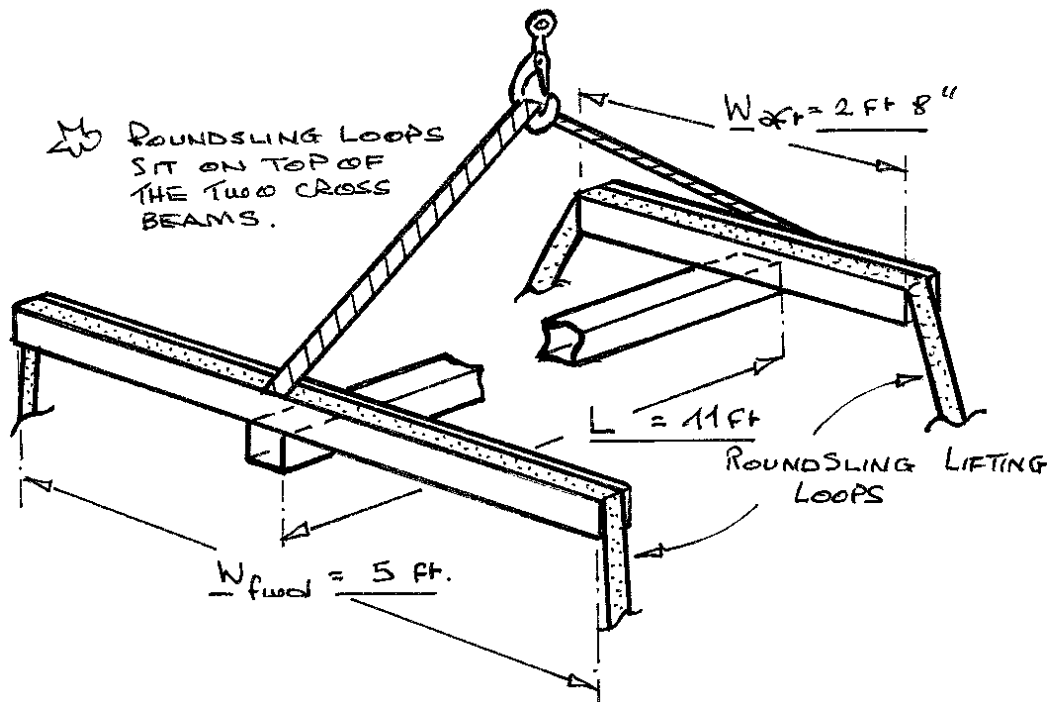


Freedom 21 Lifting Frame

I own a UK-built Freedom 21 with the twin lifting keels and it has been a problem finding a means of lowering these keels when ashore for maintenance and antifouling. My yacht club only has a very shallow lifting gantry designed for lifting International Tempest keelboats on and off their road trailers and I decided to design a simple lifting frame to allow me to lift my Freedom 21 from her road trailer and suspend her in slings to carry out work on the twin lifting keels. The sketch below shows the concept for this lifting frame and the key dimensions.



The key frame elements consist of three lengths of 100mm x 100mm (4" x 4") square-section hollow aluminium alloy tube with a wall thickness of 3.2mm (1/8"). I had mild steel plate box-section units welded-up to slide over the ends of the tube sections to make up the "H" shaped frame assembly. I used 6 metre (19ft 8") circumference round-sling stitched webbing lifting loops to suspend the boat in the frame and adjusted the lengths of the two cross



members to allow the boat to sit level when suspended from the frame. I used 6 metre lifting loops with a safe working load of 1 tonne (2200 lb) and a 7:1 safety factor which represents a good safety margin.

The steel plate end units for each of the two cross members are made with raised side plates to prevent the round-sling lifting loops from sliding off the cross members when the boat is lifted. These are clearly shown in the photo of the aft cross member fitted to a short length of tube section. Also shown in this photograph is the fibreglass “saddle” that fits over and is bolted through each cross member where it



passes through the beam-end welded plate member. This “saddle” keeps the cross beam in place and prevents it from sliding through the beam-end member.

I placed wooden chocks under the gunwales in the areas where the lifting loops apply crushing loads to the hull, holding these chocks in place with duct tape. I also padded these areas with carpet to prevent the lifting strops from scratching the hull. The “H” shaped frame was suspended from the chain hoist hook by two 2 metre (6ft 7”) webbing slings with a loop at each end. These are 2 tonne (4400 lb) safe working load slings with a 7:1 safety factor – this load capacity is needed because the angle of the slings creates a load of around 1 tonne (2200 lb) tension in each sling when the boat is lifted. In practice the frame showed no tendency to pivot about the main beam when the boat was lifted. The UK-built twin keel Freedom 21 sits low-down on



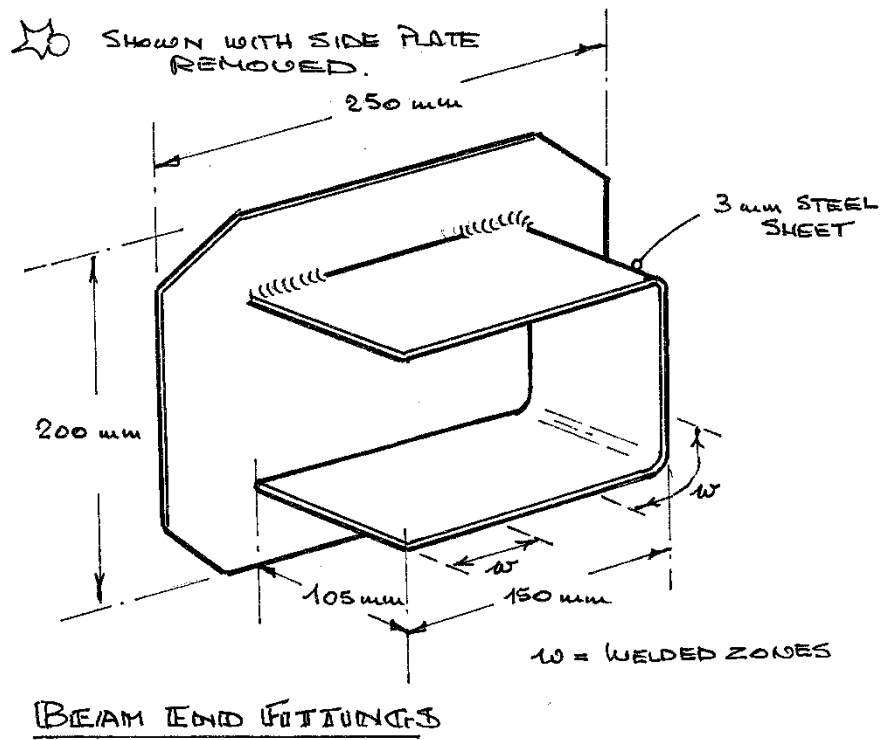
the road trailer with the keels fully raised and hence needs a lift of only about 450mm (18”) to allow the road trailer to be removed and the twin keels fully lowered. I made up two heavy duty ply chocks to support the boat when she was suspended in slings so that I could work under the boat with the extra security of having the boat supported by both the lifting slings and supporting chocks.

This arrangement proved to be a safe and simple way of getting access to the twin lifting keels for maintenance work and antifouling. But lifting a boat and working under it with the boat suspended in slings is a very serious matter and the utmost care must be taken to check all fittings and the condition of the lifting slings and loops before starting work. If anyone wishes to construct a similar lifting frame please see the attached **Appendices 1 & 2** giving details of the welded mild steel end fittings and the summary of the stress analysis calculations.

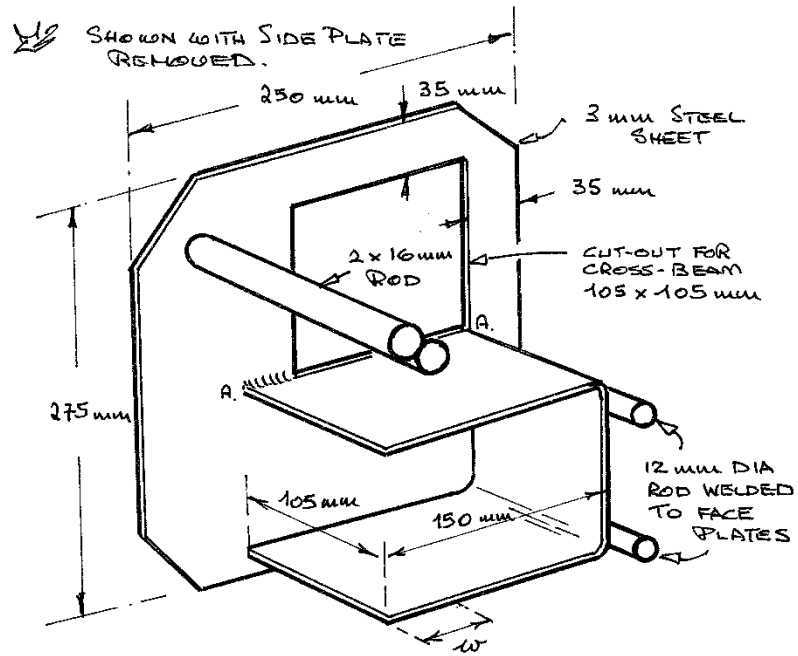
Wilf Bishop
16th January 2009

Appendix 1

Welded Steel Plate End Fittings – Cross Beam Fitting



Welded Steel Plate End Fittings – Column End Fitting

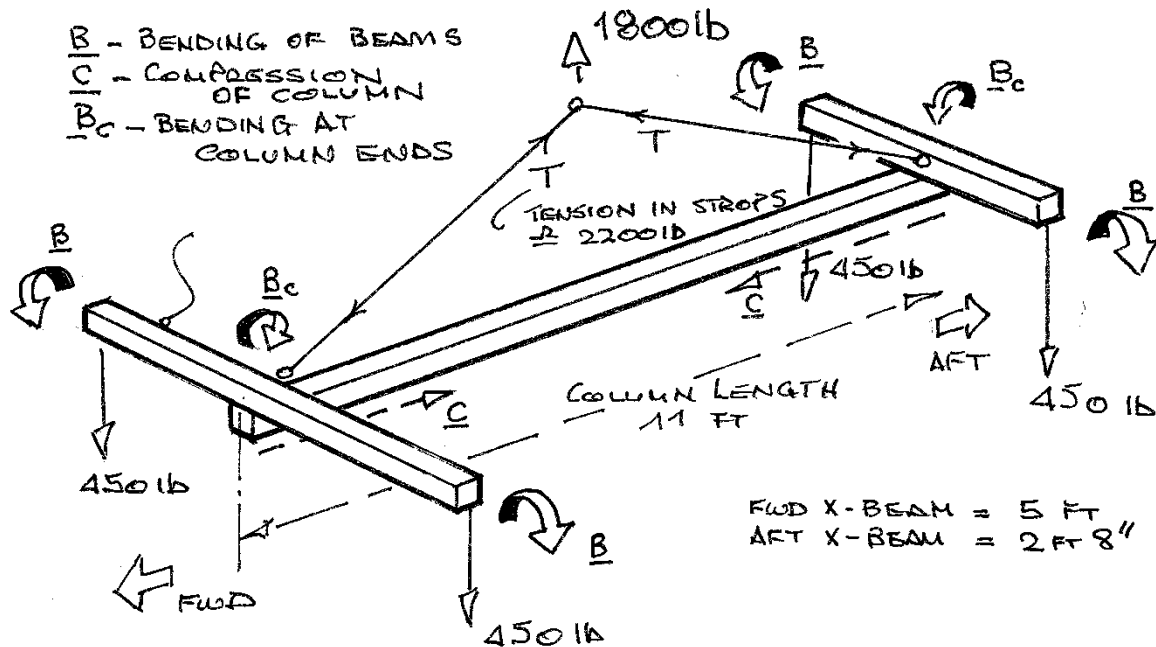


COLUMN END FITTINGS

Appendix 2

LIFTING Frame Loading / Stress Analysis Summary

When lifting the Freedom 21 with the 2 metre (6ft 7") lifting slings as described in the main article the loads applied to the lifting frame were as shown in the sketch below. Note that if longer lifting strops are used the loading in the central column decreases.



Load Distribution:

Cross Beams: Each cross beam carries half the weight of the boat (900lb) and the cross beams are stressed as simple cantilever beams of 2ft 6" span (fwd beam) and 1ft 4" span (aft beam) loaded with a tip load of 450lb.

Central Column: This column carries a compression load of 2000lb and because the end fittings transmit the lifting strop loads into the column end fittings with a degree of offset the column is also loaded with a concentrated applied bending moment at the column ends of 13,200 in-lb.

Stress Analysis Summary

Cross Beams: The highest bending loads occur in the forward cross beam is the forward cross beam where a maximum bending moment of 13,500 in-lb is developed at the centre of the cross beam. The beam is checked for tensile yield failure of the upper surface of the beam and compression buckling of the lower surface. The shear stresses developed in the beam sidewalls are trivial and need not be considered.

- Tensile yield in the cross beam upper surface – Safety factor >4.0
- Compression buckling of the cross beam lower surface – Safety factor >6.0

Central Column: Because of the local concentrated bending loads applied to the column ends this must be considered as a beam-column which can fail by Euler compression buckling or by a local bending moment developed in the beam column.

- Euler buckling of beam-column – Safety factor >6.0
- Tensile yield in the beam-column under local bending – Safety factor >3.0
- Compression buckling in the beam-column under local bending – Safety factor >5.0

Conclusions: This is a very conservative design with healthy safety factors but the following points should be noted with regard to the safe use of the lifting frame.

- This lifting frame is designed to lift the Freedom 21 with a maximum boat weight of 1800lb**
- Do NOT use this lifting frame design for lifting boats heavier than 2500lb.**
- This design depends upon having correctly welded sheet steel beam & column end fittings**
- Lifting strops/slings must be the correct lifting capacity and be checked for wear/chafe before use**
- If there is any sign of significant wear or chafe replace the lifting strops/slings immediately**
- Always use this frame with appropriate support chocks to take some of the boat weight**

Wilf Bishop
13th January 2009

DISCLAIMER: This information is provided in good faith for review and consideration by Freedom 21 owners and does not constitute an authorised lifting frame design that conforms to any national or international design norms. Since the quality of build of this design is beyond the author's control the author cannot take responsibility for the failure in service of this design and it is recommended that anyone wishing to use this information to build such a frame seeks the advice and approval of an appropriately qualified professional engineer to confirm the suitability of the design for the purpose for which it is intended.

