In the first of a trilogy looking at key safety aspects of modern yachts, Barry Deakin from Southampton's Wolfson Unit for Marine Technology and Industrial Aerodynamics reports on the 1992 Japan–Guam Race and the Japanese research that has resulted

japan-guam race tragedy

The tragedy that occurred during the 1992 Japan–Guam Race is not yet such general knowledge as the 1979 Fastnet disaster, perhaps because of its remoteness from our shores. Nevertheless, 14 yachtsmen lost their lives in this race, even though few people in the West have even heard of the incidents that occurred.

The seventh Japan–Guam Race began at midday on 26 December, 1991 off the Miura Peninsula south of Tokyo. Nine yachts crossed the start line in wintry conditions, heading for the tropical island of Guam, over 1,300 nautical miles to the south.

On the second afternoon of the race, with winds of 30 knots and waves of up to 6m, two yachts retired from the race. One, a Van de Stadt 71, was dismasted and the other, a Frers 48, suffered a torn mainsail. At 15.40hrs a crew member was lost overboard from the yacht Marine Marine, a Yokoyama 39, while trying to untangle a running backstay. He was not wearing a harness and could not be found. At midday on 28 December a female crew member from the same yacht, exhausted and incapacitated by severe seasickness, was transferred to a patrol boat which had attended to assist with the search.

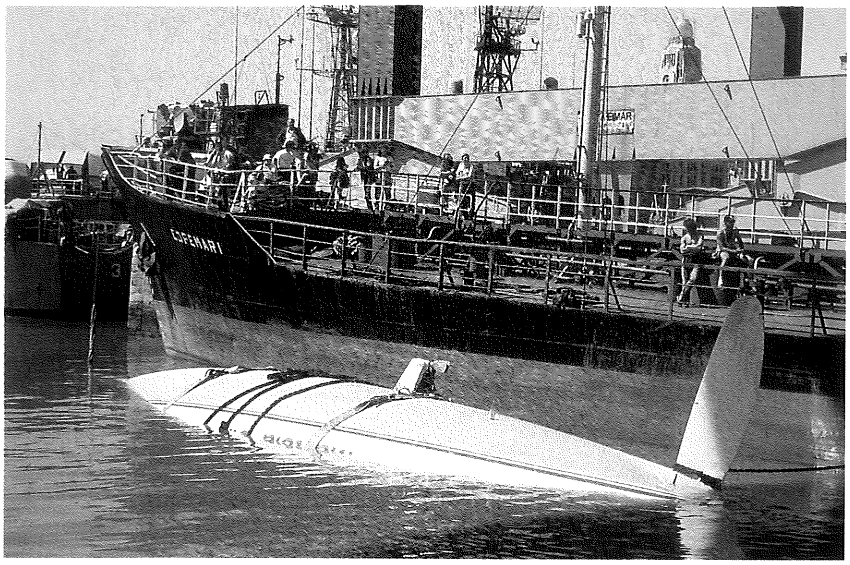
Twenty-four hours later, with the rough conditions persisting, Marine Marine's engine was started but a rope fouled the propeller and the engine stalled. A tow was requested from a second patrol boat which made five unsuccessful attempts to pass a line to the yacht. That evening one of the crew noticed that the rolling motion of the yacht felt unusual and a transfer of the remaining crew to the patrol boat was requested. It was decided, however, that it would be too dangerous in the dark and rough conditions. The crew put on life jackets and a life raft was prepared.

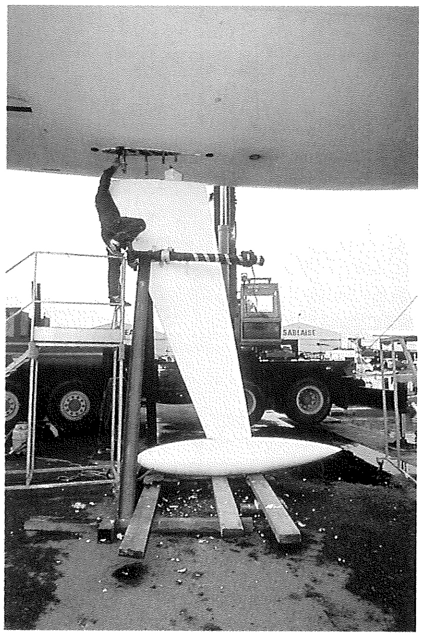
At around 05.30hrs on 30 December the keel parted from the hull, which rolled upside down and rapidly filled with water. One crew member escaped through the hatch on his second attempt, finding it difficult to dive through it with his life jacket on, to be joined a little later by two others. The incident was not seen by the patrol boat which had lost visual and radio contact with the yacht, although the empty life raft was found at 07.00hrs.

At 10.20hrs an aircraft which had joined the search located the yacht with one surviving crew member. There was a hole in the hull roughly the same size as the root of the keel but a transverse frame was seen to have remained intact inside the hull. Seven members of the crew drowned, four of their bodies being found inside the yacht.

On 29 December at 20.30hrs, while the crew of Marine Marine were beginning to worry about the motion of their yacht, Taka, a Liberty 47 about 230 nautical miles to the south, was capsized by a breaking wave while sailing under storm jib in a quartering wind of 32 knots. The maximum wave height in that area was in excess of 6m. The yacht remained upside down and after more than half an hour the four crew inside the yacht made their way out through the hatch. Their EPIRB, which did not appear to be functioning correctly, was lost at this time. They then found that one of the three on-deck crew had drowned.

After a further 15 minutes the yacht rolled back upright. The upper washboard was lost and, as the yacht was half submerged, water continued to flow in. The mast was broken and the bilge pump blocked with ropes. The life raft was inflated but it capsized soon after with the loss of some of its ▶





P. 15: Mike Plant's Coyote – a recent victim of bulb detachment. Top: Martela OF after keel failure, Whitbread 89/90. Above: Martela's keel already straining after leg 1. Right: Fleury Michon – three days into the Vendée Globe

Photos: page 15, Marine Nationale; above, Barry Pickthall – PPL; top, David Branigan; right, Jacques Vapillon – DPPI

equipment. The six remaining crew boarded the raft and drifted. Despite the mobilisation of 11 patrol boats and 52 aircraft, the raft was not found until 25 January when it was spotted by a British cargo vessel. Only one crew member remained alive, the others having died between 10-16 January.

The remaining five yachts finished the race between 1-3 January. Marishiten, a Nelson/Marek 68, broke the race record with an average speed of 10.1 knots.

An analysis of weather records for this and previous races reveals that, with mean winds of more than 30 knots and gusts of up to 50 knots during the first two days, this race was subjected to more severe weather than previously. The margins are small, however, with mean winds of 30 knots or more having been experienced during every race except one. Furthermore, such weather is typical at that time of year, so crews should anticipate very rough conditions.

The race is classified as ORC Category 1 and all yachts must meet the appropriate ORC Special Regulations in addition to a series of Nippon Ocean Racing Club regulations. All yachts must be at least 10m overall.

The NORC wasted no time in forming a research committee to investigate the casualties, it being officially approved on the same day that Taka's life raft was found. The man overboard was a case of human error, demonstrating the value of safety harnesses and lines, but the keel failure and the inability of Taka to return upright after a capsize suggest design deficiencies which were the subject of extensive research in Japan.

Two lines of investigation were followed. In the first, the detailed arrangement of Marine Marine's keel attachment and local GRP structure was studied from drawings, and calculations were carried out to assess the strength. It is not clear from the report on the investigation whether the keel landed on a fair canoe body or a laminated stub, but detailed drawings of the local laminate configurations and the attachment of transverse floors show features which the Wolfson Unit consider to be bad practice.

The laminate thickness met the requirements of the ABS rules and the calculations indicate a safety factor of 2.71 when the laminate shear strength is compared with the static load of the keel with the yacht at 90° of heel. This load is chosen in the absence of any information on actual keel loadings caused by a yacht rolling in a seaway, so it is difficult to draw definite conclusions from the value, for additional fatigue considerations.

Disturbingly, the report suggests that the hull failed in shear around the outline of the keel and at the keel bolt washers, probably as a result of fatigue, implying that other well-used yachts could lose their keels in a similar way. The hull's shell had become detached from the transverse frame.

The yacht was built in 1983 and had competed in many offshore races. It had run aground five years before the failure requiring some repair to the hull-keel joint, but details of the damage were not included in the report. The report's authors assumed that some delamination between the shell and the frame may have occurred at that time, and gone unnoticed by the repairers.

To take this study further, destructive tests were conducted on full-size samples of yacht hulls with fin keels attached in various configurations. Hulls with and without stubs were used and a range of laminate thicknesses were tested. The samples represented a yacht of only 7.5m compared to Marine Marine's 11.9m, and the sample keel weight was only 20 per cent that of the failed yacht's, so the data must be used with caution. The tests revealed that the breaking load in bending increases in proportion to the square of the laminate thickness, so any deficiency in the laminate will reduce the strength significantly. A safety factor of 3.3, similar to the calculated value for Marine Marine, was obtained with a local hull laminate thickness of 14mm which is also the same as Marine Marine's, but the keel moment at 90° ▶

for Marine Marine was over eight times greater than that for the sample yacht.

Although there are insufficient details published in the report for a direct comparison, these figures suggest an inadequacy either in the structural design or in the assumptions used to calculate the keel loadings and hence the safety factors necessary.

In the other avenue of research, the capsize of Taka prompted the Japanese to investigate its range of stability as derived from the hull measurements as part of the IMS rating process, and from drawings of the hull, keel, coachroof and cockpit arrangement. The IMS stability curve indicates a positive range of 108° (the angle beyond which the yacht would capsize in calm water) and when the cockpit and coachroof were taken into account in the independent calculation a range of 114° was derived. This range is below average for the fleet of 56 IMS yachts used for comparison, but seven yachts had lower values. The IMS rating system uses a 'Stability Index', which comprises a range set by the size of boat and its displacement/maximum beam ratio – Taka's value is only marginally below average for the fleet.

The effects of the flooding of the yacht were investigated and it was concluded that when upside down the stability gradually reduces as the amount of flooding increases. Thus the yacht remained inverted for a considerable time despite some flooding, but after the main hatch was opened the rate of flooding increased and the yacht righted itself, by now in a seriously swamped condition.

These calculations and conclusions will be familiar to those who have studied the 1979 Fastnet Race Inquiry Report, which contains precisely the same results as computed by the Wolfson Unit in response to that disaster. At that time the Wolfson Unit was also commissioned to conduct a series of model tests to examine the behaviour of yachts of various forms, both traditional and contemporary, in large breaking waves. This work has been published and discussed at length and has been complemented by parallel work conducted in the USA and The Netherlands.

None of this work is referenced in the NORC report, however, and the Japanese researchers have undertaken their own experimental study of breaking wave capsizes. Their experimental technique was very similar to that used by the Wolfson Unit, and their results and conclusions reinforce the findings of the work done previously.

At a scale of 1:10, they modelled two basic hull forms, a typical IOR form of 9.5m overall, and a traditional long-keeled cruising yacht of 9m. The first had a range of stability of 120° and the latter a range of 165°, both of which are typical for such types. The IOR yacht was capsized and remained inverted after the impact of a 3m wave. That is a wave height equal to the beam of the yacht. The traditional yacht could not be capsized, although the maximum wave height available was only 3.4m. With the masts removed the IOR yacht capsized in waves of over 2.2m and the traditional yacht was rolled through 360° by waves in excess of 3m. Because of its large range of stability it would not remain inverted.

The yachts modelled were 9m long and, if it is assumed that the principal characteristics of a yacht remain in proportion as size increases, we may infer that a wave of more than 4m high would be required to capsize Taka. The maximum wave height was well in excess of that at the time.

It did not require a freak wave therefore, but the combination of being caught beam on to, or broached by a wave of above average height which happened to be breaking at the time of the encounter. Perhaps the other competitors were fortunate enough not to have been caught in such a situation since the fleet stability statistics do not imply that they would have fared any better. At the Wolfson Unit we would consider a range of stability of 114° to be insufficient for a yacht of this size undertaking an offshore passage. Indeed the yacht would not comply with the Department of Transport's Code of Practice for sail training vessels which would require a minimum range of 125°. Perhaps racing yachtsmen are prepared to take a greater risk than those paying for an adventure at sea.

Some items covered by the ORC Special Regulations, which have been introduced to minimise the effects of failures such as these, were also inadequate. For example, washboards must be secured to the boat, but those on Taka were still swept away. Bilge pumping arrangements on Taka were inadequate because one pump was disabled. Two pumps are required by the regulations but the other was presumably submerged in the cabin.

It is important to note that neither Marine Marine nor Taka were anything other than typical offshore racing yachts, and the Force 7 to 8 conditions in which they failed were not particularly extreme, indeed were to be expected in this race.

It is unfortunate that lessons learned since the Fastnet disaster do not seem to have changed design trends significantly and, furthermore, they appear to have to be re-proven when a fresh incident occurs. ●

Barry Deakin, BSc, Wind Eng Soc, is the Wolfson Unit's specialist in the field of stability assessment.

Drum's keel failure during the 1985 Fastnet – like Martela's mishap – could easily have had more tragic consequences

Photograph: PPL