Australian Enterprise Industrial – ABN 21 585 743 778

Proudly manufacturing the worlds safest communication tower.

The One Man Tower™©.

A radical new design concept – the One Man Tower™ offers unique features, which make it the strongest and safest tower for use in the communications field.

The OMT has been examined under the criteria set out in the AS1170.2 wind code – the AS4100 steel structures code and the base pad footing defined under the guidelines of AS3600 concrete structures code.

The wind load sample used as a fixed wind load at the top of the tower is 2kN – (.7m^2) - which is included in the overall height of the tower when the overturning moment and destructive force is applied to the tower base section.

AS1170.2 calls for the structure to be examined for integrity at a wind velocity of 180kph. This has been adhered to as the structure could be erected in proximity to a dwelling house or in an area frequented by people. (Please note: The .7m^2 "wind load area" used is a convenient figure – the more complex calculations later used to determine the safe surface area for an antenna found that an area of 1.5m^2 could safely be accommodated on the towers in the 15m to 20m range. Towers of less than 15m could safely carry antennas up to 2.2m^2 or more. The exercise was terminated when the 2.2m^2 figure was reached as most common usage is well below this figure)

This paper uses the 15m "One Man Tower™" as manufactured by Australian Enterprise Industrial as the tower of concern for an application to local authorities for a permit to erect such a structure on property deemed to require a permit by the local authority.

Data is also supplied for submissions to local authorities for towers up to 20m.

A description of the structure follows.

Definition:- A radio antenna tower of square, open faced, hollow section – by design a free standing structure to be mounted on a specified concrete base pad footing and fixed by means of hold down bolts cast into the concrete base pad footing at the time of pouring the footing.

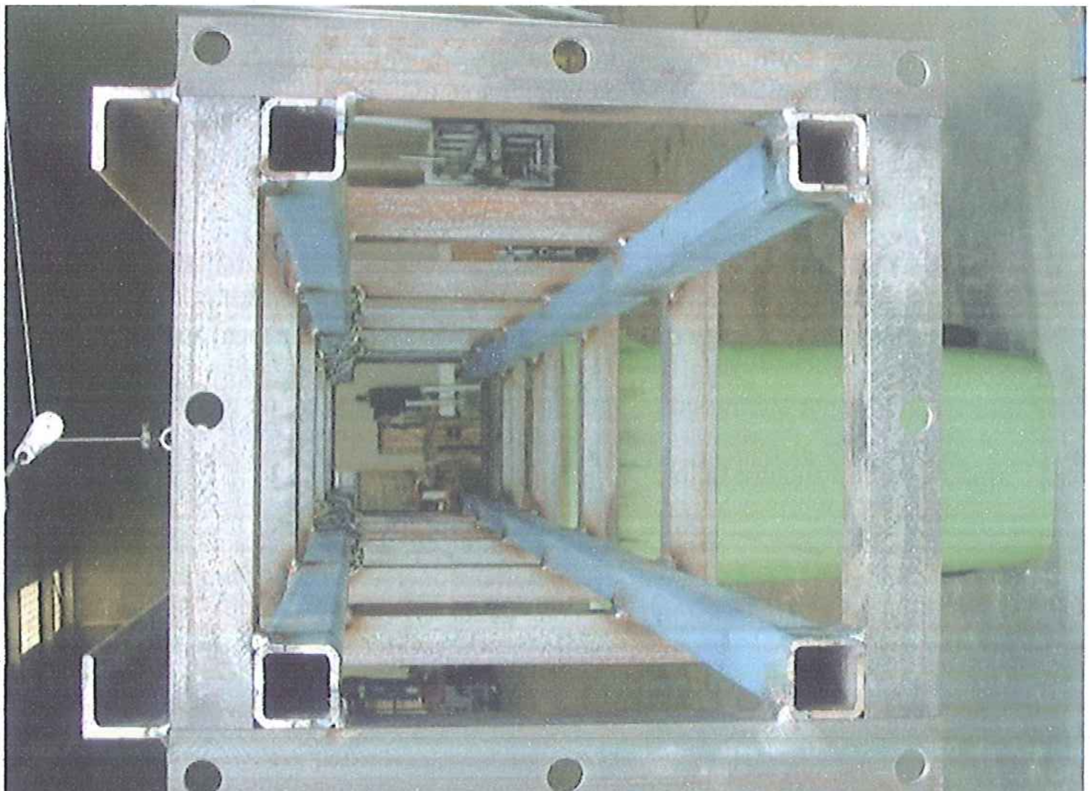
The tower is of modular construction and incorporates it's own erecting apparatus. The unique erecting apparatus transforms to a sliding carriage once the tower has been erected and the antenna is then fitted to the sliding carriage to facilitate raising and lowering the antenna by the operator at ground level.

This unique feature of the One Man Tower places the structure at the forefront of tower technology in regard to safety for people in the communications field. In addition to providing a previously unheard of degree of safety for the operator, the ability to raise/lower the antenna safely, means the potential for damage to the structure is greatly reduced by reducing the overall wind-loading on the tower. And in particular relieving the very top extreme of the tower from the direct force of wind-loading that would normally be associated with structures that do not allow the antenna to be lowered at such times.

Strength:
This is an area where the One Man Tower really stands out from the rest. One outstanding feature among many.

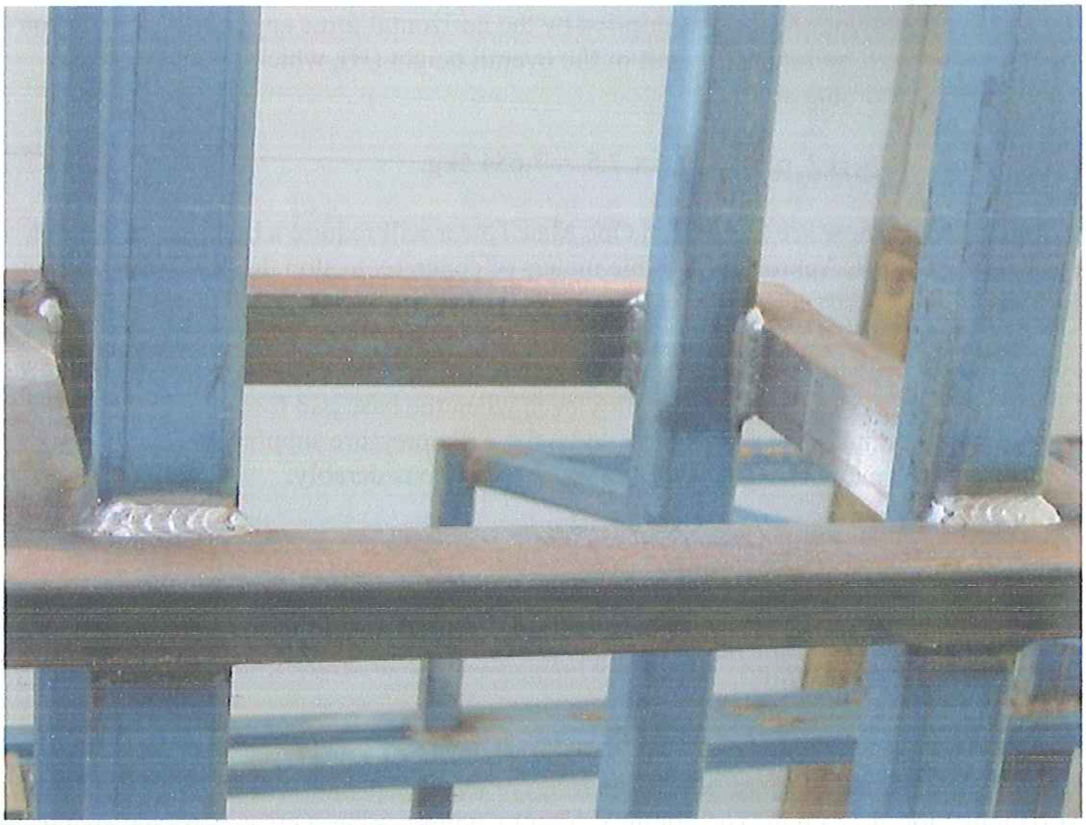
In the following photo - the construction method is shown – the four "longitudinals" are welded to bands spaced at 50cm apart and the bands are joined by two lengths of angle steel down the face of the tower.

All towers, from 10m to 15m overall height, utilise 40mm x 40mm x 4mm wall SHS of 480mpa (Dual grade 350/450) in the base section. The bands are formed from 40mm x 40mm x 6mm EA of 300mpa (300+), the same EA is employed to join the bands down the face of the tower. (Taller towers employ thicker wall SHS in the lower sections)



Next is a photo of the welded components of the tower sections.

From this you will see that each and every contact point is fully welded. The welding is performed using the atmosphere exclusion process (Mig), and periodic testing of the welding is carried out to ensure weld strength exceeds parent metal strength – welds are both dissected and examined visually and placed under a stress test in an hydraulic press.



The One Man Tower is designed to make use of a "progressive strength" construction method – as the height of the tower is increased, so to is the strength of the lower sections increased to compensate for the increased forces the tower will be subjected to.

The following calculations will display the actual strength as opposed to applied forces for the 15m One Man Tower as produced in the Mk.7 version of the tower by Australian Enterprise Industrial. The calculations apply only to a genuine One Man Tower constructed from the specified material.

Firstly the overturning moment of the tower is calculated – this will later be placed beside the required concrete base pad footing..

Wind velocity used in this example is 180kph. (V) (This is the velocity as determined by AS1170.2 for towers capable of being sited near dwellings or pedestrian thoroughfares)

Each tower section has an effective wind-load surface area of .7 square meters (A)
Horizontal force applied to one section

$Hf = .0075V^2xA \; = .0075x32400x.7 = 170.1kg$

Overturning Moment (Tipping Moment) can now be calculated.

The number of sections (Ns), is multiplied by the horizontal force applied to each section (170.1kg) and then multiplied by half of the overall height (H), which is the rotational point of the overturning structure.

TM = Ns x 170.1 x H/2 = 6 x 170.1 x 7.5 = 7,654.5kg.

From this we can now see that a 15m One Man Tower will require a base pad footing of around 7.654 tonne. Approx. 3.75 cubic meters of concrete, to stop the tower from falling over at a wind velocity of 180kph if the base pad footing were sitting on top of the ground.

This is a good counter moment to employ even when the base pad footing is located with the top of the footing level with the ground – the extra pressure supplied by the soil holding the base pad footing raises the safety margin considerably.

Structural strength of the tower:

Here we need to look at the cross sectional area of the materials used – remember we have a force of over 7 tonne being applied to the base of the structure at wind velocity of 180kph.

The cross sectional area of the 40mm x 40mm x 4mm wall square hollow section is $521mm^2$ and it has an mpa rating (yield rating) of 480mpa. This translates to a yield of 31.65 tonne for the section. The 40mm x 40mm x 6mm EA has a cross sectional area of $444mm^2$ and has a yield rating of 300mpa or 19.78 tonne for the section.

The open faced square hollow section tower sections then have a concerted theoretical yield of (31.65 x 4) + (19.78 x 2) tonne – or 166.16 tonne. This would be a good figure to have but it cannot be applied to the structure due to the unsupported distance between the fully welded contact points which is 46cm. This brings about the use of factoring to bring the actual yield of the section as described into realistic yield strength under the applied force.

The factor applied in this case is .25 which brings us to tower yield strength of 166.16x.25 or 41.54 tonne.
We now compare this with the actual force applied to the base of the tower at wind velocity of 180kph which was 7,654.5kg i.e. 7.654 tonne – and we see that we have a very healthy yield strength safety margin.

In fact the 15m One Man Tower™ was calculated to a "destruction" wind velocity of 239kph (antenna down) and exhibits far greater structural strength than any other design of free standing tower currently available.

There now follows a design report by FACET ENGINEERING CONSULTANTS – Ascot QLD.
This report was compiled on the data for the Mk.5 version of the OMT and was done to provide certification for both Australia and the USA. This tower was not as strong as the Mk.7 version as it had 8 x 16mm hold down bolts as opposed to the Mk7 version having 8 x 20mm hold down bolts.
Current production of the OMT employs Class 8 high tensile hold-down bolts in towers higher than 15m.

Facet
Consulting Engineers – Civil – Structural – Façade Engineers – Stone Specialists.
15 Yabba St. Ascot Qld. 4007 Australia.
Ph. 07 38681433 Fax. 07 38681436

We have checked the 50' tower (5 x 2.5 m sections plus 2.5 m aerial support post on top) based on AS 1170.2 (the Australia Wind Code) and AS 4100 (Australian steel code), Grade 450 steel for the tube and 4.6 Grade for the M16 bolts.

We have checked it for maximum wind speed for aerial up and aerial down, assuming the aerial has the same wind area as a 2.5 m section of tower as a worst case estimate.

The table below summarises maximum design wind speeds from our design check, expressed as aerial up or down, Terrain Category 2 or 3 (i.e. in open relatively treeless terrain such as farmland, or suburbia/forested terrain).

It is also expressed as either permissible stress design wind speed (called ASD - allowable stress design, in the USA) or ultimate limit state design wind speed (called LRFD - load and resistance factor design in the USA).

ASD is gradually changing to LRFD in the USA, so I'm not sure which one your engineer would be more conversant with.

We are ahead of them in this and made a similar change in our wind code in 1989 and in our steel code in 1990.

Maximum design wind speed:

	Aerial up		Aerial down	
	TC2	TC3	TC2	TC3
ASD kph	137	162	166	194
mph	85	100	103	120
LRFD kph	167	194	202	239
mph	103	120	125	148

In both cases the load is limited by the HD bolt capacity, but the 40 x 4 SHS capacity in the base section is very close to the HD bolt capacity for the aerial down condition.

Maximum wind speed for TC2 is lower than TC3 because TC2 is smoother terrain, thus less wind energy loss in turbulence and thus higher wind pressures on elements projecting into the air-stream for the same wind velocity.

Our wind code is based on a peak 3 sec. gust with a 5% likelihood of being exceeded in a 50 year return period.

US wind loads are derived from a 1 minute average gust intensity as I recall.

I don't have a US wind code, so I'm hoping your engineer in the US can use the wind speed data above and interpret it in terms of the US wind code requirements. In expressing the outcome in wind speed terms, it should be code independent, as a safe wind speed (ASD) should be directly usable.

This should answer the "wind rating " question and the "shear rating of the base" question. The shear strength of 8M16 4.6/s bolts is about 25 times greater than the base shear force from the wind loading.

The HD bolts fail principally in tension from overturning forces from the tower, not shear forces, and you have a sizeable reserve.

Regards.

Ron Blackwell BE(Hons 1), MIStructE, MIEAust, RPEQ.

Before proceeding further it is necessary to provide a full description of the towers in an effort to more clearly portray the "progressive strength" construction method follows.

Firstly the actual modular sections must be described and defined.

A "light section" is constructed using 35mm x 35mm x 3mm wall SHS of 480mpa.

A "standard section" is constructed using 40mm x 40mm x 3mm wall SHS of 480mpa.

A "heavy section" is constructed using 40mm x 40mm x 4mm wall SHS of 480mpa.

A "extra heavy section" is constructed using 50mm x 50mm x 5mm wall SHS of 480mpa.

A "super heavy section" is constructed using 50mm x 50mm x 7mm wall SHS of 480mpa.

The equal angle (EA) used in all sections is 40mm x 40mm x 6mm and is classed as 300mpa.

In classifying the towers the "working height" of the antenna is used to categorise the tower i.e. a 10m tower is made up from 3 x 2.5m modular sections plus the slide carriage/rotator mount/strong-back.
This means the tower is a fixed 7.5m lattice structure with 2.5m of moveable apparatus which slides up and down the face of the fixed structure carrying the antenna from ground level to a height of 10m.

A 12.5m tower has four fixed 2.5m lattice sections and 2.5m of sliding apparatus.

A 15m tower has five fixed sections and a sliding apparatus.

A 17.5m tower has six fixed sections and a sliding apparatus.

A 20m tower has seven fixed sections and a sliding apparatus.

The progressive strength comes about by the use of heavier sections in the bottom tower sections as the overall working height increases.

For example a 15m tower is made up from two heavy sections followed by two standard sections followed by one light section.

A 20m tower is made up from one super heavy sections followed by one extra heavy section followed by two heavy sections followed by two standard sections followed by one light section.

IMPORTANT NOTE: Even though a 20m tower (for example) only uses 7 fixed lattice sections for a fixed installation height of 17.5m the base pad footing dimensions supplied with the OMT are calculated to the full "working height" of the tower i.e. 20m.

The next step in proving the OMT design for structural integrity takes us to the 17.5m tower.

In this exercise another 2.5m of tower has to be applied to the equation. This presents more face area to the wind and as such the overall "horizontal force" is increased.

To counter for the increased pressure (or wind force) the OMT adopts a "progressive strength" construction method in which the lower sections are made from heavier material. The base section for the 17.5m tower is manufactured using 50mm x 50mm x 5mm wall SHS of 480mpa grade, and the hold down bolts are upgraded to Class 8 high tensile. The 8 bolts fixing the junction of the base section the second section are also upgraded to Class 8.

Thus our overturning moment is now are equated by:

Hf = 7 x 170.1 x 8.75

Hf = 10,419kg

So the horizontal forces being exerted on the tower are almost 10.5 tonne. This must be negated both by the structural yield strength of the tower and the counter tipping moment of the base pad footing. The base pad footing is a flexible figure due the criteria (Region and Terrain Category) established through the Australian Standards Association AS1170.2.

But the tower itself is not manufactured to greater or lesser strength factors. It is manufactured to far exceed the highest criteria that the Standard proscribes.

The 50mm x 50mm x 5mm wall SHS provides a cross sectional area of $814mm^2$. This gives us a yield of 38.036 tonnes for the material.
Taking the concerted yield of the material gives us a yield strength of 191.56 tonnes. But once again the .25 factor must be applied and this brings us back to a 47 tonne or more closely 47,890 kg. Providing far more strength than the force being exerted.

The 20m "One Man Tower".

The 20m tower is assembled using one of the "super heavy duty" sections in the base of the tower. 20mm Class 8 hold down bolts, are cast into the concrete base pad footing to a depth of 1m. The hold down bolts being welded into a frame which is in turn welded to a deformed bar frame. High tensile class 8 bolts are used at junctions one and two of the tower sections (i.e. the junctions of sections1 and 2 and 2 and 3).

Compiling the stress and loading figures for the 20m tower follows.

The overturning moment:

Hf = 8 x 170.1 x 10

Hf = 13,608kg

The yield strength of the base section is a whopping 61,382kg. The structural integrity of the 20m tower far exceeds the theoretical load exerted by a wind at a velocity of 180kph. Thus matching or exceeding the design criteria as set down in AS1170.2 (Wind Code)

The addition of "fish-plates" at each of the junction points of sections 1 and 2 relieve the stress applied to that junction. The four fish-plates are bolted into the inner faces at the junction of each SHS longitudinal using 16mm, class 5, galvanised bolts, passed through at the point of thickness created by the welding of the angle band and the SHS.

All materials used in the manufacture of the One Man Tower are affirmed to be as stated in the compilation of the figures. This affirmation applies only to towers manufactured by the company known as Australian Enterprise Industrial.

This document should be presented to your local authority at the time of applying for a permit to erect a tower that exceeds the "no permit" height on your property.

You most likely will have to notify the building inspector handling the permit application when you have prepared the base pad footing for the tower – under no circumstances should you pour the concrete until the inspector has inspected the footing preparation.

The hold down bolt frame supplied with your tower is to be cast into the base pad footing. It is strongly recommended that you drive several (more the better) 2.4m copper coated earth rods into the walls of the footing hole and firmly fix them (preferably by welding) to the hold down bolt frame. This is recommended as it provides a low impedance path to ground, and in the event of a lightning strike there will be less chance of the strike travelling along your feed-lines to your radio room.

It is also suggested that you draw up a plan of your property with the location of buildings and boundaries with the proposed site for your tower included.

If possible you should provide photos of some of the One Man Tower installations from other shires and council areas. It should be stressed to the local authority that the OMT allows the lowering of the antenna in the event of inclement weather or in the event that you proceed on holidays – this greatly reduces the risk of your antenna or parts of it being carried into neighbouring properties. Your local authority must consider all risks when granting a permit for a structure such as a tower. The safer the structure the less likely-hood of a problem arising in the future. No other tower sold manufactured anywhere in the world provides the safety and strength of the "One Man Tower".

Also included with this document is the specification for the base pad footing – you may think the figures excessive – but it is far better to have more than enough than not enough.

Sincerely

Kevin D. Peacock – Senior partner.
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Browns Plains. 4118.
Queensland.
Australia.

In addition to the structural calculations and information we must add this.

The One Man Tower is designed to last.

It is solidly constructed then hot dip galvanised for a long lasting resistance to corrosion of the steel. The internal surfaces of the hollow sections, as well as the external surfaces are coated with zinc.

And finally we will include some photos of some of the towers in use. 15m, 17.5m & 20m units.

This is a very small selection of the many towers put into service in the past 20 years