HOW TO BUILD A LOW COST ROLL-OFF ROOF OBSERVATORY

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1 Introduction

In 2001 I built my first roll off roof observatory for my Meade 10" LX200 on a custom built permanent pier. Having the scope permanently mounted and polar aligned in an observatory resulted in a far more pleasurable observing experience primarily because the physical logistics of observing are made easier.

In 2011 we moved house and I had to leave my observatory behind. One of my first tasks at the new house was therefore the building of a new observatory. I essentially repeated the build process I performed for my old observatory with various improvements that I learned from that first observatory build experience.

This time I decided to photograph every step of the process and this document is the fruit of those labours; it contains step by step instructions, with approximately 90 photographs, of how to build a roll-off roof observatory from scratch, or in other words, how to go:

From this…

To this…

In about 15 man days effort and for a total cost of about £450 (GBP in 2011, excluding the computer).

2 Tools, materials and required skill

To tackle this project you will need some degree of DIY ability (or at least a degree of DIY confidence). If you are the sort of person who would be happy putting up a flat pack garden shed for example then it's probably well within your ability.

Although I have worked in the computer industry for the last 25 years, I started my working life in engineering and completed a five year mechanical and production engineering apprenticeship. I would therefore classify myself as reasonably good on the general technical and engineering front which transposes itself as being a reasonably competent DIY exponent.

A couple of general concepts that I learnt from my engineering days, and which have served me well in my DIY endeavours, and certainly apply to the construction of a roll off roof observatory, are as follows:

- Plan before you do; remember the 5 'P' rule – Prior Planning Prevents Pretty Poor Performance – its' so true. Rapid Application Development may be a methodology for building computer software but it rarely works for DIY;

- Allow for contingency – when you estimate cost and time for a job, add 20% as there is always the unexpected;

- Have the right tools for the job. See Table 1 below for a list of the tools that you will need to construct the observatory. There are only a couple of items here that you may not find in your average DIY shed, and they are not mandatory.

- Let the tool do the work. This means don't force things – brute force is hardly ever needed if you plan before you do, and do things the right way.

- You will make mistakes. Using the gift of hindsight to make it better the second time.

Tool	Comment	This is what I used
Spirit Level	Possibly the most important tool of the lot as if things are not square and level during construction everything gets more difficult. Use a 1 metre one if possible.	
Square	Invaluable for good wood working	

Tool	Comment	This is what I used
Metal Tape measure	At least 3 meters.	
Hammers	A variety of tapping sticks including a wooden mallet	
Screwdrivers	Cordless electric makes life so much easier.	 
Hand Drill	Again, a cordless electric makes life easier. I use an 18v lithium battery drill.	
Saws	Hand saws and an electric jig saw if available	

Tool	Comment	This is what I used
Chisels	Useful for all sorts to things	
Spade	Digging and levelling of ground.	You all know what a spade looks like
Trowel and a bowel or bucket	Used for mixing and laying concrete and mortar	
Workbench	A Black and Decker workmate or something similar	
G-clamps	Not essential, but it makes life easier to hold items in position during construction	

Tool	Comment	This is what I used
Router	Not essential but I used one during the construction of the roof runners	
Arc welder	Not essential but I used one in my pier construction	

Table 1 – List of tools

The following table gives a summary of the main building materials required. Just about everything is available from your average DIY store (I used Wickes). All of the items below are photographed and detailed in the subsequent sections.

Item	Used for
Wood – lots of it.	See my design in section 3 below, but essentially the entire construction is based on a wooden frame. I used standard planed square-edged timber.
Shiplap cladding wood	Used for the walls.
Corrugated plastic sheets.	Used for the roof covering. See my roof design in section 3 below.
Screws – lots of them	I purchased three main lengths – a pack of a couple of hundred of each.
Metal brackets	To add rigidity to the light weight roof.
Bricks	Not essential but I used these for the observatory base.
Loft flooring chip board	Used to make the elevated floor.
Instant Concrete (just add water)	Concreting in posts and the pier – I used about four 25kg bags.
Mortar (ready mixed – just add water)	For the brick base. I used about two 25KG bags.
Plastic wheels	Used for the roll off roof runners.
A metal pier	Depends what you can get your hands on – rigidity is the primary factor here. I used an RSJ for this observatory, for my first observatory I used an 8 inch metal pipe.
Aluminium plate (10" square)	I used this to construct a head for the pier so as to mate my telescope wedge onto the pier.

Table 2 – List of building materials

3 The Observatory Plan

All builds need to be planned so that a workable design can be derived which leads to a reasonable estimate of the materials and cost. I created the following observatory construction plan shown below in Figure 1 and Figure 2.

My observatory construction design philosophy was as follows:

- The observatory was to be rectangular and just under 3 meters long by 2.4 metres wide. This provides plenty of room for my 10" Meade LX200 on a permanent pier with room for a table and a couple of chairs;

- Typical wood lengths sold by DIY stores include 3m, 2.4m and 2.1m (and obviously smaller). The observatory dimensions of 3m by 2.4m took this into account and also the fact that 3m was about the longest length I could get into my car (a VW Golf) – these sort of practicalities have to be taken into account;

- Height from floor to top of sides (when roof retracted) was to be 1.6 metres;

- Use 4 large corner posts that are to be concreted into the ground and made as level and square to each other as possible. Everything else is to be centred off of these foundation posts and hence they are absolutely key items;

- The floor is to be elevated off the ground, supported by beams across a brick base. Again, the brick base must be as level as possible and placed on top of a simple concrete foundation. The floor is to be made from loft chipboard flooring packs. Raising the floor off the ground like this keeps it away from any potential damp and the one a built for my last observatory in 2001 used this technique and it was in perfect condition after 10 years when I move house;

- Walls are to be made from shiplap cladding wood (just like your average garden shed);

- The pier needs to be concreted into the ground to a depth approximately equal to the height above the ground. In my case the pier was to be 2 metres long, therefore 1 metre of it was to be concreted into the ground. The pier is obviously a critical component and there is no such thing as a pier that is too rigid! An RSJ or metal pipe is great – but a variety of other design can be constructed from bricks or concrete;

- The roof needs to be light and hence easy to roll on and off but sufficient cross braces must be used to give enough rigidity;

- All of the main construction would be of wood that can be bought from any DIY store (in my case Wickes). The only exceptions to this are the pier components and the brick base;

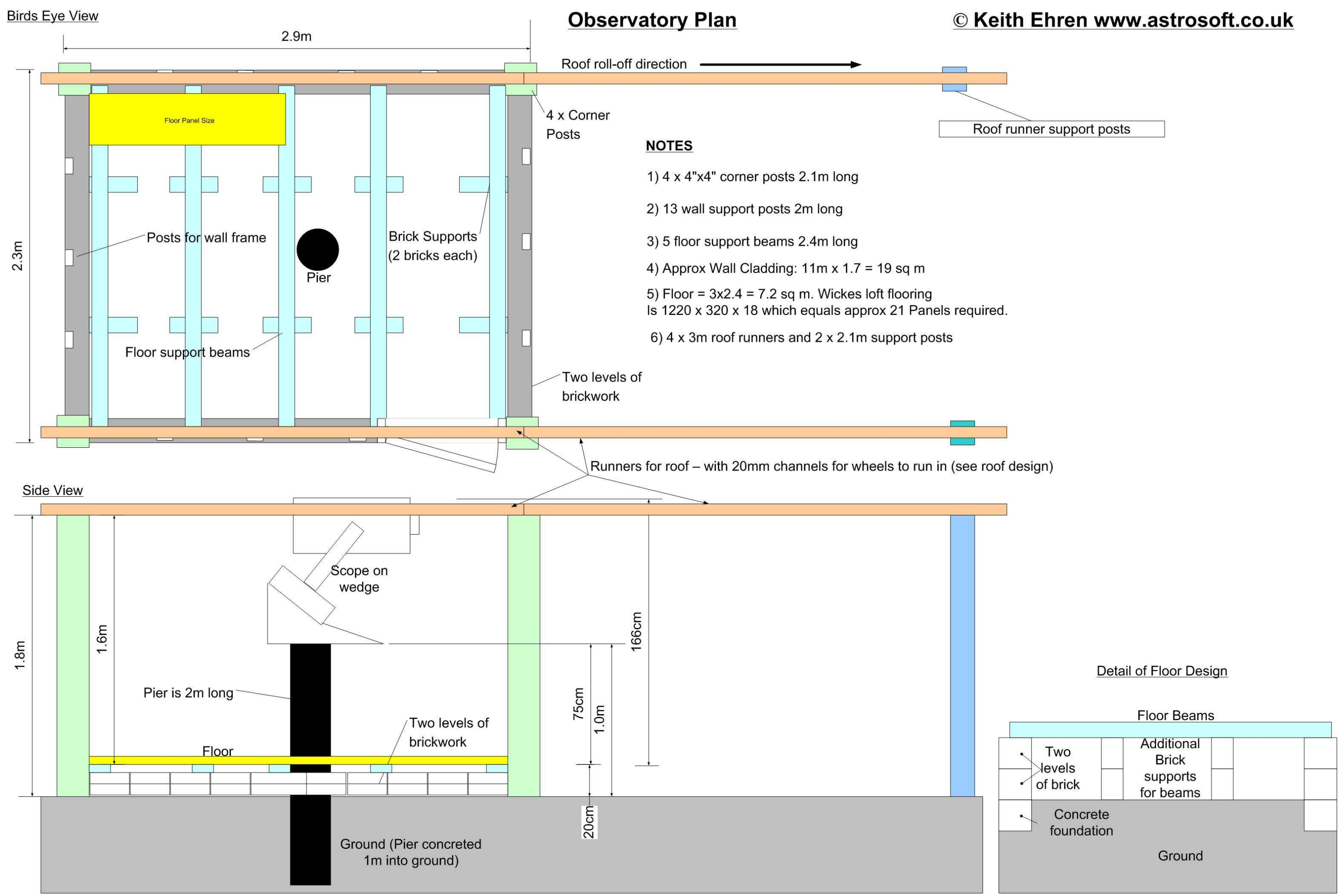

Figure 1 – The observatory plan

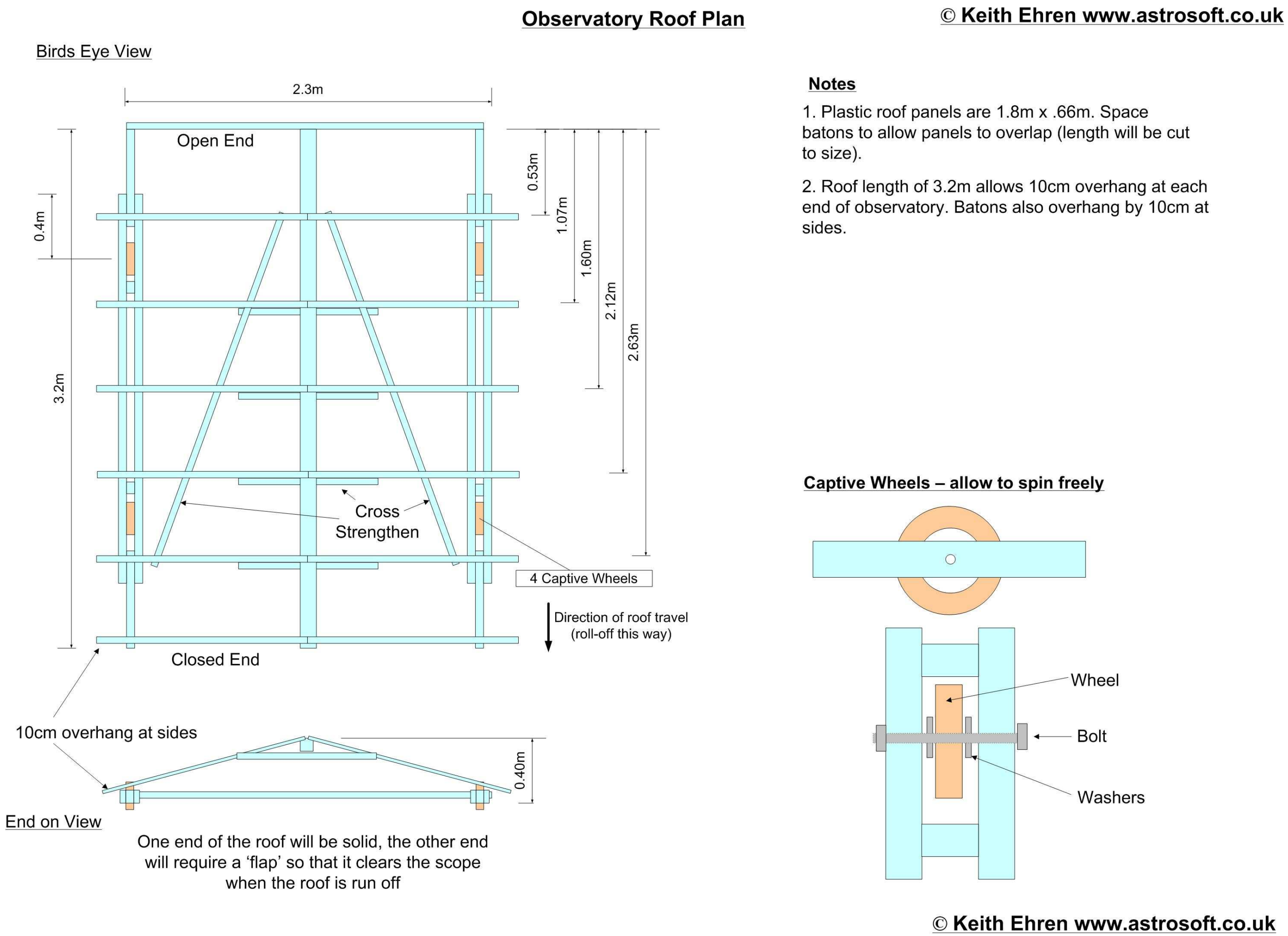

Figure 2 – The observatory roof plan

4 Observatory Positioning

The first step was to decide where to position the observatory. The obvious metric for this was to position it in the garden where the horizon would be least obscured. For me this was on a piece of scrubby old rockery (see Figure 3 below). To ensure that the selected place was suitable I then pegged out the area of the observatory as shown in Figure 4 below and dug a couple of test holes to make certain there was nothing unexpected about (or buried in) the ground.

Figure 3 – Select the best site

Figure 4 – Cleared the ground and marked out observatory area

5 Prepare the corner posts

The core components of the observatory about which everything else would (literally) be positioned against are the four corner posts. It is therefore absolutely essential that the posts are substantial enough (I used 4" square posts) and concreted into the ground so that they are as square and level to each other as possible.

The positioning and concreting of the corner posts is shown below in Figure 5, Figure 7 and Figure 8. The 1m spirit level can also be seen which I used throughout construction. The various wooden and metal cross posts and supports that can be seen are just temporary to hold the posts in place while the concrete set.

Figure 5 – Dig in the first corner post (temporary supports also visible)

Figure 6 – Get the concrete ready – just add water

Figure 7 – Concrete each post (temporary cross support also visible)

Figure 8 – Ensure the corner posts are equal spaced, level and square to each other

6 Prepare the Brick Base

The next step was to prepare the foundations for, and lay, the brick base that would be used to support the suspended floor. The foundations were simply a case of digging a trench approximately 10cm deep, filling it with concrete and then laying the bricks on top.

The process is shown in Figure 9 to Figure 15 below. I'm no brick layer, so it may not be pretty but just make certain that the base is square and solid.

At the end of this process I dug the 1m deep hole for the pier – this can be seen in Figure 15.

Figure 9 – Dig a shallow trench between posts for the brick foundations

Figure 10 – Fill the trench with concrete – just add water

Figure 11 – Concreting done - make certain foundations are square and level

Figure 12 – Mortar for the brick laying – just add water

Figure 13 – Laying the two levels of brick

Figure 14 – Checking everything is square and level


Figure 15 – Brick base completed (1m deep hole for pier also visible)

7 Side Construction

The sides are to be made from shiplap cladding. Before this can be done a simple frame needs to be constructed so that the cladding can be screwed into place.

Figure 16 – Start Side Frames

Figure 17 – Side Frames In Progress

Figure 18 – Screw Shiplap cladding to the frame

Figure 19- Add sides down to brickwork

Figure 20- First side completed

8 Roof Runners

So that the roof can roll off I placed runners along both sides of the observatory, fixed to the top of the corner posts. I made these from 3m length wood with channels cut out via use of a router (see Figure 21 and Figure 22 below) for the roof wheels to run in. I then screwed these on top of the respective corner posts as shown in Figure 23. If you do not have a router they can be hired cheaply or pre-fabricated U shaped metal sections can be purchased.

Figure 21- Start making the roof runner

Figure 22 – Cutting out a 20mm channel for the roof wheels to run in

Figure 23 – The first Roof runner in place and the second side


Figure 24 – Ensure roof runner is level

9 Complete Sides

Now it was just a case of screwing on the rest of the shiplap cladding – remember to leave space for a door!

Figure 25 – Front complete with gap for door

Figure 26 – Three sides complete


Figure 27 – Last side in progress – with other roof runner in place


Figure 28 – All sides complete

Figure 29 – All sides complete – view through door

Figure 30 – All sides complete – birds eye view

10 Making the Roof

The mechanism for the roof was based around having four captive (but freely rotating) wheels which would run in the two roof runners (two wheels per side) previously attached to the sides of the observatory. The roof frame is therefore fixed on top of 3m lengths of wood whose purpose is to hold the wheels captive.

To show this better, the completed frame is shown below in Figure 31, the subsequent dozen or so figures show the construction step by step.

An important note here is that the roof structure extends approximately 10cm over the edges of the observatory walls. An overlap is important so that any rain runs off and just drips onto the ground and does not get back into the observatory.

Figure 31 – The completed roof frame

Figure 32 –Plastic wheels for the roof runners

Figure 33 – A roof runner with its two captive wheels in place


Figure 34 – Close up of captive roof runner wheel

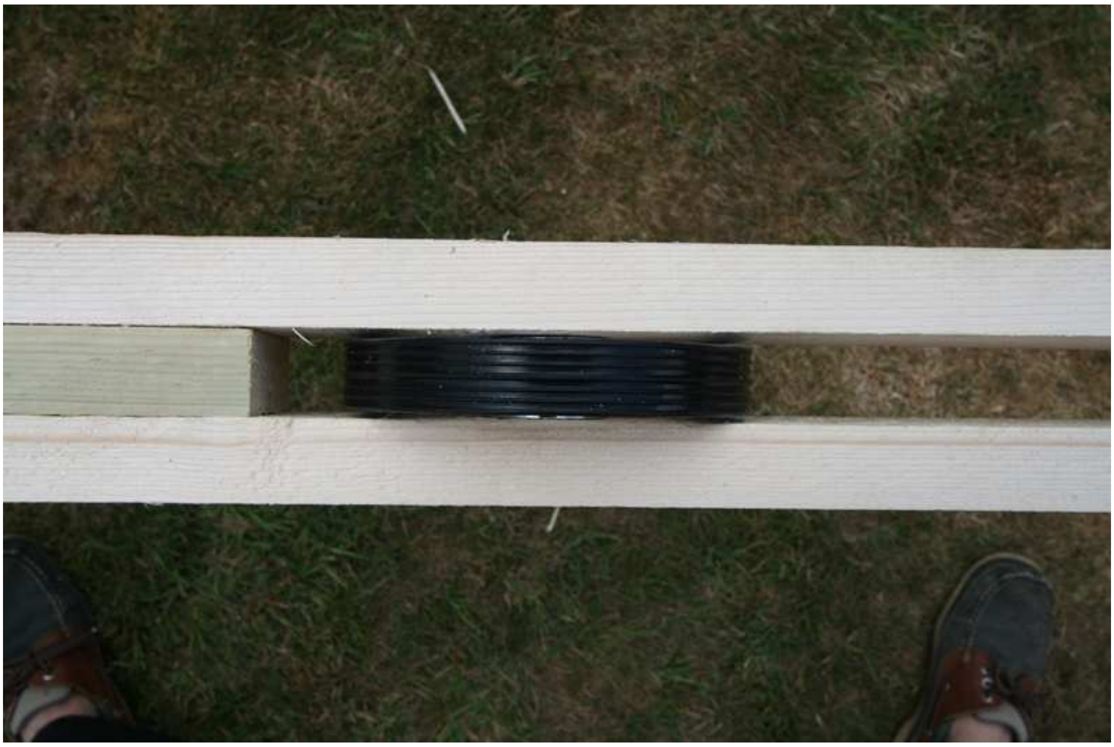
Figure 35 – Another close up of captive roof runner wheel


Figure 36 – Checking roof runner wheels for free motion in side runners

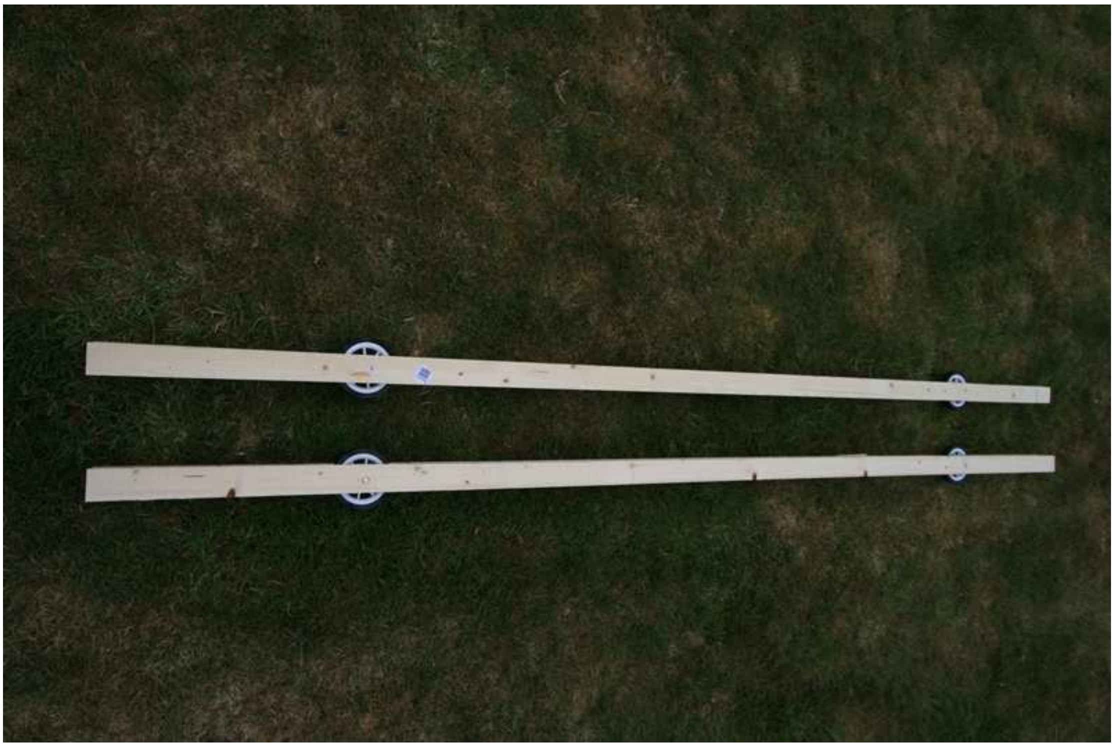
Figure 37 – Both roof runners complete

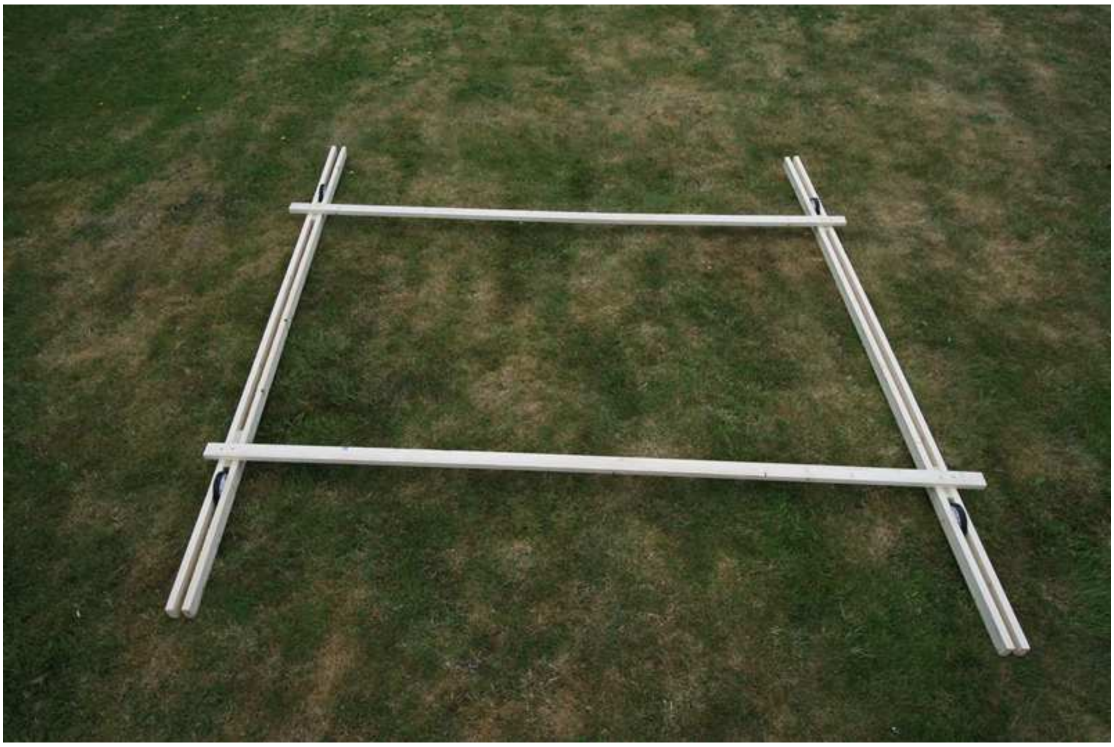
Figure 38 – Prepare for test of runners (two temporary cross braces shown)

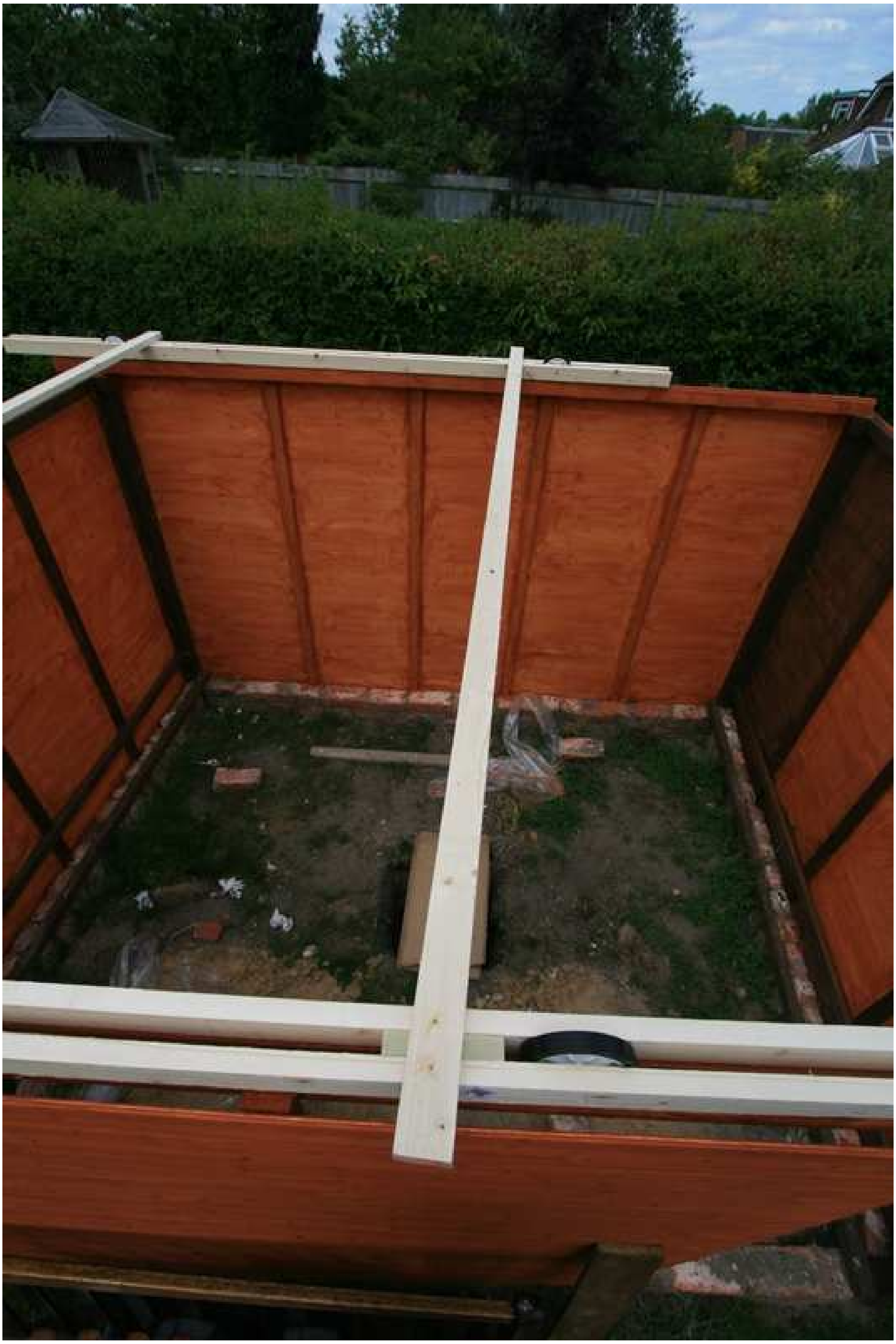

Figure 39 – Test of roof runners before roof assembly

Figure 40 – Start roof assembly

Figure 41 – Roof assembly in progress (temporary cross braces also visible)

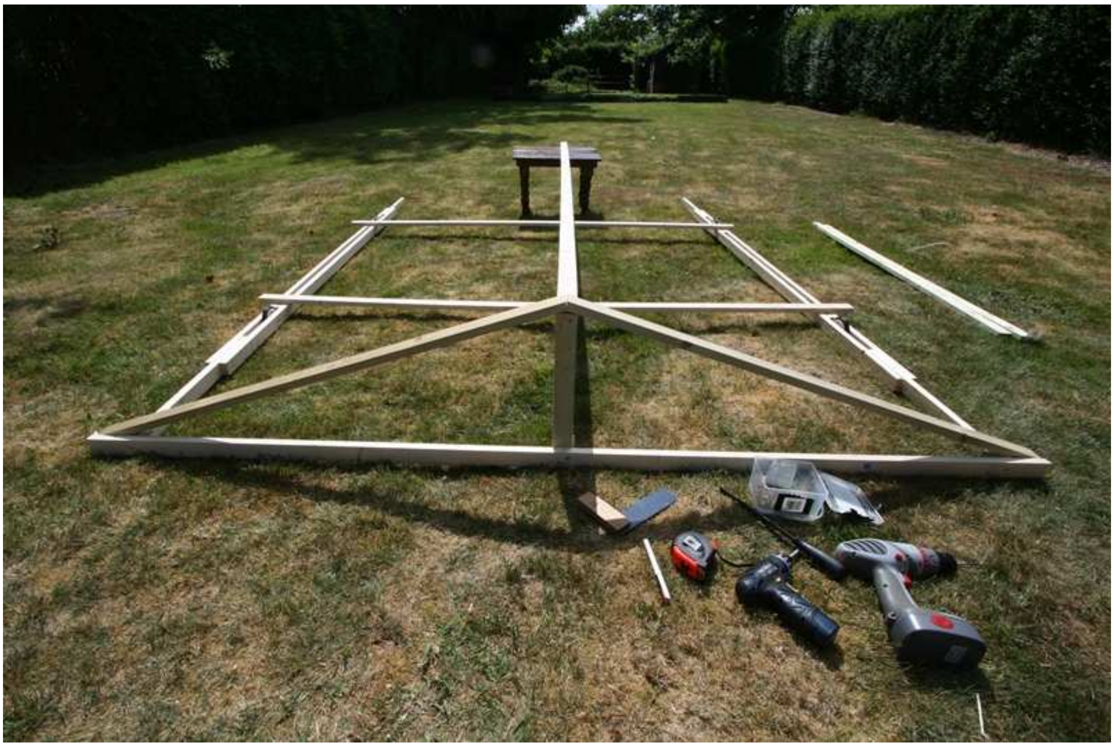

Figure 42 - – Roof assembly in progress (2)

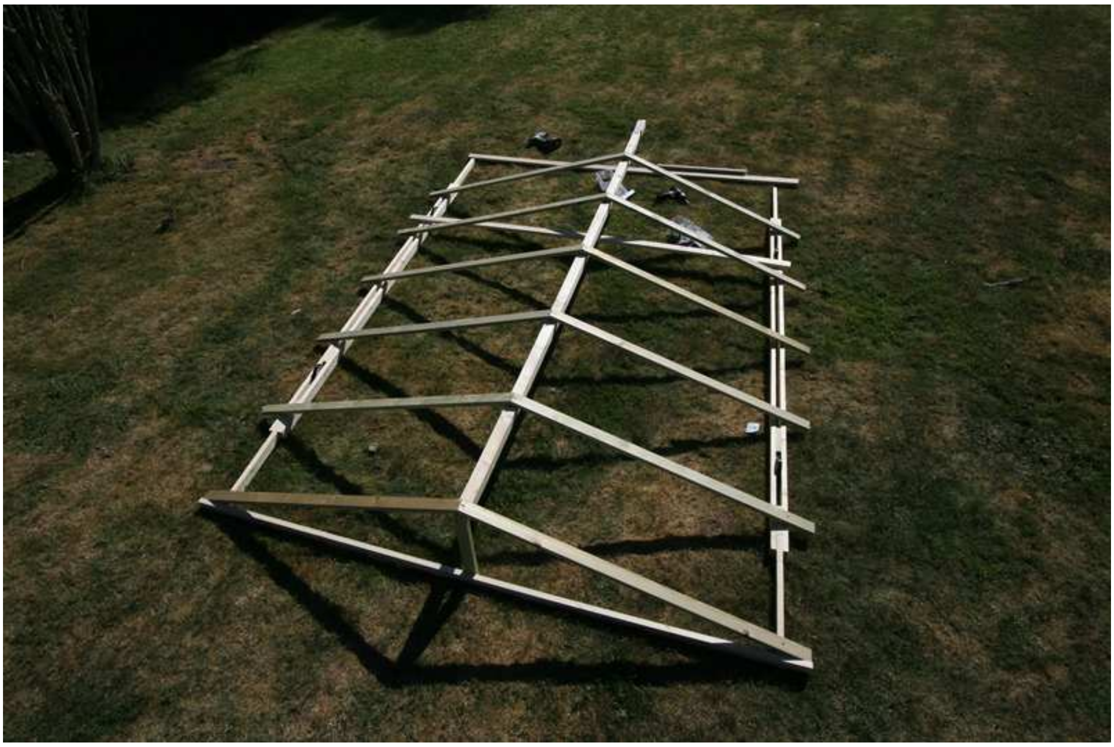

Figure 43 - – Roof assembly in progress (3)

Figure 44 – Roof assembly in progress (4)

Figure 45 – Roof placed into position (1)

Figure 46 – Roof placed into position (2) – note end overlap

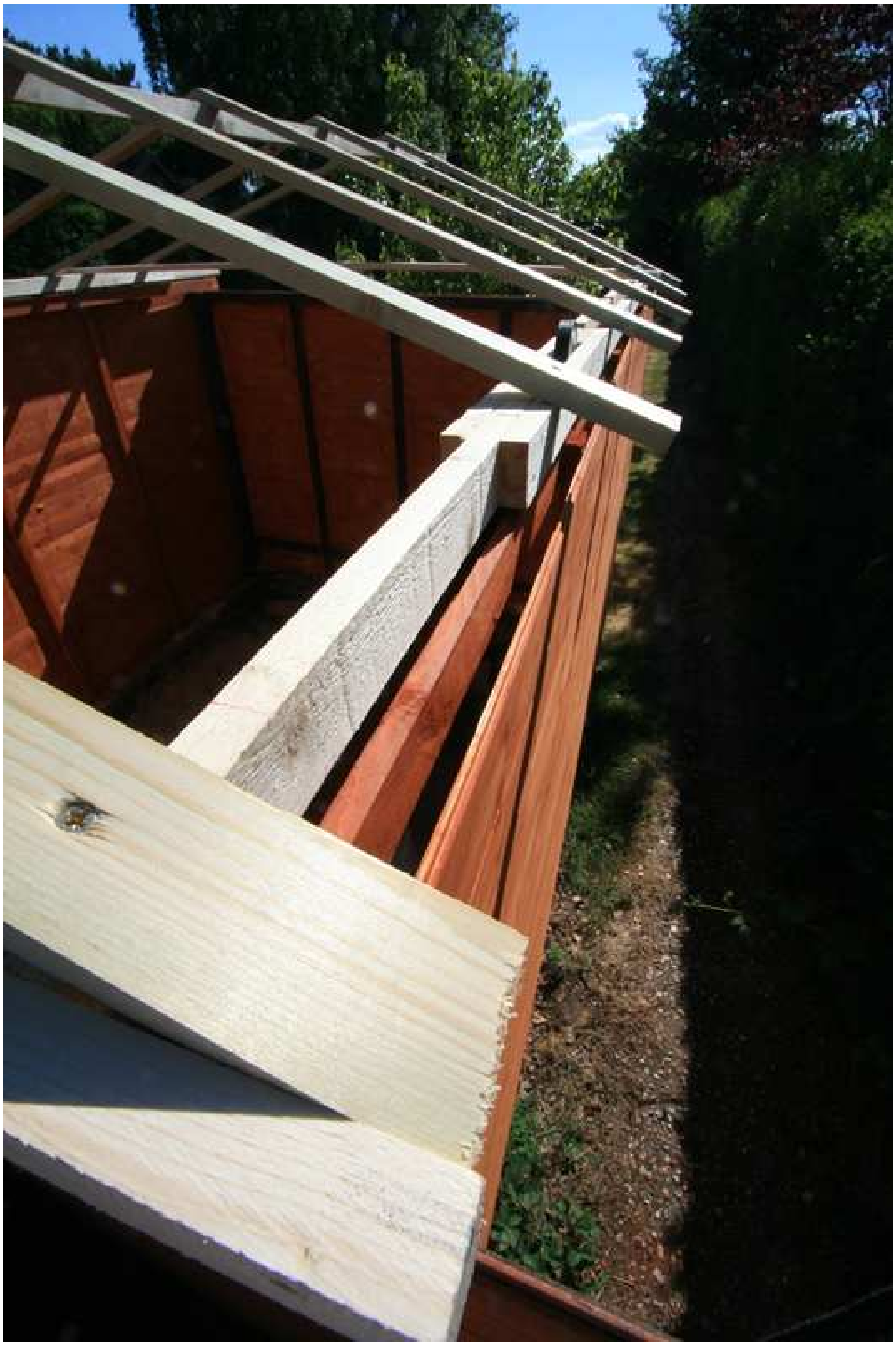

Figure 47 - Roof placed into position (3) – note side overlap

Figure 48 - Roof placed into position (4)

Figure 49 - Roof placed into position (5)


Figure 50 – Check that roof moves freely

11 Cross brace the roof

At this stage the roof is complete, in place and moving freely. To get the required rigidity metal angle brackets and wood cross braces are now added as shown in the next few figures.

Figure 51 – Adding roof cross braces and brackets (1)

Figure 52 – Adding roof cross braces and brackets (2)

12 The roof covering

The next step is to add the roof covering. To keep weight to a minimum I used corrugated plastic sheets and pre-manufactured ridge pieces. The main thing here is to ensure that the corrugated sheets are overlapped and that the ridge pieces are joined with roofing tape so that rain cannot enter. Roofing screws with built in caps are used to screw the correlated plastic to the frame.

An important note here is that the roof covering extends approximately 10cm over the edges of the observatory (as the frame has been made longer and wider that the observatory walls).

Figure 53 – Roof ridge

Figure 54 – Adding the plastic corrugated sheets and roof ridge (1)

Figure 55 – Adding the corrugated plastic sheets and roof ridge (2)

Figure 56 – Roof cover completed (1)

Figure 57 – Roof cover completed (2)

Figure 58 - Roof cover completed (3)

Figure 59 – Tape used to join the roof ridge sections

13 Add the roof ends

We now have walls and a roof, but the roof is currently open at both ends. One end needs to be solid and the other end needs a small hinged door added so that it may be opened when sliding the roof off so as to give clearance for the telescope. The construction of the end with the door is shown below.

Figure 60 – Add one roof end with a hinged door to allow for scope clearance

Figure 61 – Roof end with scope clearance door in progress

Figure 62 - Roof end with scope clearance completed

14 The Pier

For my first observatory I managed to get my hands on an 8" diameter, 2m long metal pipe. For this observatory I found a 2m steel Lintel. In the figure below I am concerting it 1m into the ground. I then subsequently filled the hole and the core of the lintel with concrete.

Figure 63 – Positioning the Pier

Figure 64 – Concreting the Lintel into the ground

15 The Floor

For the floor construction I placed wooden beams across the brick base and positioned additional brick piles to support the beams. This can been seen in Figure 65 below.

Figure 65 – Add beams for floor support

The floor itself was made out of 18mm thick loft boarding screwed onto the floor beams. This process is shown in the next few figures below.

Figure 66 – Loft boarding for floor

Figure 67 – Laying the floor

Figure 68 – Floor completed (1)

Figure 69 – Floor completed (2)

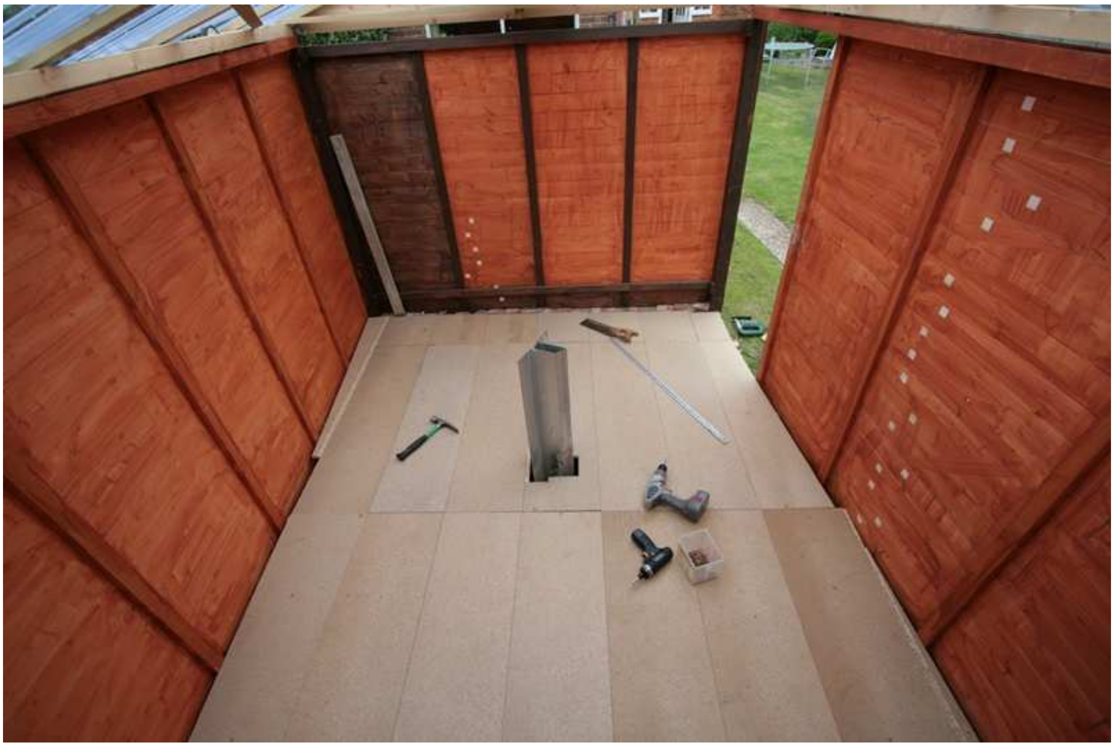

Figure 70 – Floor completed (3)

16 Add a door

The door is simply made by constructing a frame as shown in Figure 71 below and then screwing on ship lapped wood as shown in Figure 72.

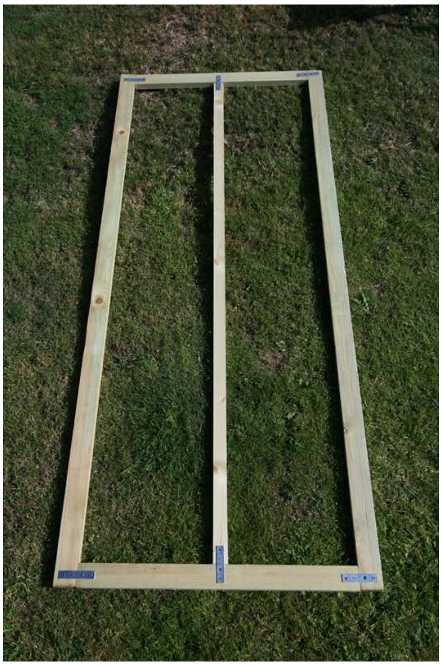

Figure 71 – Create door frame

Figure 72 – Add door covering

17 Add roof runner extensions

The next step is to add the runner extensions so that the roof can be rolled all the way off. This was a case of concreting into the ground some support posts and then extending the runners. Two 3m lengths of word were used, channelled out as shown in Figure 22 previously, and then screwed to the top of the observatory posts at one end and the new support posts at the other.

Figure 73 – Add roof runner support posts

Figure 74 – Roof runner supports posts concreted into ground

Figure 75 – Roof runner supports in place

18 Add pier head for wedge support

The basic observatory structure is now complete and the next phase was to attach my Meade Superwedge onto the pier. At this point a degree of manufacturing ability is required as something is needed that is rigid and yet capable of adjustment so that the Superwedge, and hence the telescope, can be precisely levelled.

My design for this was to use two aluminium plates held together via opposing locking nuts. The completed design can be seen in Figure 76 below. The following key points are noted:

- The top aluminium plate has bolts in it for fixing the superwedge to it, the size and spacing of these will depend upon your own wedge or pier head;
- The bottom aluminium plate Is welded to the pier. **Note**: welding can be very dangerous and should not be attempted unless you know what you are doing as accidents can result in serious injury or death.
- The two plates are locked together via 12mm studding with opposing antagonistic nuts, this allows for the top plate to be adjusted so that it is exactly level and then locked up tight.

It's important to note that although the wedge looks offset, the centre of the scope when on the wedge and hence the weight of the scope is aligned with the pier and hence the centre line of the weight distribution is down the centre of the pier, hence reducing any possible flexure issues.

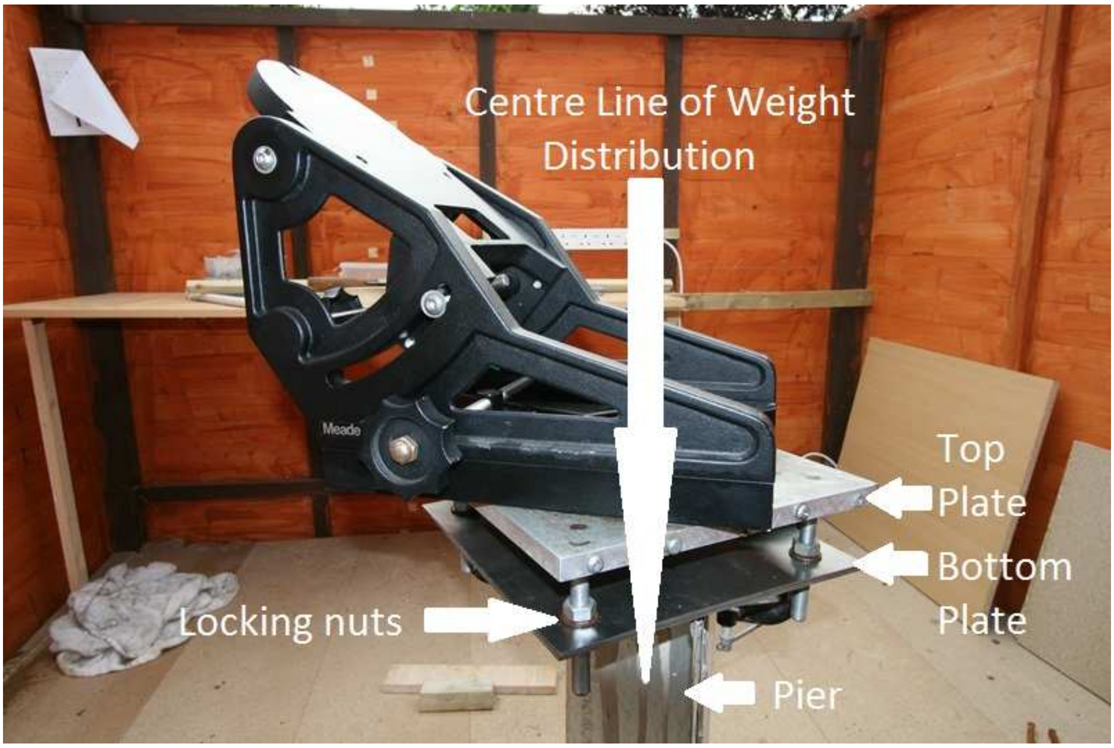

Figure 76 – The completed pier head

The following figures show the manufacturer and assembly of the pier head.

Figure 77 – Drill clearance holes for the 12mm studding in both plates

Figure 78 - Prepare pier head for Meade superwedge support (2)

Figure 79 - Assemble the two plates (1)

Figure 80 – Assemble the two plates (2)

Figure 81 – Prepare to arc weld the bottom plate to the pier

The following two photos (Figure 82 and Figure 83) show how the top and bottom plates are locked together and how the Meade Superwedge is attached to the top plate.

Figure 82 – Bottom plate welded in place and locked to top plate

The Meade Superwedge is held onto the top plate via three bolts and a central thread. The top plate was drilled and tapped to accommodate these and a hole was drilled to accommodate the back spigot. The bolts are loosened during azimuth adjustment for polar alignment (see my polar alignment procedure document on www.astrosoft.co.uk).

Note that there is not a lot of azimuth adjustment possible as the bolt slots on the Meade Superwedge are not very extensive (this can be seen in Figure 83 below). It was therefore imperative that the original position of the wedge when bolted to the top plate (once the bottom plate had been welded onto the pier) was as close to North-South alignment as possible to start with. I found that careful eye alignment using a compass was good enough. Note that the compass reading may need adjustment depending on how close magnetic north is to true north for your site.

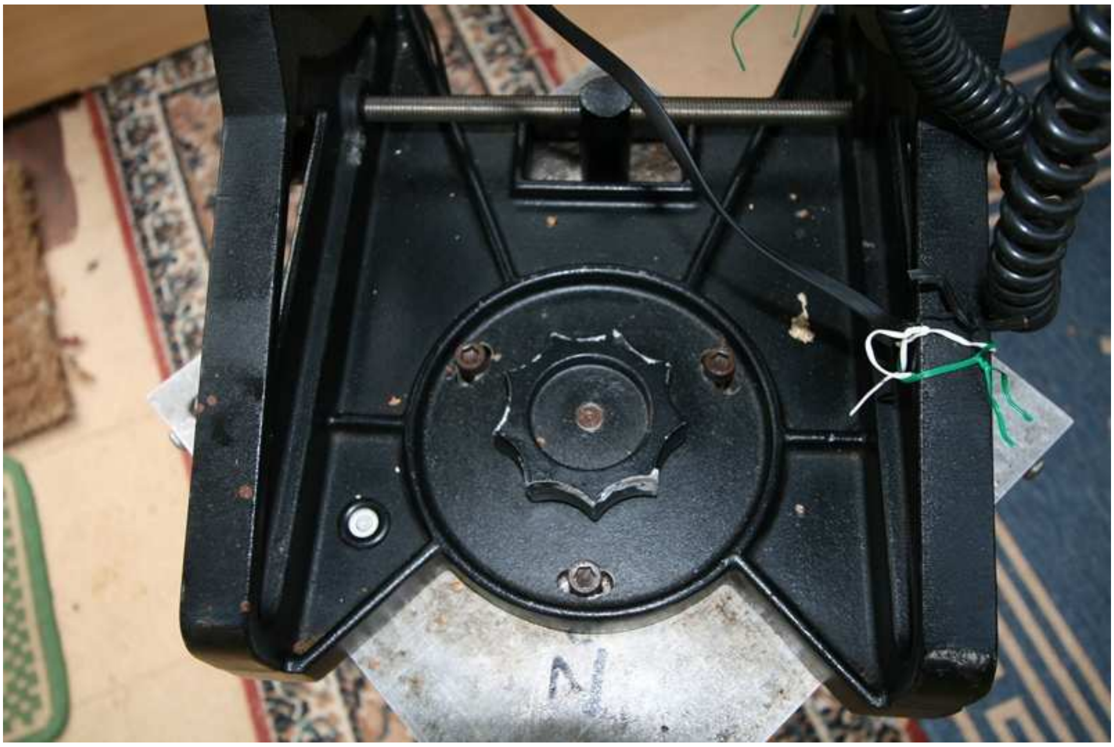

Figure 83 – Meade Superwedge on Pier


Figure 84 – A test of the scope on the pier

19 End of main construction

All of the main structural work for the observatory is now complete.

The inside of the observatory has been lined using spare bits of sheet material – this includes all of the sides and doors from an old flat packaged wardrobe and bits of laminate that I had in the garage. These have all just been screwed to the frame. Chip boarding would be fine.

Figure 85 – Main construction completed

20 Electrical

Warning: Do not attempt any kind of electrical work unless it is legal and you are qualified to do so. Mistakes can cause serious injury or death. The following section details the electrical layout for my observatory, but this in no way signifies that such a layout would be suitable for your environment.

A fused 13 Amp supply was used with a surge protection trip. For my setup, 13 Amps is ample as the following table shows:

Component	Max Load
Scope	1 Amp
Dew Heater	2.4 Amps
PC	3.5 Amps
Monitor	1 Amps
Total:	7.9 Amps

Table 3 – Electrical Load

Additional items that I use which require mains power include red and white lights and a CCD, the draw of these is minimal. Also I have never had my scope draw more than about 0.6 Amps and I very rarely have my dew heater on full. This means that the 7.9 Amp total is probably hardly ever actually realised.

Figure 86 below shows the wiring arrangement where the supply is entering the observatory from the right.

Figure 86 – Main feed into fused switch

Figure 87 – Electrical feed junction box – one output to scope, one to PC

21 Summary

Figure 88 below shows the finished observatory with my Meade 10" LX200 classic and a cheap second hand PC in place.

Figure 88 – My working observatory

I am writing this about three months after completing the observatory and so far everything is working extremely well. I would summarise the main features, which incorporate some improvements from my first observatory in 2001 where appropriate, as follows:

- Total cost was approximately £450 (GBP in 2011); I believe that it has proved to be an extremely cost effective build and solution;
- The corrugated plastic roof is light but rigid and the can easily be pushed / pulled with one hand. Dripping some engine oil into the channels now and again helps the wheels glide;
- By making the roof larger than the observatory walls, and hence providing an overlap on all sides, no water has managed to ingress into the observatory even under very wet and windy conditions;
- I have left a slight air flow through the observatory which means that the possible heating effects of having a transparent roof have not caused any temperature equalisation issues. Also I try to open the observatory an hour or so before an observing session if it has been a hot sunny day (not too much of an issue in Engalnd!). The plastic can be painted so one could just paint it to remove any such heating concerns;
- The brick base and suspended floor remains dry and free from any ground interference;
- The pier is not showing any flexure, however damping times from any accidental knock are longer than I would like. I am therefore considering building a brick chimney around the pier and filling it with concrete;

- The advantages of having a bespoke observatory that exactly fits your own requirements cannot be overstated; the very fact that it provides for your scope to be permanently mounted and ready means that you get to do far more observing.

22 First Light Pictures

And now the exciting bit – my first light pictures. This was before polar alignment, collimation, PEC training etc. – all of which are explained in separate documents available from my website www.astrosoft.co.uk.

The solar photo in Figure 89 was taken through a Thousand Oaks full aperture solar filter with my Canon EOS400D at prime focus with an exposure of 1/125 second.

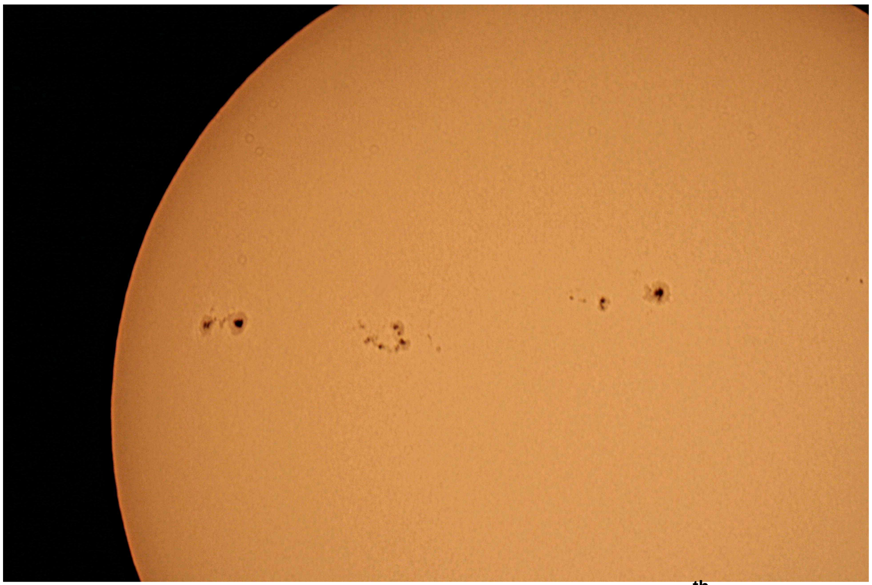

Figure 89 – Sun spots on the Sun Eastern Limb – 30th July 2011

The photo of M27 in Figure 90 below was taken using a Meade DSI II colour camera at prime focus, stacking approximately 40 images at 10 seconds each. The image below has been boosted via an unsharp mask filter in GIMP (free image processing software under the GNU General Public Licence which I reckon is as good as Adobe photoshop).

Figure 90 – M27: The dumbbell Nebulae

23 Further Information

Please visit my website www.astrosoft.co.uk for further documents and articles.

If you find this document helpful in constructing your own observatory then please consider donating £1 via my PayPal account – please see my website www.astrosoft.co.uk for details.