

SUBSEA REPAIR OF NAB TOWER

By

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and

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Introduction

Nab Tower is the only remaining tower of fourteen intended to form a chain of anti-submarine defence forts across the English Channel during World War 1. They were designed as concrete cellular caissons supporting a steel structure. Construction commenced in 1918 (see Photo Below) but by the end of the war only two were anywhere near complete. One tower was completed and replaced the Nab Tower Light Vessel in 1920, marking Nab Rock, and the other was destroyed two years later. The present Nab Tower, situated 4 miles east of the Isle of Wight in the Solent and sitting in approximately 25m water at high spring tide, continues to serve as a navigation light tower (see Photo Below). The Trinity House Lighthouse Service has been responsible for the tower for a number of years.



The now unmanned 17m diameter x 23m high steel upper structure sits on a reinforced concrete cellular structure 61m long x 50m wide x 25m high. The hexagonal shaped cells are 1.83m in size with 52mm thick mesh reinforced walls. The four tiers of concrete cells are octagonally shaped, so designed for towing. The whole structure has inclined towards the southwest by some 3° since it was floated out and sunk onto the uneven gravel and sand seabed.

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In November 1999 a number of the cells were severely damaged underwater when the 10,288 dwt freighter Dole America accidentally collided with the Tower. The ship was also damaged and only avoided sinking by running aground. The ship has now been repaired. However the Tower remained damaged until the winter of 2000 when Trinity House decided to prepare a contract to repair the underwater cells.

Client's Approach to the Tender

The approach taken by Trinity House in the tender documents was to be clear about the difficulty of working on the Nab Tower. These difficulties were explained as the short slack tidal periods, the varying wave conditions, the impossibility of continuous work and the limited acceptance of design risk. Therefore a relaxed attitude was followed from the start to accept and assess all ideas from the tenderers for the repair method. Andark Diving, along with Posford Duvivier, was considered to have prepared the most practical, detailed and informative solution regarding costs, programme and method and was subsequently awarded the contract. Although the project called for works under the ICE Design and Construct contract, the method of payment was not a fixed price. Estimates were produced based on day rates for various weather downtimes to provide a practical and realistic assessment of a final contract sum. This open approach was encouraged by Trinity House from the outset.

Planning

One of the most important aspects of underwater work of this nature is pre-planning. An integral part of this are all the personnel involved in the project. The project team in general comprised the parties listed in Table 1. The main contractor was Andark Diving Ltd with the same company taking on the diving work as well. However the project management team was the Trinity House Lighthouse Service, Andark Diving and Posford Duvivier with Charles Haswell and Partners being informed of and involved in major decisions. A number of subcontractors were employed to handle the marine plant, fabricate the grout bag and the new ladder, ferry personnel to and fro the beach and to perform laboratory testing of concrete cell samples retrieved from the Tower.

The method statement called for 4-5 days continuous working at both spring and neap tide slack water periods, which did not necessarily occur at either high or low water. Except when weathered off, this plan generally worked. With the ship having effectively shaved off 16 no. cells (damage comprising some 47 no. cell walls and 16 no. cell slabs) in whole or part up to 6m high down to 12m below water, it was decided early on to break the work into two stages. The outline contract programme thus covered some preparation and initial clearance works in Stage 1 prior to actually completing the cell repairs in Stage 2. Additionally an access ladder and some above water localised concrete faces were damaged.

An initial check on the underwater situation was performed by Andark Diving and Posford Duvivier at an early stage in the contract. Having discussed the outcome of this overall condition survey, it was agreed by all parties to clear the debris (see Photo Below), test some concrete samples and run a full-scale grout bag test onshore. Interaction of ideas and discussion between all the parties was actively encouraged throughout the whole period in order to arrive at the most practical way forward.



Onshore Work

Some concrete cell wall samples were retrieved on the first dive for analysis in the University of Portsmouth materials testing laboratory (see Photo Below). The tests called for beam and cylinder strength tests together with general comments on the steel mesh and the concrete properties. To everyone's surprise the concrete turned out to be very strong, very compact and in very good condition. Compressive strengths varied from 35-64 N/mm² with associated densities of 2260-2370 kg/m³ (flint seabed aggregate) and tensile strengths were between 2.9-3.2 N/mm². The Expamet no. 21 mesh at 3.3mm in size was also in impressive condition, considering it was 83 years old and only had 15mm cover. There was no carbonation evident and the entire concrete sample was strongly alkaline. The results of the tests were used in the design of the cell loading capability and the ladder fixings. The cell slab was calculated to be capable of only taking a 1.4m height of mixed debris with the grout bag on top.



Andark Diving put one day aside within the contract for an essential onshore grout mattress site test (see Photo Below). This proved to be very useful to iron out procedural matters and make adjustments to the design of the grout mattress, the concrete mix and the bag fixings to the cell walls before the offshore work commenced on Stage 2. The grout mix finally agreed after the test was a 1:2 cement/sand mix with a w/c ratio of 0.5 and flow cone durations of 27-33 seconds to ASTM C939-97 Flow Cone Method.



The design of the ladder was based on a standard Trinity House access ladder with some particular alterations to suit the new position. Attempts to test drill the concrete with standard tungsten carbide drill bits in order to design the fixings in this remote location proved extremely difficult due to the very tough concrete. Only diamond tipped drill bits penetrated the access platform concrete. Standard chemical cartridge bolt fixings were used for the ladder fixings.

Offshore Work

One of the most important items of the project to monitor was the weather. Constant regard to the forecast was essential at this very exposed site, which was not diveable past wind Force 4. The plan for intermittent offshore diving made it even more relevant, particularly when the “Wilcarry” (the 42m x 10m, 180 tonne load capacity, 15 tonne crane lift) barge of Williams Shipping, was moored in Southampton when not in use and required notice to be towed offshore by tug (see Photo Below).



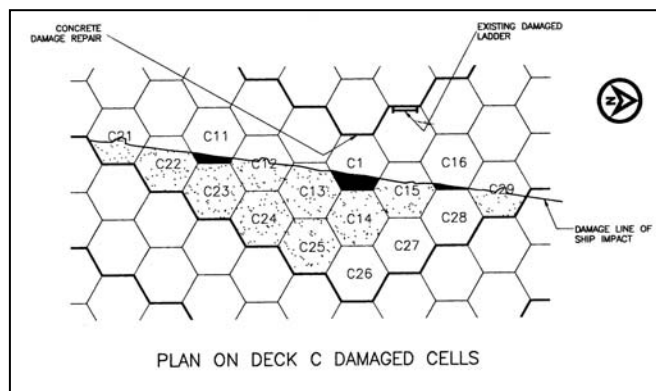
The clearance operation commenced in April 2001 with the diving team concentrating on making the site underwater safe to work around and inside the cells. The six man dive team used Kirby Morgan dive helmets and band masks with surface supplied equipment (see Photo Below). Diving was done on a ‘no-decompression’ basis to the US Navy 1995 diving tables with normally only a single working diver at high and low slack water. A considerable entanglement of steel bars and concrete slabs faced the divers at different levels. A rope grid system was set out for use as a guide to locating the cells, which were individually marked with numbered disks. The use of the Lukas hydraulic cutter, similar to the ones used by fire and rescue services, and pneumatic breaker tools helped to speed up the removal of debris (see Photo Below).



The project management team deemed the site unfit for proper clearance and further assessment, in respect of a detailed method of repair, until the area was made safe by the project diving team. This effort took slightly longer than anticipated but eventually helped the next process of trying to find out the real extent of damage and propose a detailed method of repair.

The project team decided to break down the cell repairs into three types as follows (see Plan on Damaged Cells).

- Type 1 Repair - Clear the cell out completely, where the cell walls are of insufficient height to sustain a 220mm deep grout mattress together with debris.
- Type 2 Repair - Place debris to maximum height of 1.4m and install grout mattress above debris.
- Type 3 Repair - Leave the cell untouched as clearing it out would be too difficult and not affect the stability of cell and/or structure locally.



This plan worked well and enabled a clear way forward for the offshore diving team to persist with the overall repair, namely the large debris removal, the debris levelling inside the cells and the mattress placing/grouting.

By mid-July the cells were ready for the mattress placing and the grouting up. The earlier grout mattress testing paid off dividends. The cell fixings, to which the mattresses could be attached to prevent uplift in storm conditions, were installed first. The idea of folding the mattress in two worked well and was diver-friendly with spreader bars around the edges only requiring fixing to the cell in three places to install the mattress. The mattress/cell connection was designed as a fail-safe device featuring a 'soft' link by utilising very strong plastic tie-wraps between cell wall fixing and the mattress to enable a clean break under extreme wave forces for the cell's own protection. The mattresses were then placed, one in each chosen cell, and the grouting completed in two 4-day diving sessions.

The grouting was done using a Turbosol Hydra Plus T20H 3.6m³/hour hydraulic worm grout pump. A streamlined grouting procedure organised by the diving supervisor, assisted initially by Proserve, enabled efficient use of personnel and ensured successful grouting. Finally the new ladder was bolted into place and the project was complete.

Overall the weather downtime for the contract came to 30% due to sea and swell conditions. A jack-up platform would not have improved either the in-water productive time or the divers' ability to work safely and would in fact have put the platform edge some 20-25m from the work site instead of the 10-12m with the floating barge. The interaction within the project team during the whole process was inevitably the main reason for the successful outcome of this unusual contract.

Table 1 – Subsea Repair of Nab Tower

Type of Contract:	ICE Design and Construct
Project Description:	Repair of Nab Tower underwater cells following ship collision
Estimated Cost:	£300,000
Duration:	5 months (April to August 2001)
Client:	Trinity House Lighthouse Service
Main Contractor:	Andark Diving Ltd, Southampton
Contractor's Consultant:	Posford Duvivier Ltd, Haywards Heath
Insurer's Engineer:	Charles Haswell and Partners, Bromley
Marine Plant Subcontractor:	Williams Shipping Marine Ltd, Southampton
Grout Mattress Fabricator:	Proserve Ltd, Kenilworth
Laboratory Testing:	University of Portsmouth

Acknowledgements

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BRIEF CAREER BIOGRAPHY

JAMES DALE

James Dale obtained a Bachelor's degree in civil engineering at Brighton Polytechnic (now University) in 1971 followed by a Postgraduate Master's degree in maritime civil engineering at University of Liverpool in 1979. He is a Chartered Engineer and a qualified commercial inshore air diver. He has worked in subsea, pipeline, river, coastal and maritime civil engineering, mainly for consulting engineers, (with short periods in contracting), as client's representative, designer, site engineer, project manager and diving engineer. His experience covers 30 years practice in UK and many overseas countries. At the time of writing this article he was manager of *Posford Duvivier's* Intakes, Outfalls and Underwater Engineering section. He is now an independent consulting engineer.



BRIEF CAREER BIOGRAPHY

ANDREW GODDARD

Andrew Goddard is a qualified commercial air and saturation diver and diving instructor. He started his professional diving career in the mid-seventies working in the North Sea. He established Andark in 1976 to develop a close circuit diver heating system. In the late 70's Andark concentrated on civil engineering and diving. Although most of his company's work is south coast based, it has worked in Europe and as far afield as the Yemen. His company has diversified into scuba diver training, watersport retailing and runs a sea survival and helicopter underwater escape training facility in conjunction with Walsash Maritime Centre. At present he is managing director of Andark Diving Ltd, commercial diving contractors.