ESTIMATING A SMALL CRAFT'S STABILITY BY MEANS OF ROLLING PERIOD TESTS

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> "The metacentric height is the lever by which the sea rocks the ship."
> Kenneth Barnaby

When carrying out the survey of small craft for whatever reason, the marine surveyor must always bear in mind that, among the many factors that determine whether or not she is seaworthy is an adequate metacentric stability. To determine that accurately requires a full inclining experiment and a considerable amount of detail about the vessel's hull form that is generally not available at a pre-purchase or similar stability. This method described here gives a simple rule of thumb by which a marine surveyor may make a sufficiently adequate guesstimate of the vessel's stability from which he may make a decision as to whether or not he should recommend an inclining experiment. The evaluation of a number of inclining and rolling tests according to various formulae shows that the following gives the best results and that it has the advantage of being the simplest:

$$GM_o \approx (k_{RP} B_{WL}/T_R)^2 \quad \text{m} \quad (1)$$

where

B_{WL}	=	waterline breadth	m
GM_o	=	initial metacentric height	m
T_R	=	rolling period	s
k_{RP}	=	constant (the rolling coefficient)	-

The factor k_{RP} is of the greatest importance (it's about 1.25 for a narrowboat) and it should be noted that the greater the distance of masses from the rolling axis, the greater the rolling coefficient will be. Therefore, it can be expected that:

- the rolling coefficient for an unloaded vessel (*i.e.* for a hollow body) will be higher than that for a loaded vessel.
- the rolling coefficient for a vessel carrying a great amount of bunkers and ballast both groups are usually located in the bottom (*i.e.* far away from the rolling axis) will be higher than that of the same vessel having empty fuel and ballast tanks.

Experiments have shown that the results of the rolling test method get increasingly less reliable the nearer they approach metacentric height values of 0.2 m and below.

For the following reasons, it is not generally recommended that results be obtained from rolling oscillations taken in a seaway:

- exact coefficients for tests in open waters are not available.
- the rolling periods observed may not be free oscillations but forced oscillations due to seaway.
- frequently, oscillations are either irregular or only regular for too short an interval of time to allow accurate measurements to be observed.
- specialized recording equipment is necessary.

However, sometimes it may be desirable to use the vessel's period of roll as a means of approximately judging the stability at sea. If that is done, care should be taken to discard readings which depart appreciably from the majority

of other observations. Forced oscillations corresponding to the sea period and differing from the natural period at which the vessel seems to move should be disregarded. In order to obtain satisfactory results, it may be necessary to select intervals when the sea action is least violent and it may be necessary to discard a considerable number of observations. In view of the foregoing circumstances, it needs to be recognized that the determination of the stability by means of the rolling test in disturbed waters should only be regarded as a very approximate estimation.

Although a vessel may successfully pass a roll test the results of this type of test do not provide a full assessment of a vessel's stability and can, therefore, be misleading. Current MCA guidance on the methods that can be used to assess the stability of small fishing vessels, for example, is not sufficient to provide their owners with the information needed to understand the limitations of the various options available. Like fishing vessels of less than twelve metres registered length, pleasure craft are not required to meet any statutory stability criteria. However, in response to a number of accidents that have resulted in recommendations from the Marine Accident Investigation Branch, the Maritime and Coastguard Agency intends to introduce legislation which will require small fishing vessels of under twelve metres registered length to comply with similar stability criteria to that which already exists for small commercial vessels and the small craft marine surveyor should be aware of that fact. It is also important to appreciate that the virtue of meeting the criterion in only one loading condition does not ensure immunity against capsizing or absolve the skipper from his responsibilities. It has to be assumed that the vessel will maintain adequate stability throughout her whole voyage cycle and that will only be valid if best practices with regard to operation of the vessel, the use of consumables and the stowage of the catch and gear are followed.

The Rolling Period Method

As a supplement to the approved stability information, the initial stability can be approximately determined by means of a rolling period test. Vessels with a high initial stability are said to be stiff and have a short rolling period and conversely, vessels with a low initial stability are said to be tender and have a long rolling period. The following guidance notes describe the rolling period test procedure which can be performed at any time by the crew of a small vessel.

1. The test should be conducted in smooth water with the mooring lines slack and the vessel breasted off to avoid making any contact during the operation. Care should be taken to ensure that there is a reasonable clearance of water under the keel and the sides of the vessel.

2. The vessel is made to roll. That can, for example, be done by men pushing bdown on the gunwale when the boat is at the top of its roll away from them. As soon as this forced rolling has commenced the men should stop and place the vessel allowed to roll freely and naturally.

3. The timing and counting of the oscillations should only begin when it is judged that the vessel is rolling freely and naturally and only as much as it is necessary to accurately time and count these oscillations (approximately 2° - 6° to each side).

4. With the vessel at the extreme end of the roll to one side (say port) and the vessel about to move toward the upright, one complete oscillation will have been made when the vessel has moved right across to the other extreme side (i.e. starboard) and returned to the original starting point and is about to commence the next roll.

5. By means of a stop watch, the time should be taken for not less than six of the complete oscillations. The counting of these oscillations should begin when the vessel is at extreme end of a roll.

6. After allowing the roll to completely fade away, the operation should be repeated at least twice more. Knowing the total time for the total number of oscillations made, the time for one complete oscillation, say TR seconds, can be calculated.

If the measured value of TR, in seconds, is less than the breadth of the vessel in metres, it is likely that the initial stability would be sufficient, provided that the vessel carries full fuel, stores, gear, *etc.* Equally, if it is greater, then the metacentric height is suspect and, for safety reasons, the marine surveyor should recommend a proper inclining test.

The rolling period TR usually increases and the vessel becomes more tender as the weight of fuel, stores, gear, etc., decreases. As a consequence, the initial stability will also decrease. If the rolling period test is conducted under such circumstances it is **recommended**, that for the estimate of the initial stability to be considered satisfactory, the calculated value of TR, in seconds, should not be more than 0.8 times the waterline breath of the vessel, in metres.

The method is suitable for vessels up to about 70 metres length but may not be applicable to vessels with a hull shape that dampens the rolling, for example vessels with large bilge keels or vessels of an unconventional design, such as high speed motor boats.

Stability – Weight Creep

Flooding, foundering and capsizing are all associated with a loss of transverse stability and whether or not a boat has adequate reserves of stability when newly launched, they can be lost through overloading or

ill-considered modifications before she even leaves harbour. While at sea, stability may be lost through water ingress and ice growth on the superstructure may impose additional top weight. In many cases, it will be a combination of factors which will lead to the onset of unstable conditions and, possibly, the loss of the vessel. When working out the maximum load allowed, the marine surveyor must consider weight creep – a problem which is also known as stability creep. Owners also should be warned to guard against such unaccountable gain in weight of a vessel with time; a gain which is due perhaps to rust formation, timbers becoming saturated, coats of paint being added, extra spare parts, old spare parts kept just in case, sludge in ballast and oil tanks etc. It has been estimated that a vessel can gain as much as one per cent in weight and an equal reduction in KG for each year of its life with a consequent reduction of freeboard and loss of transverse metacentric stability. It is good practice, therefore, after a rolling test also to carry out a light weight check.

Light Weight Check

In order to carry out a light weight check it is necessary to measure the vessel's freeboard accurately when she is floating at rest in still water. To be accurate, the measurement has to be carried out directly on at least two clearly identifiable places along each side of the boat making a minimum of four measurements in all. The boat has to be in light condition i.e., with no fuel, stores, fresh water or personnel on board. Direct measurement with a steel tape will be found difficult as the slightest wind will cause the tape to flap about making the process next to impossible. It is recommended, therefore, that the marine surveyor make up a stave such as that illustrated in the Figure 1 below. The angle bracket is screwed to one side and the metre long steel rule screwed to the adjacent side. The bracket can then be rested on the vessel's deck or rail at the point of zero sheer and the height of the deck at side line at that point above the water read off directly. A large section of a translucent plastic bottle cut off and placed round the stave at water level will reduce the effect of any wavelets or ripples to nothing. To use the stave correctly it should be when the vessel is moored but afloat with the marine surveyor standing on the wharf. The offside measurement should be taken with the marine surveyor working from a small boat. Using the stave while standing on the deck and leaning over the side will give a false reading. The freeboard should be read on both sides of the vessel. If the vessel has a load line mark, then the freeboard to that line on both sides should be taken and recorded as well as the actual freeboard at the time of the survey.

It is further **recommended** that a rolling test and a lightweight check be carried out at a pre-purchase survey and a light weight test every five years thereafter and the results recorded in a formal report handed to the owner. A typical such outline report is shown below.

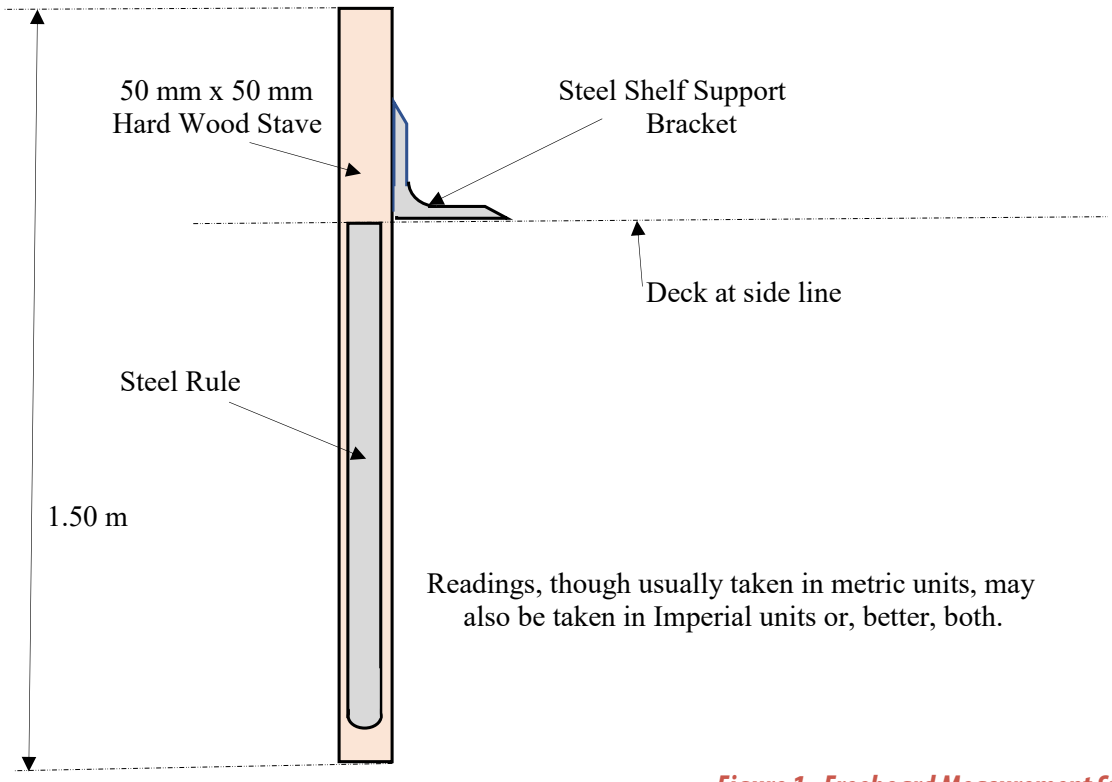

Figure 1. Freeboard Measurement Stave

A TYPICAL LIGHT WEIGHT CHECK REPORT

name and address date

LIGHT WEIGHT CHECK

This is to confirm that, at your request and in accordance with my Standard Contract of Employment and the Engineering Council, FEANI and similar Professional Society Standards of Ethics and Codes of Practice including those laid down by the International Institute of Marine Surveying and the Law Society's Code of Practice for Expert Witnesses and, where applicable, the Rules for Yachts of Lloyd's Register of Shipping Part 1, Chapter 3, Sections 2 and 7 and in accordance with the Health and Safety at Work Act and, subject to the conditions obtaining at the time, the undersigned attended the:

XXXXXXXXXXXX
O.N. XXXXXX

on the XXth XXXXXX, XXXX at the XXXXXXX XXXXX,XXXXXXX and there, in the presence of the owner, carried out a Light Weight check in accordance with OAN572 Revision 03.

Weather Conditions
The weather was fine and there was no wind. The water was calm with zero current. The vessel was moored first starboard side to but later remoored to port side to.

Ship's Condition

Fuel Tank	
F.W. Tank	
Sewage Tank	

There were no personnel on board.

The furniture and the above tank conditions were similar to those at the previous light weight check carried out on the XXth XXXXXX, XXXX.

Freeboard Measurements

The freeboards were measured as follows:

Longitudinal Position	Freeboard Port	Freeboard Starboard	Freeboard Mean	Mean Value XX/XX/XX	Difference cf XX/XX/XX
Forward					
Amidships in line with the centre of the freeboard mark					
Aft					

Conclusion
The freeboard readings taken at this light ship check correlate closely with those previously recorded at the XXXX test. The differences between the two sets of measurements are within the allowable limits stipulated in OAN572 Rev.03. There was no evidence of physical changes to the vessel that may significantly affect her transverse metacentric stability and it was, therefore, considered that the stability of the vessel may be accepted as satisfactory at this verification.*

Marine surveyor's signature *etc.*

*Delete or change as necessary.