For nearly 200 years the Bell Rock Lighthouse has helped protect mariners around the great firths of the Tay and Forth. Its design and construction were triumphs of engineering and human determination. Mr McIntosh, whose career has been dedicated to maintaining and building lighthouses, explored the origins and history of the elegant stone tower and why it qualifies as an engineering wonder of the world.

The engineering challenge was to build a lighthouse of great strength, largely by hand, on a small rocky reef that was twice-daily submerged beneath 5 metres of swirling and hostile sea. In the 18th and 19th centuries trade from Scotland’s great ports was on the increase but sailors, ships and cargoes were all at risk from its coastal hazards, especially years of great storms like 1782. As far back as the 10th century there are records of the monks of the Isle of May lighting beacons as a warning to vessels. Purpose-built structures began appearing in the 16th and 17th centuries but were small and inefficient, relying on coal fires to cast a powerful enough light to guide distant ships.

Improvements came in the 1780s when new technology, developed by Thomas Smith, that used parabolic reflectors to boost the power of lights – and was already providing gas street lighting in Edinburgh – was employed by the Northern Lighthouse Board to establish a string of new lighthouses.

According to Mr McIntosh it was an urgent task. The structures at Kinnaird Head, the Mull of Kintyre, Dennis Head on North Ronaldsay, and Eilean Glas on Scalpay, were completed in around two years even though only one site was served by a road. Smith was also stepfather of Robert Stevenson, of the great civil engineering family, in whose footsteps Mr McIntosh said he felt privileged to follow.

“Robert Stevenson learned the craft of civil engineering in general and lighthouse construction in particular under the instruction of his stepfather, and he was the founding father of this dynasty of engineers, and as such was responsible for the construction of some 15 lighthouses between 1811 and 1833. He started in Arbroath with what was possibly his most famous, the Bell Rock.”

The project was necessary because in the early 19th century there was so little help available to mariners. There were just three lighthouses round the firths of the Tay and Forth – and ships did not even have the benefit of the background lighting to illuminate the coast that comes from today’s coastal villages and towns.

The Bell Rock, 600 metres long and 12 miles out to sea, was in direct line of Dundee and Edinburgh shipping making it an important place for a light and also an incredibly difficult place to reach, let alone build a 36m high tower. It was a location so dangerous, that centuries before a bell had been placed upon it to warn vessels to keep away.

When work began in 1807 a wooden beacon house was built to keep the blacksmith’s forge above the tide and which would later provide safe accommodation for workers. Labourers also started to cut circular foundations 12.8m in diameter and 60cm deep to take the base of the tower and prevent it being washed away. One of the jobs that kept the smith busy was re-sharpening the picks used to chip away at the rock. Each time the tide receded the hole had to be pumped out, reducing the working day to a few hours.

Stevenson had spent some six years working on the design of the lighthouse, which although loosely based on the trunk of an oak tree, he adopted the cycloidal curve tapering upwards so waves would sweep round it, minimising their impact on the stonework. Every piece of the tower was individually planned so the stones would connect to each other like a jigsaw. “The yard established in Arbroath was the land base and focal point for the construction works. Every one of
the stones was cut, shaped and dovetailed there before it was shipped out to the rock." Only once
the third and fourth courses were complete were the workers above the tide and such was the
need for strength of construction that the first 10m of the tower are entirely solid. One indication of
the quality of workmanship is that the cast iron railway completed in 1809 to allow the easier
landing and moving of 1,000 tons of stone has survived to the present day despite the ferocity of
the ocean.

Despite the enormous care that went into the preparatory work the challenges of the job meant that
many pieces of equipment were developed or refined as work progressed. One piece of equipment
that resulted from the project, variously attributed to Stevenson or his junior engineer, was the
balance crane which is now used on construction sites worldwide.

Stevenson was determined that 1810 should be the last season of construction work and the final
stone was laid on 3, August.

During the project Stevenson had won the admiration of the workforce. Mr McIntosh said: "His
drive and enthusiasm was greatly respected. He was always concerned about safety on the ships
and on the rock and for looking after the men if they were injured, or their families if they lost their
main breadwinner. "He was well-known for his strong religious beliefs but almost more so for his
belief in the need for the project to succeed and for mariners to be protected from the hazards of
the Bell Rock."

There was great relief when the light finally went on 1 February 1811, using parabolic reflectors to
increase the power of the lamps which were fuelled by sperm whale oil.

Stevenson had used winter months away from the rock to experiment with the best colours and
settled on alternating red and white.

While Stevenson’s name is most closely associated with the feat, it was John Rennie who held the
title of chief engineer, and disagreement continues over the amount of credit each should be
awarded.

Once operational, Bell Rock became workplace and home, for shifts of a month at a time, to
generations of lighthouse keepers. Their conditions were cramped but their work in maintaining the
lights and winding the clockwork mechanism every 45 minutes was vital.

Over the decades the light itself was changed and upgraded to use rape seed oil, then paraffin,
followed by acetylene lamps from Swedish company Aga when the site was first automated in the
1980s. Nowadays it has electric lights powered by large batteries with a diesel generator, and
maintenance work is carried out by NLB Engineers flown in by helicopter.

Mr McIntosh described how technology has transformed the job of providing hazard lights, showing
pictures of a small solar-powered unit with LED lights that he was involved with creating on a small
island near Skye.

There are some 80 Scottish lighthouses which are listed buildings, in recognition of their
architectural or historical importance.

But after long and valuable service they are now occasions when, as a result of consultation with
users, a few of the lighthouses are identified as no longer required by the mariner. Questions are
being raised about their future – not least because many are remote and finding new uses could be
difficult but at this stage the users still use lighthouses as part of the Aids to Navigation system. Mr
McIntosh said the Northern Lighthouse Board would continue looking after its lighthouses so long
as funding was available.

In closing his talk he pointed to the continuing role of the Board in ensuring the safety of mariners
and quoted its motto – In Salutem Omnium – For the Safety of All.

The Northern Lighthouse Board operates under statute – the Merchant Shipping Act 1995 – and is
the General Lighthouse Authority for Scotland and the Isle of Man. The Board currently operates:
209 Lighthouses, 162 Buoys, 37 Beacons, 4 Differential Global Positioning System Stations, 27
Racons and 1 eLoran. The Board is funded entirely from the General Lighthouse Fund, sourced by
"Light Dues", a levy paid by shipping. The Board receives no direct funding from the Exchequer or
taxpayer. The other General Lighthouse Authorities are the Commissioners of Irish Lights
(Republic of Ireland and Northern Ireland) and Trinity House (England, Wales, the Channel Islands and Gibraltar).

Following the lecture the chair of the session, Professor Sue Black OBE FRSE, thanked Mr McIntosh and led a question and answer session.

As ships make increasing use of GPS, rather than relying on lighthouses, Professor Black asked if there were moves to safeguard the future of the buildings that are such an important part of our heritage. Mr McIntosh said the Board is looking at a system to grade properties in terms of importance to try to ensure the preservation of good examples from each era.

Asked if there was a role for councils in the future of lighthouses Mr McIntosh said authorities had taken differing approaches to getting them listed. He said that while listing brings protection it also creates restrictions as special consent has to be sought for major changes to the buildings.

Professor Black asked if ship owners now argue that in the age of GPS they should no longer have to pay a levy for lighthouses. Mr McIntosh responded that this was the case, but that lighthouses act as a standby in case the GPS system fails. He added that there is a move away from using them to mark coasts to a situation where they alert mariners to hazards in difficult areas.

Mr McIntosh was asked why the lighthouse levy falls on commercial shipping, which often doesn’t use lighthouses, rather than leisure craft. He responded that there is a commitment to the principle that the user should pay, but that no effective mechanism has yet been designed for charging leisure crafts.

Asked about the power of lights Mr McIntosh said that hazard markers are normally visible for 11 miles and full-intensity lighthouses could be seen for 23 miles. Early lights were hundreds of candlepower in strength, modern ones are in the millions.

Arbroath Academy headmaster David MacDonald ended the session with a vote of thanks for Mr McIntosh.

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