UPGRADABLE LATTICE TOWER AND COMPONENTS THEREOF

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ABSTRACT
A lattice tower (1) is provided comprising generally upright leg elements that are arranged in plan view at the corners of a polygon with horizontal struts and diagonal braces interconnecting the leg elements. The lattice tower has a first arrangement of basic leg elements (2), basic horizontal struts (3) and basic diagonal braces (4) providing a first and basic predetermined load carrying capacity of the tower. Selected basic leg elements and/or basic horizontal struts and/or basic diagonal braces are provided with attachment formations whereby additional leg elements (10) and/or additional horizontal struts (7) and/or additional diagonal braces (8) may be secured to the basic leg elements and/or basic horizontal struts and/or basic diagonal braces to provide an increased predetermined load carrying capacity of the lattice tower.
UPGRADABLE LATTICE TOWER AND COMPONENTS THEREOF

FIELD OF THE INVENTION

This invention relates to an upgradable lattice tower of the general type commonly used for supporting elevated loads that often assume the form of wireless transmission equipment, especially wireless transmitters and antenna. The principles of the invention are, however, also applicable to other lattice towers such as may be used for the purpose of supporting water tanks or the like, or any other elevated loads, and such lattice towers are intended to fall within the scope of this invention. The invention also relates to components of such lattice towers.

It is to be understood that the term lattice tower as used in this specification is intended to mean a tower having a latticed framework type of structure typically comprising generally upright leg elements (that may converge somewhat over at least a generally lower part of the height of the tower) that are generally arranged in plan view at the corners of a polygon, most commonly a square or triangle, and interconnecting horizontal struts and diagonal braces interconnecting the leg elements.

BACKGROUND TO THE INVENTION

Various types of tower structures are employed for the purpose of supporting wireless transmission equipment with a monopole being typically favoured for relatively low heights and lattice towers being favoured for their cost effectiveness for higher applications, typically tower heights in the range of from 20 to 100 metres.

Wireless telecommunication traffic has increased dramatically in recent times and added to cell phones are wireless Internet communications and other protocols such as WiMAX and Wi-Fi. This has resulted in a tremendous increase in wireless traffic. Associated with the increased traffic is the need for additional transmission equipment in order to handle the increased information load.

In accordance with one aspect of this invention there is provided a lattice tower comprising generally upright leg elements (that may converge somewhat over at least a generally lower part of the height of the tower) that are arranged in plan view at the corners of a polygon with horizontal struts and diagonal braces interconnecting the leg elements, the lattice tower being characterised in that it has associated therewith a first and basic arrangement of leg elements (herein termed basic leg elements), horizontal struts (herein termed basic horizontal struts) and diagonal braces (herein termed basic diagonal braces) providing a first and basic predetermined load carrying capacity of the tower and wherein at least selected basic leg elements and/or basic horizontal struts and/or basic diagonal braces are provided with attachment formations whereby additional leg elements and/or additional horizontal struts and/or additional diagonal braces may be secured to the basic leg elements and/or basic horizontal struts and/or basic diagonal braces to provide an increased predetermined load carrying capacity of the lattice tower.

SUMMARY OF THE INVENTION

Accordingly, when the time comes to add additional equipment that exceeds the capacity of a tower, the network owner is faced with a number of difficulties. Erecting a new tower structure requires new permits that must be issued by the regulatory authorities as well as, in many instances, an application for re-zoning. New permits and re-zoning involve additional expenses and the time necessary for obtaining such new permits is often unpredictable. In addition, there is the inevitable downtime that is required to disassemble one tower and assemble its successor, such downtime having tremendous financial implications and resulting in considerable inconvenience to the customer.

Various attempts have been made to increase the load bearing capacity of tower structures by means of reinforcement. Probably the most relevant, as far as applicant is aware, is that described in U.S. Pat. No. 6,944,950 in which it is proposed to clamp additional frame panels to an existing tower frame; one main aim of this proposal being to avoid welding or drilling of the existing structure. In applicant's view this proposal is likely to be costly; needs to be individually designed and fabricated to custom requirements for each tower structure at the time the necessity for reinforcing the structure arises; and provides unpredictable results in terms of the increased load capacity of the tower.
such marking optionally involving the use of colour coding and/or numbering; for predetermined sets of additional components to be designed to provide predetermined increases in the predetermined load carrying capacity of the tower such that one, and preferably at least two, predetermined stages of upgrade are provided; for an upgrade to include a stepwise addition of foundation material to a foundation of the basic lattice tower, and for the lattice tower to have three or four symmetrically arranged legs.

An upgrade may be achieved by the introduction of additional struts and additional diagonal braces that have the effect of reducing, typically halving, the span or buckling length of the basic components. An upgrade may also be achieved through doubling up of predetermined leg elements, predetermined horizontal struts and diagonal braces using parallel offset additional leg elements, additional horizontal struts and additional diagonal braces.

Preferably, holes for bolts in the leg sections are all located with a constant backmarking so that angle sections of different cross-sectional sizes can have their corners aligned both longitudinally (in butted end on end relationship) and in juxtaposed relationship.

A foot arrangement for each leg may comprise an anchor plate with a foot for the basic leg sections and an additional attachment for additional leg sections.

Alternatively, a foot arrangement for each leg may comprise an anchor plate composed of a plurality of separate parts each having at least one attachment hole and standing flanges between which flanges of an end of a leg section may be secured so that the separate parts of the anchor plate are secured together in use.

In accordance with a second aspect of the invention there is provided a system for the upgrading of the load carrying capacity of a lattice tower wherein a basic arrangement of leg elements (herein termed basic leg elements), horizontal struts (herein termed basic horizontal struts) and diagonal braces (herein termed basic diagonal braces) may be assembled that is designed to provide a first and basic predetermined load carrying capacity of a lattice tower and wherein one or more increased load carrying capacities of the tower may be implemented by adding to the basic arrangement at least selected additional leg elements and/or additional horizontal struts and/or additional diagonal braces and that may be secured to the basic leg elements and/or basic horizontal struts and/or basic diagonal braces to provide one or more predetermined increased load carrying capacities of the tower.

The invention also provides components of a lattice tower that are particularly adapted for use in a lattice tower or system as defined above. In one implementation of the invention a first upgrade may be achieved by the introduction of additional struts and additional diagonal braces that have the effect of halving the span or buckling length of the basic components and by adding to an existing cement foundation platform.

In such an implementation of the invention a second upgrade may be achieved through doubling up of predetermined leg elements and predetermined horizontal struts and diagonal braces using parallel offset additional leg elements, additional horizontal struts and additional diagonal braces and by adding further to the foundation platform.

In order that the above and other features of the invention may be more fully understood one embodiment and system according to the invention will now be described with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:-

FIG. 1 is a perspective view illustrating one embodiment of lattice tower to which the invention has been applied;

FIG. 2 is a front elevation thereof;

FIG. 3 is a front elevation thereof after having a first upgrade has been applied thereto;

FIG. 4 is a front elevation of after having a second upgrade applied has been a thereto;

FIG. 5 is an enlarged elevation of the lower part of the lattice tower illustrated in FIGS. 1 and 2;

FIG. 6 is an enlarged elevation of an upper part of the lattice tower illustrated in FIGS. 1 and 2;

FIG. 7 is an enlarged elevation of the lower part of the lattice tower illustrated in FIG. 3 with the first upgrade applied thereto;

FIG. 8 is an enlarged elevation of an upper part of the lattice tower illustrated in FIG. 3 with the first upgrade applied thereto;

FIG. 9 is an enlarged perspective view of the lower part of the lattice tower illustrated in FIGS. 3 and 7 with the first upgrade applied thereto;

FIG. 10 is an enlarged perspective view of an upper part of the lattice tower illustrated in FIGS. 3 and 8 with the first upgrade applied thereto;

FIG. 11 is an enlarged elevation of the lower part of the lattice tower illustrated in FIG. 4 with the second upgrade applied thereto;

FIG. 12 is an enlarged elevation of an upper part of the lattice tower illustrated in FIG. 4 with the second upgrade applied thereto;

FIG. 13 is an enlarged perspective view of the lower part of the lattice tower illustrated in FIGS. 4 and 11 with the second upgrade applied thereto;

FIG. 14 is an enlarged perspective view of an upper part of the lattice tower illustrated in FIGS. 4 and 12 with the second upgrade applied thereto;

FIG. 15 is a more enlarged perspective view illustrating one upgradeable foot of the tower;

FIG. 16 is a schematic end view of a leg section having the second upgrade applied thereto;

FIG. 17 is a more enlarged perspective view corresponding to FIG. 14 and showing more clearly the horizontal struts to which a second upgrade has been applied;

FIG. 18 is a perspective view of an alternative foot arrangement (with all fasteners removed) without a second upgrade leg section attached thereto;

FIG. 19 is the same as FIG. 18 but with a second upgrade leg section attached thereto;

FIG. 20 is a perspective view of the foot shown in FIG. 19 from the outside thereof; and,

FIG. 21 is a perspective view of the foot shown in FIG. 19 from the inside thereof.

DETAILED DESCRIPTION WITH REFERENCE TO THE DRAWINGS

Before proceeding with a detailed description of the embodiments of the invention illustrated in the drawings, it is to be noted that upgrades as envisaged by this invention do not need to take place in complete upgrades as will be described
in the example and each upgrade could take place in phases according to the increased load carrying capacity to be achieved. Thus, for example, a small increase in load carrying capacity could be achieved by upgrading using only some additional diagonal braces and possibly some additional horizontal struts that effectively halve the bending length of the relevant existing diagonal braces, horizontal struts and leg elements.

[0044] On the other hand, larger increases in carrying capacity may require doubling up of some or all of the horizontal struts and some or all of the leg elements. Each permutation and combination of components of a lattice tower that need to be introduced or upgraded by doubling their configuration can be planned in advance using appropriate design considerations and associated calculations at the outset.

[0045] It is to be understood that the terminology of first and second upgrades is not intended to mean an order in which the upgrades should be applied to a basic lattice tower and indeed components described as belonging to a second upgrade can be applied before components that are described as belonging to the first upgrade. The order of upgrading is thus dependent on the increase in load bearing capacity to be achieved and the design of the lattice tower.

[0046] Also, some preferred attributes and properties of the lattice towers produced according to the invention are as follows:-

[0047] The complete structure is preferably assembled using one common size of nut and bolt and using a number of common predrilled connector plates as may be required.

[0048] No welding whatsoever is thus required at any stage, either during initial erection or later upgrading. The components of a lattice tower can thus be flat packed and transported at low cost. All components are pre-drilled with all holes necessary to secure not only the components of the basic lattice tower together, but also to attach any additional components necessary in order to achieve a first and/or second upgrade as described in more detail below.

[0049] The components are all symmetrical so that the ends are reversible and the components can easily be manufactured using CNC punching techniques. All components are common in this preferred implementation of the invention, made of angle iron that is typically galvanised or otherwise surface treated to inhibit corrosion. As regards the leg sections, it is also convenient to bend these from flat metal plate cut to the required shape followed by bending the desired section of the legs. Thus, for a three legged structure the metal plate may be bent along a longitudinal line so that the two flanges extend at an angle of about 60° to each other to correspond roughly sides of the triangular lattice tower whilst in the instance of a square cross-section tower into planters can extend at about 90° to each other.

[0050] Also, the holes in the leg sections are all located with a constant backmarking (that is a fixed distance from the corner or toe-end of the angle section) so that angle sections of different cross-sectional sizes can have their corners aligned both longitudinally (in butted end on end relationship) and in juxtaposed relationship. This also equates connector plates to be used to connect collinear leg sections that are standard to all the joints, irrespective of whether the same size of angle section is used or not.

[0051] Thus, when a smaller size angle iron is used as a leg section towards the top end of the tower, the constant backmarking ensures that the legs remain in line. This has obvious advantages when analyzing the strength of the tower. For example, if it is decided to use a larger profile angle iron on a doubled up section of the legs (to increase the load bearing capacity even further), the larger profile can be accommodated due to the constant back mark without the larger profile interfering with other components of the structure.

[0052] All the struts, braces and leg elements may be premarked, numbered, and optionally colour-coded in order to facilitate on-site assembly.

[0053] Reverting now to the particular embodiment of the invention illustrated in the drawings, and with particular reference, at this stage, to FIGS. 1, 2, 5 and 6, a lattice tower, generally indicated by numeral (1), is constructed from components made and bolted together as described above and comprises generally upright basic leg elements (2) that converge somewhat over a lower part of the height of the tower and that are arranged in plan view at the corners of a square, in this instance. The leg elements are interconnected by a series of vertically spaced basic horizontal struts (3) and basic diagonal braces (4). The general dimensions of such a tower are widely variable but simply by way of example, in the instance of a 45 meter high lattice tower, the footprint could be a square having a side of about 5 metres. Also, for convenience, the leg elements are preferably about 2 metres long and using conventional design principles, thus provides for a maximum length of diagonal brace of about 3.7 metres. The attachment of collinear leg elements to each other is achieved using suitable connector plates and multiple bolts securing the connector plates to the flanges of the leg elements that are arranged in butt joint fashion.

[0054] Each of the lowermost leg elements (2), as shown in FIG. 5, is supported by a concrete foundation (5) by way of a foot (6) that is itself anchored to the foundation.

[0055] As indicated above the basic lattice tower is the simplest form of the tower and all the components are provided with additional holes for receiving bolts and that may be required in order to achieve the upgrades described below.

[0056] Referring now to FIGS. 3, and 7 to 10, a first upgrade may be achieved by introducing additional horizontal struts (7) and additional diagonal braces (8) at predetermined positions selected to provide the required increased load carrying capacity of the lattice tower. Effectively these additional horizontal struts and additional diagonal braces, at least in this embodiment of the invention, have the effect of halving the unsupported span or buckling length of the associated components to which they are attached.

[0057] The first upgrade also involves the addition of foundation material (9) that is appropriate to the additional load to be accommodated by the upgraded lattice tower, particularly the cantilever load imposed on the tower by wind forces.

[0058] In this embodiment of the invention, and as illustrated in FIGS. 4, 11 to 14, and 17, a second upgrade may be achieved by doubling up on predetermined basic leg elements, predetermined basic horizontal struts and predetermined basic diagonal braces using parallel offset additional leg elements (10), additional horizontal struts (11), and additional diagonal braces (12) and by adding yet another quantity of concrete (13) to the foundation platform.

[0059] In this embodiment the additional leg elements, as illustrated most clearly in FIG. 16, are orientated with the corners (14) of the angle sections spaced apart and the flanges (15) extending in opposite directions. Securing of the additional leg elements to the basic leg elements is achieved using flat connector plates (16) orientated
alternately at 90° to each other and spaced apart appropriately to provide composite leg section having the required strength.

[0060] Of course, the lower end of the lowermost additional leg elements needs to be satisfactorily attached to the foundation and one way of achieving this is shown most clearly in FIG. 15. In this instance each foot (6) is prefabricated with an additional angle sectioned attachment (17) that enables the additional leg element to be secured in butt end relationship with it, and thus to the foundation, as in the case of the lowestmost basic leg element. Both the original foot (6) and the additional angle sectioned attachment (17) are thus both secured to the usual anchor plate (18) that is secured in the normal way to the foundation.

[0061] The gap between the corners of the leg elements allows for optimal force transfer between the inner and outer legs. This space also creates space for supporting brackets for existing and future antenna and other transmission equipment. It is to be noted that existing antennas and other transmission equipment are not affected when adding additional leg elements

[0062] As shown most clearly in FIG. 17, doubling up of a horizontal strut is achieved by bolting an oppositely directed angle section of the additional horizontal strut (11) to the outside of the supporting flange of the associated basic leg element using the same bolts as are used to secure the basic horizontal strut (3) to the inside of the same supporting flange.

[0065] The innermost part (20) of the composite anchor plate has attached to it extended attachment flanges (24) that have provision not only for securing the lower end of a lowermost leg section (2) between them and attachment flanges (25) on the two lateral parts (21, 22) of the composite anchor plate, but also for the lower ends of diagonal braces (4), as shown in FIG. 21.

[0066] The outermost part (23) of the composite anchor plate has attachment flanges (26) only for attachment to a lowermost second upgrade leg section (10).

[0067] It will be understood that with this foot arrangement, replacement of individual parts thereof is substantially facilitated when compared to replacement of a foot arrangement as described with reference to FIGS. 15 and 16. It is to be mentioned that shims (27) may be used between the adjacent flanges in which the leg sections are clamped in order to accommodate varying thicknesses of leg section and also, possibly, construction tolerances.

[0068] The four parts making up a foot arrangement of this type can be fabricated by cutting and welding processes or they can be made as integral parts, the example by steel casting procedures.

[0069] It will be appreciated that exercise of the invention therefore enables the load carrying capacity of a lattice tower to be upgraded, as and when required, in order to increase the load carrying capacity thereof. This can be achieved without any downtime to the communications of the network operator. Existing fasteners are used wherever appropriate during the upgrade such as in the instance of doubling up of the horizontal struts and diagonal braces. In all other cases the same size of nuts and bolts is used to attach additional components wherever necessary.

[0070] Exercise of the invention also enables any component showing signs of corrosion to be removed and replaced as and when appropriate.

[0071] Of course, three legged towers, or alternatively towers having more than four legs, can also be manufactured using the principles provided by this invention.

1. A lattice tower comprising frame members including generally upright leg elements that optionally converge somewhat over at least a generally lower part of the height of the tower and that are arranged in plan view at the corners of a polygon and horizontal struts and diagonal braces interconnecting the leg elements to define the lattice structure, the lattice tower having associated therewith a first and basic arrangement of basic frame members including basic leg elements, basic horizontal struts and basic diagonal braces that provide a first and basic predetermined load carrying capacity of the tower and

wherein at least selected frame members are provided with attachment formations whereby additional frame members selected from additional leg elements, additional horizontal struts and additional diagonal braces may be secured to the attachment formations on the basic frame members to provide a predetermined second and increased load carrying capacity of the lattice tower to thereby provide a selection of at least said first and basic load carrying capacity and said second and increased load carrying capacity.

2. A lattice tower in claim 1 in which the leg elements, horizontal struts and diagonal braces are all of a standard metal section with the leg elements, horizontal struts and diagonal braces having the same or different cross-sectional dimensions.

3. A lattice tower in claim 2 in which the standard metal section is an angle section.

4. A lattice tower as claimed in claim 1 in which the attachment of each of the leg elements to each other and to the horizontal struts and diagonal braces is by two bolts and, as appropriate, connecting plates wherein the attachment formations whereby additional frame members may be secured to the basic frame members are holes for accommodating bolts passing therethrough.

5. A lattice tower as claimed in claim 1 in which the components of the lattice tower are reversible as regards their ends.

6. A lattice tower as claimed in claim 1 in which the components of the lattice tower are pre-marked as regards which component is to be attached to another component.
7. A lattice tower as claimed in claim 1 in which predetermined sets of additional components are designed to provide predetermined increases in the predetermined load carrying capacity of the tower such that predetermined stages of upgrade are provided.

8. A lattice tower as claimed in claim 1 in which an upgrade includes an addition of foundation material to a foundation of the lattice tower.

9. A lattice tower as claimed in claim 1 in which a foot arrangement for each leg comprises an anchor plate with a foot for the basic leg sections and an additional attachment for additional leg sections.

10. A lattice tower as claimed in claim 1 in which a foot arrangement for each leg comprises a plurality of separate parts each having at least one attachment hole and upstanding flanges between which flanges of an end of a leg section may be secured so that the separate parts are secured together in use.

11. A lattice tower as claimed in claim 1 in which an upgrade is achieved by the introduction of additional struts and additional diagonal braces that have the effect of halving the span or buckling length of the basic components.

12. A lattice tower as claimed in claim 1 in which an upgrade is achieved through doubling up of predetermined leg elements and predetermined horizontal struts and diagonal braces using parallel offset additional leg elements, additional horizontal struts and additional diagonal braces.

13. A lattice tower as claimed in claim 1 in which holes for bolts in the leg sections are all located with a constant backmarking so that angle sections of different cross-sectional sizes can have their corners aligned both longitudinally in butted end on end relationship and in juxtaposed relationship.

14. A system for the upgrading of the load carrying capacity of a lattice tower comprising frame members including a basic arrangement of basic leg elements, basic horizontal struts and basic diagonal braces that may be assembled to provide a first and basic predetermined load carrying capacity of a lattice tower wherein one or more increased load carrying capacities of the tower may be implemented by adding to the basic arrangement at least selected additional frame members selected from additional leg elements, additional horizontal struts and additional diagonal braces and that may be secured to the basic frame members to provide at least a second predetermined increased load carrying capacities of the tower to thereby provide a selection of at least said first and basic load carrying capacity and said second and increased load carrying capacity.

15. (canceled)

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