C4 self - steering system – HABER 800C4, HABER 34C4

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1. Threats during downwind navigation in a strong wind on a typical modern sailing yacht with an outside ballast.

A typical modern yacht with an outside ballast has a positive righting moment up to a heel angle of about 130 o-140 o. In case of capsizing, the yacht of this type will remain at this position because it achieves negative values of the righting lever. In a typical modern sailing yacht with an outside ballast the maximum values of negative righting levers are usually about 40% – 50 % of the maximum positive righting levers. To recover to the keel-down position from the 180° heel, such a yacht must receive an impulse from outside (e.g. an additional hit of a wave of sufficient energy), this impulse will force the yacht to an angle smaller than the angle corresponding to the righting lever at the 0 value (less than 130 o-140 o) in the direction of the positive value of this lever. See fig. 4.

Excessive heeling like this can occur while navigating on especially high and steep waves. Typical modern sailing yachts with an outside ballast sailing downwind are especially vulnerable to potential capsizing. On a broad reach, while going down the wave, there is a tendency for the boat to round up, which is caused by rising of the stern, the waves hitting it and the boat heeling to the leeward side simultaneously. This causes acceleration of the yacht on the face of the wave and rounding of the stern, which in consequence leads to turning of the yacht towards the wind and displacement of the center of the wind pressure on the sails. This displacement in turn increases the horizontal distance (the lever hauling the yacht up “r”) between the center of the wind pressure on the sails (component F of the P force working forwards) and the center of the resistance of the hull in the water (the R force working backwards). The result is a combined force which drives the yacht windward. Affected by these forces, the yacht changes its course (hauls up) in relation to the wind and the wave, but partially retains its previous direction, “remembers” its old course for a short time after hauling up. The “tripping” effect occurs – pulling the yacht by the surface of the ballast fin (see fig.1.1). The yacht cannot slide with the wind (sideways) because the surface of the ballast fin creates hydrodynamic lift and lateral resistance. The dynamics of this process is also a significant factor which is hard to measure. It also causes mass centrifugal forces in the mast rigging which increase the heel and consequently the hauling up.

It is possible to counteract the above through adequately early countering with the rudder – before or when the wave begins to lift the stern. If the reaction to the incoming wave is delayed (or if the wave is especially dangerous), the yacht will point closer to the wind and turn its side to the wave. The yacht has a considerable speed at this time. With a side facing the wave, the yacht can be heeled by the wave significantly, laid down with its mast on the water or rolled over by breaking wave in a particular case.

The delay may be due to tiredness or a failure to predict a particularly dangerous wave. With an unusually large and steep wave the yacht can roll over. A typical modern sailing yacht with an outside ballast can only right itself if one of the incoming waves forces the yacht to heel back until a positive righting moment occurs (see fig. 4).

A capsize of this type (a rollover) as well as an overturn (also while sailing downwind – on the running course) can cause the loss of the mast or serious damage to the rigging and other parts. The moment the mast hits the water, forces resembling shock forces occur. The rigging experiences stress which is a multiple of the regular stress caused by the working sails. It is especially dangerous when the mast is tall - the linear velocity of the mast top is directly proportional to the square of the distance from the axis of the rotation of the yacht during the capsize. A shorter mast is safer.

A typical modern sailing yacht with an outside ballast can be positioned with its side to the wind also in case of loosing control of the yacht due to damage to the steering device. The most common cause of a breakdown of the steering device is overloading it with hard work during permanent, strong countering while sailing downwind and with the wave.

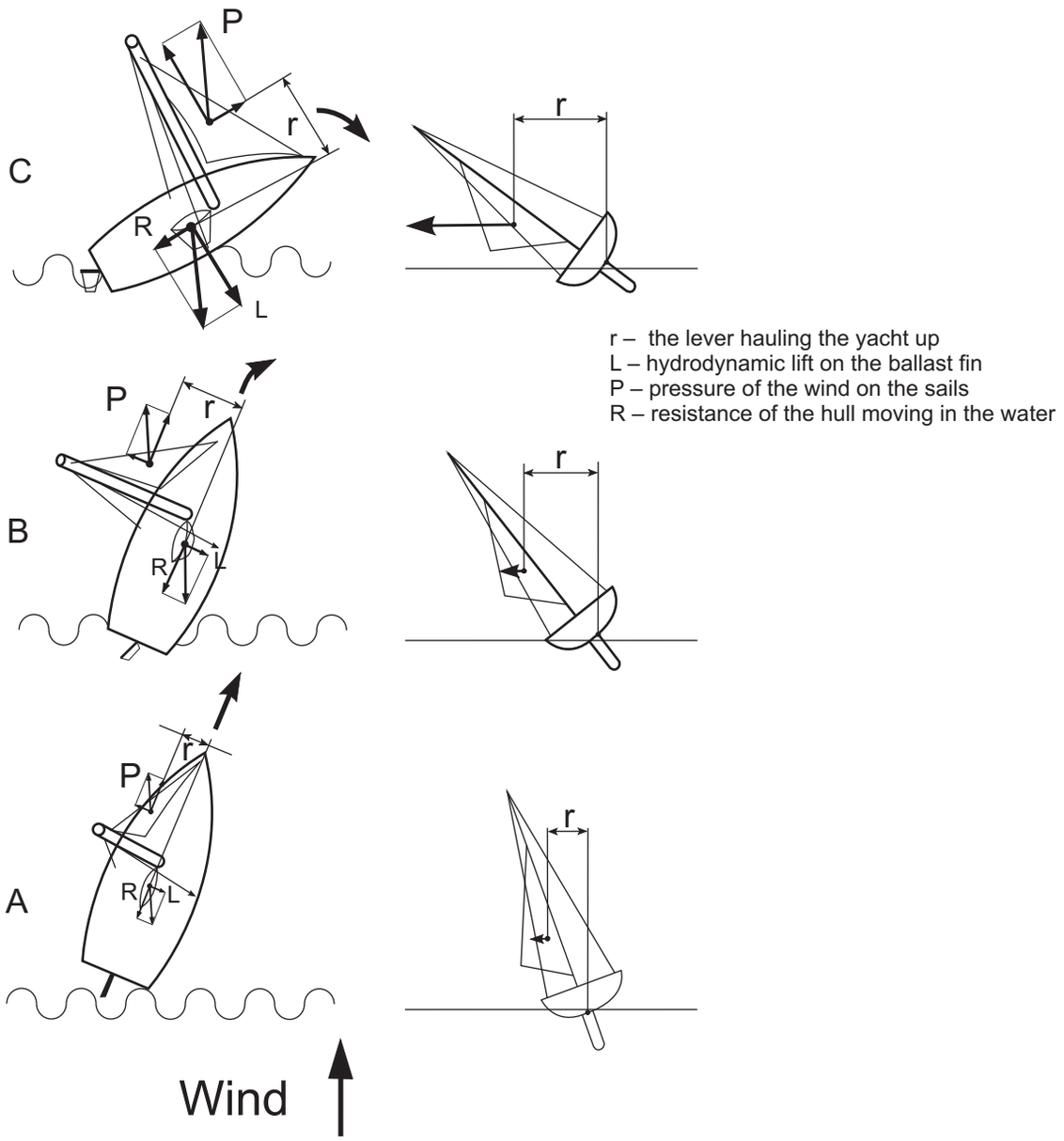


Figure 1.1. The hauling-up and the effect of "tripping" during downwind navigation in a strong wind on a typical modern yacht with an outside ballast

2. Threats in navigation close to the wind in a strong wind on a typical modern sailing yacht with an outside ballast.

During navigation close to the wind in stormy conditions there occur a number of phenomena which, in extreme cases, can render a typical modern sailing yacht with an outside ballast incapable of gaining height. As long as the strength of the wind allows the use of the smallest trysail and jib, the yacht will be well balanced in terms of the sails and will be capable of sailing windward. However, as the wind strength increases, the surface of both sails may turn out to be too large. The helmsman then has to decide which sail to take off .

If he decides to leave the trysail on, the yacht will be propelled by the less effective sail in comparison with the jib. Furthermore, the helmsman will be forced to counter with the rudder very strongly to prevent the hauling up of the yacht, which will decrease the yacht's capability to hold to its course and will increase leeway. It may turn out that it is impossible to sail any closer to the wind than a close reach or the beam reach. After taking the leeway into account it may turn out that the yacht does not gain the height and sticks to the windward shore.

If the helmsman takes off the trysail and leaves the jib on, the speeding yacht will hold to the windward course

until it gets hit by a wave. If this situation repeats for several consecutive times, or if a single wave that comes next is strong enough, the yacht will lose its speed and will be positioned with its side to the wave. The lead of sail will be too big for the yacht to be able to hold to its course at a speed which is too small (after slowing down due to the waves), and in consequence, the yacht's bow will be shifted to the beam reach. In order for the yacht to gain speed, the helmsman will have to loosen the jib and then, as the yacht picks up speed, to make the yacht haul up, and haul in the sail. As long as the helmsman finds the way between the crests of the waves, he will be able to sail windward. However, the moment he does not find the way between the crests of the waves, the yacht will be hit by one of them. It will lose its speed again and the helmsman will have a limited choice. If after the first hit of a wave, subsequent hits occur, the yacht will be positioned with its side to the wind again. Repetition of such a situation leads to the crew's exhaustion. The yacht may not gain height and may be carried off its course by the wind.

The basic problem is that such a yacht needs a considerable speed necessary to haul up and therefore it attacks the waves at a great speed. The distance between the center of effort and the center of lateral resistance is too big and the yacht, hit by the incoming wave, slows down, and then gets turned by the wave to a beam reach. The relatively great speed of the yacht which is necessary to keep it on its windward course exposes the yacht to big loads when it is hit by the waves. This may lead to damage. Another dangerous moment occurs when the yacht is positioned with its side to the incoming, collapsing waves. The yacht's speed is then too small and the yacht itself becomes difficult to control. A wave collapsing at such a moment can cause a lot of damage. With its side to the wave the yacht can be heeled significantly by the wave, laid down with its mast on the water or rolled over in certain circumstances.

3. Directional stability – experience.

About 24 years ago I was coming back from a holiday cruise from Lake Jeziorak heading for Gdańsk on Karolinka, a cabin centerboard yacht (5.75 m) with a very shallow draught. The yacht did not have any inside ballast and was capsizable. Throughout the previous week we had been sailing in typically inland conditions, in highly changeable winds coming from quickly changing directions. It was all very pleasant but I soon started missing the open water and a clear wind. We decided to sail to Vistula Lagoon (Zalew Wiślany), east of Gdańsk. I sailed on a broad reach from the estuary of the Elbląg River to the point where you enter the Nogat river. The wind increased relatively quickly from 3B to 7B. The sea began to build up and started tossing the boat dramatically. The sailing was becoming more and more difficult and I raised the centerboard almost completely. Even then it was difficult to keep the yacht on a broad reach course.

The challenging conditions were making the situation increasingly dangerous - I had to reduce the area of the sails. Pointing directly into the wind and taking the mainsail off was simply not feasible and would pose a real threat of capsizing. The only possibility was to take the foresail off. The crew mate on board had no sailing experience. I explained to him the steering of the yacht, watched him for a short time to make sure he was able to steer the boat safely and I left the cockpit. I had to return quickly to the cockpit to save the boat from jibing, in the nick of time. I repeated my explanation about the challenges of steering in those conditions and tried to take off the sail for the second time. Finally, at the fourth attempt, we succeeded. We managed to pull the foresail down – we survived!

I have remembered this incredible experience ever since and the memory of this has always been with me. This memory made me think about a safe yacht with a shallow draft on which you can sail one day on inland waters and the next day on the Baltic Sea and beyond.

The first thing was to ensure sufficient stability. By means of using appropriate weight of the inner ballast it is possible to achieve stability which meets requirements of a classification society.

The next issue was the directional stability – the thought which never left me. On the next boat I made, Zośka 6.7m, I designed and built a stern centerboard that could easily be lifted. Because of lack of time and proper motivation immediately afterwards I did not install it or test this item myself. My friend Zbyszek Gołębiewski saw the new part and used it on his Chochlik (7.5m) on which he sailed from Gdańsk to Kiel soon after I had designed the centerboard. During the trip he experienced an 8B quartering wind and used the stern centerboard for the first time. He was absolutely thrilled with the performance of the boat and he was sure the stern centerboard allowed for a much safer, more comfortable passage in very difficult sea conditions.

At that time I was involved in the design and construction of Absolwent 900 (9m) – an ocean-class centerboard yacht. In the final stage of the preparation for sea tests in October 1994, I remembered my previous experience with directional stability. Because of the significant difference in the design and the equipment, I could not use the central stern centerboard so I devised a different solution - two stabilising centerboards fixed to the transom. They were hinged and fixed to lifting lines allowing their easy withdrawal from the water in a semi-circular motion. During tests on the Gulf of Gdańsk the results exceeded my expectations. The wind was coming from the Gulf of Bothnia, the wave was coming from the open sea into the Gulf of Gdańsk and was building up quickly. Initially, the wind was 5-6B and quickly increased to 8-9B. The boat was on a broad reach experiencing wave heights from 3 to 4 m. The yacht was rigged with a foresail and a flat mainsail reefed to the first reefing points. After lowering the centerboards on the transom into the water and raising the main centerboard, the yacht achieved self-steering and gained speeds of up to 8 knots. We sailed like this for a long time – without even touching the tiller. The wind was blowing so hard that during the docking process in a marina in Gdynia we had to use a winch to moor to the peer. The crew of Absolwent were Tadziu Świst, Stefan

Ekner, Wojtek Kuczkowski, Józek Głębocki, Grzegorz Szczepański, Wiesiu Teska and me. The next day we were going back to Górki Zachodnie, when about 1 mile before the entrance the wind began to increase and the yacht heeled significantly, starting to round up. After lowering the leeward centerboard into the water, the heel increased but the tendency of the yacht to round up disappeared altogether.

On 7th of December 2005 I had a chance to sail on HABER 800 on the Adriatic Sea in Slovenia. We had the Bora wind (a local wind coming down from the mountains) of up to 4-6B of strength. The wind was gusty, reached 5B at times and slowed down to 1B in 3 minutes only to strengthen again to 6B after only five minutes and lasted for 1 or 1.5 hours. We fixed the temporary version of one of the stern centerboards from Absolwent to the transom of HABER 800 (because of the lack of space on the transom we could not fix the other centerboard). Full self-steering and significantly improved tracking were achieved in a range of courses from 45o to 65o- 70o to the wind. The tiller worked freely. On the beam reach and a broad reach, there was some necessity for a limited help of a helmsman which meant intermittent tending to the tiller. We made short films of this initial test. The crew during the test were Urban Rybak, Rolland Rühl and me. HABER 800 has a long shallow keel. To ensure self-steering on a broad reach course the surface of the stern centerboards must be increased (relatively to our experience during the tests on the Adriatic in December 2005).

4. Directional stability – the role of additional centerboards.

View of the under water part of the HABER 800C4 yacht with all centerboards dropped.

Full speed and full directional stability.

Relation between sail balance and directional stability.

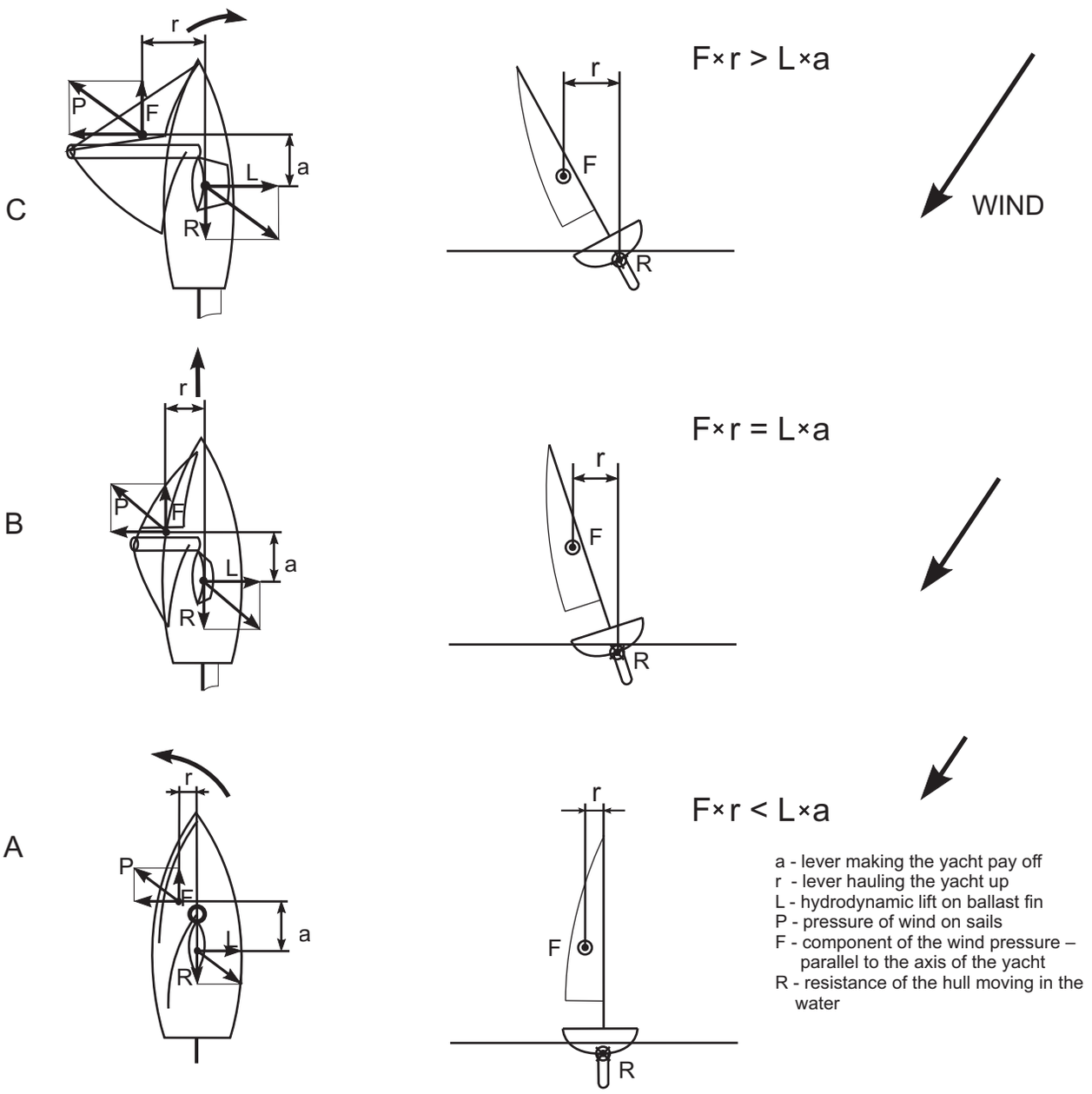


Fig. 1.2. Relation between sail balance and directional stability

Three typical states of balanced sailing yacht in relation to the strength of the wind (assuming that the sails are the same in each of the states) are shown on the figure 1.2:

A - the yacht pays off: light wind, yacht sails with no heel

B - the yacht keeps the course: the state of course balance: medium strength of the wind, moderate heel

C - the yacht hauls up: strong wind, extensive heel

Highlights and assumptions:

-the tilt of all the centerboards is smoothly adjusted in the full range from 0 to 100% of the area of each of them, -the halyards on all of the centerboards are operated from the cockpit.

-when approaching harbours and maneuvering, all the additional centerboards (the main centerboard must be left dropped) must be lifted because it is difficult to abruptly change the direction of the yacht with additional centerboards in the down position. While changing the direction of the yacht with the additional centerboards down, it is necessary to use great strength while operating the rudder, and the radius of the rudder angle is much bigger,

-it is possible to lift the additional centerboards at any time and sail "manually" or to use the autopilot.

The operation of the centerboards on HABER 800C4.

HABER 800C4 is equipped with 4 centerboards: standard pivoting main centerboard; pivoting bow centerboard and two sliding & pivoting stern centerboards.

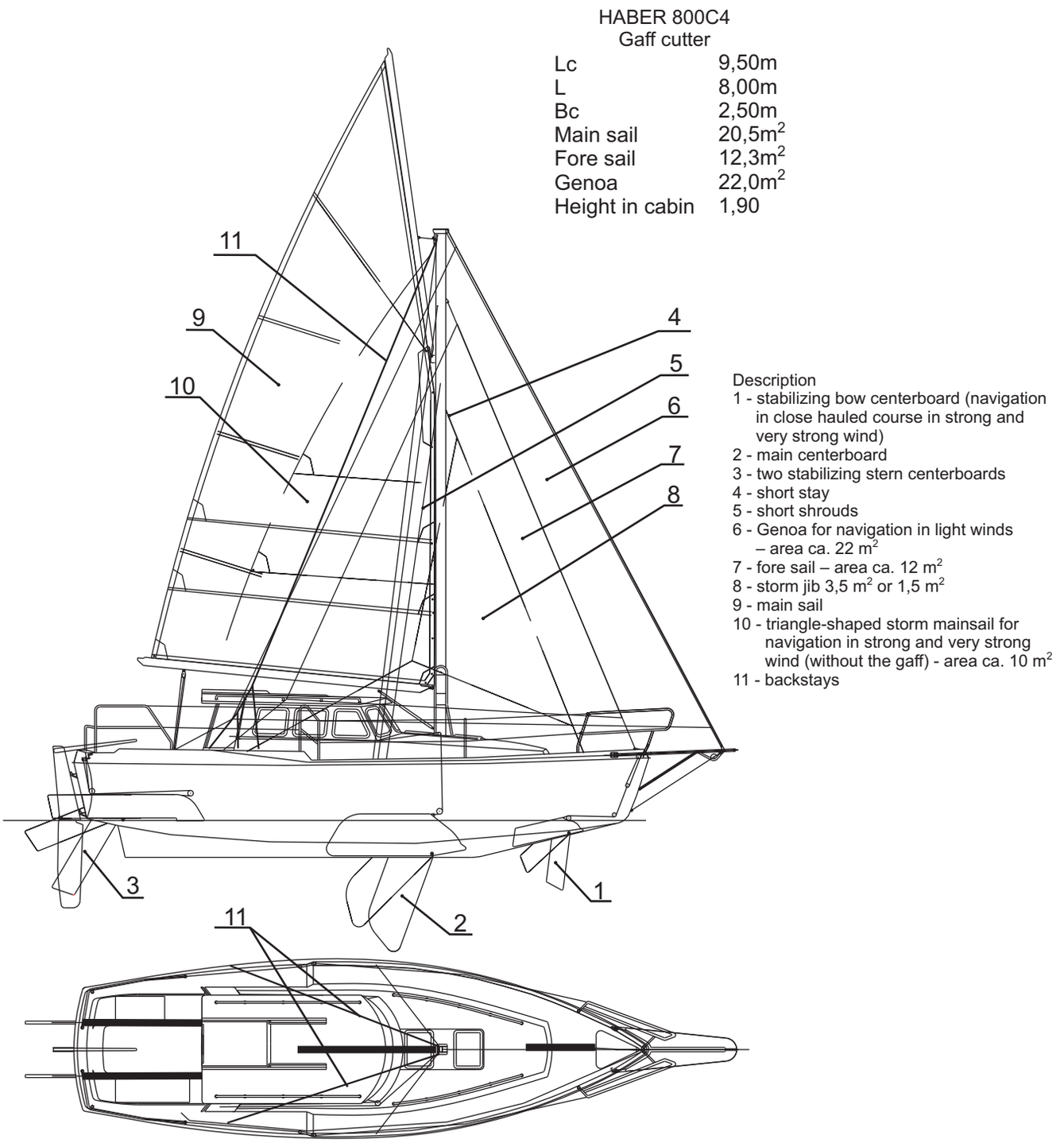


Figure no 2. HABER 800C4 with additional elements of the rigging.

The centerboards are to improve directional stability on all courses as well as to gain self-steering on courses from a sharp close haul through the beam reach and a broad reach to running inclusive.

With appropriate choice of sails to the course and to the strength of the wind and appropriate setting of centerboards we influence the distance between center of effort and center of lateral resistance ("a' on the figure 1.2). We are bringing it to the state when full course stability occurs. Distributing the area of lateral resistance on a larger number of centerboards allows the yacht to keep full course stability in a range of the wind speed. At the change of the strength of the wind by 1 B (up or down) the yacht sails correctly. Deviations of the yacht from the course are little. Coming back to the optimal course, after the strength of the wind is stabilized at the new level (e.g. 1 B more) needs a small change in setting of one of the centerboards.

System is easy, quick and practical in use – also on short distances.

After elementary experience is achieved (2 days of common sailing) 15 sec. is enough to achieve preliminary directional stability. In case of strong wind – during next 20 seconds full course stability is achieved. At the light wind c.a. 1 minute is needed

Achieving self-steering in a close hauled point of sail (45° – 50° to the wind)

To achieve self-steering in a close hauled point of sail:

- choose sails adequate to the force of the wind at this point of sail and set them properly
- adjust the centerboards adequately.

Light wind - from 0.5 to 2B

sails up: mainsail and foresail

- main centerboard dropped entirely
- stern centerboards dropped, one or two, adequately to the point of achieving directional stability

or

sails up: mainsail, foresail and genoa (cutter rigging)

- bow centerboard dropped entirely
- main centerboard dropped entirely
- stern centerboards dropped, one or two, adequately to the point of achieving directional stability

Note: reaction of the yacht to the adjustment of the sails and the centerboards at light winds can be slow and patience is required. The lighter the wind the more patience needed.

Medium wind – from 3 to 4 B

Sails up: mainsail and foresail

- main centerboard dropped entirely
- stern centerboards dropped, one or two, adequately to the point of achieving directional stability

or

Sails up: mainsail, foresail and genoa (cutter rigging)

- bow centerboard dropped entirely
- main centerboard dropped entirely
- stern centerboards dropped, one or two, adequately to the point of achieving directional stability

Strong wind – 5B

Sails up: mainsail and foresail

- main centerboard partly dropped in 50-75%
- stern centerboards dropped, one or two, adequately to the point of achieving directional stability

Strong wind – from 6 to 7 B

Sails up: mainsail on 1st or 2nd reef and foresail; (a full triangular storm mainsail can be used instead of the main gaff sail on 2nd reef)

- main centerboard partly dropped in 50-75%
- stern centerboards dropped, one or two, adequately to the point of achieving directional stability

or

Sails up: foresail

- bow centerboard dropped entirely
- main centerboard partly dropped in 25-50%
- stern centerboard ejected or dropped adequately to the point of achieving directional stability

Stormy wind – 8 B

Sails up: foresail

- bow centerboard dropped entirely
- main centerboard partly dropped in 25%
- stern centerboard ejected or dropped adequately to the point of achieving directional stability

or

Sails up: storm mainsail on 1st reef (triangle – without gaff) and storm jib 3,5 m2

- main centerboard partly dropped in 25-75% or entirely
- stern centerboards dropped, one or two, adequately to the point of achieving directional stability

Stormy wind – from 9 to 10 B:

sails up: storm mainsail on 2nd reef and storm jib 3,5 m2

- main centerboard partly dropped in 50-75% or entirely
- stern centerboards dropped, one or two, adequately to the point of achieving directional/course stability

or

sails up: storm jib 3,5 m2

- bow centerboard dropped entirely
- main centerboard partly dropped in 25-50% or entirely raised
- stern centerboard ejected or dropped appropriately to the point of achieving directional/course stability

Stormy wind – over 10 B:

sails up: storm jib 1,5 m2

- bow centerboard dropped entirely
- main centerboard partly dropped in 25-50% or entirely raised
- stern centerboard ejected or dropped adequately to the point of achieving directional stability

Paying off from a close hauled course to full courses

In order to pay off from the windward course in both strong and light winds to the beam reach or a broad reach, you need to loosen the mainsail, and then start raising the main centerboard to the point of gaining balance.

If the yacht has been sailing on a close hauled course with the genoa and the mainsail (or the genoa, the foresail and the mainsail) with the bow centerboard dropped, paying off must begin with loosening the mainsail. The next step is to raise the bow centerboard and to appropriately raise the main centerboard if necessary .

In a stormy wind and while sailing with the foresail and the bow centerboard dropped completely, you first need to raise the bow centerboard and, as the paying off proceeds, loosen the foresail. If the stern centerboards have not been dropped enough they must be dropped appropriately. The above should be continued until the directional stability (self-steering) on the desired course – the beam reach or a broad reach - is achieved.

Paying off from a close hauled course to the beam reach or a broad-reach course can be achieved by moving the center of effort forward through loosening the sails and by moving the center of lateral resistance backwards through raising the bow and main centerboards and dropping the stern centerboards. On broad-reach courses moving the rudder blade forward as much as possible can also be helpful.

To set the yacht into self-steering on the running course, the bow centerboard and the main centerboard must be raised entirely and the stern centerboards must be dropped entirely. The next step is to achieve running by using the rudder. Set the sails into the "butterfly" position. If the yacht does not sail precisely enough on the running course, the area of the leeward sail needs to be decreased or the area of the windward one needs to be increased. At the wind over 4B the yacht keeps the course very well with the genoa and the foresail set into the "butterfly" with the use of telescopic booms. Moving the rudder blade as much as possible forward can also be helpful in keeping the self-steering.

The use of the stern centerboards in running.

In running, after you have taken off all the sails and completely dropped one of the stern centerboards, the yacht sails exactly downwind. It holds to its course with great precision, and at a wind from 25 to 30 knots achieves the speed of 2.2-3 knots. While sailing on this course in storm conditions, dropping the other stern centerboard might be necessary to ensure directional stability.

Sailing without sails in running during a heavy storm is possible till the yacht starts to exceed a safe speed while sliding from the wave. It may end up with an overturn. If such a situation happens, further sailing on this course with the increasing strength of the wind becomes dangerous and impossible. The smallest jib must be put on the short stay, and, with the stern centerboards being adequately adjusted, the course should be changed into the full broad reach. The distance between subsequent waves will increase. The angle of the yacht's sliding on the wave will change into a safer one.

The significance, the use and the operation of the bow centerboard.

If sailing with the storm jib on a broad reach becomes dangerous (an increase in the strength of the wind) or there will be no place for storming downwind, a change of the technique of storming will be a solution – sailing windward with the storm jib with the use of the bow centerboard.

Application of the bow centerboard keeps the bow close to the line of the apparent wind direction at the slow speed of the yacht. A slow speed in a close haul ensures a gentler performance of the yacht on the wave. It also improves the living conditions of the crew and reduces the overall load on the yacht's construction.

Self-steering while storming on a close haul can be achieved in the following way:

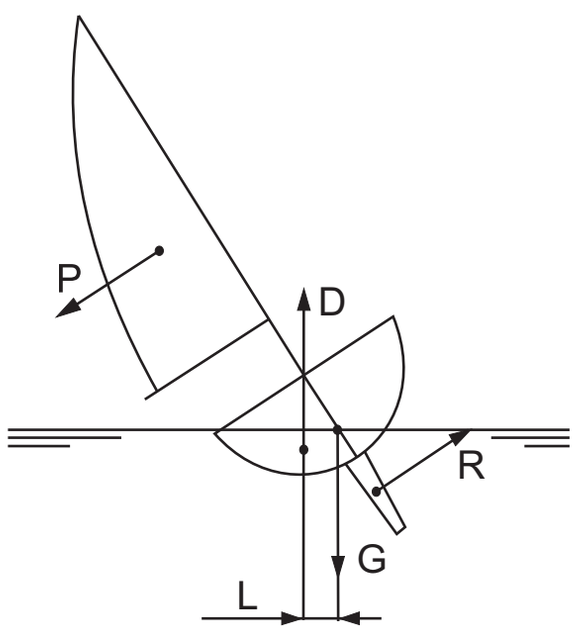
- put the short stay and the low shrouds on
- put a 3,5-m2 or a 1,5-m2 storm jib - adequately to the strength of the wind
- drop the bow centerboard completely
- partly drop the main centerboard – to ensure sufficient counteracting the leeway while decreasing the heel of the yacht at the same time
- eject the stern centerboard or drop it partly till achieving directional stability

In specific cases side centerboards can be applied. However, such a case is not described in this analysis.

5. Additional rigging elements increasing the capabilities of HABER 800C4 in ocean navigation – figure 2.

The triangular storm mainsail for heavy and very heavy winds – without gaff.
The gaff mainsail, in case of long-term heavy winds, can be replaced with the triangular storm mainsail reaching the top of the mast. The area of the sail ca. 10 m2, 2 reefs.
Stronger rigging.
Fixing additional lower shrouds and a short stay (fastened to the aft deck of the anchor locker) will make the mast stronger. It also allows for use of a 3,5-m2 storm jib and a 1,5-m2 storm jib. Because of large angles between the shrouds, the stay and the mast, the forces in the rigging are relatively small. The lower shrouds and the short stay are put on at the wind of 7B. The low center of the pressure on the sail is responsible for a smaller heeling moment. By moving the storm jib backwards to the stern (on the short stay) and cutting the foot of sail up it is less exposed to damage by the waves. It also helps to achieve a sail balance on a close haul using only this sail and having the bow centerboard dropped.
Backstays – a perfect and partly forgotten rigging element. On the cutter version of HABER 800 they run from the top of the mast to the sides near the back wall of the superstructure. They are tightened with purchases with the help of sheet winches. Apart from additional hold of the mast from the stern they significantly improve the work of the front sails. Owing to the stretch of the windward backstay, the stay, especially the front stay, have a significantly smaller bend. This improves the aerodynamics of the front sails. It increases their dragging strength and allows sailing on close hauled courses.
In heavy storm conditions, while sailing only with the storm jib, both backstays should be tightened, which makes the whole rigging much stronger. It also provides extra security to the crew and protects them from falling overboard.

6. Stability characteristics of HABER 800.



P – pressure of the wind
R – hydrodynamic lift on ballast fin
D – buoyant force
G – gravity force
L – righting lever

Figure no 3. The righting lever

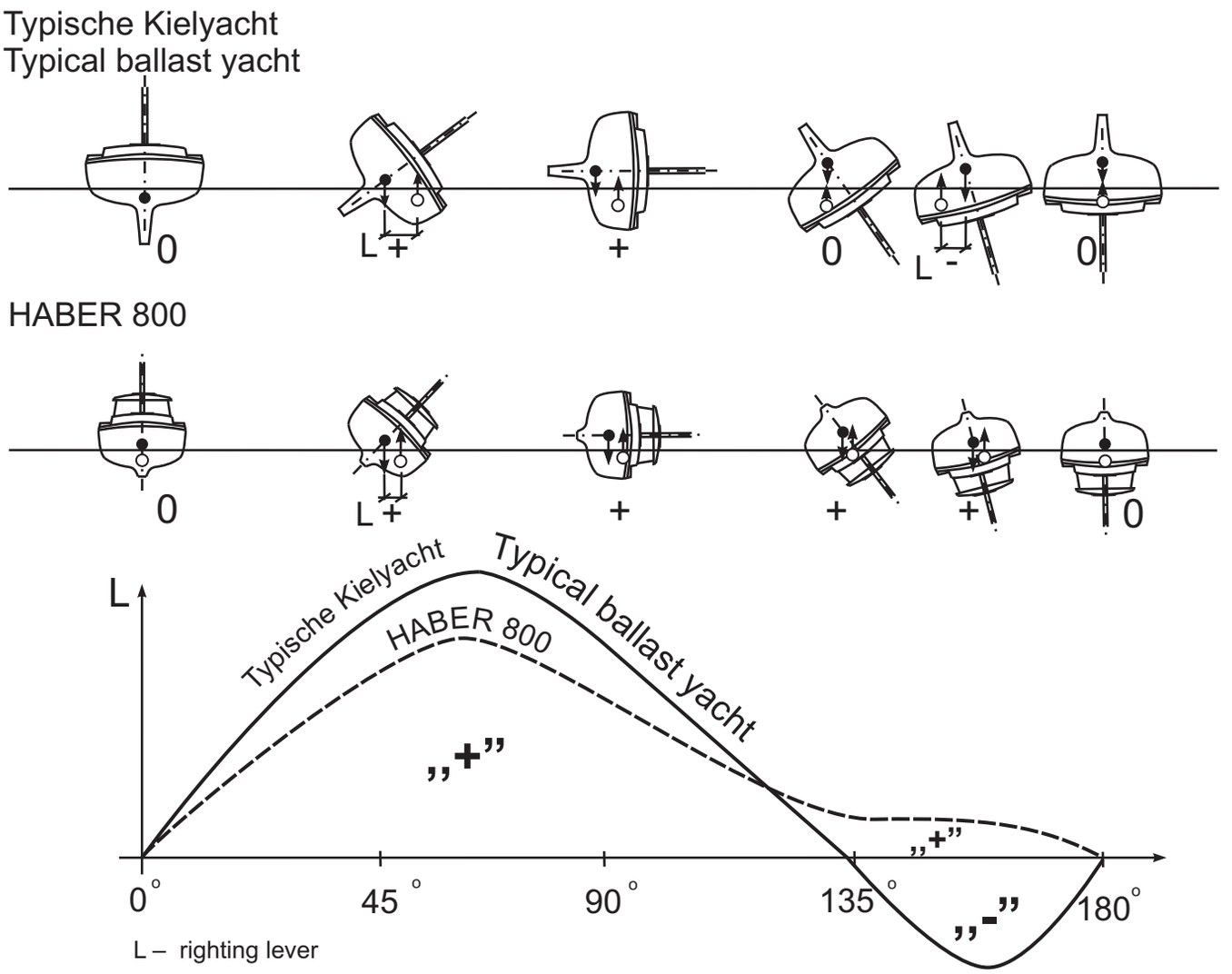
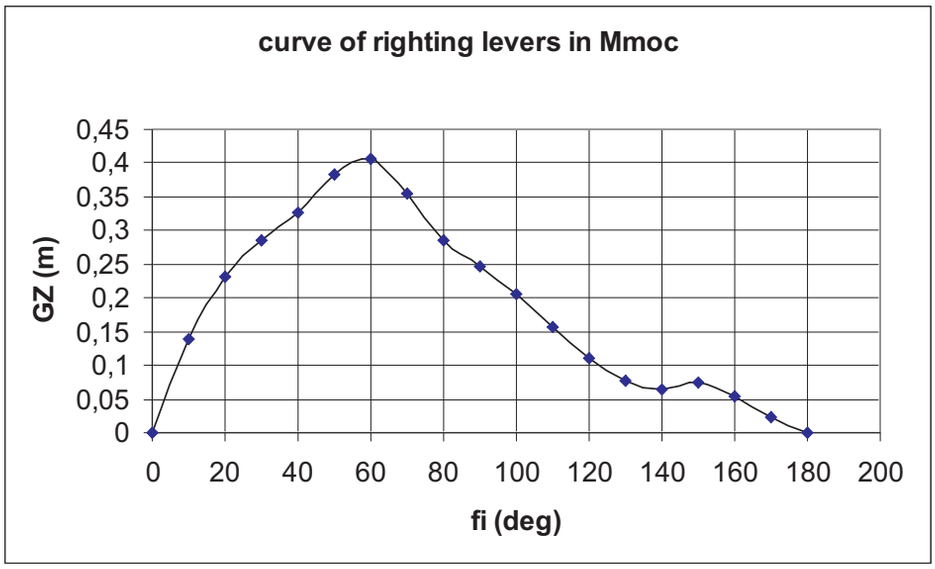


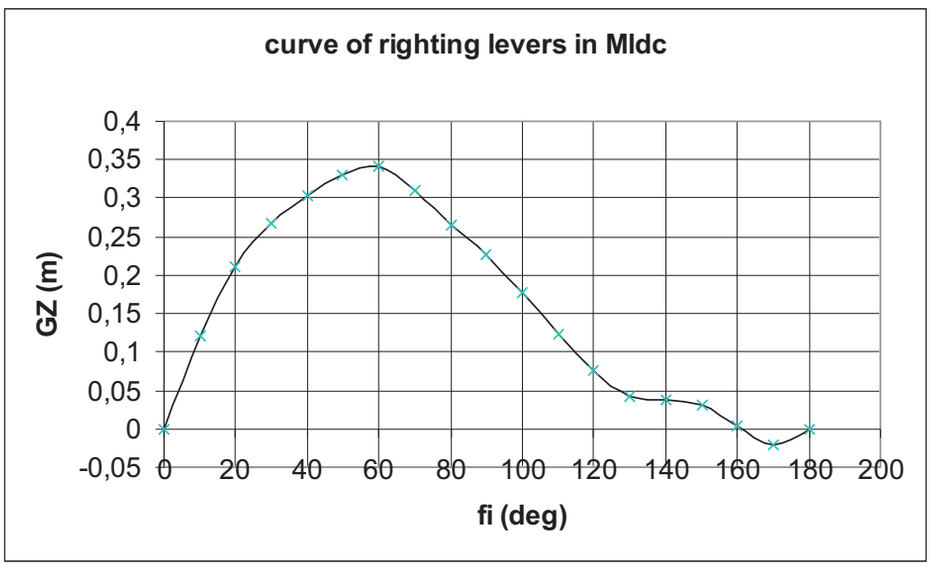
Figure no 4. The curve of the righting levers - comparison.

A typical modern sailing yacht with an outside ballast has a positive righting lever up to the heel angle of ca. 130 o - 140 o. Above this heel angle the righting lever achieves quite a large negative value of even up to 50% of the value of the maximum positive righting moment, reaching zero at 180°. See figure 3 and 4.
HABER 800 in the loaded displacement condition (5 people on board) has a positive righting moment in the heel angle range from 0o to 162 o. The biggest negative righting lever is achieved at the 170 o and equals 0,02 m, which is no more than 6% of the maximum positive righting lever.
HABER 800 in the minimum operating condition (1 person on board) has a positive righting lever in the heel angle range from 0 o to 180 o. The curves of the righting levers for both these situations are shown in figure5.
The difference in stability between a typical modern sailing yacht with an outside ballast with a low superstructure and HABER 800 (especially at heel angles above 80 o) is caused by a considerably high superstructure "entering" into the water. The length-to-beam ratio is another element which has a big influence on the characteristics of the curves of the righting levers (see figure no. 4).

ATTENTION. Basic assumption: the stability of the yacht, regardless of whether it is a yacht with an inner ballast or with a ballast as the outer keel, meets the requirements of classification societies. In the common sailing jargon the expression 'uncapsizable yacht' is often used.



The curve of righting levers in minimum operating condition (1 person on board).



The curve of righting levers in loaded displacement condition (5 people on board).

Figure no 5. The curve of righting levers – HABER 800.

7. A comparison of the properties of the HABER 800C4 type and a typical modern sailing yacht with an outside ballast - conclusions.

The choice of sails:

Sailing in light winds (0 – 2 B) – the choice of sails

HABER 800:

Sails for all the courses in light winds:

- large mainsail with the area of about 21 m2
- foresail with the area of about 12 m2
- genoa on a roller for light winds on the forestay – the area of about 16 m2
- the gaff sloop version
- genoa on a roller for very light winds on the forestay – the area of about 22 m2
- the gaff cutter version

With the full use of a large genoa, the telescopic genoa boom is very useful. The telescopic genoa booms significantly improve the efficiency of the front sails from downwind courses to a close hauled course. The sails are durable and easy to use.

A typical modern sailing yacht with an outside ballast:
The mainsail and a large genoa are used in close hauled sailing.
Gennakers and spinnakers are used in sailing from the beam reach to running.
The sails have relatively complicated equipment. The crew must be fit to operate it.

Sailing in medium winds (3 – 5 B) – the choice of sails

HABER 800:
Sails for close hauled courses in medium winds:
- full mainsail or mainsail on the first reef - the area of around 16-17m2
- genoa or foresail on the stay – the area of around 12m2

Sails for full courses in medium winds:
- 21-m2 mainsail
- large genoa on the forestay with the area of 16 or 22 m2

A typical modern sailing yacht with an outside ballast:
Sails for close hauled courses in medium winds:
- mainsail, medium genoa or foresail.

Sails for downwind courses in medium winds:
- mainsail and medium gennaker or spinnaker

Sailing in strong winds (6 – 7 B) – the choice of sails:

HABER 800:
Sails for close hauled courses in strong winds:
- mainsail reefed on 1st or 2nd reef (ca. 15,5 m2 or 12 m2) and foresail or only foresail
- gaff mainsail, which in case of long-term heavy winds can be replaced with a triangular mainsail reaching the top of the mast. The area of ca. 10 m2, 2 reefs.

Sails for downwind courses in strong winds:
- full mainsail or mainsail on 1st reef and foresail

A typical modern sailing yacht with an outside ballast:
Sails for close hauled courses in strong winds:
- mainsail reefed on 1st or 2nd reef and foresail

Sails for downwind courses in strong winds:
- full mainsail or mainsail on 1st reef and small genoa or foresail

Sailing in very strong winds (from 8B up) – the choice of sails:

- Close hauled sailing in very strong winds

HABER 800:
After dropping the bow centerboard, sailing on a close haul is only possible with a front sail chosen adequately to the strength of the wind – a foresail or a storm jib. The bow centerboard helps keep the bow close to the line of the wind. The yacht does not pay off and the helmsman does not have to haul up.

A typical modern sailing yacht with an outside ballast: Because of the permanent position of the lateral center of resistance (fixed keel), it is necessary to use a reefed storm mainsail or a trysail and a front storm sail in order to keep the course in close hauled sailing.
The problem starts when we can no longer have the smallest front storm sail or the trysail or the storm mainsail reefed on the last reef. We are forced to make a choice: which sail to keep? However, only with the trysail on, the yacht does not have enough power, is hauled up, and achieves the height with difficulty.
Only with the jib or the storm foresail on, it is very difficult (and virtually impossible in the long term) to keep the bow of a traditional sailing yacht close to the line of the wind.
Manual steering is necessary in order to find the way between the breaking crests of the waves. If the helmsman does not find the way between the crests of the waves, the yacht slows down while going through a wave. After 2 or 3 passes through the waves in short periods, the yacht loses the speed (and steering qualities) and is positioned with its side to the wave (a very dangerous position – a breakdown of a wave can roll the yacht).
The help of the helmsman in hauling up after paying off is necessary. After positioning the yacht with its side to the wave the speed is so low that hauling up is only possible after loosening the foresail and accelerating the yacht. Only then is hauling up and hauling the sheet of the front sail possible.

Making these manoeuvres in storm conditions is a big burden for the crew. If this situation repeats, the crew looses energy very quickly. If the yacht is pressed by the wind to the shore the situation can be critical.

Sailing downwind in very strong winds (running and broad reach courses):

- HABER 800:
  HABER 800C4 has a unique ability to sail downwind with a fantastic accuracy, keeping the course with its stern centerboard lowered and without the sails. In the wind of 30 knots the yacht reaches the speed of 2,2-3 knots, with the deviation from the course not exceeding 5°. You can also put up an adequately chosen storm front sail and sail on a broad reach course. Thanks to this ability the yacht has incredible capabilities in storming when running, ensuring at the same time comfort and safety.

  A typical modern sailing yacht with an outside ballast:
  A very difficult and dangerous course for this type of yachts. It is very difficult to maintain the yacht safely on a downwind course. The helmsman has to be extremely focused all the time. The strong broaching effect occurs, posing a threat of the yacht's "tripping" the moment the yacht has gone more windward. There is a possibility of serious damages. This situation is described in details in part I of this study.

Other important properties:

A threat of loosing the mast during a capsize or when the yacht is rolled by a wave:

HABER 800:
Minimal threat – a low mast and very simple and uncomplicated rigging (without spreaders). It is possible because of the use of the huari type of gaff rigging. An important characteristic is a large mainsail area with a relatively low mast. Using additional low shrouds, a short stay and backstays increases the capability of the rigging to survive a capsize in good condition. Additionally, a storm jib with the area of 3.5 or 1.5 m2 can be mounted on the short stay for sailing in storm conditions.

A typical modern yacht with an outside ballast:
Significant threat of serious damage to the rigging.

Capability of returning from the 180° heel (mast down)

HABER 800:
A unique characteristic of the stability of the HABER type – both HABER 800 and HABER 660 right themselves immediately from 180° to the keel-down position.

A typical modern sailing yacht with an outside ballast:
Typical wide modern sailing yachts with flat decks and a fixed outside ballast lose the positive righting lever at 130° - 140° heels. It means that if the yacht is rolled by the wave (situation described in the part 1 and 6 of this study), the yacht will not right itself from this heel.
This situation on the sea is not only hypothetical. It has happened to many yachts. According to an analysis carried out by the University in Southampton, a yacht which is positioned with its side to the wave can be "rolled" by a wave whose height equals 30% of the length of the waterline of this yacht.

Possibility of self-steering:

HABER 800:
The yacht HABER 800C4 has a self-steering possibility from a close haul, through the beam reach and a broad reach to running. The correct choice and set up of the sails as well as the set up of centerboards adequate to a given course are necessary. The yacht keeps the course in relation to the wind and in case of any change in its direction it follows it. It immediately detects even the smallest change in the direction of the wind. The yacht achieves about 0.5 to 0.8-knot increased speed compared with manual steering. It works much better on the wave as well. A difference in the quality of the work of the boat can be felt in all courses – it is particularly impressive in sailing windward and against waves.
This system of achieving self-steering works well in light, medium, strong and very strong winds –there are virtually no limits to the strength of the wind. Apart from a small effort of muscles necessary for setting the centerboards up, there is no other source of energy needed. The yacht has a unique ability to sail on the running course with its stern centerboard lowered and without sails, holding to its course with fantastic accuracy at the

same time. It is helpful to have an alarm device providing information about the yacht's deviation off its geographic course beyond the assumed normal changes resulting from change in the direction of the wind or its strength – a course alert.

A typical modern sailing yacht with an outside ballast: Occasional directional stability is achieved on some courses, but usually special electronic steering devices and electric or wind devices updating the course automatically are necessary. In case of electric and electronic devices – significant dependence on electric energy. Proper work of charging devices is a problem especially in storm conditions. In case of electric Autopilots, they need the most energy in rough conditions. There is also a problem of the quality of the autopilot's steering on irregular waves.

Condition of the crew in sailing

HABER 800:
One advantage of self-steering is that in a strong and very strong wind, the yacht is relatively easy to handle and therefore does not make the whole crew excessively tired. It also makes long trips possible when there is only one person with sailing experience who can run the yacht - other members of the crew can limit themselves to assistance in sailing the yacht and to other onboard activities. The self-steering improves the safety of the yacht and the crew to a large extent, especially in storm conditions on all courses.

A typical modern sailing yacht with an outside ballast:
A necessity of harder work of the crew or the use of automatic steering devices. In situations created by a strong and very strong wind, automatic steering devices will not be able to control the boat and the crew's effort to control the boat will be necessary, which means the members of the crew have to be present and working all the time on board. Such a situation requires a bigger number of well-trained people. Loading these people with work connected with keeping the course and with operating the sails leads to quick exhaustion and a decrease in their efficiency. In effect it can cause a big threat to the safety.

Sailing in shallow waters:

HABER 800:
Due to a relatively shallow draught the yacht has a capability to sail in shallow waters, canals and rivers. For HABER 800 in the design category C and B the minimum water depth is 0,7 m. HABER in the design category A, depending on the ballast version, needs 0,75 m of depth or ca. 1,1 m.

A typical modern sailing yacht with an outside ballast:
There is a limited ability for a fixed keel boat to sail in shallow waters with depth greater than the draught of the keel. For a yacht of the length similar to that of HABER 800 it usually means 1,7 m.

Visibility from the cabin (from inside)

HABER 800:
Excellent visibility in all directions without opening the companionway or walking outside.

A typical modern sailing yacht with an outside ballast:
Usually lack of visibility forward, limited side visibility, fairly good visibility aftward through the companionway.

Conditions in the cockpit and on the deck:

HABER 800:
A very firm, glazed and high superstructure naturally protects the crew from the wind and rain. While sailing windward the cockpit is very silent regardless of the strength of the wind. The long roof of the superstructure provides a dry interior even during long-term rain.
The deck of the yacht, which is placed low in relation to the water level, ensures movement of the people on board on a small radius during swaying and lowers the center of gravity. Owing to the high superstructure, the handrail fixed to its roof is always close at hand while walking on the comfortable gangway towards the mast. Together with the firm storm rail it provides very good safety conditions for those working on board.

A typical modern sailing yacht with an outside ballast:
The superstructure typical of such a yacht does not give the feeling of safety to the people moving on board. In order to protect the crew from the wind and water sprays, canvas covers with plastic windows (sprayhoods) are installed. However, such covers cannot stand heavy conditions or are just removed. On yachts of the size of HABER 800 the deck is positioned higher owing to the high sides, which in turn raises the center of gravity of the

yacht and the people on board. The people moving on the deck are further from the center of the turn of the yacht and sway on a bigger radius. Comfort and safety on board are not very big – it is necessary to use very good personal means of security.

Threats of resonance in longitudinal sway of the yacht on the wave .

HABER 800:

Threat is not big, it occurs only in sailing at the close hauled point of sail in strong wind in shallow waters. In such a situation it is enough to pay off ca. 10-15 degrees from the most possible close hauled point of sail. Excessive sway calms down immediately.

A typical modern sailing yacht with an outside ballast:

This effect occurs very often. It creates pendulum effect caused by low placed ballast and movement of the yacht on the wave. The yacht looses a lot of energy when gets into resonance in longitudinal sway. Its velocity decreases and capability to sail in close hauled course also reduces. It has a very tiring influence on the crew.

Transport, winterizing, service works during the stay on the land.

HABER 800:

Easy to transport on the road. Simple boat trailer. It is possible to visit remote places in short time. Possibility of towing the yacht with comfortable conditions for 2 persons with off-road car. Big comfort while winterizing on land. Simple support – compact construction without high props. The support is very easy to store during the summer time. Easy access to the deck – the deck is placed 1,4 m above the ground.

A typical modern sailing yacht with an outside ballast:

Difficult to transport on the road. Complicated and expensive boat trailer or necessity of hiring expensive special transport. Complicated support – spacial construction with high props. It takes a lot of space during the summer time. Difficult access to the deck – the deck is placed 2,5m. above the ground.

Seaworthiness:

HABER 800:

A sturdy construction for seaworthiness, very crew-friendly. One person is enough to sail this unit in any conditions. The properties which contribute to the above are:

- capability of sailing on close hauled and running courses in any conditions which can be encountered during offshore sailing,
- ease of operation in offshore sailing and maneuvering in the harbour due to the small size of the yacht,
- application of the huari gaff: a large mainsail for light winds, a small and low storm mainsail, a short mast,
- division of sails comfortable to use, easy-to-use storm sails and large genoa on a roller on the bowsprit instead of a spinnaker,
- in relation to its size this is the unit with medium-to-big displacement – it does not react abruptly to the rough sea,
- possibility of equipping the yacht with equipment adequate to sailing in assumed sailing conditions,

A typical modern sailing yacht with an outside ballast:

Regatta's formulas have big influence on constructions of the first group of modern yachts with an outside ballast. A lot of "speed machines" did not stand and were damaged during regatta in heavy sea conditions. Events accompanying the regatta Fastnet 1979 and Sydney-Hobart 1998 could serve as an example. Many of them were left by the crew – they were very difficult to sail in heavy conditions. Due to their light construction and the resulting strong reaction to the waves the condition of the crew deteriorates.

The second group – the most numerous – they are mostly the yachts built for chartering. The most desirable feature of these units is the maximum personal load capacity and low cost of production. They are very rarely seaworthy units. They cope with heavy conditions similar to the yachts from first group.

The third group of units are the ones being built based on the experience of generations of boat builders, e.g. Nauticat, Sirius, or based on old patterns, e.g. Colin Archer. It is the least numerous group. Usually they are the yachts with big displacement and deep draught.

After almost eighteen months of tests of the first three HABERS 800 in this version this is the 3rd edition of

“HABER 800C4 – a self-steering sailing yacht”. It is an incredible adventure. During that time I had an opportunity to carry out a few tests on these yachts for sailing magazines and to train our clients and our dealers. All of them, including Harald Schwarzlose from the German “Yacht” magazine, Martin Kopač (the most experienced owner of HABER 800C4) or Jerzy Rakowicz (a Polish single-hander) say that only sailing on this yacht gives a full picture of how it works. It is difficult to imagine this – reality overtakes imagination.

Janusz Konkol

Iława 2012.11.11

During the period after issuing this elaboration more than ten HABERs 800C4 have been built and two new types of the yachts with C4 self-steering system – HABER 660C4 and HABER 34C4 have been designed and built.

In both cases the C4 system works very well and confirms its usefulness. With permanent wind, regardless to the strength of the wind, either is medium or strong, the system works perfectly.

HABER 34C4

HABER 660C4

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