DAVIS MARINA MOORING GUIDELINES

Version 1 May 2019

History The design of Davis Marina's moorings has evolved over more than 70 years. Our high success rate has been the result of learning and experience. In the last two decades we have been applying classic engineering principles in tandem with our experience. In-house computer programs have been developed to calculate the tension in our mooring tackles, the holding capacity of our mooring blocks has been measured and the wear rates of our chains and components has been documented so that we can predict accurately the safe working lives of our moorings.

This work has led to a greater understanding of how moorings work and in the last few years an improved design. As each of our mooring blocks and their tackles undergo their 3 to 5 yearly major service they will be upgraded and re rated to meet our new design standard.

General arrangement of moorings Our moorings consist of a heavy concrete mooring block, ground chain, thrashing chain, rope and deck chain as shown in Appendix A

Wind speeds Design wind speeds are taken from AS1170.

Apparent areas of boats The side on profile area of a boat is calculated from the length overall and free board plus cabin area, plus mast height and width etc. It is assumed that the boat yaws through 30 degrees either side of the up-wind direction and so the apparent area is half of the side profile area.

Wind loads The design wind loads are calculated from AS 1170

Wave loads The wave loads are 1 kn x the apparent length (half of the length overall).

Current loads The tidal prism in north Harbour is very small and hence tidal currents can be ignored. The catchment area for flooding is also very small and can be ignored.

Coefficient of drag The coefficient of wind drag on boats is assumed to be = 1.

Total force The total forces on moored boats is assumed to be the wind force plus the wave force.

Storm Surge Storm surge is assumed to be 2.4m above LAT (lowest astronomical tide).

Tension in mooring apparatus The ground chain is assumed to be a catenary and the thrashing chain and rope are assumed to be weightless. The following formula is used to analyse the forces acting on the ground chain.

$y = \frac{T_0}{\mu} * \frac{\sinh(\mu * x)}{T_0}$ and the tension at any point is given by $T = T_0 + \mu * y$

Where:

T= tension at any point in the ground chain

T_0= tension mid span

μ=weight per metre

Davis Marina's in-house computer program can determine the tension in any part of the complete mooring tackle.

Uplift on mooring block Forces on mooring blocks are shown in Appendix B

Coefficient of resistance of mooring block The coefficient of resistance is similar to a coefficient of friction and has been physically measured at two sites within the Davis Marina mooring field by load testing. C_r is assumed to be 1.7 and the following formula applies.

$$R_x = C_r(W_s - U)$$

Where:

Rx = horizontal reactive force

Cr = Coefficient of Resistance

Ws = Submerged weight of mooring block

U = uplift on mooring block applied by ground chain

Components Shackles and swivels are used to join chains and allow the mooring to untwist. To reduce the amount of electrolysis, Davis Marina uses as much mild steel as possible and, because the material properties of "off the shelf" components are unknown, we manufacture our components in house. Swivels are located within the thrashing chain so that they can unweight and swivel as they land on the harbour bed during the tidal cycle.

Wear rates of chains and components Chain wear is measured by cross sectional area lost during the service life. Measurements taken over a number of years give the maximum expected loss for various chains as follows:

Ground chains	50 mm^2/year
Thrashing chains	100 mm^2/year
Deck chains	75 mm^2/year

The maximum allowable stress in any chain or fitting is 50mpa and the following formula is used to determine the minimum starting diameter.

$$D = \sqrt{\frac{4\left(\frac{F}{2\sigma} + \mathrm{rt}\right)}{\pi}}$$

Where:

D=Diameter at start of service life

F=Tensile force in component

r=Rate of wear

t=Length of service life

σ =Shear stress in link, dee shackle or other fitting

Typical service life (time between inspections) of chains and components

- Deck chains, ropes and thrashing chains – yearly
- Ground chains – 3 to 5 years depending on the condition of the chains

Spacings between blocks

The number of mooring allocations in North Harbour and the average boat length does not allow for each boat to have its own swinging area at full tackle extension. Rather, they rely on ground chains for each mooring in the field to be drawn out in the same direction or in the same pattern by the last significant wind. Hence in very light winds, when adjacent moored boats are most likely to collide, they swing on a radius determined by their thrashing chains plus the overall boat length.

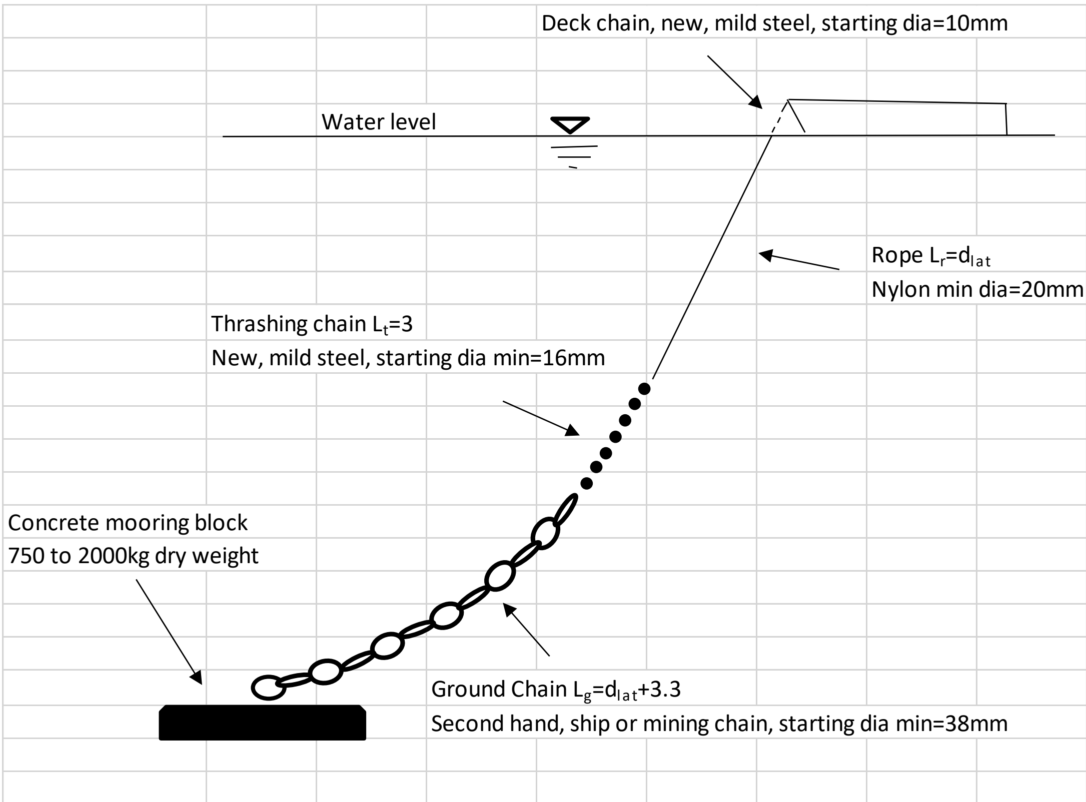
Swing radius = 3+LOA

Where LOA=overall length of boat

Further, an allowed over lap of 1.5m has been found to be satisfactory.

Appendix A

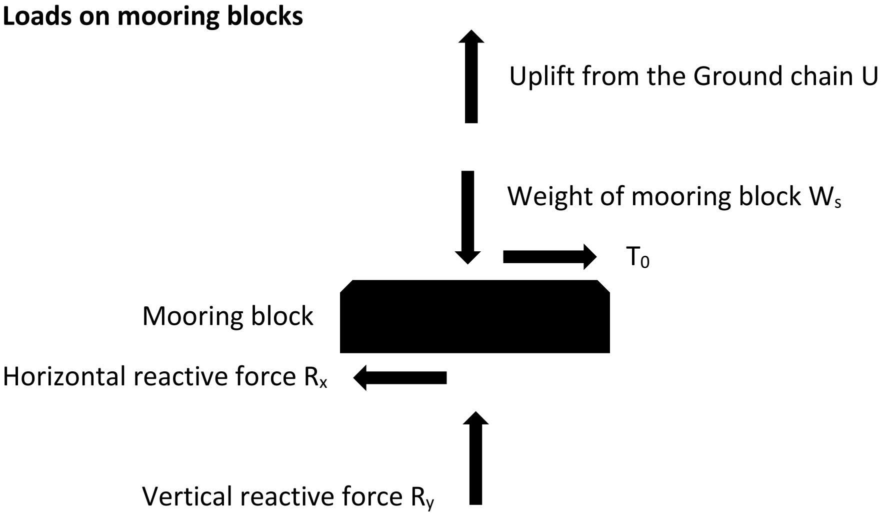
General mooring arrangements



Where: L_r = length of rope L_t = length of thrashing chain L_g = length of ground chain d_{lat} = depth of water at lowest astronomical tide

Appendix B

Loads on mooring blocks



Where:

U=uplift force applied by the tackle W_s=submerged weight of the mooring block R_x=horizontal reactive force between the harbour bed and the mooring block R_y=vertical reactive force between the harbour bed and the mooring block T_0= tension mid span or total load from wind and wave on the boat