2012

ENGINEER
BIOGRAPHY

engineering timelines

All items by **Robert Stevenson**
Everything built ... **1772 - 1850**

This biography was funded by the ICE R&D Panel

Bell Rock Lighthouse

Robert Stevenson

born 8th June **1772**, Glasgow, UK
died 12th July **1850**, 1 Baxter's Place, Edinburgh, UK
buried Family vault, New Calton Cemetary, Calton Road, Edinburgh, UK
era **Georgian**

Written by **Eleanor Knowles**, edited by **Jane Joyce**
in association with **Professor Roland Paxton**

Robert Stevenson triumphed over his initial lack of learning to become one of the most famous of all lighthouse engineers. His name is synonymous in the public mind with **Bell Rock Lighthouse** — constructed between 1807 and 1811, with significant input from John Rennie Snr. Stevenson overcame the considerable practical difficulties of constructing it, on a tidal reef far from land, and both men took much inspiration from **John Smeaton**'s earlier work, **Eddystone Lighthouse**.

Shrewd, ambitious and hard-working, Stevenson set his standards high and expected everyone he worked with — including himself — to reach them. He set up a multi-disciplinary engineering firm that would operate continuously until the mid 20th century, and he mentored a large number of young engineers and apprentices.

Though he is remembered chiefly for his Scottish lighthouses and establishing the Northern Lighthouse Board service, Stevenson also made important contributions to maritime and river navigation engineering, and canal, railways and highway infrastructure. Significant examples include **major bridges in Edinburgh, Stirling and Glasgow**, improvements to the **Tay navigation** and the cycloidal curve profile **sea wall at Trinity** near Edinburgh. He was very interested in coastal erosion, and he invented the 'hydrophore', an instrument for measuring water temperature at different depths.

Robert Stevenson was the founder of the Stevenson dynasty of engineers, collectively responsible for numerous lighthouses and other civil engineering works, in public and private capacities over nearly 150 years, through four generations. The famous Scottish author, Robert Louis Stevenson (1850-94), was his grandson, born four months after the engineer's death. Robert Louis trained as an engineer for a time but his talents lay elsewhere — he is known to readers worldwide for such works as *Treasure Island*.

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Robert Stevenson

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Early years

Robert Stevenson was born in Glasgow on 8th June 1772 and named after his paternal grandfather. His mother Jean Lillie (1751-1820) — also known as Jane — had married his father Alan Stevenson (1752-74) sometime in 1771, possibly eloping to do so. Robert was to be their only child and both parents were only 20 years old at the time of the marriage.

Jean's father, David Lillie (1710-74), a Glasgow builder and Deacon of the Wrights, had married her mother Isobel Miller (d.1774) on 27th May 1739. They presided over a large family of 12 or 13 children, of whom Jean was the sixth or seventh child. She had attended a private school for girls in Edinburgh.

Alan Stevenson came from a family of Glasgow maltsters (brewers) and he worked with his brother Hugh (1749-74) for a firm trading in the West Indies. His father Robert (1720-64) had married his mother Margaret Fulton (c.1722 - c.1825) in 1742, and they had had 10 children.

For young Robert's mother Jean, 1774 was a difficult year. Both her parents died. Then, on 26th May in St Kitts, Robert's father Alan succumbed to a fever described as 'night dew'. She was left alone with a toddler not yet two years old. Her brother-in-law Hugh also perished from a tropical fever in Tobago.

However, three years later, on 19th April 1777, Jean married Glasgow merchant James Hogg. He is described variously as a gunsmith, weaver, hammerman and manufacturer. She was already pregnant and she gave birth to a son in October. The couple moved to the village of Milton-of-Balgonie, near Glenrothes in Fife, some time before the birth of their second son on 7th December 1780.

They later moved to Edinburgh. But Hogg deserted Jean and went to England, leaving her once again in straitened circumstances and looking after Robert, who was still quite young. Robert's half brothers were not living with Jean at that time nor later — there is no record of what happened to them.

Stevenson attended a charity school until he was about 14 years old. His mother had hoped he would become a church minister but lack of funds made that difficult, and in 1786 he took an apprenticeship with Edinburgh gunsmith, Francis Innes. By about 1791 he was described as a gunsmith himself.

At some time during his apprenticeship, while he and Jean were living in Edinburgh High Street, Stevenson met the man who would have a profound influence over the future direction of his life — Thomas Smith (1752-1815).

Smith was originally from Ferryport-on-Craig in Fife, south east across the Forth of Tay from Dundee. He had moved to Edinburgh around 1770 to set up his own tin smithing and lamp-making business. By 1790, he had premises in Blair Street and had expanded his interests in lighting to the illumination of lighthouses, including inventing an oil-fired reflector lamp to replace the coal fires or candles often used.

On 22nd January 1787, Thomas Smith was appointed the first engineer to the Northern Lighthouse Board — the body formed in 1786 to be responsible for lighting the coast of Scotland and the Isle of Man. The Northern Lighthouse Board would figure significantly in Stevenson's life. But for the moment, in 1791, Stevenson joined Smith's workforce. He was embarking on the career for which he is now so famous — lighthouse construction.

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Robert Stevenson

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A practical education

By 1791 Robert Stevenson was 19 years old and starting his engineering career — working for Thomas Smith, engineer to the Northern Lighthouse Board. The young man is described as having large features and a clean-shaven ruddy complexion, with grey eyes and chestnut brown hair, standing 1.7m (5ft 7in) tall.

Smith and Stevenson were engaged on lighthouse projects together at a time when Smith was suffering private grief. He had married Elizabeth Couper (1758-1786) on 19th February 1778 and they had had five children, three of whom died young. This left the eldest child Jean (1779-1846) and her younger brother Thomas. After Elizabeth died, Smith had married Mary Jack (1762-1791) on 20th October 1787, and they had a daughter (Janet) before Mary too died.

Stevenson's mother, who had been a friend of both Elizabeth and Mary, moved with her son into Smith's household to look after his three children while he was away on lighthouse business. They became close but before they could marry, they had to find Jean's errant husband. This they did and a divorce was procured in 1792.

Though Stevenson was only 20 years old at the time, and appeared as a witness in the court proceedings (with Smith and lawyer John Easton) over the divorce, he was never to tell his own children or descendents about his mother's second marriage. She was a very religious woman and perhaps he wanted to spare her feelings — he even omitted to note it in the family Bible, where other significant dates were inscribed.

Jean Hogg married Thomas Smith on 14th November 1792. They had one daughter Elizabeth (1796-1803), known as Betsy, to whom Stevenson was much attached.

During the winters of 1792-94, Stevenson attended classes in natural philosophy at Glasgow University. These were delivered by Professor John Anderson (1726-1796), a former soldier with interests in field artillery and experimental physics, the latter of which gave rise to the nickname 'Jolly Jack Phosphorus' bestowed on him by the students. Anderson directed Stevenson towards an engineering career.

During the summers, he assisted Smith with lighthouse work such as reflector installation and building maintenance. He also gained experience by working on the construction of **Little Cumbrae Lighthouse** (1793) and **Pentland Skerries Lighthouse** (1794).

The first was a new lighthouse on the west coast of the islet of Little Cumbrae in the Firth of Clyde, built for the Clyde Lighthouses Trust to replace the original lighthouse (1757) atop the centre of the islet. Stevenson had more involvement with the second, at Pentland Skerries south of the Orkney Islands, where he supervised construction for the Northern Lighthouse Board. He was to rebuild it in 1821-30.

From 1796 until 1802, Stevenson was apprenticed to Smith. However, from 1797 onwards he exercised considerable autonomy in the firm's lighthouse work, beginning with **Cloch Lighthouse** (1797) on Orkney for the Clyde Lighthouses Trust. His career was becoming established.

Stevenson had grown to love his stepsister Jean Smith, also known as Jane. They married in Edinburgh on 3rd June 1799. His stepfather was now also his father-in-law, as well as being his mentor and friend.

Stevenson continued to develop his engineering vocation by attending classes at Edinburgh University during the winters of 1800-04. He studied mathematics, natural philosophy, chemistry and natural history. He was never to gain a degree yet always recognised the value of learning. By 1802 he was in full partnership with Smith and had celebrated the birth of his first child, another Jean (1801-64).

He then embarked on the construction of the last two lighthouses with which Smith would be involved. Both were for the Northern Lighthouse Board and the first was at **Inchkeith** (1803-04) in the Firth of Forth, near Edinburgh. The second was at **Start Point** (1806) on Sanday in the Orkney Islands, where it replaced an unlit masonry tower and had the first revolving light of any Scottish lighthouse.

The Stevenson family was marked by the tragedy of infant deaths but also cheered by the births of two sons who did survive to adulthood — Alan (1807-65) and Robert (1808-51). The boys attended the same school until 1821.

In 1808, Thomas Smith retired from business and as engineer to the Northern Lighthouse Board. Stevenson was appointed Smith's successor on 12th July that year, by which time the 36 year old's reputation as a lighthouse engineer was assured. His most famous work — **Bell Rock Lighthouse** — was to be his next adventure.

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Bell Rock Lighthouse showed its light for the first time on 1st February 1811. It was manned by a team of four keepers whose families were accommodated in Arbroath. Three keepers were in residence at the lighthouse at any one time.

The tower is 35m tall to the top of the light room, 12.8m diameter at the base — where the wall is 2.1m thick — tapering to 4.6m diameter at the top. It contains some 795 cubic metres of stone and weighs about 2,130 tonnes.

Five cantilevered, bonded stone floors divide into five chambers the 17.4m of tower between its solid base and the light room. The design of the floors improved on the flat arches used at Eddystone Lighthouse and was adopted in many subsequent stone lighthouses. The three lower rooms each have two windows and the upper two chambers have four.

Robert Stevenson

continued

Bell Rock Lighthouse

Robert Stevenson's most memorable achievement is his work on **Bell Rock Lighthouse**. The treacherous reef on which it stands is in the North Sea, between the Firths of Forth and Tay, some 19km south of Arbroath and 23km south east of St Andrews. The red sandstone outcrop is 435m long and the lighthouse is founded on the main section, 130m long and 70m wide, and only 1.2m above the surface at low water spring tide.

The reef was known originally as Inchcape Rock or Cape Rock. According to tradition, in the 14th century the Abbot of Aberbrothok (Arbroath) placed a floating bell on it to warn mariners, hence its present name. Sometime later a Dutch pirate removed the bell but he was later shipwrecked and perished on the same reef. The rocks were dangerous to ships sailing along the east coast of Scotland and by the end of the 18th century the need for a lighthouse was clear.

A severe storm in December 1799, in which about 70 vessels were wrecked, prompted Stevenson to propose a beacon-style lighthouse on six cast iron pillars. It was comparable with the **Smails Lighthouse** (1775-76) built west of Milford Haven by Henry Whiteside (1748-1824). Stevenson submitted a scale model of his idea to the Northern Lighthouse Board in summer 1800 — accurate physical modelling was to become something he often employed subsequently on important projects.

In October 1800, Stevenson and his friend the architect James Haldane visited Bell Rock for the first time. The visit showed that his cast iron structure would not be sturdy enough to resist the sea — a stone lighthouse would be needed. Stevenson was aware of the work that **John Smeaton** (1724-92) had undertaken in the course of erecting **Eddystone Lighthouse** south of Plymouth, and this design influenced his own, for which he built another scale model.

A Parliamentary Bill was raised for the work in 1803 but it didn't make it through the House of Lords. In January 1804, the 64-gun ship HMS *York* (launched 1796) foundered on the Bell Rock and was lost with all hands. The Northern Lighthouse Board grew concerned about the hazards of constructing a lighthouse on the rock and the considerable public expenditure it would require. In 1805, they obtained the support of eminent engineer John Rennie (1761-1821), who visited the rock on 16th August. The Cape Rock Lighhouse (Scotland) Act was passed on 21st July 1806.

The Northern Lighthouse Board appointed Rennie as "chief engineer for conducting the work" on 3rd December 1806. On 26th December, Rennie proposed "that Mr Stevenson should be appointed assistant engineer to execute the work under his superintendence", to which the board agreed. The post meant that Stevenson acted in effect as resident engineer.

Stevenson estimated the cost of his stone lighthouse at £42,685. Rennie overhauled the design, though also drawing heavily on Smeaton's Eddystone innovations. Rennie's design — implemented by Stevenson — was for a taller and more slender tower above a tapering base shaped to cycloidal curves, constructed using dovetailed stone courses jointed with mortar and faced with Roman cement. He costed the whole at £41,843.

Work began in 1807, the same year that Stevenson's son Alan (1807-65) was born. Alan would grow up to follow his father's lead and became a lighthouse engineer and engineer to the Northern Lighhouse Board.

Despite the controversy that sprang up between the families in later years over claims of who designed and built the lighthouse, records show that Rennie and Stevenson had a good working relationship at the time. In 1807, Rennie wrote encouragingly to the younger man hoping that the spirit of Smeaton would "now and then take a peep of us, and inspire you with fortitude and courage to brave all difficulties and all dangers, to accomplish a work which will, if successful, immortalise you in the annals of fame". And so it proved. Stevenson's classic *Account of the Bell Rock Light-House* was published in an edition of 300 copies in 1824.

A yard was leased for seven years at Arbroath, where stone blocks for the courses were shaped and trial fitted, and accommodation was provided for men and materials. The first task was to erect a floating light near the reef, equipped with stores for men at work on the rock. An 81 tonne vessel with three masts, captured from the Prussians and renamed *Pharos*, was moored 2.4km north west of Bell Rock on 14th July 1807. A light was exhibited on each mast from 15th September.

A new 41 tonne sloop — named *Smeaton* at Stevenson's suggestion — was built at Leith and came into service in August. Rennie visited the site to inspect progress on 6th October 1807, just before work halted for the winter. A temporary beacon of 12 timber beams had been erected, though little had been achieved in preparing the rock surface for the lighthouse foundations. From 1808, the beacon supported a working platform and barracks, designed by foreman millwright Francis Watt, which remained in place until September 1812.

The year 1808 was a busy one for Stevenson. On 10th July he laid the lighthouse's foundation stone, which was almost at the level of low water spring tide, and two days later he was formally appointed as the Northern Lighthouse Board's engineer. The board also provided a new tender, the 81 tonne *Sir Joseph Banks*, to be used as living quarters for those working on the reef.

By the end of September, four courses of the lighthouse tower were complete, two of which were sunk into the bedrock, and work at sea stopped for the year. Rennie made his annual inspection on 25th November 1808.

Stevenson also celebrated the birth of another son, his namesake Robert (1808-51), who was destined for a career in medicine rather than engineering.

Model of the construction of **Bell Rock Lighthouse**
Photo: © The Trustees of the National Museum of Scotland

Model of the construction of **Bell Rock Lighthouse**
Photo: © The Trustees of the National Museum of Scotland

Trip to Bell Rock Lighthouse
Video: by pariawatcher on YouTube

The next work season, April to September 1809, brought the lighthouse to a height of 9.6m. Up to 9.1m the tower was solid masonry, apart from a 250mm diameter hole designed for the reflector-moving machinery. Rennie visited on 24th September and saw the iron balance cranes (forerunners of modern tower cranes) atop the tower, moveable jib cranes for unloading stone from the boats and the cast iron railway for transporting materials around the reef. These innovations were devised under Stevenson's direction and designed and constructed by Watt from 1808 onwards with Rennie's approval.

The lighthouse structure was completed the following year. Stevenson laid the last stone at the top of the 96-step staircase on 2nd September 1810. The timber bridge that had connected the lighthouse to the barrack since April was dismantled the same day and replaced by a rope ladder. The light room was completed on 24th October and the interior of the lighthouse by 5th November.

Bell Rock Lighthouse exhibited its light for the first time on 1st February 1811. It was manned by a team of four keepers, three in residence at a time, each paid about £50 per year. The keepers' families were accommodated in Arbroath, where the shore-based communications comprised a 15m high signal tower (completed 1813) and a 41 tonne supply vessel. The total cost of the project, at both Bell Rock and Arbroath was £61,331.

The light room is 3.7m in diameter and 4.6m high. Apart from the 6mm thick glass, the walls and balcony were made from cast iron and it had a domed copper roof. The original array of seven rotating oil lamps were fitted with Argand burners—invented by Ami Argand (1750-1803) circa 1781 — placed in front of parabolic silver-plated copper reflectors. It was the first lighthouse to display both white and red flashes of light, owing to Stevenson's use of red glass in front of some of the reflectors.

While it is now clear that Rennie had a greater role in the design of the lighthouse than has been acknowledged hitherto, Stevenson deserves full credit for overcoming the physical difficulties of translating the design into reality. He could not have achieved it without the efforts of his dedicated workmen, many of whom &,dash; and their relatives — continued to work for him on other projects.

Bell Rock Lighthouse is the oldest surviving rock lighthouse in the UK. It is still in service, now with a nominal range of 33km, but is unmanned — as are all UK lighthouses: **Fair Isle South Lighthouse** in Shetland was Scotland's last manned lighthouse, automation being completed on 31st March 1998. The keepers left Bell Rock on 26th October 1988, and from the end of 1999 the light has been powered by solar panels with back-up generators.

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A lot more lighthouses

Robert Stevenson was not yet 39 years old in February 1811 when light first shone from **Bell Rock Lighthouse**. His reputation was already assured, though he did not neglect other avenues of engineering. By 1821 he had established one of Scotland's leading locally-founded civil engineering practices.

However, Stevenson did inaugurate the modern lighthouse service in Scotland. He went on to build at least a further 20 lighthouses and he remained engineer to the Northern Lighthouse Board until 1843, carrying out regular inspections of their installations — flying his own pennant to alert lighthouse keepers to his arrival. The recognisable style of his lighthouses is characterised by their conical towers, domed lanterns and flat-roofed adjoining dwellings — these days the majority are Category A or B listed buildings.

Of the lighthouses he designed after 1811, all but two were constructed for the Northern Lighthouse Board. **Toward Point Lighthouse** was built for the Cumbrae Lighthouse Trust and **Douglas Head Lighthouse** for the Isle of Man Harbour Commissioners.

In the second decade of the 19th century Stevenson designed five lighthouses — **Toward Point** (completed 1812), **Isle of May** (1816), **Corsewall** (1817), **Point of Ayre** (1818) and **Calf of Man** (1818). He and his wife Jean produced two more sons, who would later join their father to become celebrated lighthouse engineers — David Lillie (1815-86) and Thomas (1818-87).

A coal-burning beacon was established on the Isle of May, Firth of Forth, in 1636. This was the first permanent light station in Scotland and the last one to be in private ownership. The Northern Lighthouse Board bought the island in 1814 and Stevenson's lighthouse was completed in 1816. Its 24.1m high square-plan unpainted masonry tower and adjoining dwelling resemble a castle. His grandson David Alan Stevenson (1854-1938) would install a new lantern there in 1924.

Stevenson's Calf of Man Lighthouse, on an islet off the south west tip of the Isle of Man, has twin towers — high light and low light — to illuminate Chicken Rock to the south. In 1869-74, it was replaced by a lighthouse on Chicken Rock itself, built by Stevenson's sons David and Thomas, which began shining in 1875 and is still operational. From 1874, the original lighthouse was used as a shore station for Chicken Rock.

Stevenson completed another five new lighthouses in the 1820s — **Sumburgh Head** (1821), **Eilean Glas** (1824), **Rhinns of Islay** (1825), **Buchan Ness** (1827) and **Cape Wrath** (1828). He also rebuilt Thomas Smith's 1788 **Mull of Kintyre Lighthouse** and the twin towers of Smith's 1794 **Pentland Skerries Lighthouse**. He constructed a low light tower at Smith's 1790 **Pladda Lighthouse** off Arran so that it could be distinguished from other lights.

Sumburgh Head Lighhouse, on the southern tip of the Shetland mainland, is the oldest lighthouse in Shetland. Its 17.1m high white tower has a double wall thickness construction to protect against damp. The keepers' accommodation is now used by the RSPB and for overnight visitors to the Sumburgh Head Nature Reserve.

At Eilean Glas Lighthouse in the Western Isles, Stevenson added a second tower near the 1789 one built by Smith, which it replaced. Stevenson's structure is 29.9m tall and painted with alternate horizontal red and white bands.

Buchan Ness (Buchanness) Lighthouse at Boddam in Aberdeenshire had a twinkling light that revolved faster than any other when it was first exhibited in 1827. The islet on which it stands was connected to the mainland by a timber bridge in 1834, at Stevenson's direction. His grandson David later instructed (1907) that a central red band be painted on the 35.1m white tower, so it could also be used as a day mark.

At Cape Wrath Lighthouse, on the north west tip of mainland Scotland, Stevenson had first to construct both a quay some 1.5km from the site to import building materials and an access road 19km long with numerous bridges.

In the 1830s Stevenson was even busier designing lighthouses, and seven more were finished — **Tarbat Ness** (1830), **Mull of Galloway** (1830), **Dunnet Head** (1831), **Douglas Head** (1832), **Girdle Ness** (1833), **Barra Head** (1833) and **Lismore** (1833).

Tarbat Ness Lighthouse, on the peninsula between the Firths of Dornoch and Moray, is the tallest lighthouse on the Scottish mainland at 41.1m. Its white tower is painted with two red bands.

No trace now remains of Stevenson's Douglas Head Lighhouse at the entrance to Douglas Harbour on the Isle of Man. It stopped exhibiting a light after 1850 and when the Northern Lighthouse Board assumed responsibility, it was demolished and replaced by a new tower built in 1857-59 by his sons David and Thomas.

Stevenson's son Alan was resident engineer for the Girdle Ness (Girdleness) Lighthouse in Aberdeen. This was the only Scottish lighthouse to have two fixed lights on one tower. The lower light was shown from a glazed cast iron gallery at about one-third of the way up, but was discontinued in 1890 when the upper light was upgraded.

Barra Head Lighthouse, on the island of Berneray at the south of the Outer Hebrides, probably has the most dangerous landing place in Scotland. It is also Scotland's highest lighthouse — the light on its 18m tall white tower is 211.2m above sea level.

Stevenson also turned his attention to lighthouse illumination, developing further Thomas Smith's pioneering work with curved reflectors and oil lamps. He improved the catoptric system, which uses silvered copper parabolic reflectors and Argand lamps, increasing the power and range of the lights.

LIGHTHOUSES AFTER 1811

For a comprehensive list of Stevenson's works, see selected works

Toward Point Lighthouse (completed 1812)
Cowal Peninsula, Firth of Clyde
— tower 19.2m high, painted white ... guides vessel between the Isle of Bute and mainland Scotland ... r owned and operated by the Clyde Port Authority

Isle of May Lighthouse (1816)
Isle of May, Firth of Forth
— tower 24.1m high, unpainted stone

Corsewall Lighthouse (1817)
near Stranraer, Loch Ryan
— tower 34.1m high, painted white

Point of Ayre Lighthouse (1818) (**upper tower**)
Isle of Man, northern tip
— tower 29.9m high, painted white with two horizon red bands ... still uses an 1890 Fresnel dioptric lens oldest lighthouse on the island

Calf of Man (1818)
Isle of Man, south west tip
— two of its three towers are by Robert Stevenson

Kinnaird Head Lighthouse modifications (1820s)
Fraserburgh, Aberdeenshire
original by Thomas Smith (1787)
— first Northern Lighthouse Board lighthouse ... Stevenson modified the tower and installed a new lantern

Pentland Skerries rebuilding (1820s)
Orkney, original by Thomas Smith (1794)
— twin towers rebuilt

Mull of Kintyre Lighthouse rebuilding (1820s)
Mull of Kintyre, original by Thomas Smith (1788)

Pladda Lighthouse low light (1820s)
Arran, original by Thomas Smith, 1790
— new low light to enable it to be distinguished fron other lights

Sumburgh Head Lighthouse (1821)
Shetland, southern tip
— tower 17.1m high, painted white

Eilean Glas new tower (1824)
Scalpay, off Harris, Western Isles
original by Thomas Smith (1789)
— tower 29.9m high, painted in alternating red and white bands

Rhinns of Islay Lighthouse (1825)
Orsay, south west of Islay
— tower 29m high, painted white ... in a Special Protection Area designated for its bird life

Buchan Ness Lighthouse (1827)
Boddam, Aberdeenshire
— tower 35.1m high, one central red band

Cape Wrath Lighthouse (1828)
Cape Wrath, north west tip of Scottish mainland
— tower 20.1m high, painted white

Mull of Galloway Lighthouse (1830)
Galloway Peninsula, Irish Sea
— tower 25.9mm high, painted white ... most southe lighthouse in Scotland

Tarbut Ness Lighthouse (1830)
Tarbat Ness, between Firths of Dornach and Moray, Highland
— tower 41.1m high, painted white with two horizon red bands ... tallest lighthouse on the Scottish mainl

Dunnet Head Lighthouse (1831)
Easter Head, Caithness
— tower 20.1m high, painted white ... most northerl point of mainland Scotland

Douglas Head Lighthouse (1832)
Douglas Harbour, Isle of man
— demolished and replaced 1857-59

Barra Head Lighthouse (1833)
Berneray, Outer Hebrides
— tower 18m high, painted white ... its lamp is 211.2 above sea level

Girdle Ness Lighthouse (1833)
Greyhope Road, Aberdeen
— tower 36.9m high, painted white ... only Scottish lighthouse to have had two fixed lights in one tower (lower one now disused)

As more lighthouses were built around the country, it became more difficult for those at sea to distinguish between them, even where there were two fixed lights, such as at Pladda, Pentland Skerries, Calf of Man and Girdle Ness. To alleviate this problem, Stevenson devised intermittent and flashing lights.

Stevenson's portfolio of lighthouses is impressive and represents a large part of his marine and maritime engineering, but he still found time to apply his skills and ideas in other areas. In particular, he applied his growing knowledge to the design and modification of other water-related features such as harbours, sea walls, bridges, canals and river navigation works.

Lismore Lighthouse (1833)
Eilean Musdile, Sound of Mull
— tower 26.2m high, painted white

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The sea wall, enclosing pier and breasting of the southern area at **Stonehaven Harbour** were designed by Robert Stevenson and constructed 1825-26. The internal jetty dates from 1837. Stretching out to the right (out of shot), a mass concrete breakwater (1901) protects the harbour, which is south of Aberdeen on the Scottish east coast. It was once a herring port but is now used for recreational boating.

The **sea wall at Trinity** in Edinburgh was constructed in 1821 and about 275m of it is still in use. Its cycloidally curved profile is considered proof of Stevenson's definitive understanding of maritime engineering.

Photo: Roland Paxton

Robert Stevenson

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Maritime and river engineering

As mentioned earlier, the success of the work on **Bell Rock Lighthouse** enabled Stevenson to establish his own civil engineering practice by 1821. The multi-disciplinary firm would go on to operate continuously until 1952, employing Stevenson's own descendants and those of his trusted staff.

The largest part of the work undertaken was marine and maritime engineering, which of course included the more than 20 **lighthouses** described earlier. However, the numerous proposals made by Stevenson — many of which were implemented — included many maritime works, such as harbour improvements in Scotland and northern England, and some navigation schemes. He also reported on ferry crossings and fisheries.

Among the harbours for which he proposed improvements are those at **Aberdeen**, **Ardrossan**, **Ayr**, **Ballyshannon**, **Chester**, **Cockenzie**, **Crail**, **Dundee**, **Fisherrow**, **Fraserburgh**, **Grangemouth**, **Granton**, **Kirkwall**, **Leith**, **Lossiemouth**, **North Berwick**, **Perth**, **Peterhead** (**Peterhead South Harbour**, **Peterhead North Harbour**), **Rothesay**, **Stonehaven** and **Sunderland**. The river navigation schemes he looked at include those on the Rivers **Dee**, **Erne**, **Forth**, **Lune**, **Mersey**, **Ribble**, **Severn**, **Tay**, **Tees** and **Wear**. Among the ferry crossings he reported on are ones on the Firths of **Dornoch**, **Forth**, **Pentland** and **Tay**, and on the River **Severn**. Quite an impressive list.

While working at Aberdeen in 1812, Stevenson found that salt water from the ocean flowed up river in a layer distinct from the fresh water flowing towards the sea. The salt water is denser (heavier) and tends to sink, so the lighter fresh water overflows it. This discovery led to his invention of the hydrophore, a water sampler for procuring samples at different depths. It also led to further experiments in Scottish rivers and firths. In May 1817, he published his results in a Royal Society of Edinburgh paper entitled *On vertical differences of salinity in water*.

Stevenson was intrigued for most of his working life by coastal erosion and its causes, believing that it resulted from the raising of the sea bed, which then triggered a rise in sea level. He made extensive studies of the bed of the North Sea and he delivered his findings to the Wernerian Society (existed 1808-58, affiliated to the Royal Society of Edinburgh) in a series of papers. The papers are entitled *Observations upon the alveus or general bed of the German Ocean and British Channel*, which was read in March 1816, followed by *On the bed of the German Ocean, or North Sea* read in March 1820, and *Remarks upon the wasting effects of the sea on the shore of Cheshire, between the rivers Mersey and Dee*, which was read in March 1828.

In 1821, Stevenson proved his definitive understanding of maritime engineering with the design and construction of a **sea wall at Trinity**, between Granton and Leith, now part of Edinburgh. About 275m of this wall, west of Trinity Road, is still in service. It has a cycloidally curved vertical profile in order for the upper part to "bring gravity into action against the rise of the waves". For economy the wall was made mainly in roughly dressed beach boulders but, as can be seen today, its curve proved difficult to execute accurately. Nevertheless, it's stood the test of time. However, at his later harbour works, such as Fisherrow and Stonehaven, Stevenson did not repeat cycloidal design, using a steep uniform batter instead. These too remain in service.

In 1933-34, Stevenson and his son Alan worked together on the improvements to the **navigation channel in the River Tay** between Perth and Dundee. They deepened the main channel so that ships could reach Perth without waiting for high tide.

Meanwhile, he continued with practical experiments on the progressive damage to timber by Limnoria terebrans. This small creature, commonly known as gribble, is a marine isopod crustacean that bores into, and ultimately destroys, submerged timbers. It had been discovered by Stevenson in 1808. He had set up comparative trials on Bell Rock, using different types of wood, and he monitored the results in 1814, 1821, 1837 and 1843. His work influenced the universal adoption of greenheart (Ocotea rodiaei) — a resistant South American tropical hardwood — for marine and maritime timbers.

Stevenson's three engineer sons joined him in partnership in the practice — Alan in about 1832, David in 1838 and Thomas in 1846 on his father's retirement. His other surviving son, Robert Jnr, became a doctor of medicine and at the time of his father's death in 1850 was Surgeon of Her Majesty's Third Regiment of Foot.

Alan, David and Thomas built a further 43 lighthouses between them, and more were constructed when Robert's grandsons joined the family firm. Perhaps the most notable of all these is Alan Stevenson's **Skerryvore Lighthouse** (1838-44), which is the tallest lighthouse in Scotland.

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Railways, roads and bridges

From 1811 onwards, Stevenson pursued a number of other projects besides lighthouses and maritime work. There were several canal schemes (though none were executed, mainly on grounds of expense), and rail, road and bridge projects. The rail and road projects often involved him in a promotional role as well doing the engineering.

In 1817, Stevenson proposed a canal on one level between Edinburgh and Glasgow — including a tunnel nearly 5km long beneath the Bathgate Hills — with a connection to Leith that had locks. The estimated total cost was £491,999. He also proposed a canal in the Vale of Strathmore, almost 26km long, between Forfar and Arbroath, estimated at £88,378.

He worked with engineers **Thomas Telford** (1757-1834) and Alexander Nimmo (1783-1832) on a proposal for a new harbour at Wallasey, connected by an 11km ship canal across the Wirral Peninsula to the Hilbre Islands off West Kirby. This would have linked the Rivers Mersey and Dee. Their joint report was submitted in May 1828, with a construction estimate of £1.4m (unexecuted). In all his canal schemes, Stevenson endeavoured to keep levels constant and locks to a minimum.

He applied a similar 'keep it close to level' design philosophy for rail tracks — even if it meant detours or additional viaducts. By about 1818 he had decided that railways were superior to small canals for inland communication. At this time it was all horse-drawn railways, as locomotive engines didn't come into general railway use until after 1825, despite **Richard Trevithick**'s (1771-1833) pioneering work on steam locomotion in 1801-08.

In 1818, Stevenson advocated the use of 3.7m - 6.1m long, malleable iron-edge rails in preference to the much shorter (typically 900mm long and weaker) cast iron rails then prevalent. Rail pioneer George Stephenson (1781-1848), acknowledging Stevenson's influence on John Birkinshaw's development of malleable wrought iron rails — forerunner of modern steel rails — wrote to Stevenson on 28th June 1821, "I know you have been at more trouble than any man I know of in searching into the utility of railways".

Later that year, he proposed the construction of Edinburgh Railway, to connect the city and its port of Leith with the Midlothian coalfields, in a report addressed to Walter Montagu Douglas Scott, Duke of Buccleuch and Queensberry (1806-84), among others. This work helped the successful completion of the **Edinburgh & Dalkeith Railway** in 1831 for a group of subscribers led by the Duke. In 1819, Stevenson proposed a railway in Angus between Montrose and Brechin.

Also in 1819, Stevenson advised on the line for the **Stockton & Darlington Railway**, which was intended to be a horse-drawn plateway. However, it later became the first permanent public railway to be powered by steam, and was constructed under George Stephenson's supervision in 1822-25.

By 1820, Stevenson was the leading authority on horse-traction railways in Scotland. He edited and produced accompanying notes for the numerous *Essays on Rail-Roads* submitted to the Highland Society in response to a competition they initiated in 1818, with a premium of 50 guineas (£52.50) for the best essay on railway construction. His *Notes* were published in 1824.

By 1836 he had planned enough railway schemes to traverse Scotland east from the Tweed Valley to Perth and Aberdeen, and west from Edinburgh to Glasgow via Bathgate. His schemes were close to the routes of the eventual rail network but the financial climate at the time was unfavourable and the necessary finance for their implementation was not forthcoming. The only scheme constructed was the short **Newton Colliery Railway** to Little France near Edinburgh, part of his original Edinburgh Railway proposals.

However, Stevenson was more successful with road making and with the promotion of stone tracks in city roads. **Granton Road** (now in Edinburgh) was built as part of his 1834 proposals for **Granton Harbour** and its road and rail infrastructure. He was a notable highway planner and bridge engineer — proposing, designing and constructing many different types of bridges throughout Scotland.

Stevenson's masonry bridges are characterised by segmental arches. Fine examples still exist — **Marykirk Bridge** (1811-14), **Annan Bridge** (1824-27), **Stirling Bridge** (1829-32) and **Allanton Bridge** (1840-42). In 1816-17 he took charge of widening **Lugton Bridge** (c.1765), and later he also planned the town approach for his William IV or 'New' Bridge in Stirling.

He was instrumental in the improvement between 1815 and 1819 of his home city of Edinburgh. He designed the **London Road** approach and **Regent Road** approach to the east end of Princes Street, skirting Calton Hill and including the single span **Regent Arch** with its open parapets. He was also responsible for the construction of

the roads, which involved blasting, rock excavation and a massive retaining wall.

In Glasgow, Stevenson built two bridges over the River Clyde. The first was **Hutcheson Bridge** (1831-34), a five span masonry structure that was described by Stephen Fenwick, of the Royal Military Academy, in his 1861 book *The Mechanics of Construction* as "one of the best specimens of the segmental arch". It was demolished in 1868 after its piers were undermined by navigational deepening of the river, despite evidence, provided by Stevenson's son David among others, that it could have been repaired. It was replaced by the wrought iron **Albert Bridge** (1871-72).

The second was a 9.75m wide 14-span temporary timber bridge (1832) over the Clyde at South Portland Street. It accommodated traffic while Telford's **Glasgow Bridge** was being constructed (1833-35) at Broomielaw. It was retained as a pedestrian bridge until 1846 and then replaced by the present **suspension bridge** (1851-53).

He also designed metal bridges, such as the three span wrought iron **Abbey St Bathans footbridge** (c.1833). This was closed in 1925 and replaced by a cable stayed timber bridge (c.1983) erected by the army.

He adopted cast iron segmental arch solutions in major proposals for additions to existing stone bridges, designed to increase traffic capacity. These included Robert Mylne's (1733-1811) bridge at Newcastle upon Tyne (1774-81, demolished c.1876) in 1826, John Smeaton's **Perth Bridge** (1766-71) in 1827, and Edinburgh's **North Bridge** (1765-72, designed by Mylne's brother William) in 1832. None of them were executed.

Stevenson designed other kinds of bridges too. He developed an innovative (unexecuted) laminated timber arch for Dornoch Firth in 1830, and a new type of medium-span wrought iron suspension bridge without towers. He proposed the latter for numerous locations. Its novelty was that the roadway superstructure rested on the catenarian chains rather than being suspended from them. This, and other Scottish bridge developments, were reviewed in his authoritative article *Description of bridges of suspension*, published in the Edinburgh Philosophical Journal in October 1821 and translated subsequently into French, German and Polish.

He first proposed the new type of suspension bridge — called underspanned suspension — for crossing the River Almond at Crammond, north west of Edinburgh, in 1820. It wasn't built but the concept led to the development of the truss principle, and by 1850 numerous small-span bridges were constructed to this basic plan in Britain and on the continent. Several underspanned suspension bridges would be built in Europe and India by 1870.

Though not implemented as intended, Stevenson's proposals together with details of his Glasgow and Stirling bridges, were disseminated widely through John Weale's (1791-1862) *The Theory, Practice, and Architecture of Bridges of Stone, Iron, Timber, and Wire* (1839). His ideas undoubtedly influenced subsequent bridge-building practice nationally.

Stevenson also found time to advise on diverse other structures, notably **Arbroath Abbey** (founded 1178), **Montrose Church** (rebuilt 1791-93) and the **Melville Monument** (1821). In 1809, he rebuilt Arbroath Abbey's circular window in the south transept gable, which had become a useful landmark for shipping. In 1811, he found the bell tower of Montrose Church (now Old and St Andrew's Church) cracked and unsafe, though no action was taken until it was demolished in 1831 and replaced by the present steeple in 1834. In 1821, he was consulted over the foundation design for the Melville Monument in St Andrew Square, Edinburgh, and supervised its erection — using the type of balance crane he had used on **Bell Rock Lighthouse.**

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Character, writings and final years

Robert Stevenson was a lifelong believer in the power of education and the importance of knowledge, and he never stopped trying either to increase his own knowledge or to promote what he had learned. He was a practical self-made man, who always expected his children and staff members to work as hard as he did.

He was also a devoted husband, father and grandfather but wasn't given to spoiling his family. His character had a religious aspect too — he was a member of the Church of Scotland and an elder in Edinburgh, at St Mary's in 1828-43 and after that at Greenside parish church.

However, the relationships between Stevenson and Smith families were complicated — Stevenson's stepfather was also his father-in-law and business partner. Perhaps because of this, he saw no problem with encouraging nepotism, either in his own family or in relation to the families of his workforce.

It has been noted that there were two competing impulses in Stevenson's character. One was his great desire for adventure and belief in enterprise. The other was his perfectionist nature that had him always looking for order. It was this side of his character that led him to instinctively follow military-like arrangements for the running of his workforces in lighthouse construction.

Stevenson was energetic and focused, with a fierce gaze and something of a twinkle in his eye. In the summer of 1817, he wrote a lively and informative series of letters to his 16 year-old daughter Jean (also known as Jane), while travelling through the Netherlands visiting drainage and embankment schemes. The letters were published in the Scots Magazine in 1818-21. Stevenson later published the 14 letters privately under the title *Journal of a Trip to Holland* (1848).

Indeed, Stevenson's numerous writings appeared in more than 60 publications. Many were engineering reports, though about one-third achieved much wider circulation through leading periodicals and encyclopaedias. He contributed six significant articles to the Edinburgh Encyclopaedia between 1810 and 1824, and five to the Encyclopaedia Britannica between 1816 and 1819.

The depth and authority of Stevenson's published works means they now represent a valuable historical resource to engineers and historians alike.

He was an enthusiastic member of plenty of learned societies, starting with the Highland Society in 1807. He joined the Wernerian Society in May 1809, becoming a member of the council by 1812. He was a founder director of the Astronomical Institution of Edinburgh in 1813. In 1815, he was elected to fellowships of the Royal Society of Edinburgh, the Geological Society and the Society of Antiquaries of Scotland. In 1821 he became a founder subscriber, and later director, of the School of Arts in Edinburgh (the precursor of Heriot-Watt University). He was elected to membership of the Smeatonian Society in 1827 and the Institution of Civil Engineers in 1828.

Stevenson retired from his position with the Northern Lighthouse Board at the end of 1842, aged 70 years. His three engineering sons would follow in his footsteps his lead — all would hold the post of Engineer with the Board: Alan from January 1843 until March 1853, when ill health dictated his retirement; David until March 1855; and thereafter David and Thomas as joint Engineers until 1884.

In 1846, Stevenson's wife Jean died — and this was also the year that marked his retirement from all engineering matters. Stevenson himself died at the family home — 1 Baxter's Place in Edinburgh — on 12th July 1850, aged 78 years. They are both buried in a tomb in Edinburgh' New Calton Cemetery. The five surviving children outlived them, and sons Alan and Thomas were also eventually buried in the family vault.

Alan and David both penned biographies of of their father after his death. To them, the prominent points of his character were sagacity, fortitude, perseverance, unselfishness, generosity and a strong sense of duty. He was tireless in helping young men, many of them apprentices in his own firm, to progress through life in general and the engineering profession in particular.

The Northern Lighthouse Board commissioned a marble bust of Stevenson on 19th July 1824, when he was 52 years old and his account of work on Bell Rock Lighthouse had just been published. The bust was carved by Samuel Joseph (1791-1850) and completed in 1827. Unlike many other eminent engineers, Stevenson was not immortalised in memorial statuary after his death — perhaps his lighthouses serve that purpose. Navigation around the coasts of Scotland is safer thanks to his sustained efforts, and those of the dynasty of engineers that he engendered.

In 1970, Stevenson College of further education was founded in Edinburgh, something of which its namesake undoubtedly would have approved.

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Selected works

1791	Employed by Thomas Smith, first engineer to the Northern Lighthouse Board
1793	Works on construction of **Little Cumbrae Lighthouse** for Thomas Smith
1794	Works on construction of **Pentland Skerries Lighthouse** for Thomas Smith
1797	**Cloch Lighthouse**, Orkney ... with Thomas Smith
1803-04	**Inchkeith Lighthouse**, Firth of Forth ... with Thomas Smith
1806	**Start Point Lighthouse**, Orkney ... with Thomas Smith
1807-11	**Bell Rock Lighthouse** ... with John Rennie Snr
1808	Appointed engineer to the Northern Lighhouse Board (12th July), succeeding Thomas Smith
1811-14	**Marykirk Bridge**, Aberdeenshire
1812	**Bell Rock Shore Station**, Arbroath
1812	**Toward Point Lighhouse**, Firth of Clyde
1812	**River Dee navigation improvements** (parts), Aberdeenshire
1812-14	**North Berwick Harbour breakwater report**, East Lothian
1813-21	**North Carr Rock Beacon**, Fife Ness
1814-16	**Isle of May Lighthouse**, Firth of Forth
1815-17	**Corsewall Lighthouse**, Stranraer
1815-18	**Point of Ayre Upper Lighthouse** and **Lower Lighthouse**, Isle of Man
1815-19	**The Regent Arch** and **Regent Road approach**, Edinburgh
1816-17	**Lugton Bridge widening**, Dalkeith
1818	**Calf of Man Lighthouse** (two of three towers), Isle of Man
1818	**Newton Colliery Wagonway** (the 'Edmonstone'), Newton to Little France on the Dalkeith Road, Edinburgh
1818-21	**Fraserburgh South Quay**, and harbour improvements, Aberdeenshire
1820s	Additions to **Kinnaird Head Lighthouse**, Aberdeenshire
1820s	**Pentland Skerries Lighthouse rebuild**, Pentland Firth
1820s	**Mull of Kintyre Lighthouse rebuild**
1820s	**Pladda Lighthouse modernization**, Arran
1821	**Melville Monument**, Edinburgh
1821	**Sumburgh Head Lighthouse**, Shetland
1824	**Eilean Glas Lighthouse new tower**, Scalpay, Outer Hebrides
1824-27	**Annan Bridge**, Dumfries & Galloway
1824-27	**Buchan Ness Lighthouse**, Aberdeenshire
1825	**Rinns of Islay Lighthouse**, Inner Hebrides
1825-30	**Stonehaven Harbour**, Aberdeenshire
1826	**Alloa Piers**, Clackmannanshire
1826-28	**Crail Harbour West Pier**, Fife
1828	**Cape Wrath Lighthouse**, Sutherland
1828-30	**Tarbat Ness Lighthouse**, Dornach and Moray Firths
1828-30	**Mull of Galloway Lighthouse**, Stranraer
1829-32	**William IV ('New') Bridge**, Stirling
1830	**Laminated timber arch bridge** (unbuilt), Dornach Firth
1830-33	**Barra Head Lighthouse**, Berneray, Outer Hebrides
1831	**Dunnet Head Lighthouse**, Pentland Firth
1831-32	**Douglas Head Lighthouse**, Isle of Man
1831-34	**Hutcheson Bridge** (demolished), Glasgow
1832	**Portland Street Footbridge** (demolished), Glasgow
c.1833	**Abbey St Bathans Footbridge**, Scottish Borders
1833	**Girdle Ness Lighthouse**, Aberdeen
1833	**Lismore Lighthouse**, Sound of Mull
1833	**Perth Harbour planning**, Perth & Kinross
1834 on	**River Tay navigation improvements**
1834-37	**Granton Harbour recommendations** (not fully implemented) and **Granton steam boat pier** (supervised by David Stevenson), Edinburgh
1835	**Cockenzie Harbour improvements**, East Lothian
1839 on	**River Ribble navigation improvements** (implemented by his sons)
1840-42	**Allanton Bridge**, Scottish Borders

1842	Retires from his position as engineer to the Northern Lighhouse Board
1843	**Fisherrow Harbour**, Musselburgh, East Lothian
1843 on	**Forth River navigation improvements** (Stirling to Alloa), initial report 1828
1846	Retires from engineering work
1850	Dies on 12th July

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