engine.

