newsletter OF THE JAMES CLERK MAXWELL FOUNDATION

William Dyce Cay (1838-1925), Civil Engineer

James Clerk Maxwell's mathematical cousin

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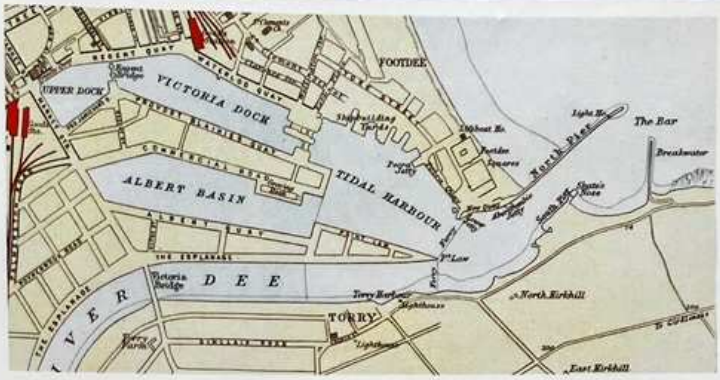
William Dyce Cay © ICE Archives

William Dyce Cay, second son of Robert Dundas Cay, W.S., lawyer and brother of Frances Cay the mother of James Clerk Maxwell (1831 – 79) was born on 28 March 1838 at 18 Rutland St. Edinburgh. He was educated at the Rev. Wm. Bliss's school, Peebles from 1844–53 and Edinburgh University where, in 1856, he obtained its highest mathematical prize, the Straiton Gold Medal and 1st prize in the 2nd Division of the Natural Philosophy class.

In obtaining these awards, Cay acknowledged that the '*tuition and example*' gained from his cousin (Maxwell) on long walks from the estate at Glenlair, Kirkcudbrightshire, in 1855 had '*had good effect*'. This was even though '*before I had got to the bottom of one example he had rushed off into another*'! In 1856 Maxwell went with Cay to Belfast and introduced him to his friend James Thomson (elder brother of William, later Lord Kelvin), Engineer to Belfast Waterworks and, from 1857, Professor of Engineering at Queens College, Belfast.

Cay's Glenlair road bridge – 45ft span © K. McCrae



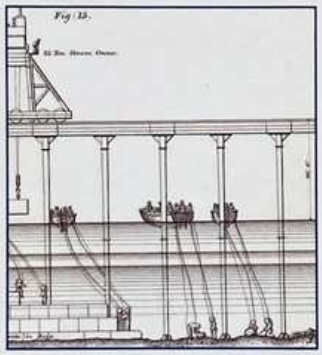
Aberdeen Harbour after improvement Groome's Gazetteer 1882

Cay served as a pupil under Thomson from 1856–58, completing his four-year apprenticeship in November 1860 as an assistant resident engineer with leading Edinburgh consulting engineers B. and E. Blyth. He worked on the construction of the 60-mile Portpatrick Railway (from Castle Douglas) from the firm's Creetown site office and afterwards in its Edinburgh office. Interestingly, a resident engineer contemporary on this project was Maxwell's fellow Edinburgh Academical, Allan D. Stewart (1831 – 94 – a Cambridge University 9th wrangler in 1853, the year before Maxwell became 2nd wrangler). Stewart later contributed significantly to the design of the Tay and Forth Bridges, including the Forth suspension bridge (abandoned in the wake of the Tay Bridge failure) in the feasibility report on which it was noted that he applied *'Professor Clerk Maxwell's diagrams of forces … with much skill'*.

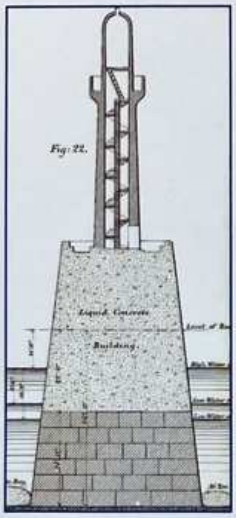
From June 1862 to August 1863 Cay worked as resident engineer on the Turin and Savona Railway under its chief engineer James Abernethy, then for two years in London as an assistant to A.M. Rendel, returning to Scotland from 1865 – 67 as chief assistant to James Leslie, Edinburgh Waterworks Engineer. In a testimonial to Leslie, Maxwell, who had returned to Glenlair after resigning his Natural Philosophy chair at King's College, London, wrote of Cay:

'His mathematical knowledge is sound and he has made a special study of iron and stone bridges, some of the results of which he has been in the habit of communicating to me … A skew bridge had to be erected, but some of the stones … were not properly shaped. Mr. Cay however designed the correct form … and the bridge was erected according to his plans. Mr. Cay has made a design of a bridge for me across the the River Urr which I intend to have executed next Spring' (1866 – still in service, see above).

Cay then embarked on his most important civil engineering work as Resident Harbour Engineer at Aberdeen from 1867–80. His direction of major improvements to the harbour (see map) included channelizing about a mile of the river Dee and construction of the present South Breakwater (1050ft long) – see illustrations.



South Breakwater being built under Cay's direction MPICE 39



Breakwater end and Lighthouse

In constructing the harbour entrance, still in service, Cay adopted concrete, in preference to traditional rubble and masonry, using about 15,000 tons of Portland Cement in liquid concrete and large blocks. Full width single pours ranged up to a then remarkable 1,300 tons. He designed the plant and staging and implemented, from 1872, a new mode of depositing liquid concrete from a hopper barge to 20ft below Low Water in jute bags holding up to 100 tons.

Cay also designed steam-operated barges for carrying dredged material and a concrete mixing machine. His experimental work included quantifying the increased early strength of cement briquettes made with salt water. Although he did not invent the concrete bag technique, he was the first to use it on a large scale to fit a breakwater sole neatly to an undressed firm foundation, minimising costly excavation. Cay's achievement at Aberdeen was illustrated in Vernon-Harcourt's Harbours and Docks classic text book and, that he deserved *'great credit'*, was also publicly acknowledged by other eminent engineers including Abernethy and Sir John Hawkshaw.

Cay's innovations earned him a bronze medal at the Royal Mining Engineering and Industrial Exhibition at Newcastle-upon-Tyne in 1887 and a Brisbane Medal from the Royal Scottish Society of Arts in 1888. By then his concrete in bags technique (although of limited later application as sheet steel and the use of compressed air developed) had been used at Buckie, Lerwick, Arbroath, Fraserburgh and Newhaven (Sussex) harbours, and New Plymouth Breakwater (Ngamotu), New Zealand.

By the 1870s Cay had become a leading member of his profession.

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