From shipping container to studio flat

I first became inspired about the use of shipping containers architecturally in 2002, when I read an article about the Future Shack by Melbourne based architect Sean Godsell. He used a standard ‘20 foot’ (6m) shipping container to provide disaster relief housing. I was particularly inspired by the environmental credentials of recycling shipping containers and I have been eager to build a dwelling using one or more shipping containers ever since.

At the time I was not in a creative career but had a yearning to change jobs and become a building designer and, if possible, incorporate shipping containers into my designs. Well over a decade has passed since I read that article and I have retrained as a building designer and now run Tasmanian based Deep Green Building Design, specialising in sustainable building design.

Studio flat

In an effort to showcase the use of shipping containers as homes and also to provide accommodation for my mother-in-law, I commenced the build of a studio flat in May 2012, next to our cottage in North Hobart. The available building site was extremely small, approximately 4.5 x 6m and so was ideally suited to a six metre shipping container whose external dimensions are 2.5 x 6m.

Council approval proved to be really straightforward. Our block is zoned ‘Central Services’ and so residential developments are discretionary and as such it had to be advertised to allow for
THE OWNER BUILDER

Moving the container

The removal of the roof deck structure prior to transportation would involve unscrewing the balustrades, the cladding on the balustrades, the decking and then joists and finally the bearers, which are secured to the steelwork welded to the roof with self-tapping screws.

The removal of the lower deck would involve the unscrewing of the decking, followed by the joists and then the bearers, which are secured to the 'fork lift slots' also with self-tapping screws.

The stairs can also be removed in one piece if you have a few strong people to assist by removing the self-tapping screws that secure it in place. The stairs could either be dismantled and stored in the container during transportation or tied down to the steelwork on the roof.

On the last day of May at 8am the shipping container appeared on the back of a truck and by 8.40am it had been manoeuvred into place by a franna crane (with the ability to lift and move while loaded), all paperwork had been taken care of and the truck was moving off down the lane. I wiped my brow as I realised that the location of the footings had been spot on and that the shipping container had not smashed into our house.

Openings

The first task in turning the shipping container into a home was the addition of windows and doors. This was when I sought help from Benj, a good friend with welding skills, who kindly donated a whole weekend to me to weld reinforcing steel around the openings. With my trusty $100 angle grinder, I cut the openings whilst Benj welded the 75 x 50mm galvanised rectangular hollow section (RHS) around each opening.

Design

My design philosophy for this shipping container studio flat was to provide a dwelling that was affordable, cheap to run, environmentally sustainable and transportable. I believe that dwellings like this provide scope for young people to enter the property market in a manner that won’t break the bank, those wanting to downsize and even those wanting to take their home with them when they move could do so after having dismantled those parts of the structure external to the container (see sidebar).

In order to keep running costs to an absolute minimum and, in turn, reduce the environmental impact of the flat, it was designed to require little or no heating or cooling. This was achieved

The container

I had already purchased a slightly battered six metre ‘high cube’ shipping container from about 30km away in the Derwent Valley and I now arranged for it to be delivered at the end of May, allowing the footings to cure for a couple of weeks. It was important to use a high cube container as they are taller than the standard containers (by about 300mm) and so allow for the minimum ceiling height of 2.4m required for habitable rooms.

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Framing and insulation

A timber frame had to be constructed inside the container to provide attachment points for the windows and doors to be secured to.

The first part of the frame to be constructed was the floor structure, using 90 x 35mm F17 hardwood which was bought as water damaged salvage, but had only superficial discolouration. The insulation dictated the height of the floor structure, and I chose to use 25mm Foilboard.

In order to maximise the level of insulation, I needed to trap as many reflective air spaces as possible, with each trapped 25mm reflective air space having an R value of approximately R0.6. The space was created using 25mm timber spacers.

With this in mind, the timber was placed wide side in contact with the shipping container floor (making the timber 35mm high) at either edge of the floor and also at the centre of the floor and extending the length of the shipping container, forming a kind of base plate. These were then secured to the metal with counter sunk self-tapping screws. Bearers were then screwed into the ‘base plates’ in the traditional upright position and floor joists placed between them going across the width of the shipping container. The joists were secured to the bottom plates and the bearers.

The resulting floor structure was 125mm in height allowing for the following insulation configuration to be installed (from the container metal floor upwards): 25mm reflective air space, 25mm Foilboard, 25mm reflective air space, 25mm Foilboard, 25mm reflective air space. The resulting R value for this configuration is approximately R4.7 (including internal and external air films and lining).

Before the wall framing could be installed, one layer of 25mm Foilboard was secured to all interior walls to provide a thermal break to the outside metal walls. Vertical top plates/bearers were bolted to the sides of the container at 2410mm (allowing for ceiling thickness) above what would be the finished floor level. These top plates/bearers would provide a place to attach the ceiling structure to and also the wall frame structure.

The wall was constructed of 90 x 35mm MGP10 (machine graded pine), and was secured not only to the top plate but to the side floor bearers. The studs were orientated so that the 90mm faces were facing inwards (i.e. 35mm depth) spaced 10mm away from the Foilboard. A 20mm reflective air space was left and then

Reflective air spaces

The actual R value of an air space is enhanced by the reflectivity of the Foilboard surface (or sisalation, AIRCELL etc.), as opposed to an air space with no reflective surface adjacent. Your Home Technical Manual (www.yourhome.gov.au/technical) has some more information under 4.8 Insulation Installation.
and pumps it through a 20mm pressure pipe together with the waste water from the kitchen sink, bathroom basin and shower, from where it’s directed to the sewer. The use of a macerating pump allows for easy connection to the sewer should the dwelling be moved to a new location.

Also with an eye on transportability, a 50 litre hot water cylinder was installed below the kitchen work bench, next to the kitchen sink, removing the need for another layer of 25mm Foilboard was cut and wedged tightly between the studs and finishing flush with the face of the studs. The resulting wall structure was 70mm thick. The R value of this system is approximately R3.4 (including internal and external air films and lining).

The studs were held 10mm away from the Foilboard using 10mm timber spacers. There was sufficient room to move with the top and bottom plates to allow me to attach the studs to them with the 10mm spacers attached. In hindsight using 90 x 45 would have saved me a lot of time and effort!!

Securing the windows and the door proved relatively straightforward, with the possible exception of the fire rated glass brick window, which was a little trickier and certainly messier. A fire rated window was required by the Building Code as the container is located hard up against a boundary and had to be 60 minute fire rated. Similarly, the wall facing the boundary also had to be fire rated for 60 minutes. Securing the glass brick aluminium frame itself just required the bolting of the frame to the welded RHS reinforcement. Getting a professional finish on the mortar between the glass bricks proved difficult, but a satisfactory result was achieved.

The internal layout of the flat is open plan with the exception of the bathroom and so the only other framing required was for this room. The bathroom dimensions are 1.1 x 2.3m, with the width being dictated by a salvaged Marbeltrend enclosed shower unit. The framing for the bathroom used 70 x 35mm MGP10 studs.

The ceiling structure used more of the 90 x 35mm F17 hung between the top plates/bearers using joist hangers and spanning the width of the shipping container. The insulation configuration for the ceiling from the roof downwards was: 50mm reflective air space, 25mm Foilboard, 30mm reflective air space, 25mm Foilboard, 35mm reflective air space – giving an R value of in excess of R4.7 (including internal and external air films and lining).

Services

As this flat was designed to be easily transportable, I considered that standard sewer connections weren’t suitable and opted for a Saniflo Sanipro macerating pump, which macerates all black water
connecting hot water upon arrival at a new site. Instantaneous hot water with bottled gas was considered (it was my preferred choice); it was only rejected on budget grounds.

**Fit out**

Once the electrician and plumber had finished, I lined the floor with 18mm E0 (Ultra Low Emission) rated FSC (Forest Stewardship Council) plywood. I then set to lining the bathroom and end walls in 9mm E0 rated FSC plywood (except walls in proximity to the shower, which were lined with wet area fibre cement). All other walls were lined with 6mm fibre cement. All the non-waterproofed edges of the ply and fibre cement were butt joined and all surfaces sealed with E0 rated sealer, but otherwise left in their raw finish to give a slightly industrial feel.

The ceiling throughout was also lined with the 9mm plywood, but was given one thin layer of white Porter’s Milk Paint to allow the grain of the plywood to remain visible, and yet help relieve the possibility of ‘plywood overload’!

By this time October had arrived and it was time to put in the rudimentary possibility of ‘plywood overload’! By simply locating a long thin retro (circa 1970s) timber cabinet ($40 from a charity shop) and attaching workbenches of macrocarpa at either end.

The bathroom now only required a lick of paint on the fibre cement walls and a few finishing touches. It provided a strange joy to me for a while to flush the toilet or turn on a tap and hear the Saniflo quietly pumping the waste out through the tiny pipe secured to the bathroom wall.

October also saw the fitting of a ply single bed base (with storage space underneath) which folds out into a queen bed and also acts as a sofa during the day. Shelving was added at the end of the bed to provide even more storage.

The outside walls of the shipping container took a couple of days to give two coats of ecolour zero VOC exterior paint to match the ironstone colour of the windows and the roof was given a thick coat of tar paint to help ensure that the roof remained watertight.

Installation of the Ezy-Lite fire rated board came next, which was secured using the screws and sealer provided by the manufacturer to battens attached to the north-eastern wall of the shipping container. I then also painted this with the ecolour paint.

**Roof deck**

The roofs of containers are naturally curved, which directs the water down the walls of the container. Water is directed around window and door openings by flashing.

I had already constructed the lower deck framework using the water damaged F17, with bearers secured into the container’s forklift holes and cantilevering 800mm with floor joists hung between. It was now time to call in Benj and his faithful welder again, to weld to the roof of the shipping container the galvanised steelwork to which the timber framework for the roof deck, balustrade and stairs would be attached. Essentially, the steelwork consisted of galvanised post holders welded to the roof into which 90 x 90mm treated pine posts would be secured to support the balustrades, and two lengths of the RHS that span the width of the roof and then cantilever out to support the stairs and landing at the top of the stairs, also welded to the roof.

The remainder of the steelwork consisted of three lengths of 75 x 75 x 4mm galvanised equal angle (EA) spanning the width of the roof and again welded to it. More 90 x 35mm F17 bearers were attached to the RHS and the EA and the same timber was used for floor joists hung between each bearer on joist hangers. Treated pine posts were attached to the post supports and topped off with either recycled oregon or F17 balustrades.

Next came the stairs, the prospect of which I found quite daunting! They were made from 240 x 45mm treated pine for both the stringers and the steps themselves. All in all probably they took about three days to make and secure to the cantilevered RHS and to the container by means of self-tapping screws. The base of the stairs was also attached to and incorporated into the lower deck structure. The passing of the next week saw the securing of treated pine decking to both decks. I would have preferred to use recycled hardwood decking, but sadly funds would not permit.

By now, it was mid-December and I could walk up the stairs to the roof deck and look out over the rooftops of Hobart and up to Mount Wellington, what a great spot for a glass of red! Before I could relax and have the red, I had some cladding to do!
Exterior cladding

I chose to clad the shipping container in macrocarpa, which has a tendency to drop large branches that are often bulldozed into piles and burned. I bought the macrocarpa from a contact that salvages this timber and mills it, ordering 25 x 25mm battens of sufficient quantity to cover the container. I also ordered a few 25mm thick slabs for work benches, boxing in of pipes and architraves.

I chose macrocarpa as it’s a renewable resource, is locking up carbon and it has a lovely golden hue to it. It took me from mid December 2012 to the first week in February 2013 to clad all of the balustrades, and the two sides of the shipping container visible from the street.

The other two sides on the container were left unclad. The macrocarpa battens were individually pre-drilled and screwed into the Ezy-Lite board on the north-east elevation or into more macrocarpa battens secured vertically to the shipping container on the south-east elevation by self-tapping screws. Each macrocarpa batten was spaced 10mm apart, to allow the shipping container to be glimpsed behind, but only on close inspection.

All of the external timber was given a healthy coat of Sceneys old fashioned Weatherproof Oil. Finally, the shipping container flat was finished! The Occupancy Permit arrived on the 6th February and my mother-in-law moved in on the 7th.

I have learnt so much from this little project. If I had this opportunity again, I would probably use wider macrocarpa battens for the cladding, as they would be less likely to warp and there would be less screws and so less time consuming fixing involved. I believe that having separate timber wall framing internally is a bit of overkill and that the additional cost of buying pre-made insulated wall panels for example, would have saved a huge amount of labour. And how much did it cost? A shade over $23,000 excluding my labour, which I think is pretty reasonable for a fully self contained studio flat, that can travel with you (albeit with a little dismantling required)!

Am I still inspired by shipping containers? You bet! I am eager to put the skills that I have learnt on this project into practice on future shipping container design projects of all sizes.

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Links & resources

- Future Shack
  Recycled shipping containers are used to form the main volume of a mass produced relocatable house for emergency and relief housing.
  www.seangodsell.com/future-shack

- Foilboard
  An expanded polystyrene rigid insulating board that has reflective coatings on both sides, contains no VOCs and no CFCs used in its manufacture.

- Saniflo Sanipro
  Enables a toilet, shower and wash basin to be installed almost anywhere.
  02 9882 6200, www.saniflo.com.au

- Porter’s Milk Paints
  A traditional finish with a rustic, chalky appearance, made from milk by-products mixed with powdered oxide pigment.

- ecolour
  Paints having zero volatile organic compound (VOC) offgassing.

- Ezy-Lite
  Fire rated boards made from inorganic minerals that are bonded with two layers of fiberglass mesh to provide superior.
  03 9359 2336, www.ezylite.com.au

- Sceneys Weatherproof Oil
  A general purpose product that can be used in all applications, providing a clear matt finish that enhances the colour and grain of the timber.
  03 9311 7477, www.sceneys.com.au