# Going Forth – and multiplying

**Protecting the environment was top priority for Scottish school children in their futuristic designs for a new Forth bridge to be built a century from now.**

There were 200 entries for the competition conceived and run by the ICE with the National Museums of Scotland. Pupils were asked to imagine that it was 2090 and that a new crossing was needed (*Institution Forum* 15 February). Professor Paul Jowitt, announcing the winners, said that all the entries showed concern for the environment, and all had more than one function including, for example, hotels or leisure centres.

Prizes were awarded during a talk given by Professor Ted Happold of Bath University, the last in an enormously successful series held in Edinburgh to celebrate the rail bridge's centenary. Each talk had been attended by about 300 people and organiser Roland Paxton has arranged for the papers to be published by Thomas Telford as an illustrated book in September.

The winning competition entry from Kirkcaldy High School was for a bridge of four arched tubes to carry vehicles and trains which were driven by compressed air. The school also made a video of its entry which was screened to the audience.

Other entries included a steel arched retractable bridge that – like two horns – disappeared into each side of the river when not required and a 'blob' that transported people across the Forth without the need for a bridge.

Happold gave his own views on how the Forth might be crossed in 2090. A structure based on nature would be the likely choice if the Forth bridges were replaced a century from now he felt.

In our time and in the future structures will depend on energy efficiency, said Happold. Ultimately mankind depends on the sun for energy and structures must harmonise with these energy needs, he said.

Roland Paxton had opened the lecture series with a talk explaining the challenges of crossing the Forth in the days before the bridge. It was always a busy waterway for coastal and continental boats. Many improvements to the existing harbours were considered and effected by engineers such as Telford, Rennie and Stevenson.

There were sections of tunnelling under the Forth at least four centuries ago to extract coal, he said. Mining engineer John Grieve proposed twin arched tunnels with a central drain in 1805 but this was never started. Paxton said that the ground would have been much worse than the engineers of the day imagined.

Thomas Bouch was first to consider the Queensferry site for a bridge across the Forth. The Bridge of the Forth, planned in 1865, was a viaduct with 62 wrought iron close lattice girder spans and four navigation spans. The 150m main girders would have been the longest in the world.

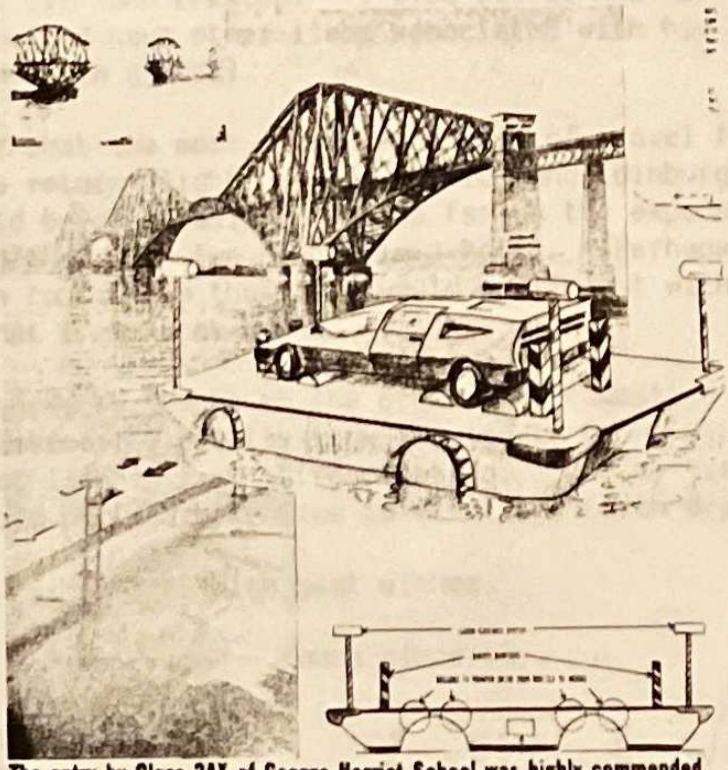
Boreholes showed 'not a single bit of stone' but Bouch's subsequent bearing capacity tests encouraged him to proceed. He proposed building and loading an experimental pier in situ. The trial platform was towed to site but when preparations were almost ready the project was abandoned for financial reasons.

This was almost certainly fortunate, according to Paxton, not only because of the questionable nature of its structural continuity and foundations in mud, but also because of its probable instability in strong wind.

**Kirkcaldy High School used four arched tubes to carry vehicles.**

chosen points of contraflexure. These breaks or hinges transformed it into a series of cantilevers and suspended spans. The first proposal was modified by Sir John Fowler and his junior partner Benjamin Baker to the form that is known today.

Shipway discussed the method of analysis, the materials, allowable stresses and forces in the bridge. 'Checking the figures has been a fascinating exercise but suggests the Forth bridge is not as over designed as is often supposed' he concluded.



**The entry by Class 2AX of George Herriot School was highly commended.**

The pressure for bridging the Forth did not subside for long, Paxton continued. In 1871 Bouch put forward a design for a suspension bridge. Work started in 1878 and by the end of 1879 William Arrol was hard at work preparing the steelwork.

But the Tay bridge fell and after the disaster public and press were loud in their criticism of Bouch's Forth bridge design and there was a massive loss of faith in the project said Jim Shipway, in the second talk of the series.

A fixed communication over the Forth was still felt neccessary and the design that emerged was for a continuous girder with definite breaks at

There were six kinds of men behind the bridge: men of vision, substance, learning, ingenuity, skill and muscle according to Ron Birse.

The men of vision dreamed up plans for spidery suspension bridges and cavernous tunnels that were impractical at the time but certainly pointed the way to the future.

The more solid Victorian virtues of ambition and determination were needed to make the bridge. The men who achieved it were men of substance, the railway barons, said Birse, because the North British Railway desperately needed bridges across the Forth and the Tay.

It was fortunate that the science and technology of the time were equal to the task, thanks to the efforts of the men of learning and ingenuity. It was equally fortunate that the designers were capable of combining the best in structural theory and practice with the advantages of steel over wrought iron, said Birse.

Contractor William Arrol, too, was without doubt the right man for the job, an intuitive builder of great bridges, said Birse.

The men of skill and muscle who erected the bridge worked through seven summers and winters and 57 are recorded as losing their lives on the bridge he said.

Bill Cox gave a talk on the construction of the bridge. There are three main towers, known as Queensferry, Inchgarvie and Fife. Each was built on four caissons and due to ground conditions all four at Queensferry and two at Inchgarvie had to be sunk under compressed air and landed on clay. Those at Fife were sunk in open conditions onto rock (*NCE* 1 March).

A large workshop and prefabrication area was set up on the south bank where components for the bridge were trial assembled and marked to ensure a good fit.

ScotRail's area civil engineer David Grant spoke on the bridge's maintenence. 'The one fault I would find is that the designers did not have a crystal ball and could not have foreseen the Health & Safety at Work Act of 1974. Perhaps if they had they would have done one more thing: design in a safe system to allow future generations to reach all the steelwork for maintenance purposes.'

There does not seem to have been any degradation of the granite of the piers, said Grant. On the approach spans there is a grit blasting and painting plan which started last year. The rails are ultrasonically tested and rail flaws in the older rails are more of a problem as year succeeds year.

□Roland Paxton is keen to hear from people who would like to order copies of the published papers at a discounted price of not more than £10. It is intended that subscribers names will be included in the volume. Write to him at Lothian Regional Highways department, 19 Market Street, Edinburgh, EH1 1BL.