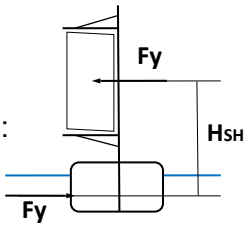
RIG STRUCTURE LAY-OUT

Sailing Rig Loading and Heeling

A sailing rig structure is loaded by the wind pressure on the sails. The load is limited by the stability of the vessel's upright floating position, i.e. the dynamic heeling moment due to the wind pressure on the sails must be balanced by the static righting moment of the hull at a safe and allowable heeling angle.
The heeling moment M_H due to the wind pressure **p** on the sail area **As** and the height H_{SH} of the lateral sail force over the lateral hull force is: $M_H = p \cdot As \cdot H_{SH}$
the righting moment M_R due to heeling of the hull of total weight $W = g \cdot \Delta$ at an angle ϕ with a metacentric height **GM** is: $M_R = W \cdot GM \cdot \phi$
The heeling angle for the balanced condition $M_H = M_R$ is:

$$\phi = p \cdot As \cdot H_{SH} / (W \cdot GM)$$



or the lateral wind force **Fy** is limited according to the limiting heeling angle ϕ:

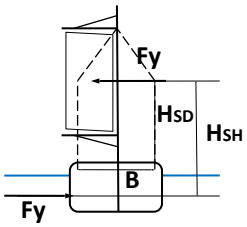
$$Fy = p \cdot As = W \cdot GM \cdot \phi / H_{SH}.$$

Pre-Tensioning the Standing Rigging

The standing rigging consists of the trapezoidal stay system of Fore-Stay, Top-Stay and Aft-Stays in longitudinal direction; and of the Upper- and Lower Shrouds in transverse direction.

If the shrouds are pre-tensioned by ΣF_{ZO} on port- and starboard side, the heeling moment due to the horizontal wind force **Fy** on the sails will cause a horizontal shift of the vertical shroud tension from the leeward shrouds to the windward shrouds by -+$\Sigma\Delta F_Z$:

$$\Sigma\Delta F_Z = M_H/B = Fy \cdot H_{SD}/B$$



as long as $\Sigma\Delta F_Z < \Sigma F_{ZO}$ until the leeward shrouds are falling slack.
This limit is reached, when the heeling moment M_H reaches the value:

$$M_H = \Sigma F_{ZO} \cdot B,$$

with **B =** ship's beam or spacing of the shroud's chain plates.

The heeling moment M_H is balanced by the hydrostatic righting moment M_R:

$$M_R = W \cdot GM \cdot \phi \; != M_H = \Sigma F_{ZO} \cdot B,$$

and the resulting heeling angle ϕ is prescribed as a limiting condition:

$$\phi = M_R/(W \cdot GM) = \Sigma F_{ZO} \cdot B/(g \cdot \Delta \cdot GM).$$

The heeling moment M_H is caused by the wind pressure **p:**

$$M_H = p \cdot As \cdot H_{SH} \qquad \text{with: } p = 1/2\ \rho_A \cdot U_A^2 \cdot Cy,$$

at an apparent wind speed U_A of:

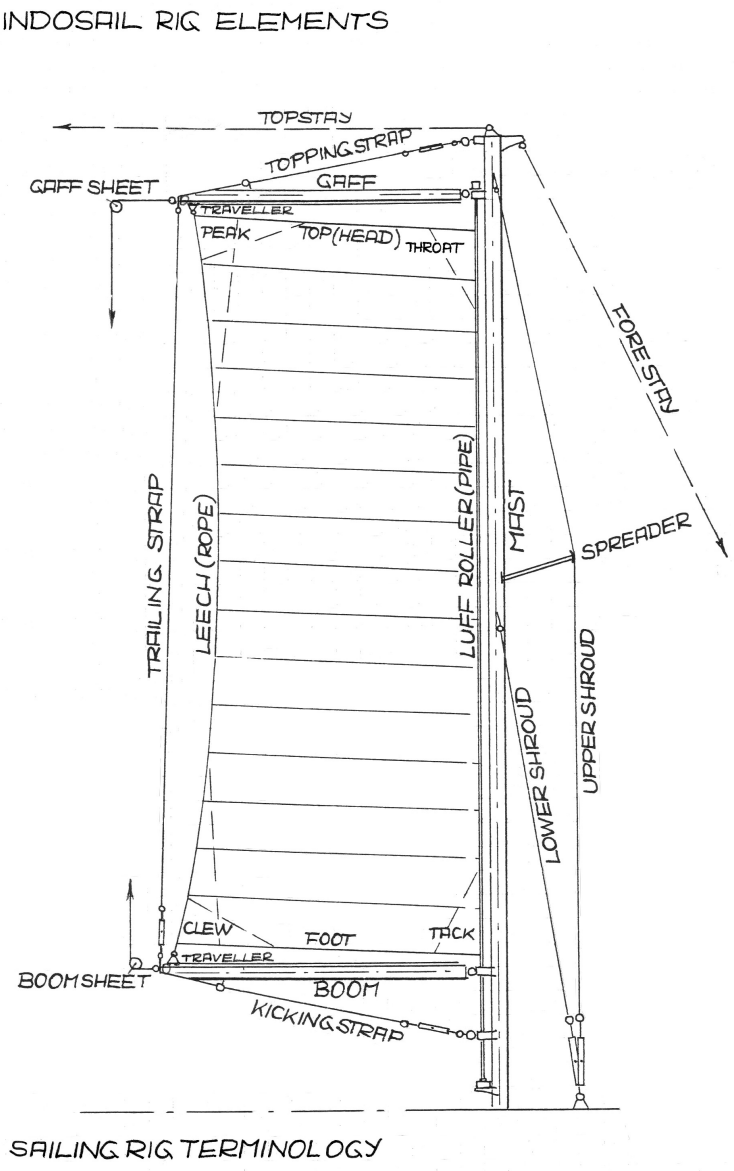
$$U_A^2 = p/(1/2\ \rho_A \cdot Cy) = M_H/(1/2\ \rho_A \cdot Cy \cdot As \cdot H_{SH}).$$

The longitudinal stay system of a single forestay, double top-stays and double aft stays is also pre-tensioned to prevent whipping of the masts in case of heavy pitching motions.

The pre-tension forces are determined according to the pitching accelerations and inertial forces as specified by the class regulations.

The Pre-Tensioned Sail Frame – The Suspension Effect

The Suspension Sails are opened, trimmed, reefed and furled within a movable sail-frame, made up of the mast, the boom with kicker, the gaff with topper and the trailing strap between the peaks of boom and gaff.



The almost rectangular gaff-sails are unfurled from luff roller pipes at the rear side of the masts, between the goose necks of boom and gaff. The leech is held by strong, curved leech rope in the hollow-cut roach seam between traveler cars on the boom and under the gaff. This curved leech rope carries the horizontal cloth tension in the same way as also the cambered sail cloth profile carries the wind pressure, both by the suspension bridge effect. (See under ‘Suspension Effect sails’).

The Trailing Strap between boom & gaff is pre-tensioned with a force equal to the tension that the parallel leech rope attains in the limiting load case of the sail. In this case, the leech rope takes over the full tension load from the trailing strap and the unloaded strap starts to fall slack – a visible signal to start reefing the sail and a more direct signal than the heeling angle in the close-hauled conditions.